02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Matthew B Johnson

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race:
(Select one or more)
☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☒ White

Disability Status:
(Select one or more)
☐ Hearing Impairment
☐ Visual Impairment
☐ Mobility/Orthopedic Impairment
☐ Other
☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

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PI/PD Name: Gregory J Salamo

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-23	FOR NSF USE ONLY
NSF 04-580 **01/24/05**	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) **DMR - MATERIALS RSCH SCI & ENG CENT**	**0520550**

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				848348348	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS ☐ A RENEWAL ☒ AN ACCOMPLISHMENT-BASED RENEWAL	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)
736017987	**0080054**	

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
University of Oklahoma Norman Campus	**University of Oklahoma Norman Campus** **731 Elm Avenue, Room 134** **Norman, OK. 73019**
AWARDEE ORGANIZATION CODE (IF KNOWN) **0031849000**	
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE	ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE
PERFORMING ORGANIZATION CODE (IF KNOWN)	

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS | ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Center for Semiconductor Physics in Nanostructures (CSPIN)**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **9,802,158**	**72** months	**09/01/05**	**0455519**

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.A)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.B, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.1)
- ☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date ______
- ☐ HUMAN SUBJECTS (GPG II.D.6) Exemption Subsection ______ or IRB App. Date ______
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ______
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.E.1)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Department of Physics and Astronomy	**440 West Brooks Street** **Norman, OK 73019** **United States**
PI/PD FAX NUMBER **405-325-7557**	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Matthew B Johnson**	**Ph.D.**	**1989**	**405-325-3961**	**johnson@mail.nhn.ou.edu**
CO-PI/PD **Gregory J Salamo**	**Ph.D.**	**1973**	**479-575-5931**	**salamo@uark.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Appendix D of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Leslie M Flenniken	Electronic Signature	Jan 25 2005 9:07AM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
405-325-4757	gradora2@ou.edu	405-325-6029

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

2. Project Summary

Overview: The Center for Semiconductor Physics in Nanostructures (CSPIN) is an ongoing partnership between researchers at the Universities of Arkansas (UA) and Oklahoma (OU). It is rooted in our common interest in nanoscience and in our need for a greater collaborative circle to address interdisciplinary materials science issues which are critical for both future technologies and fundamental physics. The partnership of 22 researchers spanning Chemistry and Biochemistry, Electrical Engineering, Physics, Engineering Physics and Mechanical Engineering, will allow us to tackle projects of a scope and complexity not feasible under the traditional funding of individual research projects. During the next six years we propose to improve material science education from K-12 to graduate school to the general public. We will explore and develop the collective behavior of periodic arrays of nanostructures and uncover and utilize the science of mesoscopic narrow bandgap systems by means of our *unique* breadth of fabrication techniques and range of materials which we bring to bear on the study of nanoscience.

Rationale: The quest for improvement in computing power, data storage, and communication requires new approaches to fabrication, new materials systems and new methods of operation. Both OU and UA have strong traditions of research in novel materials and in a broad spectrum of complementary nanoscale fabrication and characterization techniques. Our partnership is born of necessity ñ only together do we have the required scope of tools and expertise. Our IRG1 collaboration brings together proficiency in molecular beam epitaxy (MBE), electron microscopy, and optical probe techniques which resulted in our previous success in the fabrication and understanding of the underlying materials science and behavior of self-assembled structures. Building on this foundation we will advance the science and tailor the behavior of organized arrays of nanostructures. These advances will provide the basis for high density memory elements, crafted photonic lattices, and high efficiency arrays of light emitters and detectors. Similarly, IRG2 research in high mobility narrow bandgap semiconductors is a collaborative effort with demonstrated successes in growth, ballistic transport and optical studies of important spin behaviors with potential applications in bio-magnetic sensing and spintronic devices. We also have a strong record in science education outreach and educational and scientific human resource development in a region that is badly in need of both. The renewal of C-SPIN will allow us to capitalize on our previous successes and enhance our significant regional outreach and national scientific impact.

Proposed activities:

<u>*Collective Properties of Nanostructure Arrays (IRG1):*</u> A near term goal of IRG1 is to further refine our skills in MBE, colloidal and templated growth, which have already yielded beautifully ordered 2- and 3D arrays of quantum dots, wires and rings (noted in *Science* [1]). This effort will be expanded to include ferroelectric arrays, thus taking advantage of a theoretical strength (see *Nature* [2]). Achieving this control over growth will yield systems that give new insight into the collective interactions between individual units and will provide the basis for new optical and electronic materials. A longer term goal is to tailor a number of remarkable properties of 3D arrays: geometry dependent excited state lifetimes; improved size uniformity; tailored refraction and dispersion, and enhanced nonlinear optical, dielectric and piezoelectric coefficients, to produce negative refractive index materials that increase the limits of optical resolution, to advance handheld wireless devices, and to provide inexpensive memory that is fast, flexible, scalable, low-power, and non-volatile.

<u>*Mesoscopic Narrow Gap Systems (IRG2):*</u> The demand for higher speed operation, denser memory and increased functionality has motivated research on nanoscale electronic devices that now exploit quantum mechanical effects. We propose to utilize the unique properties of narrow bandgap materials to address these needs. Our narrow gap growth effort already boasts the worldís highest room temperature mobility in *any* semiconductor quantum well. We anticipate that these materials which are ideally suited to quantum confinement will make significant contributions to read-head technology, bio-magnetic field sensors, ballistic transport devices and spintronic devices.

<u>*Education and Human Resources*</u>***:*** Our ambition is to encourage inquiry based learning for the improved understanding of K-12 science and to promote materials science at the undergraduate level, graduate level, and to the general public. We propose to extend our programs which have already reached 1500 students, teachers and undergraduates with new efforts for expanded community outreach *via* partnerships

with regional museum consortia to promote inquiry-based learning museum exhibits and a peer-reviewed nanoscience digital library for teaching resources tied to science education standards. We have also united several new and existing efforts into an initiative to improve diversity within the Center. We will also expand our OU based K-5 after-school science program, and UA-based BEST robotics competition, GK-12 program, and microelectronic photonics IGERT, in addition to the REU, RET and nanotechnology pedagogy programs located at both campuses.

Seed: We propose Seed projects which enhance interdisciplinary and inter-campus efforts within the Center. The first adapts a novel nanopore microscope for optical and electronic sampling of single molecules. A second focuses on the tremendous potential for engineering surfaces to improve tribiological properties by exploiting our previous success in nano-templating. The final Seed develops a new partnership with our Colleges of Education by forming teams of pre-service teachers and Center scientists to design and implement inquiry based science curricula with dissemination through established networks of science teachers and school administrators.

Intellectual Merit: Each of our IRGs has been organized as a team with a proven track record in its research focus. CSPIN is rare in its breadth of nano-fabrication techniques (from molecular beam epitaxy to colloidal growth to the use of anodized aluminum oxide templates), its wealth of materials systems (III-V, II-VI and IV-VI semiconductors) and its diversity of characterization tools. The merit of the Center can be viewed on three levels:

! *Fundamental science:* The Center has targeted areas of broad fundamental importance. IRG1 will investigate the growth of nanostructure arrays to better understand their chemistry, surface energies and relaxation dynamics. This will produce a laboratory in which we can tune a wide range of properties (e.g. Coulomb interactions, tunneling, and confinement energy) in a periodic system to investigate how each alters the optical and electronic collective behavior of the array. IRG2 promises fundamental progress on quantum, ballistic and spin physics in relatively untapped materials ideally suited for these studies.

! *Enabling technologies:* Both IRGs develop fabrication and processing techniques that are enabling to the semiconductor and photonic industries. IRG1 will develop techniques to nanomanage the structure, spacing, and coupling of quantum dots, rings, wires and molecules in 2D and 3D, while IRG2 will develop technologically important high-mobility narrow bandgap semiconductor materials and devices.

! *Potential Applications*: The success of our research efforts will have a profound impact on device technology. IRG1 promises a variety of high density memory elements, small, high-bandwidth photonic switching devices, and high efficiency light emitters and detectors. The high mobility and strong confinement effects in narrow gap materials of IRG2 imply higher operating temperatures for ballistic transport, and greater sensitivity for magnetic field sensors, while the enhanced spin effects provide an additional opportunity for spintronic devices with new routes for computation and data storage.

Broader impact: Broader impact will accrue on three levels.

! *Environmental issues:* CSPIN research will have immediate societal impact as evidenced by our initiatives to develop greener synthesis techniques for greener nanomaterials.

! *Regional education and economy:* Since neither Arkansas nor Oklahoma has a high tech economy, we have a proportionally larger impact on science education and the development of high tech industry in our region than do most Centers. Our Center provides R&D tools for regional industry, skilled labor and new partnerships with academia. Our Outreach will fill a local science education vacuum by connecting with: the community *via* public talks on nanoscience and hands-on materials science museum displays; educators through training, graduate curriculum development and research experiences; and K-20 students through after school science clubs, classes and research opportunities.

! *Diversity:* Our vision is to enhance diversity in the nanotechnology workforce. Currently one quarter of our graduate students are women, and one tenth are members of minority groups. Our goal is for half female and one quarter minority representation by 2010. This will provide a diverse mentoring population for future students at all levels.

Human Resources: We play statewide roles in the development of human resources for both scientific *and* educational venues through our research opportunities for undergraduate students (REU), graduate students (UA IGERT in microelectronics) and teachers (RET) and have been particularly successful at increasing the participation of underrepresented groups in science. Additionally, UA boasts a GK-12 program which integrates our research and educational goals by pairing graduate teaching fellows with middle school math and science teachers. These programs will expand, while we propose to make an even larger impact with the addition of museum outreach, the development of a nanotechnology digital library for teaching resources and inquiry based science modules for classroom use. By improving science education, enhancing minority participation in science, promoting careers in materials science, spinning-off new small business and assisting industry, we not only train the next generation of scientists and engineers, we also sow the seeds for the economic development of the region and country.

Shared Experimental Facilities: The Center will leverage the comprehensive equipment base of its investigators as well as its shared facilities. Both OU and UA have molecular beam epitaxy systems with *in situ* scanning probe microscopy; while similar, these systems can grow different materials and have complementary capabilities. *Ex situ* optical studies of Center samples will be done primarily at UA, while high-resolution TEM and most transport measurements will be done at OU. This proposal will fund upgrades to existing fabrication and characterization facilities at UA and OU.

Industry and Academic Partnerships: Over the last 4 years, CSPIN researchers have increased their expertise in growth, characterization and theory and have developed outstanding shared facilities for growth and analysis. Our strong research capabilities have allowed for a number of external collaborations both industrial (e.g. NTT, Hitachi, IBM) and international (e.g. UniversitÈ de Franche-Comte, Humboldt University, University of Alberta). But perhaps the most exciting opportunity for the Center is the spinning-off of three companies. Nanoferr Inc. focuses on the development of layered ferroelectric structures. Minotaur Inc. is focused on the development of sensing technologies. NN-Labs has received two Phase II SBIR awards, marketed two complete product lines and three partial product lines based on colloidal structures. All three companies are intimately connected to CSPIN and involve several of CSPINís faculty, postdocs, and students.

Management: Administration of the IRGs will be the responsibility of the MRSEC director (Johnson), IRG directors (Salamo and Santos), and the supervising faculty members for the industrial (Xiao) and educational (Mullen) outreach. They will continue to hold weekly video conferences dealing with routine matters. Every 12 months the Center and IRG directors will solicit requests for support from Center researchers, as well as seed proposals from faculty outside the Center. Evaluation criteria include: scientific merit, past productivity, the degree of collaborative activity, and past participation in Center outreach activities. An External Review Board, (ten members from state government, industry and academia), will continue to receive yearly written reports on each IRG, and conduct biannual site visits. Since the Center spans two universities, we will continue to make use of teleconferencing facilities for our weekly meetings and seminars. However the drive time (under four hours) is no impediment to regular visits by Center personnel. Our annual graduate student research days, which are a big hit, will continue at alternating institutions. We will also arrange a yearly workshop among Center participants that will discuss not only our progress in research but share our successes in outreach and education.

Organizational Setting and Commitment: OU and UA are each the flagship research institution of their state. OU has over 31,000 students, a total operating budget of over $1 billion per year and yearly research expenditures of $210 million; UA has over 17,000 students, a general education budget of $270 million, and research expenditures of $116 million. Together with their state governments they have been strong supporters of the MRSEC, contributing over the last five years matching funding of over $2.5 million in direct support. This is also evident by the match for this proposal - two new permanent technical staff positions (in device processing and applied optics) plus dollars for a total of $3.7M in match (37.8% of NSF request).

This Center, founded on our separate research efforts, driven by our combined need for collaboration, and aided by our industrial and international partnerships, will provide the technology personnel and educational resources that are essential for the continued success of the U.S. in nanotechnology.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

4.A Participating Senior Investigators

University of Oklahoma:

Lloyd Bumm	Assistant Professor	Physics and Astronomy
Ryan Doezema	Professor and Chair	Physics and Astronomy
Matthew Johnson	Associate Professor	Physics and Astronomy/Engineering Physics
Patrick McCann	Professor	Electrical and Computer Engineering
Kieran Mullen	Associate Professor	Physics and Astronomy
Sheena Murphy*	Associate Professor	Physics and Astronomy/Engineering Physics
Michael Santos	Professor	Physics and Astronomy/Engineering Physics
Zhisheng Shi	Associate Professor	Electrical and Computer Engineering
Xincheng Xie	Professor	Physics, Oklahoma State University
W.T. (Ivan) Yip	Assistant Professor	Chemistry and Biochemistry
Caroline Hall*	Project Manager	
Bruce Mason	Associate Professor	Physics and Astronomy: Science Education
Joel Keay	MBE/SPM Specialist	Physics and Astronomy
Guoda Lian	TEM Specialist	Physics and Astronomy
Tetsuya Mishima	TEM/MBE Specialist	Physics and Astronomy

University of Arkansas:

Laurent Bellaiche	Associate Professor	Physics
Huaxiang Fu	Assistant Professor	Physics
Julio Gea-Banacloche	Professor	Physics
Jiali Li*	Assistant Professor	Physics
Omar Manasreh	Professor	Electrical Engineering
Hameed Naseem	Professor	Electrical Engineering
Xiaogang Peng	Associate Professor	Chemistry
Greg Salamo	University Professor	Physics/ Electrical Engineering
Surendra Singh	Professor	Physics
Z. (Ryan) Tian	Assistant Professor	Chemistry
Min Xiao	Professor	Physics/ Electrical Engineering
Min Zou*	Assistant Professor	Mechanical Engineering
Paul Calleja	Educational Outreach	
Ron Foster	Industrial Outreach	
Gay Stewart*	Associate Professor	Physics: Science Education
Ken Vickers	Research Professor	
Yongfen Chen	Colloidal Growth	Chemistry
Vasyl Kunets	Transport/ Noise	Physics
Yuriy Mazur	Visiting Professor	Physics
Zhiming Wang	Associate Research Professor	Physics

* Female Participant

4.B PERTINENT ACHIEVEMENTS UNDER PRIOR NSF SUPPORT

Under prior MRSEC support C-SPIN has successfully formed research teams with diversified expertise. These collaborations, both inter-campus and intra-campus, achieved significant progress towards the Centerís goal of growing novel nanostructures and understanding their underlying physical (optical and electronic) properties. Since inception in 2000, C-SPIN researchers have published 208 manuscripts and been awarded 15 patents. The following sections highlight the ability of C-SPIN research teams to tackle interesting and significant physical questions in nanoscience that could not be accomplished by individuals, and present our milestones in Education, Human Resources and Industrial Outreach, and Diversity. These achievements show that C-SPIN has succeeded to establish highly collaborative research teams and that the Center is in an excellent position to deliver on our newly proposed efforts in nanostructure arrays and mesoscopic narrow band gap systems.

IRG 1: ***Nanostructures-Growth and Behaviors.*** IRG1 focused on revealing the underlying science governing the growth and behavior of nanostructures. To ensure success, we assembled a team with a broad variety of expertise to approach the fabrication of nanostructures with a host of complementary self-assembly approaches: molecular beam epitaxy (MBE); colloidal chemistry; and templated processing. The effort encompassed not only the growth of such structures, but also their characterization and manipulation for novel phenomena, in both experimental and theoretical contexts.

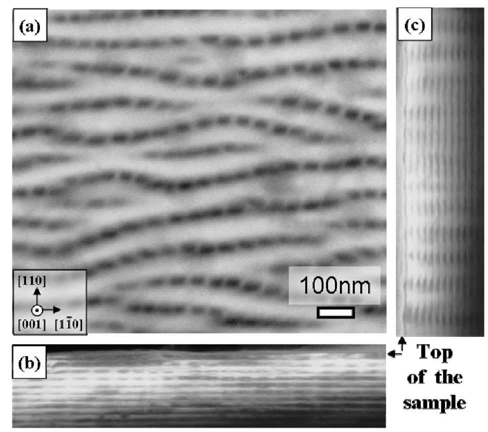


Fig. B1. TEM images of MBE grown QD chains. a) Plan-view from [001] direction b) X-TEM from the [110] direction and c) X-TEM from the [1-10] direction.

One highlight is our production and understanding of the growth of organized *three-dimensional* quantum dot arrays. These organized arrays are key to the success of our newly proposed efforts. For the past few years Salamo has manipulated the delicate energy balance associated with the MBE growth of strained monolayers to demonstrate control over shape, size, and density of quantum dots (QDs) and quantum wires (QWRs) [B3-B28]. As shown in the transmission electron microscopy (TEM) images in Fig. B1, the group has succeeded in arranging quantum dots which are ordered in all three dimensions. More recently, his group discovered a growth technique which produces quantum dot chains that are remarkably over *five microns long* with excellent size homogeneity [B29] and have also made use of surface diffusion to produce checkerboard arrays. Through an able combination of Xiaoís expertise in optical spectroscopy and Johnsonís expertise in high-resolution TEM, the physics underlying the growth mechanism was uncovered. By measuring a transition from a zero-dimensional QD electronic structure at low temperatures to a one-dimensional QWR at higher temperatures, the team identified the existence of a crucial one-dimensional wetting layer [B30], later confirmed by collaborators at the University of Alberta performing THz spectroscopy [B31]. This observation was used in turn to develop a diffusion model which led to the use of high index surfaces to engineer more uniform diffusion, an achievement of improved understanding and fabrication made through a feedback loop based on targeted characterization. Over the last four years, additional studies of these and related QD stacks by Xiao, Johnson, Ding, and other collaborators have resulted in over 30 joint publications. By working together they have been able to uncover many of the subtle rules governing the growth of QDs and QWRs.

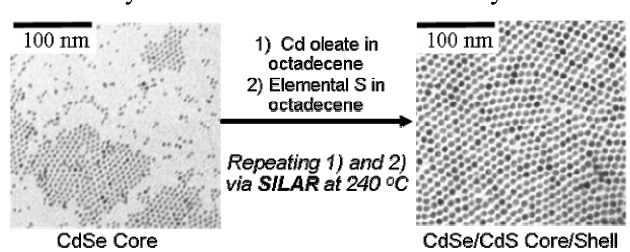


Fig. B2. Left panel: Precursor CdSe core nanocrystals. Right panel: CdSe/CdS core/shell nanocrystals. The SILAR process (successive-ionic-layer adsorption and reaction) yields unprecedented size and distribution control for the growth of core/shell nanocrystals.

Another IRG1 highlight is the important contribution to high quality colloidal nanocrystal fabriccation by Pengís group. These inexpensive nanocrystals are anticipated to provide new approaches to solar cell and biosensor development. The beauty of Pengís approach lies in his introduction of green chemistry principles for environmentally benign, inexpensive, and safe semiconductor nanocrystal production [B32]. As of yet existing theories cannot predict and explain crystallization processes systematically, hence the group has focused on the understanding of growth mechanisms for size- and shape-control [B33] and on the ligand chemistry of nanocrystals [B34]. The resulting high quality nanocrystals form the basis of the larger collaboration of Johnson, Xiao, and Peng. The team has skillfully carried out structure characterization of these new high quality nanocrystals [B35]. Additionally, Xiao and Peng have systematically studied optical properties [B36-B40] and related potential applications, such as gas sensing, [B41-B42] with theoretical work provided by Mullen and Fu. By working together they have been able to lead the field in inventing new colloidal structures and understanding their optical behavior.

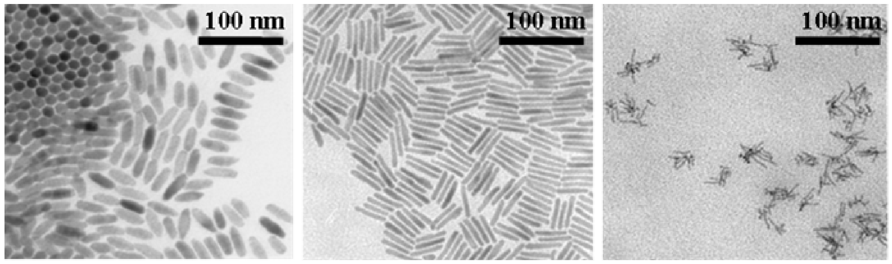


Fig. B3. Nonspherical nanocrystals, from left to right: rice, rods and tetrapods.

A complementary Center fabrication technique uses self-assembled anodic alumina oxide (AAO) templates in conjunction with conventional fabrication techniques to form nanostructures. Via this method, Johnson has fabricated highly ordered arrays of dots, wires, and rings from semiconductors, metals, superconductors, and ferromagnets [B43]. Within the Center, this effort has formed the basis of a theoretical collaboration with Mullen, who has predicted a new antiferroelectric phase transition in such ring arrays [B44] and an ongoing experimental endeavor with Murphy, seeking low temperature transport signatures of commensurability between magnetic flux lattices and anti-dot arrays in thin film superconductors. This effort has also inspired much external experimental collaboration including: Sandia (periodic modification of a high mobility two dimensional electronic system); IBM (persistent currents in normal metal rings); North Carolina State (ordered array silicon nanotube growth), and NASA-Huntsville (ordered array carbon nanotube growth).

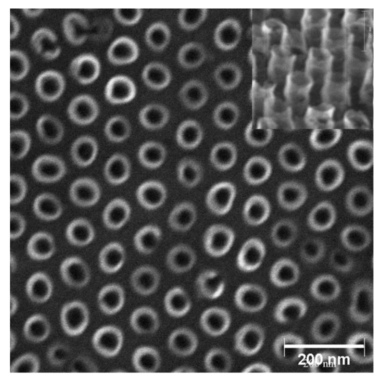


Fig. B4. SEM image of 150nm tall Ni tubes with 50nm diameters on Si substrates fabricated by AAO templating. Inset is an oblique view on the same scale.

In a final IRG1 highlight, Bellaiche and Fu have developed and used first-principles-derived techniques to explore piezoelectric semiconductors, multifunctional materials, and ferroelectrics, including nanostructures, resulting in a recent Nature article, 8 PRLs and numerous other publications [B45-B64]. Of particular import is their work on nanoscale ferroelectrics. Bulk ferroelectrics undergo structural phase transformations, giving multi-stable degenerate states with spontaneous polarization. Accessing these states by applying, and varying the direction of, an external electric field is a key principle for the operation of devices such as non-volatile ferroelectric random access memories (NFERAMs). Compared with bulk ferroelectrics, low-dimensional finite ferroelectric structures promise to increase the storage density of NFERAMs 10,000-fold, but this anticipated benefit hinges on whether phase transitions and multi-stable states still exist in low-dimensional structures. Previous studies have suggested that phase transitions are impossible in one-dimensional systems, and become increasingly less likely as dimensionality further decreases. Their *ab initio* studies of ferroelectric nanoscale disks and rods of technologically important $Pb(Zr,Ti)O_3$ demonstrate the existence of previously unknown phase transitions in zero-dimensional ferroelectric nanoparticles [B65], enabling an ultimate NFERAM density of 60×10^{12} bits per square inchó that is, five orders of magnitude larger than those currently available.

This highly successful theoretical effort, has spurred the Center such that a theoretical and *experimental* ferroelectric nanostructure team is now featured in our new IRG1.

IRG 2: ***Nanoscale Interface and Magneto-Electronic Properties.*** Under previous support, IRG2 was a multi-faceted effort to improve interfaces in semiconductors with the goal of exploiting that improvement for magneto-electronic experiments and devices. Successes in that effort, in particular for narrow band gap semiconductors, have directed our newly proposed IRG2 focus onto mesoscopic narrow band gap systems. Collaborative highlights of the current IRG2 are discussed below.

Experimentalists at both C-SPIN campuses had complementary approaches to the optimization of nanoscale interfaces. Experiments at UA concentrated on *in situ* STM studies of GaAs surfaces prepared by MBE. By augmenting the capabilities of the *in situ* STM with the substitution of a ferromagnetic tip, Thibado and Salamo were able to demonstrate the transfer of spin polarized electrons from a ferromagnet into a non-ferromagnetic semiconductor without substantially degrading the polarization. This team achieved polarization injection efficiencies as high as 92% into GaAs at temperatures of 100K. Their results, reported in *Science,* advanced the realization of using both charge and spin in future devices [B66]. An additional highlight of the GaAs effort was the joint experimental/theoretical work of Thibado, Bellaiche, and Mullen. This work, reported in two PRLs, provided fundamental understanding of how epitaxial growth proceeds on this technologically important surface. They explained that the coverage of a GaAs surface under a range of As overpressure and substrate temperature could be described in terms of a 2D lattice-gas Ising model and that the surface ìpre-roughensî by forming islands of specific size and shape [B67,B68].

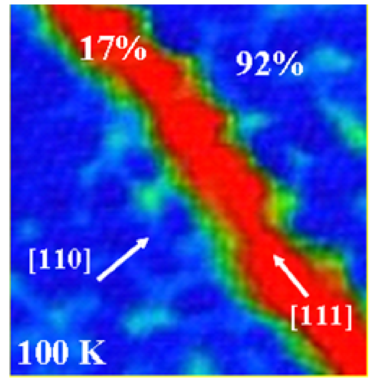


Fig. B5. The spatially resolved spin injection probability for GaAs(110). The blue region is a flat terrace and indicates a high spin injection efficiency (~92%). The red region is about 10 nm wide and corresponds to a 5 nm high step where the spin polarization drops to 17%.

Another experimental effort targeted InSb, a narrow gap semiconductor with a high room-temperature mobility and enhanced spin effects. Narrow gap semiconductors have received much less attention than others, in spite of several attributes that are highly desirable for nanoscale devices such as high mobility, small effective masses, and large LandÈ g factors and spin orbit effects. Such attributes imply higher operating temperatures for ballistic transport devices and enhanced quantum confinement for low dimensional devices. Moreover, enhanced spin effects provide an additional opportunity for spintronic devices. As technology demands require higher computational speeds and higher density circuitry, device dimensions shrink and quantum effects begin to interfere with standard classical operation. Spintronics provides a method of exploiting this new arena and may provide new routes for computation and data storage. One drawback to InSb growth, however, is the lack of a lattice matched III-V insulator to serve as a substrate material. Through extensive cross-sectional TEM measurements, Santos and Johnson improved the understanding of micro-twin defects in InSb [B69-B71] resulting in the design of new heterostructures with less disorder [B72]. The improvement in growth led to a number of cooperative efforts in both transport and optics. For example, Santosí collaborators at NEC demonstrated that InSb based magnetic-field sensors relying on the extraordinary magnetoresistance (EMR) effect [B73] provide a new route to commercially viable recording densities approaching 1Tb/in^2 [B74], an order of magnitude denser than possible with layered magnetic material. In a move towards even more innovative technology, a team of Santos, Murphy, and NTT collaborators fabricated the first ballistic transport devices made from InSb quantum wells. They observed ballistic transport in 0.5 micron-long structures at temperatures as *high as 200K* [B75], which is

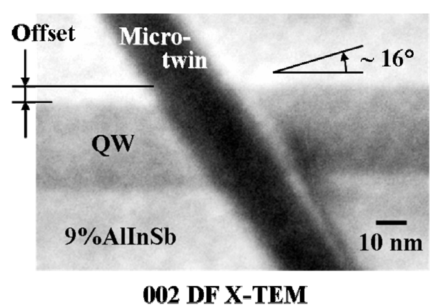
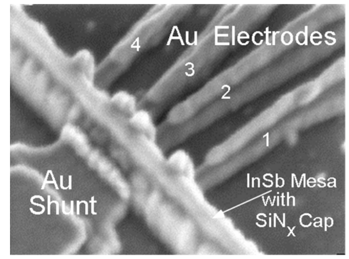


Fig. B6. An X-TEM micrograph of an InSb-AlInSb heterostructure grown on GaAs displaying a microtwin defect interesecting the quatum well.

100K higher than observed in GaAs. The team also made the first observation of quantized conduction through InSb point contacts [B76,B77]. These are important steps toward realizing a spin-polarized current source and other practical devices based on ballistic transport.



Additional fundamental physics experiments conducted by Murphy and Santos at the National High Magnetic Field Laboratory exploited the large Lande *g* factor of InSb to produce Ising-like quantum Hall ferromagnets [B78]. Mullen assisted in the interpretation of these experiments in which many body interactions conspire to create an exchange gap that preserves the otherwise vanishing quantum Hall state. By means of a seed grant, additional theoretical support was provided to IRG2 by Xie, who has extensive experience [B79-B81] with the S-matrix method originally developed by Buttiker and Landauer to study electronic transport in mesoscopic systems. His contributions are reflected in some new directions for the proposed IRG2 in which he is a senior investigator. Finally, the high quality InSb samples also enabled optics experiments that probe the unique spin properties of narrow gap materials [B82]. A far-infrared photo-conductivity experiment conducted by Doezema and Santos demonstrated that Rashba spin splitting, due to spin-orbit coupling in an asymmetric confinement potential, is large in InSb-based 2D electrons systems[B83]. This is key discovery for spintronics, as a large Rashba effect is essential for new devices based on electron spin precession, such spin transistors [B84].

Seed: C-SPIN sponsored a number of seed projects under previous funding. Two of them are highlighted here. The first Seed melded the colloidal chemistry effort in IRG1 with biology for the development of colloidal nanocrystal biosensors. The key challenge for this effort is to understand and control the surface (ligand) chemistry of the nanocrystal. In particular, the preferred photochemical active core/shell nanocrystals for this application displayed mediocre stability (lifetimes of 100 hours). This seed project addressed the lifetime issue by concentrating on the fabrication of super-stable box nanocrystals. The Seed project was very successful producing nanocrystals with no measurable degradation over 400 hours. Subsequently, this technology was transferred to NN-Labs (a privately held company founded by Peng). As a result, NN-Labs was awarded a Phase I SBIR grant from the NIH in 2004 to prepare luminescent anti-prostate specific antigen (PSA) single chain antibody fragment-quantum dot conjugates that can be used for the detection of prostate cancer. This conjugate has the advantages of small size, simple structure, easy preparation, low production costs, and easy modification via genetic engineering.

The second seed project highlighted here was also of a biological nature. This Seed supported the research of a new faculty member at UA (Jaili Li) to build a nanopore microscope to study single bio-molecules. She has built the nanosculpting system to make the nanopores in a Si_3N_4 membrane (diameter typically 3-50 nm). The nanopore microscope consists of a single nanopore separating two solution chambers. A bias voltage applied between the two chambers causes an ion current to flow through the nanopore. The pore is small enough that large molecules (*e.g.* DNA) partially block the ion current when they translocate the pore. The magnitude and duration of the ion current blockage is used to deduce the effective ìdiameterî and length of the molecule. Under seed funding she successfully implemented this research program in her new lab and it has formed the base of a newly proposed interdisciplinary seed (see proposed seed section) involving faculty at both campuses in Chemistry and Physics, which expands the project to include optical detection. The new Seed will augment the ion current signal with optical measurements of molecules in the nanopore as well as exploit the large electric fields in the nanopore for dielectrophoretic trapping and electroluminescence excitation.

Education, Human Resources and Industrial Outreach: Under previous funding, C-SPIN has evolved a well developed Educational Outreach effort, promoted the development of Human Resources through our graduate programs and postdoctoral appointments, and enhanced Industrial Outreach. Highlights of each are described below.

Our Educational Outreach program is currently coordinated by the team of Caroline Hall (10 years of middle/high school teaching experience) at OU and Paul Calleja (PhD in Kinesiology Pedagogy) at UA. With assistance from C-SPIN scientists they manage a K-12 program focused on inquiry based methods of learning science. We estimate that over the last 4 years 1500 students participated in these programs. The Center also provided meaningful research opportunities for 19 high/middle school teachers *via* an RET program over this period and 48 undergraduates *via* an REU program (with a 32%/37% minority/female participation rate at UA and 25% female participation at OU). Below we describe in greater detail our K-12 initiatives: *SeeS*; *GK-12 K.I.D.S.*; and *BEST*.

SeeS (Sooner Elementary Engineering and Science) is a stimulating OU-sponsored after-school K-5 science club run with the aid of undergraduate physics and engineering students. During the year, the program provides participating schools with six interactive science sessions on chemistry, electricity, and magnetism boasting an average attendance of 65 kids per session (>60% female, of which we are particularly proud). To better facilitate the goal of enhancing opportunities for underrepresented populations C-SPIN expanded this program to include a Title 1 school with a relatively large minority population for Norman (11% African-American, 8% Hispanic, and 14% Native American).

GK-12 K.I.D.S.* (*Kids ñ I Do Science) is a program sponsored by NSF and UA that places physics, engineering, and chemistry graduate fellows into six Arkansas middle schools and integrates research and education. Fellows, paired with middle school math and science teachers develop inquiry-based modules that fan a childís natural curiosity about science. To date, 25 fellows (ten performing research with C-SPIN faculty) and 12 teachers have participated in the program. Eleven of the teachers have been female and 32% of the fellows have minority backgrounds.

***BEST* (*Boosting Engineering, Science, and Technology*)** is a robotics contest that lets junior high and high school students experience the passion of being a scientist or engineer. C-SPIN promotes Northwest Arkansas BEST through volunteer participation and financial support, sponsoring an average of 20 local teams per year comprised of 10 students each, culminating in a game day at the Fayetteville High School where teams compete for an opportunity to advance to the national competition held at SMU in Texas.

Since 2000, the Center has promoted Human Resource development in Nanoscience with the matriculation of 15 graduate students to M.S. or Ph.D. programs. Additionally, eight Ph.D.s have gone on to scientific employment after holding postdoctoral positions within C-SPIN. Our programs for undergraduate and graduate students included three new courses on nanotechnology. Two graduate courses (Advanced Nanomaterials Chemistry and Science of Nanodevices) were developed by Peng and Salamo with C-SPIN support, with the latter teleconferenced for joint OU/UA enrollment. At the undergraduate level, NanoLab, a sophomore-level hands-on laboratory course in nanotechnology has been developed by Bumm and Johnson with NSF-NUE funding and taught at OU, August intercession 2003 and spring 2005.

Industrial outreach included workshops on proposal writing and entrepreneurship, as well as partial support of UAís ìInnovation Incubator,î which worked on the commercialization of ten patent disclosures made by Center participants. Our Center director has made several presentations to organizations promoting regional venture capital and serves on state-wide committees sponsoring high tech development. The most exciting opportunity for the Center is the spinning-off of three companies: NN-Labs led by Peng and based on colloidal structures; Nanoferr Inc., led by Bellaiche and Salamo, focused on the development of ferroelectric layered structures; and Minotaur Inc., led by Xiao, and focused on the development of sensing technologies.

Diversity: We are encourage by our previous record on faculty diversity with two female scientific PIs (3 in this new proposal) and two male minority PIs (1 continuing). We also have very healthy representation of female (25%) and minority (10%) C-SPIN graduate students, and minority graduate fellows (32%) in the UA GK-12 program. UA has done a particularly fine job of attracting underrepresented groups to their REU program (50% female/25% minority, in 2004) and retaining them for graduate study; a record OU hopes to emulate by adopting some of the UA strategies. Diversity at both C-SPIN campuses should improve further within new initiatives as discussed in the EHR section of this proposal.

4.C IRG1: COLLECTIVE PROPERTIES OF NANOSTRUCTURE ARRAYS

Faculty: Bumm, Johnson, McCann, Mullen, Shi, (OU); Bellaiche, Fu, Gea-Banacloche, Manasreh, Peng, Salamo, Tian, and Xiao (UA); 6 postdocs, 6 graduate students; **Partners:** Humboldt Universit‰ (Germany), University of Central Florida, UniversitÈ de Franche-Comte (France), University of Arkansas-Pine Bluff, see sections 4.E.2 and 4.E.4 for descriptions of other collaborations.

Focus: Based on the observation that all bulk material properties depend upon the spatial order of identical units (*i.e.* atoms or molecules), the two overarching goals for this IRG are to:

! Refine and apply a host of fabrication techniques to synthesize ordered arrays of nanoscale *synthetic* units (dots, wires, rings, shells, etc.) for a range of material systems that will allow exploitation of their coherent and collaborative behavior.

! Combine these techniques with modeling capabilities to understand, predict, and tailor properties, such as excited state lifetimes, refractive index, ferroelectric coefficients *etc*. for technological applications.

Motivation: The last decade has seen great advances in our ability to create semiconductor structures on the submicron scale. This has been driven in a large part by the desire for increased chip performance, and memory density. Submicron linewidths are now routine in commercial semiconductor devices, but as structure size dwindles, traditional lithographic techniques are encountering fundamental limitations. To achieve smaller feature sizes more innovative techniques such as self-assembly or nanosculpting must be explored. C-SPIN researchers have demonstrated success in a number of complementary techniques of self-assembly [C01-C10], and in the optical, electronic, and crystallographic understanding of the resulting individual nanostructures [C11-C22].

While we continue to pursue control over the morphology and behavior of individual nanostructures we now have the exciting opportunity to explore their collective behavior. *Periodic* nanostructure arrays are desired for two reasons. First, they are much more uniform, which greatly improves their efficiency as lasers, detectors, memory systems, and nonlinear optical devices. Second, the collective properties of these arrays, such as their index of refraction, their polarizability or their bandstructure depend upon their spacing, degree of interaction, defects, characteristic single electron energies, etc. While we are well aware of the collective behavior of solids, we have a new playing field to study and engineer ìcollective behaviorî. Shown in Fig. C1 is the x-ray diffraction pattern of 2D lattices of QDs. The peaks in the x-ray pattern tells us that we have an array that mirrors a typical crystal. As a result, we can expect that by nanomanaging the structure of an organized array of synthetic units we can create systems in which we have control of their optical and electronic properties, even tailoring them to regimes not found in Nature. For example, we can create media with abnormally large or even negative indices of refraction, nonlinear optical photonic crystals that can dramatically change its reflectivity with an applied electric field or increasing optical intensity, or a 2D system that is metallic in one direction and tunable from an insulator to an electron or hole conductor in the perpendicular direction. Such ìmaterial by designî control would open a new era in applications ranging from improving ferroelectric memory densities by a factor of 10,000 to optical circuit that rival their electronic counterpart.

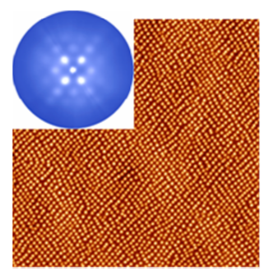


Fig. C1. An organized QD 2D array. The insert is an x-ray pattern that reveals the array periodicity. QD size is 20 to 30 nm.

Proposed Research: We intend to develop understanding and control of an array of synthetic units by creating highly ordered arrays of III-V, IV-VI, and II-VI semiconductors and ferroelectric materials. Based on our earlier work we know this goal requires an interdisciplinary research team. For example, given the complexity of cooperative effects and the large range of material parameters, modeling of arrays of synthetic units (Bellaiche, Fu, and Mullen) will provide the needed guidance to growth (Johnson, McCann, Peng, Salamo, Shi, and Tian) while the validity of modeling and the quality of growths must be tested by observing and exploiting behavior (Bumm, Gea-Banacloche, Johnson, Manasreh, Salamo, and Xiao).

Below we first discuss our research on the fabrication of semiconductor nanostructures. Fabrication will continue to be an area of active research, and C-SPIN greatly benefits by the cross-communication between its fabrication groups. We then discuss particular systems, starting with quantum dot (QD) arrays. We divide this large topic into research on their optical properties and their electronic properties. Next we discuss quantum rings (QRs), explaining how their physics differs from dots, and our plan to explore their collective behavior. Finally we will discuss ferroelectric (FE) nanoparticles and nanorods, explaining their unique opportunities, fabrication challenges, and applications.

Nanostructure Fabrication: We will create arrays of dots, rings, and wires ranging from clusters of several dots to periodic structures with thousands of units. To explore their collective properties we will require fine control of their lateral and vertical spatial position. To accomplish this we plan three related directions of fabrication research: MBE self-assembly, colloidal growth, and nanotemplating. Although our initial effort is focused on semiconductor and ferroelectric (see below) *synthetic* units we will expand and explore new materials as our expertise develops.

<u>*MBE Growth:*</u> Under the previous IRG1, Salamo demonstrated exceptional control of QD arrays grown via MBE *self-assembly* wherein the strain of one epitaxial material on the next, causes the new growth to spontaneously form 3D islands (see adjacent) [C23-C26] that are typically only 10 nm across.

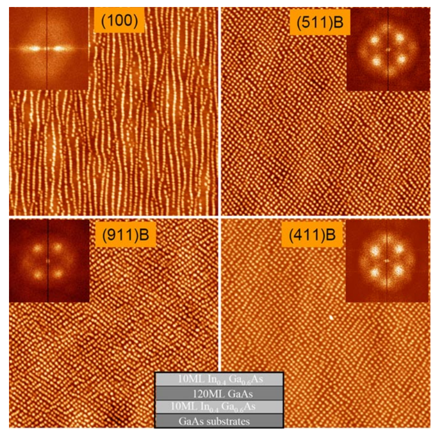


Fig. C2. Examples of the rich variety dot ordering that can be obtained using the interplay of stain field and diffusion asymmetry.

Strain-driven, self-assembled, three-dimensional InGaAs islands and quantum dots (QDs) randomly distributed over GaAs (100) surfaces have been an exciting area of research for the last decade and one in which C-SPIN has made significant contributions. Our more recent results show how the interplay between the long-range nature of the strain field and the asymmetry of diffusion, can cause QDís to order vertically *and* laterally (see Fig. C2) with a typical spacing on the order of the dots themselves, but much work still needs to be done to fully understand the underlying physics. For example, this research leads to a new question: is this strain-driven process sufficient to achieve our desired control over QD positioning or is outside help, such as lithography, required?

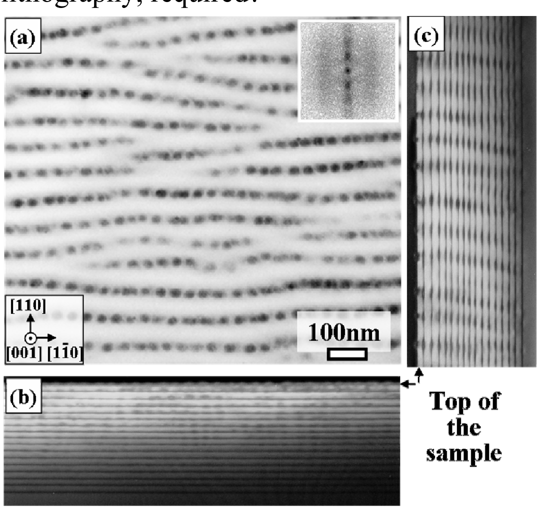


Fig. C3. TEM images of MBE grown QD chains.

In this new effort Salamo, Shi, and McCann will use stacking techniques to exploit the amazing organizational ability resulting from strain to produce new structures *i.e.* a square lattice of single QDs or a regular array of QD pairs, triplets, or even clusters in III-V and IV-VI materials. Guided by TEM (Johnson) this team will explore different growth conditions, and index surfaces. Their goal is to better understand the roles that diffusion, strain, composition, temperature, and over-pressure play in determining the lowest energy state of the surface, the knowledge of which can provide control for the precise positioning of our nanostructures. Such control is vital since variations in feature size or spacing can profoundly alter collective behavior.

Our proposed approach can be best explained with some preliminary results. It is easy to see that for stacks of dots we can form excellent dot chains, and that by varying the separation thickness (from 60ML to

90ML) we can control the strain transferred from layer to layer. Fig. C3 shows that with increasing separation the dot chain becomes less well defined. In addition, it shows that by decreasing the In content the strain in any one layer is insufficient to form dots before a wire becomes the lowest energy configuration. This behavior indicates we have an initial understanding of the formation mechanism and implies we can engineer the lateral and vertical ordering. We propose that the transfer of strain from one layer to the next is not uniform due to the asymmetry in diffusion. The result is that the strain is large perpendicular to the dot chain but low along the chain since the high diffusion rate along the dot chain direction tends to relax the strain along the chain. If this is true, then by using a high index substrate we can design steps along the dot chain that decrease diffusion and allow us to produce 2D lateral ordering. Initial results agree with this prediction, again showing the potential of self-assembly to naturally order the dot array.

While this is a start, there is still much to learn. We propose to investigate the lateral strain on the surface using TEM, the growth dot-layer by dot-layer using STM, and the nature of the dot-layers after coverage using AFM and an etching technique that can remove one dot layer at a time. While the above discussion is focused on III-V structures, we will do the same for IV-VI materials.

A related path to quantum wire arrays will be pursued in IV-VI materials. Fig. C4 depicts the atomic arrangement at the CaF_2/Si interface, and Fig. C4 (b) shows an electron microscope image of an as-grown CaF_2 surface [C27]. Using the scanning probe microscopy (SPM) and associated surface morphology characterization equipment attached to our (McCann) IV-VI MBE growth chamber, studies of initial nucleation behavior (i.e. whether PbSe begins in the valleys or on top of the ridges) will be performed. It is expected that the low energy of the [001] PbSe surfaces perpendicular to the (110) growth surface and parallel to the [$\bar{1}$10] direction will promote the formation of PbSe stripes parallel to the [$\bar{1}$10] direction. Alternating growth between sub-monolayers of PbSe and wider bandgap PbSrSe matrix material, for example, will result in an embedded quantum wire structure. Initial work suggests that it should be possible to obtain PbSe quantum wire arrays free of twins. Center facilities such as HRXRD and TEM will be used to help answer such growth questions.

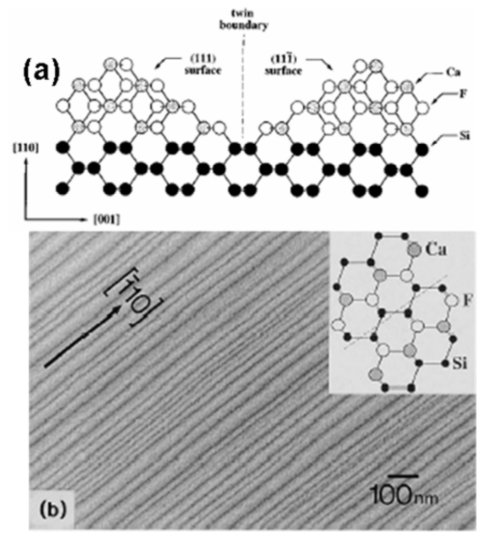


Fig. C4. (a) CaF_2/Si(110) interface looking in the [$\bar{1}$10] direction. (b) SEM micrograph of the surface morphology of CaF_2/Si(110) Inset: plan view of a possible bonding arrangement at the CaF_2/Si(110) interface.

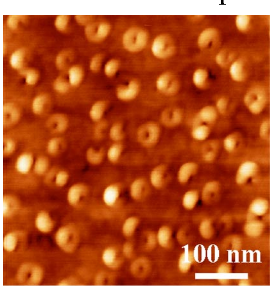


Fig. C5. AFM image (500 nm on a side) of an array of GaAs/AlGaAs rings.

In addition the dot-layer method to self-assemble ordered arrays we also have begun to explore another technique. While the Stranski-Krastinow growth approach has had dramatic success with lattice-mismatched systems, a different approach is needed for lattice matched systems such as GaAs/AlGaAs. Lattice matched material systems can have as much, if not more, technological importance. *Droplet epitaxy* offers the possibility of formation of quantum dots without the need for a lattice mismatch. In droplet epitaxy of GaAs/AlGaAs, Ga is first deposited to create liquid Ga droplets on a AlGaAs surface and subsequently exposed to a high arsenic flux that transforms the droplets into GaAs nano-crystals or quantum dots [C28]. We can extend droplet epitaxy to grow a plethora of GaAs nanostructure geometrical shapes never explored before. GaAs nano-rings (Fig. C5), flat, round nano-coins containing square holes, coupled dot pairs and even structures shaped like a lit candle can be observed under different substrate temperatures and arsenic fluxes.

This is but the beginning. For example, we will try droplet epitaxy with In droplets to form strain relaxed InAs QDs on GaAs. Using this dot layer we will be able to explore stacked dot layers and investigate the possibility of organized arrays. Another direction is to use rings to seed dots that form in a ring pattern. The possibilities are limited only by our imagination.

Finally, while QD arrays can be described as ideal lattices with nodes occupied by QDs, arrays may also contain topological defects, such as dislocations, vacancies and interstitial QDs. The defect in arrays of QDs can potential affect the properties of QDs. Defects can cause stress which can influence the structure, composition, and the shape of QDs. Of course missing rows of dots can also play an important role in photonic crystal behavior. As a result, using patterned surfaces to play with deviations of QDs from their equilibrium spatial positions in arrays offers exciting possibilities to further engineer the collaborative elastic and energetic characteristics of the array.

Colloidal Chemical Growth: A parallel effort is to grow QDs from colloidal suspensions via chemical synthesis of nanocrystals. C-SPIN will address two challenges: developing greener approaches to greener products, and using them to grow self-assembled 3D arrays of QDs from colloidal suspensions.

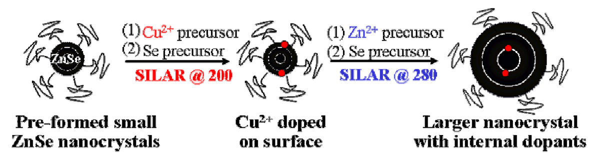


Fig. C6. Illustration (using copper doping as example) of the doping strategy to be developed in this project.

Previously C-SPIN worked on ìgreenerî (i.e. less toxic) synthesis techniques of high quality II-VI nanoscrystals, mainly on CdSe since it has been the focus of the field to date [C29]. While the *technique* is much improved, the main ingredient (cadmium) is extremely toxic and highly carcinogenic. We propose to use transition metal doped ZnSe and ZnS as alternatives to cadmium based nanocrystals. Zinc is much more environmentally ìfriendlyî in comparison to cadmium. We propose to alter our previous green approaches to now produce high quality zinc chalcogenide host nanocrystals. The bulk bandgap of ZnSe (2.7 eV) and ZnS (3.5 eV) is too high to make nanocrystals that emit in the visible, or NIR window for optoelectronics and bio-medical labeling. However, doping them with transition metals will resolve this problem.

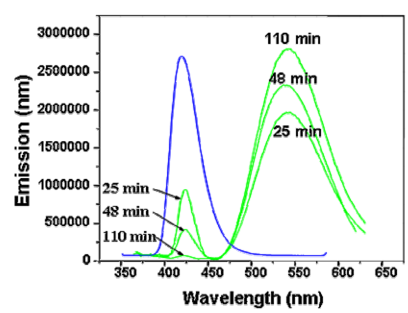


Fig. C7. Copper doping process monitored by the temporal evolution of PL spectrum.

The key when synthesizing doped nanocrystals is to controllably place dopants in every nanocrystal at designated positions. Our strategy is based on the newly introduced Successive-Ionic-Layer-Adsorption-and-Reaction (SILAR) or Solution Atomic-Layer-Epitaxy (SALE) technique for the growth for core/shell nanocrystals [C8]. These techniques rely on alternating injection of the cationic and anionic precursors into the nanocrystal solutions, a concept which is again brought into the colloidal field from MBE through the collaboration between PIs in our center. The amount of each injection would be sufficient for the growth of one monolayer of the shell. In this way, homogenous nucleation of the shell material is greatly suppressed. A slight variation of SILAR can be used for the growth of controllably doped nanocrystals.

This strategy differs from existing ones in that the doping occurs after the nucleation stage. By manipulating growth conditions and reactivity of the precursors, this strategy allows the sole growth of the doping atoms without the growth of the host. Therefore, it is possible to allow the system to react until it reaches an optimal doping distribution. Our preliminary results indicate that it is possible to dope all nanocrystals in the reaction system, judged by the complete elimination of the bandgap emission and appearance of a strong doping emission (up to about 30% quantum yield).

The second major Center initiative in colloidal growth is to assemble periodic 3D arrays. As explained in 4.B, C-SPIN has (Peng) in the past five years developed expertise with one of the broadest spectra of colloidal nanocrystals available, with a variety of sizes, shapes, compositions, and ligand modifications [C30,C31]. The new challenge is to use these nanocrystals as building blocks in periodic structures. Tianó a new Center member and a pioneer on hierarchical assembly of colloidal nanostructuresó will develop sophisticated 3D arrangements nanostructures in solution or on substrates. The current state-of-the-art, mostly developed by his group, is limited to building blocks bigger than several tens of nanometers [C32] typically made from SiO_2. We have two projects in C-SPIN using this hierarchical technique.

First, we plan to incorporate useful materials (e.g. semiconducting or metallic nanocrystals) into the current SiO_2 arrays. This will give us periodic 3D arrays of nanoparticles but with a period on the order of microns, the same as the host lattice. A second, more ambitious initiative is to combine Pengís expertise on synthesis and manipulation of nanocrystals, Tianís knowledge of hierarchical assembly and Johnsonís TEM ability, to develop 3D assemblies of nanocrystals, far smaller than anything currently achieved, We will build ZnO nanostructures with different dimensionality, geometry, as well as dominating crystalline surfaces. By seeding the substrates with Center produced nanocrystals of different sizes and shapes, we will be able to grow oriented ZnO nanorods with different diameters and heights simply by controlling reaction parameters such as time, temperature, and precursor concentrations. This will give us hierarchical structures where we can tune the pore size in the range of a few to tens of nanometers. One immediate application of such structures would be as improved catalysts for oil cracking refinery and photodecomposition of large organic pollutants. By controlling the self-assembly we can control porosity and dominantly exposed crystal face. For example, the (001) surfaces are commonly linked to the ZnO catalytic properties; developing a synthesis in which they dominate will improve catalyst performance. Other, collective properties are discussed below.

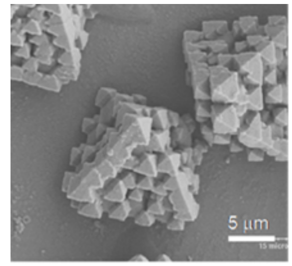


Fig. C8. Self-assembled 3D clusters of colloidal SiO_2 particles.

Nanotemplated fabrication In this approach we use anodized aluminum oxide (AAO) templates as ordered masks for both etching and deposition. By controlling the electrochemistry, we can achieve trigonally ordered arrays of pores in AAO with pore diameters ranging from 10 to 100 nm, and an inter-pore separation about twice the pore size itself [C10]. The correlation length of the array itself can be varied from a few pores to several microns depending upon etch conditions. The resulting AAO mesh is then thinned to a thickness of 3-500nm and placed atop any substrate. The simplest application has been the use of the masks to etch or deposit semiconductors grown within the Center as discussed in section 4.B. These techniques can also be used to grow more complicated structures: at the right is an array of amorphous silicon rings formed by sputtering a silicon substrate through an AAO mask. The sputtering removes the oxide surface, exposing the silicon below. Upon further sputtering this exposed silicon is knocked from the surface and redeposits in rings on top of the insulating oxide layer.

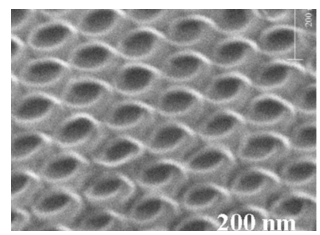


Fig. C9. SEM view of amorphous Si rings on an Si substrate.

We are researching three new fabrication areas based on these nanotemplates: using them for patterned self-assembly, using them to create nano-contact printing masks, and developing nanotextured quantum wells.

Johnson, Salamo, and Peng will use these structures to do *in situ* electron or ion beam ì millingî of substrates. Subsequent MBE growth will spontaneously self-assemble upon the nanosculpted substrate. Such ìpatterned self-assemblyî will result in control over QD spacing and array patterns opening the opportunity for studies on coherent optical effects, photonic crystals, and lattice defects. A second, related effort is to use milled substrates to guide colloidal nanocrystals into depositing on a substrate in a periodic pattern. These arrays can then be processed further either with MBE or wet chemistry. A complementary approach by Xiao and Salamo will use optical interference and e-beam lithography (both in house and with Humboldt Univ.) to pattern substrates.

Second, Bumm and Johnson will exploit AAO templates as mold masters for nano-contact printing [C33]. Preliminary work shows that PMMA can be molded into 50 nm fingers. Nanotextured patterns like this will be used as a contact printing stamp to transfer chemical patterns (alkanethiols, alkanoic acids, dendrimers, etc.) onto semiconductor surfaces (band-gap perturbation) and onto metal surfaces (resists) for ZnO growth (Tian).

Finally, we also propose to explore nanotextured quantum wells made possible by using our AAO templates to deposit materials on top of Center grown samples (Johnson, Salamo). The key insight is that these masks can be used to create periodic arrays of *any* material: semiconductors, ferromagnets, superconductors, etc. grown atop semiconductor quantum wells. We would then have a technique to periodically perturb the bandgap, spin field, strain field or screening of the electron gas below. Not only can this be used to create QD and quantum antidot arrays, it makes possible a wide variety of spin and charge textured arrays in the underlying quantum well.

QD Array Applications: Below we describe our proposed research into the optical and electronic properties of the QD arrays whose fabrication was described above.

<u>QD Array Optical Applications:</u> We will integrate our QD arrays into a host material that mediates the coupling between the dots and understand, predict, and tailor their properties. While the QD size will be on the order of 5 to 50nm, the dot separation will vary from close packing to the order of the wavelength of light. These arrayss will be used in four interdisciplinary themes. Below we first discuss the bulk optical properties of such structures, *e.g.* the index of refraction. We then discuss the possibilities inherent in 3D microcavities and QD fiber lasers. We conclude with a discussion of quantum dot molecules.

A collaboration of Salamo, Xiao, and Gea-Banacloche will use their experience in coherent pulse propagation and quantum optics to design and measure dot arrays with tailored absorption and dispersion properties [C34]. A very large change in refractive index can slow down the propagation of light to enhance the matter-light interaction and greatly increase optical nonlinearities at low light levels. Long term a negative dispersion slope will be designed through the dispersion relations of coupled oscillators producing a group velocity that is faster than the speed of light [C35]. Collaborating with the Universities of Central Florida and de Franche-Comte, they will design an enhanced nonlinear optical response using solitonic waveguides (Salamo) [C36] using dot arrays. They will also use electromagnetically induced transparency (EIT), a phenomena in which Xiao and Gea-Banacloche are experts [C37,C38], to produce enhanced nonlinear optical coefficients. Arrays may enable EIT using induced collective coherence to tailor absorption and dispersion. This will lead to optically controlled optical switches.

Another exciting opportunity is the manipulation of temporal and spatial dispersion by organizing oscillator phases to control optical behavior. For example, cooperative emission from QD ordered arrays can be lengthened or shortened. Guided by TEM (Johnson) Xiao, Salamo, and Manasreh will rely on their experience with the atomic and solid state to measure, design (with Mullen and Fu) and control the radiative decay time (T_1) and the dephasing time (T_2) by varying the array geometry using patterned substrates [C39,C40].

The second optical research theme is to use synthesized 3D nanocrystal arrays and hierarchically assembled microcavities to study novel effects in cavity-quantum electrodynamics. For example, by putting single nanocrystals inside a 3D microcavity we will investigate the modified emission of the semiconductor nanostructures, especially quantum dots, and strong coupling between the quantum dots and the high-Q cavity modes. The 3D cavity mode structures will have very different features compared to the usual planner cavity in the microcavity situation and have better mode confinement in all directions. With a coupled system of semiconductor nanocrystals inside a 3D microcavity, we can study the lasing properties of a single semiconductor quantum dot, which has been predicted to have a very low threshold, or may even be thresholdless. In addition, a single quantum dot inside a microcavity would display optical bistability, which can have important applications in optical switching and optical logic gates. Xiaoís group has extensive experience with studying optical bistability in a system with two- and multi-level atoms inside an optical cavity.

A related project will be the incorporation to develop a combination of solid state fibers and semiconductor lasers, to produce mid-IR lasers. Bulk IV-VI materials in all forms have demonstrated strong mid-IR light emission. This property should survive their incorporation, either by deposition or solid solubility, into glass fibers. The fibers then offer a single mode of light propagation, circular beam output, and high thermal conductivity, all useful properties for a laser [C41-C43]. We (Peng) will fabricate PbSe (PbSnSe) QD and fill them into a mid-IR hollow fiber, and then measure the light emission properties of the fiber with PbSe QD develop the cavity for the fiber, and investigate the laser beam quality and modes (Shi). The proposed research could result in a robust, environmentally insensitive and low-cost mid-IR laser that can meet the requirements for military and commercial applications.

New insight into the physics of the coupling between QDs can be gained by investigating InAs/GaAs bi-layers possessing unequal-sized QDs in the first (seed) and subsequent (second) layer separated by a GaAs spacer of variable thickness [C44-C46]. Such pairs form ìquantum dot moleculesî (QDMs). Up to now the channels of energy transfer from the smaller QDs in the seed layer to the larger QDs in the second layer in asymmetric QDMs are not totally clear [C44,C47]. In order to uncover details of the energy transfer routes, the QDMs states have to be distinctly isolated in the complex array of states seen in the photoluminescence (PL) or PL excitation (PLE) spectra of bilayer structures. In order to unravel the complexity of states we will clad a bi-layer structure with AlGaAs layers to provided additional confinement and prevent carrier diffusion from the QDís volume.

We will investigate the energy states of self-assembled QDs in bilayer InAs/GaAs structures using PL, PLE, and RPL techniques. These states will be selected by the strong PL line narrowing (on the order of FWHM ~ 30 meV) and selective PL enhancement when the spectral range of the QDís transitions in the seed layer is investigated. Experiments will also explore size and separation effects. This study will provide new insight into the nature of QDMs and mechanisms of inter-layer electronic coupling. We also propose to use TEM and NSOM to study coupling between the QD pair as shown in Fig. C10. In this case early results clearly show a dot pair has formed but much work has to be done to control the size and separation in order to understand and provide evidence for a molecular energy structure. We will also design experiments to explore the temporal behavior of excited arrays to understand the various decay routes.

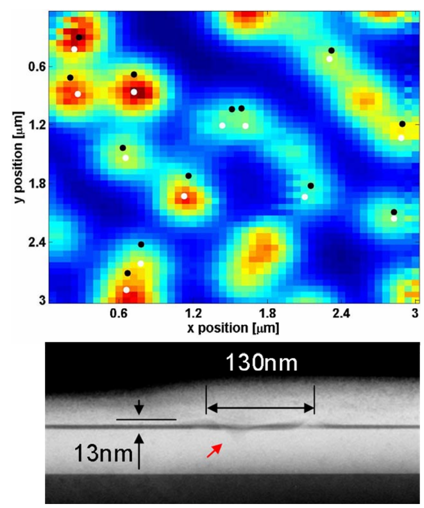


Fig. C10. (top) NSOM data indicates two well separated spectral peaks (a black dot for the high energy and a white dot for the low energy) for each quantum dot molecule. (bottom) XTEM of one dot pair.

QD Array Electronic Properties: : We propose three areas of interdisciplinary study in the collective electronic properties of periodic nanostructures. The first is an applied study of thermoelectric effects in IV-VI semiconductors, the second an investigation of ìquantum dot moleculesî, and the third a longer term and more speculative study of creating conducting 2D and 3Dd superlattices in periodic QD structures. We describe each in detail below.

Thermoelectrics are industrially important materials that have applications in power generation and cooling. Thermoelectrics are rated by their ìZT value,î a figure of merit that incorporates the ratio of the temperature gradient to the voltage developed, and the thermal and electrical conductivities; typical ZT values are around 1.0. Recent work by Harman et al. [C48] has shown that IV-VI semiconductors with quantum dot arrays can achieve ZT values approaching 2.0. The embedded quantum dots enhance phonon scattering and thus reducing the thermal conductivity while the modulation doping provides high charge carrier mobilities. ZT values greater than 5.0 are predicted for materials that contain quantum wires.

Certain combinations of quantum dot/wire dimensions and well depth will produce electron and hole energy level spacings that are equal to transverse optical (TO) and/or longitudinal optical (LO) phonon energies. This will produce a strong electron-phonon resonance that can enhance thermoelectric performance. If quantum wires (or wells) are engineered to obtain an electron-phonon resonance involving quantized charge carrier states, transfer of energy between these modes will be made more efficient. Optimizing the system will require theoretical modeling (Mullen, Fu), a tight feedback loop between sample growth and analysis (Shi, McCann, Johnson), as well device characterization (Manasreh) all brought together in this proposed research center.

A second project is the electronic properties of QDMís fabricated by vertically stacking two layers of epitaxially grown self-assembled QDs [C49]. We propose that QDMs can serve as a quantum bit (qubit) in quantum computing [C50] for the realization of quantum gates processing two-qubit operations [C51,C52]. The challenge is to obtain resonant quantum-mechanical coupling in spite of the size, composition, and strain inhomogeneities inherent in the growth of QD ensembles. Indeed, QD arrays arising due to spontaneous self-assembly on a highly-strained (In,Ga)As epilayer grown on the GaAs (100) substrate reveal a large inhomogeneity (∀10%) [C53-C56]. Nevertheless the strain-driven vertical alignment of island stacks discovered in multilayered samples [C57,C58] opens new design possibilities in coupled quantum structures. For example, recent achievements in growth technology has resulted in the fabrication of InAs/GaAs QDMs exhibiting quantum mechanical coupling with an energy splitting of several tens of meVó a value that is comparable to the inhomogeneous broadening [C49]. We propose to studys electroluminescence (induced with an STM tip) and differential capacitance to explore the QDM states as a function of the energy mismatch between the two QD layers and their separation. Manasreh, Salamo, and researchers at Humboldt University take both transient and steady state measurements which will be compared with theoretical models by Mullen.

The third research area focuses the range of opportunities made possible by electron transport in 2D and 3D QD superlattices. The most straightforward investigation is to examine magneto conductance in antidot arrays. Several experimental studies have investigated the electron quantum states in 2D heterojunctions with a lateral surface superlattice of quantum antidots [C59]. Our antidot systems will be used to nvestigate both classical effects (commensurability of the lattice periods and cyclotron radius, transition to chaos, etc.) and the energy spectrum consisting of the magnetic subbands.

In order to investigate *collective* effects, we need to have long range coherence. In larger periodic structures thermal effects prevent the development of extended electronic states. However we have already fabricated small dot clusters that show extended states that range across several dots. Despite this success, we must be cautious in extending this result to a periodic QD superlattice. First, small variations of dot shape and size would alter the quantum confinement energy within the dot. Moreover, the tunneling amplitude between quantum dots is *exponentially* sensitive to the distance between QDís. Such disorder always leads to localized states [C60]. However, all states are strictly localized only for an infinite size system. For sufficiently small disorder finite sized arrays will still show extended states and can even have bands. We plan to push this limit by using nanotemplated growth to produce nanotextured quantum wells. By depositing small islands of dissimilar material on top of a quantum well we can periodically perturb the band structure in the quantum well through the strain field of the islands. The electrons in the quantum wells are in the nearly free limit, and disorder, while present, can be pushed to a much smaller level. If we can create such a 2D superlattice, then we can artificially create minibands. This can be used to produce photodetectors, devices with negative differential resistance.

On a more speculative level, it has been suggested that for particular array geometries some semiconductor systems can actually go superconducting [C61] (albeit with transition temperatures near 90mK). Even without such extreme behavior QD arrays are a laboratory wherein we can tune Coulomb and tunneling energies to investigate the effects of correlation and exchange [C62]. At integer filling (one electron/dot) we expect the system to be a Hubbard insulator. Near this point we can have correlated electron states, just as in the Hubbard model. However, competing with these coherent states will be the many dissipative degrees of freedom that drive the system to act more classically. We (Mullen) will look theoretically at how the environment affects these idealized models using an influence functional theory approach. Experimentally we (Salamo) can alter the spin coherence between dots, their dephasing time and a range of other properties that determine how correlations will form. As we increase the tunneling amplitude we develop a new laboratory for many-body physics.

Quantum Ring Arrays: Rings present their own set of novel dynamics. Because they are not ìsimply connected,î their wavefunction are fundamentally different from those of dots. For example, single semiconducting rings demonstrate persistent currents like that in a superconductor. Electron states on rings display an Aharanov-Bohm effect not present in dots. The experimental observation of this effect demonstrates that the electronic states about the ring are phase coherent. An electron on a ring also cannot have a zero dipole moment; its magnitude is fixed, although its orientation is random. Finally, rings, unlike dots, can act as a 1D system, displaying many-body effects like a 1D system.

The fabrication of small rings has been discussed above. Fu will calculate single particle ring states for realistic ring materials and geometries. This will allow us to examine when the 1D ring approximation is valid. While the self-assembled rings are crystalline, the AAO produced rings in general are not. However, for small enough rings, disorder does not lead to localization, since it is ìperiodicî as one circles the ring. This periodicity leads to a bandstructure. Again we will theoretically examine the validity of the 1D approximation in this case.

Preliminary theory (Mullen) indicates that singly charged nano-ring arrays (i.e. one electron/ring) undergo a phase transition from isotropic to anti-ferroelectric ordering as their interactions are increased (Fig.11). We will detect and study this phase transition in the excitonic gap of these structures and in their collective electronic excitations (Johnson and Xiao) comparing it to theoretical models (Mullen). We will investigate how tuning the ring geometry can produce structures with anisotropic polarizabilities. Such materials will have potential applications as optical switches and ferroelectric memory.

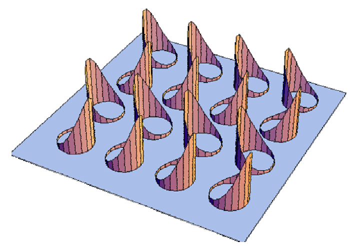


Fig. C11. Charge distribution of single electrons on 1D rings.

Longer term projects will investigate controlling the charge on each ring either via tunneling from a back gate, or remote doping. The strong Coulomb interaction between rings guarantees that charge will be spread as uniformly as possible across the structure. While we have predictions for what should happen for a filling factor of one electron/ring, little is known what happens away from this point. As more electrons are added to an isolated ring, it can make a transition from a state where the electrons are localized (like beads on a ring) to extended. When arrays of rings interact, we can arrange for the number of electrons on the rings to have a symmetry commensurate or incommensurate with the array geometry. (E.g. a square array of rings with three electrons/ring, will display frustration.)

Finally, if inter-ring tunneling is significant, the magneto-conductance of ring arrays will have a rich structure due to interference effects. Electrons will accumulate one Aharonov-Bohm phase as they circle a ring, and a second as the tunnel from one ring to another. When these phases are incommensurate this will show up in the nature of the extended states. Exciton transfer in close-packed arrays of quantum rings will be interesting to explore for similar reasons.

Ferroelectric Dot and Rod Arrays: Compared to bulk FEs, low-dimensional finite FE structures promise to increase the storage density of nonvolatile ferroelectric random access memories (NFRAM) ten thousand fold. This anticipated benefit, however, hinges on whether the phase transitions and multi-stable states still exist in low-dimensional structures. This question is the subject of much contention and vital for understanding collective interactions. Previous studies have shown that phase transitions are impossible in 1D systems and become increasingly less likely as dimensionality further decreases, thereby limiting the potential rewards for NFRAM. Recently, however, Fu and Bellaiche have demonstrated state-of-the-art *ab-initio* simulations [C63-C65] that led to the discovery that (1) phase transitions do exist in dot and rod FE nanostructures; (2) these phase transitions profoundly differ from those occurring in bulk in that they form a spontaneous solenoidal moment below a critical temperature; and (3) the resulting low-temperature phases promise the generation of new devices with phenomenal capabilities [C66]. Further, the minimum diameter of the disks that display low-temperature structural bistability is 3.2 nm, enabling a NFRAM density of 60 Terabits/inchó five orders of magnitude larger than currently available.

FE Fabrication: Motivated by the above theoretical results, Salamo and Peng have begun growth of FE dots, rods, and wires via MBE and colloidal suspension. Salamo has built a special MBE chamber designed for oxide growth combined with traditional cells as well as e-beam heated sources. Peng also has a unique colloidal growth system for ferroelectrics in operation and has already grown $BaTiO_3$ colloidal dots. In MBE we will begin with the deposition of $BaTiO_3$ and $SrTiO_3$ to explore the ferroelectric behavior of strained $SrTiO_3$ films and compare with the teamís first principles calculations. Then we will explore superlattices of $BaTiO_3/SrTiO_3$ in order to check the structure property relation in the system and compare the superlattice of $BaTiO_3/SrTiO_3$ with solid solution $BaSrTiO_3$ thin films. Using this experience we will explore the more novel non toxic material $BaZrTiO_3$.

Building on this experience we propose to grow ferroelectric dots, both MBE and colloidal, and compare with the teamís first principle calculations that help us understand ñ how small and what number of unit cells are desirable to have the ferroelectric effect; domain wall understanding; role of chemical and physical defects; organized nanoclusters; ferroelectric bubble domains (analogous to magnetic case); engineered ferroelectric relaxors; property graded materials; and organized ferroelectric stacks of dots. Another exciting direction is to explore novel nano composites involving semiconductor and ferroelectrics which have potential as weak magnetic field sensors.

FE Array studies and applications: Since the domain structure is directly related to the macroscopic properties, such as switching behavior, hysteresis, piezoelectricity, and electro-optical effects, it is of paramount importance to study the both the domain structure of individual dots as well as across arrays in our nanoferroelectric growths. Recently developed scanning probe microscopy techniques, such as electrostatic force microscopy [C67] and voltage-modulated scanning force microscopy [C68], have proven to be very powerful for examining ferroelectric domains and surface structures [C69-C72]. Our measurements will be made using a homemade piezoelectric response module added to a commercial scanning force microscope. The technique, called voltage-modulated scanning force microscopy is based on the detection of local vibrations of a ferroelectric sample induced by a testing AC signal applied between the conductive tip of the microscope and the bottom electrode of the sample. The first harmonic oscillations of the cantilever are detected by a lock-in technique. If the sample surface is piezoelectric, the oscillating electric field causes a deflection of the sample surface through the converse piezoelectric effect. This offers a technique to examine domain and domain structures of piezoelectric materials at the nanometer scale. The local oscillations of the sample surface are transmitted to the tip and detected using usual lock-in sensitive techniques. The *out-of-plane signal* from the lock-in is extracted from the z-deflection signal given by the detector electronics, and represents the local oscillations perpendicular to the plane of the sample surface. Similarly, if the signal is obtained from the x-deflection signal it represents the oscillations of the surface perpendicular to the cantilever, in the plane of the film. The piezoelectric response, both the out-of-plane and in-plane (shear), will provide information about the ferroelectric domain configuration.

The team will image ferroelectric domains, recording local piezoelectric hysteresis loops, and measuring piezoelectric coefficients, all with a lateral resolution down below 10 nm and with high sensitivity. We will also explore phase transitions in arrays of nanodots, to see if they are sharp, as well as the nature of the spontaneous moment using a custom piezoelectric sensor added to a scanning force microscope. The precise effects of the substrate, growth orientation, surface termination, and thickness on the ferroelectric properties of nanodot arrays are not clear. We will investigate if there is a critical thickness below which FE can not occur, and if it exists, how this critical thickness depends on the boundary conditions (i.e., short-circuit *versu*s open-circuit). A team of Manasreh, Xiao, and collaborators from UA-Pine Bluff will measure linear and nonlinear optical and piezoelectric character of quantum wells perturbed by a periodic FE dot array. We will also use ellipsometry, Raman and IR spectroscopy for revealing the nanostructure ferroelectric behavior even when global centric symmetry is expected.

Although the microscope images, both out-of-plane and in-plane, will provide interesting information about the ferroelectric domain configuration, given the tensorial nature of piezoelectricity, a quantitative analysis is very challenging and complex, and the unique interaction between theory and experiment in this IRG provides a special opportunity to understand and utilize ferroelectricity on a nanoscale.

Summary: C-SPIN brings together a rare and essential combination of techniques and talents to design, grow, and study nanostructures. Together this group has the power to uncover the nature of collective dynamics in quantum dot and ring arrays and nanoferroelectrics and begin an era for their application.

4.C IRG2: MESOSCOPIC NARROW GAP SYSTEMS

Faculty: Doezema, Murphy, Santos (OU), Bellaiche, Fu, Salamo (UA), Xie (OSU), 4 postdocs, 6 graduate students. **Partners:** NTT Basic Research Laboratories (Japan), Hitachi Global Storage Technologies, Humboldt Universit‰(Germany)

Focus: Narrow band gap materials possess unique, but relatively untapped potential for quantum confined, magneto-electronic, and spin devices. We will capitalize on our previously demonstrated successes in growth, device fabrication, optical, transport, and theoretical studies of such narrow gap materials for enhanced understanding of both the fundamental physics and novel technologies that these materials can yield.

Motivation: The demand for higher speed operation, denser memory, and increased functionality of semiconductor technologies has motivated research on nanoscale electronic devices that exploit quantum mechanical and spin effects. The field has embraced both non-traditional materials (such as nanotubes, DNA, and molecular conductors) and materials related to the two most common semiconductors used in current commercial devices (Si and GaAs). In contrast, semiconductors with narrow band gaps have received much less attention, in spite of several attributes that are highly desirable for nanoscale devices such as high mobility, small effective masses, and large spin splitting. Such attributes imply higher operating temperatures for ballistic transport devices, stronger quantum confinement for low dimensional devices and greater sensitivity of magnetic field sensors. Moreover, enhanced spin effects provide an additional opportunity for spintronic devices which may provide new routes for computation and data storage.

Background: The vast majority of commercial devices operate in the diffusive transport regime where electrons behave classically; however as device dimensions continue to shrink, electron transport will become ballistic and then increasingly quantum mechanical. These regimes provide new opportunities for science and technology. Because of their small electron effective masses and correspondingly high mobilities, narrow band gap materials reach the ballistic and quantum limits at larger (and more accessible) length scales than do other semiconductors. This is evidenced for the quantum limit by Fig. C11 which displays the de Broglie wavelength of various III-V semiconductors at room temperature. Additionally, the Rashba effect (spin splitting due to structural inversion symmetry) is predicted to be large for the narrow band gap materials. This effect which couples the electron spin to an externally applied *electric* field is the enabling mechanism of many proposed spintronic devices.

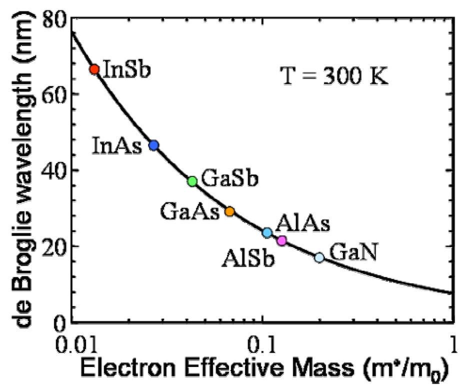


Fig. C11. The deBroglie wavelength for various III-V semiconductors evaluated at 300K [Adapted from Ref. C73].

Research on narrow band gap materials has flourished within the broader scope of C-SPINís current IRG2. As mentioned in the Pertinent Achievements section, our InSb heterostructures hold the world record for room temperature mobility of *any* semiconductor quantum well and display ballistic transport at length scales of at least 0.5μm at 200K. We have not only made significant advances in materials growth, but also in the use of these materials for fundamental experiments including quantum point contacts, quantum Hall ferromagnetism, and optical studies of the Rashba effect. Additionally, we have developed invaluable theoretical tools: *ab initio* calculations that describe the responses of semiconductor nanostructures to electric and magnetic fields and S-matrix methods to study transport in nanoscale systems. The proposed IRG2 grows out of these previous accomplishments and is focused on *mesoscopic* narrow gap systems, *i.e.* those at the interface between the quantum and classical regimes. The proposed IRG2 is a complementary theoretical and experimental effort to improve narrow gap materials growth and to utilize these materials for a host of fundamental and technologically motivated experiments on quantum confinement, spin transport, magnetic field sensors, and other related studies.

The Team: This IRG is a strongly collaborative team that will integrate all of the requisite expertise to accomplish our goals. The narrow gap materials growth proficiency for our inter-campus team is provided by Santos ($InSb/In_xAl_{1-x}Sb$, InAs/AlSb) and Salamo ($In_xGa_{1-x}As/In_yAl_{1-y}As$). Each supervises a molecular beam epitaxy (MBE) chamber with an attached *in-situ* STM chamber at his respective campus. Cross-sectional transmission electron microscopy (TEM) analysis of grown structures is performed at OU. Optimized heterostructures will be fabricated into devices by Murphy using the OU semiconductor fabrication facility, which in turn will be studied via transport by Murphy in her low temperature/high field laboratory or via noise spectroscopy by Salamo. Optical expertise provided by Doezema (far infrared) and Salamo (time-resolved mid-infrared) will yield information on spin-orbit effects and spin coherence. The local team is completed with theoretical support from Fu and Bellaiche who use first-principles-derived screened atomic pseudopotentials (SAP) to accurately describe the *bulk-like* electronic states in nanostructures and Xie who has extensive experience [C74-C77] with the S-matrix method originally developed by Buttiker and Landauer to study electronic transport in mesoscopic systems. Additional expertise in device fabrication technology is provided by our industrial and international collaborators at NTT Basic Research Laboratories (Japan), Hitachi Global Storage Technologies (San Jose) and Humboldt Universit‰(Germany).

Research Plan: Below we present our plans for research on mesoscopic narrow gap systems. First we describe the proposed MBE growth efforts which will yield narrow-gap quantum wells with state-of-the-art crystalline quality. Then we discuss experiments that will survey the spin dependent transport behavior of mesoscopic structures fabricated from the narrow-gap quantum wells. The unusual electronic properties will enable us to explore a variety of proposed spintronic device schemes. Next we explain a series of optical experiments that will probe additional aspects of spin physics in narrow-gap systems. Finally, we discuss the advantages of mesoscopic narrow-gap systems in magnetic field sensing applications. We are confident that our collaborative approach is the most promising avenue for addressing the numerous scientific and technical issues in each of these challenging areas.

Growth of Narrow Gap Heterostructures: Many properties of semiconductors become more favorable for electronic device applications with decreasing band gap. As shown in Table C1, a narrower gap results in electrons with a smaller effective mass, a larger LandÈ *g*-factor, and larger spin orbit coupling. These attributes do not come without a cost, however; many narrow-gap materials must be grown on substrates with mismatched lattice constants that give rise to defects during growth. This is the case with InAs- and InSb-based structures when semi-insulating substrates are required and for $In_xGa_{1-x}As$ compositions where no lattice-matched substrate exists. The semi-insulating substrates of choice are GaAs substrates due to their low cost and high quality. The large lattice mismatch between the GaAs substrate and the epilayers will inevitably result in dislocations in the epilayers, but the density of dislocations can be reduced through insertion of buffer layers between the substrate and the epilayer. Compositional grading of the buffer layer (including continuous grading [C78], step grading [C79], and inverse step grading [C80]) has resulted in significantly improved metamorphic $In_xGa_{1-x}As$-based high electron mobility transistors [C81,C82].

Semiconductor	Band gap (eV)	Effective mass (m^*/m_0)	LandÈ *g*-factor	Spin split-off band (eV)
GaAs	1.43	0.067	-0.44	0.34
$In_xGa_{1-x}As$ ($0 \leq x \leq 1.0$)	1.43 to 0.33	0.067 to 0.023	-0.44 to -15	0.34 to 0.41
InAs	0.33	0.023	-15	0.41
InSb	0.18	0.014	-51	0.80

Table C1. Electronic properties of various III-V semiconductors. Splitting due to the Rashba and Dresselhaus effects scales with the energy of the spin split-off band.

Santos has attained similar success in overcoming the challenges in the MBE growth of InSb-based heterostructures on GaAs substrates. Atomic force microscopy and TEM reveal topographical features due to micro-twins and dislocations. Such defects are not uniformly distributed but rather collect along specific crystalline directions, resulting in anisotropic electron mobility [C83,C84]. As shown in Fig. C12, the densities of microtwins and dislocations at the quantum-well layer depend strongly on the composition and structure of the buffer layers between the substrate and the active layers. These preliminary experiments [C85] indicate that strain plays an important role. We propose to continue to study defect reduction through modification of the buffer layers. With strong guidance from cross-sectional TEM measurements, we will efficiently determine the best buffer layers for our structures and help elucidate the general understanding of strain-induced dislocation filtering.

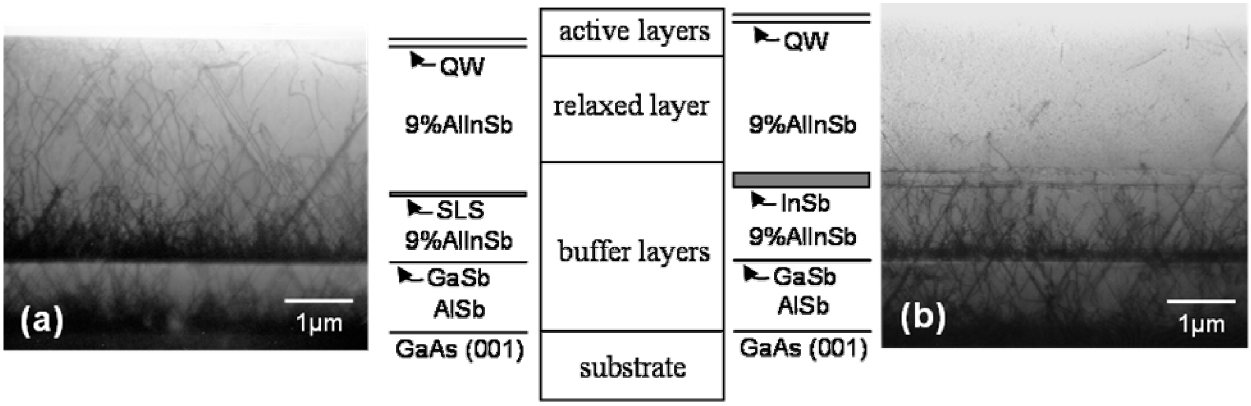


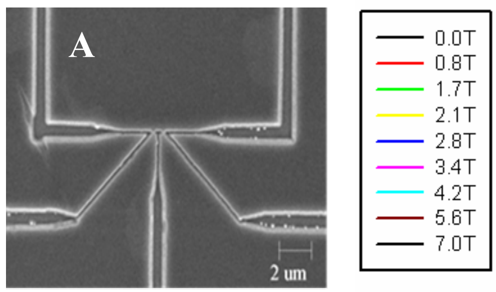
Fig. C12. Cross-sectional TEM micrographs of InSb/AlInSb heterostructures grown on GaAs substrates, (a) filtering of micro-twins and dislocations through GaSb and AlSb buffer layers, (b) additional filtering though an InSb interlayer.

We also propose to broaden our materials scope to include InAs-based and $In_xGa_{1-x}As$-based heterostructures grown by Santos and Salamo, respectively. The acquisition of valved group-V effusion cells through this renewal will enable the growth of mixed antimonide-arsenide heterostructures. Each of these materials has particular advantages that make it most suitable for a specific application. For example, a very high density of electrons can be contained within an InAs quantum well since AlSb, which has a very large band gap, can be used as a barrier material. Also, Monte Carlo simulations indicate that InAs is the semiconductor with the highest maximum electron drift velocity [C86]. On the other hand, the density of crystalline defects is much lower in $In_xGa_{1-x}As$ with x=0.53 since this material can be grown on a lattice-matched InP substrate. Also, the techniques for gating $In_xGa_{1-x}As$ heterostructures are much more developed than for InAs and InSb heterostructures. Roughly speaking, there is a trade-off between a narrower gap and a higher defect density. Different materials are optimal for different applications depending on the relative importance of these two factors. Hence, the development of a variety of narrow gap materials is essential for addressing a wide range of applications.

Of the materials listed in Table CI, InSb potentially offers the most benefits and presents the most challenging materials issues. Even though GaAs substrates are not lattice matched to $InSb/Al_xIn_{1-x}Sb$ epilayers, they are only one sixth the cost of InSb substrates and are semi-insulating even at room temperature. For these reasons, we will continue to grow many structures on GaAs substrates. InSb substrates, however, present a more attractive option for measurements that require the lowest disorder. Although it can be difficult to thermally desorb the native oxide from InSb substrates [C87], we have recently developed a procedure for effective thermal desorption. To eliminate parallel conduction through the InSb substrate at higher temperatures, we are developing a method to remove the substrate from beneath the active area of the device. In a photolithographic processing step, a selective etch in combination with a stop etch layer will allow us to open a window in the substrate under the active device area, while retaining a thicker frame for ease in device handling. We have already developed a solution which preferentially etches InSb over $Al_xIn_{1-x}Sb$ by a factor of 6 and are working to enhance the etch selectivity. Note that the structures must still be metamorphic (*i.e.*, grown on a relaxed $Al_xIn_{1-x}Sb$ buffer layer) because the $Al_xIn_{1-x}Sb$ barrier layers are too thick to be completely strained to the substrate lattice constant. Nevertheless, the density of defects in the quantum well layer should be much lower than in structures grown on GaAs substrates. The mobility is expected to increase by a factor of two at 300K and an order of magnitude at 4.2K, with significant improvements in the ballistic transport and spin lifetimes.

Spin Dependent Transport Phenomena: The generation of a spin-polarized current in a semiconductor has proven to be one of the most significant and challenging issues in recent condensed matter physics. Due to the fact that semiconductors are in general spin-unpolarized, the key for generating polarized current has been through spin injection from a polarized source, *e.g.* electrons from ferromagnets or polarized photons. However, neither of these spin injection methods [C88,C89] are very satisfactory since the spin-polarization efficiency from a ferromagnet into a semiconductor is around 1% [C90,C91], while the polarized optical methods prove difficult for integration with electronic devices [C92,C93]. In this section, we proposed to explore several novel device concepts for generating a spin-polarized current: current focusing devices, tunneling structures, and spin interference devices. We then discuss how the strong spin splitting in narrow gap system will enable new experiments on quantum point contacts, single electron tunneling devices, and electron-nucleus spin interactions. Collaboration between theorists and experimentalists will be essential for the success of all these projects.

One of the principal advantages of narrow gap materials is the enhancement of spin effects that can be exploited for spintronic devices and experiments. Indeed, electron spin resonance measurements by Doezema on asymmetric InSb quantum wells [C94] have revealed a zero-field spin splitting of several meV due to a large Rashba effect, which is essential to the development of several suggested spin transistors and spin filters. The large Rashba effect derives from an intensified spin-orbit coupling in narrow gap systems. The Dresselhaus effect, an analogous spin-splitting mechanism due to asymmetry in the crystal structure of the quantum well, is also strong in narrow gap materials. Both mechanisms allow for the possibility of separate trajectories for electrons with different spin projections *(i.e.* the development of spin polarized sources). Santosís collaborators at Ohio University have already demonstrated that electron scattering by the boundaries of InSb structures depends on the spin polarization [C95] and recently, researchers have demonstrated weak spatial filtering due to spin-orbit effects in magnetic focusing experiments on a 2D hole system in GaAs [C96]. For a related experiment involving electrons, Santos, Murphy, and collaborators at NTT Basic Research Laboaratories have fabricated a similar double quantum point contact device in InSb, as shown in Fig. C13a. We anticipate superior performance (*i.e.* more well separated paths) for this device due to stronger spin-orbit coupling.



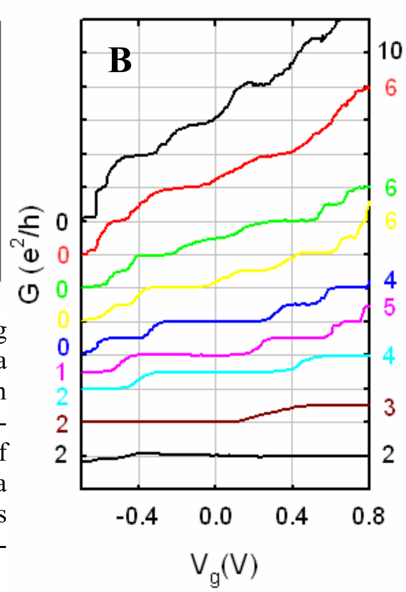


Fig. C13. (a) SEM of a current focusing device. In the event of a significant Rashba effect, this device is predicted to produce spin polarized currents in low applied perpendicular fields. (b) Conductance in units of (e^2/h) for an InSb quantum point contact as a function of gate voltage. The separate traces correspond to nine different applied perpendicular magnetic fields.

With our wide selection of narrow gap materials, we will also be able to realize several types of recently proposed transistors, spin filters and interference devices [C97-C102] that exploit the Rashba and Dresselhaus mechanisms. These include InAs/AlSb/GaSb and $In_{0.53}Ga_{0.47}As$/AlInAs devices where spin polarized injection is designed to be accomplished through tunneling structures [C97,C99]. These spintronic device concepts are especially attractive because ferromagnetic contacts are not required. This avoids complex materials issues and unwanted stray fields. The operation of the proposed tunneling devices relies on applied electric fields only, which can be modulated at considerably higher rates than magnetic fields.

Additional theoretical work by Xie supports the development of devices that allow for the generation of spontaneous spin-polarized current in the absence of *any* magnetic material or magnetic field [C103]. While the proposed work focuses on the Rashba interaction, the same idea applies to the Dresselhaus interaction. Fig. C14 shows the principle of generating a spin-polarized current. For simplicity, we assume two paths for an electron traveling from one terminal to the other, as shown in Fig. C14a. Since the Rashba interaction strength α is tunable in experiments [C104,C105], we can choose different values of α for the two paths. This generates a phase difference that depends on the spin of an incident electron. Thus, a spin-up or spin-down incident electron will have a different transmission probability through the two-path device and a spin-polarized current is generated. We propose to carry out a theoretical study of more realistic set-ups using sample parameters from narrow gap materials. The theoretical study will help in designing an experiment for the detection of the polarized current. Because of a phase-locking effect [C106], the total current through a two terminal device must be unpolarized even when the local spin polarization is large in some areas. This limitation can be overcome by employing three drain terminals (regions V, VI, VII) to extract spin polarize current, as shown in Fig. C14b. Regions II and III are designed to have different Rashba interaction strengths. This is the configuration for which we will determine optimal dimensions for maximum spin polarization. As shown in Fig. C14c, we have calculated that the local spin polarization in Region IV can be over 10% (assuming a realistic difference in ! of ~$3x10^{-11}$eVm), which is much higher than seen in devices employing electrical spin injection. The optimization of the spin polarization via theoretical means should greatly aid the experimentalists in their prototype designs.

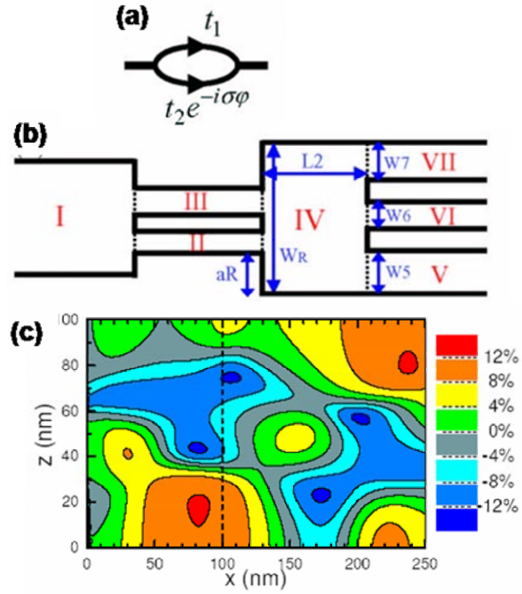


Fig. C14. (a) Schematic of a two-terminal spin-interference device, (b) a device with three drain terminals, (c) calculated spin polarization in Region IV in a two terminal device.

The strong spin-orbit coupling will also enable experiments that address unresolved issues in mesoscopic physics, such as the ì0.7 anomalyî observed in GaAs quantum point contacts [C107-C109]. The 0.7 anomaly has been shown to be related to Kondo physics [C110], hence, spin degrees of freedom are expected to play an important role. In collaboration with NTT, Santos and Murphy have succeeded in the fabrication of InSb quantum point contacts (QPCs) [C111,C112] as described in Pertinent Achievements (the quantum conductance of a typical QPC is shown in Fig. C13b.) The experimental investigations will be greatly aided by a complementary theoretical effort by Xie who will use his expertise in nanostructure transport to conduct an investigation of ballistic transport through a narrow band gap QPC, taking into account the large spin-orbit interaction present. This theoretical study will help to determine the sample conditions for the observation of the 0.7 anomaly and will also provide understanding of physical mechanism which lies behind it.

With collaborators at NTT, we will also undertake several experiments that take advantage of the large Zeeman spin splitting in narrow gap systems. Our collaborators have a well-established reputation for performing difficult experiments on GaAs-based quantum-confined systems, including studying the dynamics of single electron tunneling (SET) devices [C113,C114], coherent control of electronic states in double quantum dots [C115] and the interaction of electron spin with nuclear spin in the fractional quantum Hall regime [C116,C117]. Zeeman splitting in GaAs SET devices has been difficult to observe since the splitting is even weaker than in bulk GaAs [C118,C119]. This makes realization of a spin-qubit more difficult despite the favorable features of the SET geometry for quantum information processing. The much larger Zeeman splitting expected for InSb SET devices will enable the first studies of electron spin resonance in SET devices and enable a new approach for coherent control of single electron spin.

The electrical measurements on a single pair of lithographically-defined quantum dots will complement the effort in IRG1 to fabricate an array of self-assembled pairs of quantum dots.

Possible applications in quantum computing have also sparked renewed interest in nuclear spin systems in solids because of the long coherence times. Recent experiments by our collaborators at NTT have demonstrated that the nuclear spin states can be manipulated by a gate voltage that controls the electron density of a GaAs-based two-dimensional electron system (2DES) at high magnetic field [C116,C117]. This effect requires the 2DES to be at a Landau level filling factor of 2/3, where a crossing occurs between Landau levels of composite Fermions with opposite spin. The large *g*-factor of an InSb-based 2DES will enable an analogous crossing to occur for electrons with opposite spin. By tilting the 2DES at ~70^o with respect to the magnetic field, the Zeeman splitting can be made to equal the Landau level separation. As described in Pertinent Achievements, Murphy found that the degeneracy of different spin states is lifted by the formation of an Ising-like quantum Hall ferromagnet (QHF) in the integer quantum Hall regime [C120]. It is hypothesized that significant coupling between the electronic spins and nuclear spins will occur when the magnetic field is swept at a rate that is an order of magnitude slower than in the QHF experiments. We propose to perform such experiments at NTT. If successful, these experiments would significantly improve the likelihood of practical application by removing reliance on composite fermions, which are fragile many-body electron states.

The experimental effort on mesoscopic devices will benefit from the theoretical support of Fu and Bellaiche. This theoretical approach is based on first-principles-derived screened atomic pseudopotentials (SAP) that accurately describe the electronic states in nanostructures. We have already used SAPs to study the electronic properties of several other semiconductors [C121]. For narrow gap materials, the small band gap and large spin-orbit coupling present additional challenges. We have overcome these challenges in our preliminary effort for InSb, and have constructed highly accurate SAP. With spin-orbit coupling included, the calculated energy gap at Γ (0.22 eV), the electron effective mass (0.016), and the heavy-hole mass (0.30 along the 111 direction) are all in excellent agreement with experimental values (0.235 eV, 0.014, 0.34, respectively). We have further successfully overcome another challenge and generated good passivation potentials at nanostructure surfaces---a crucial step for studying semiconductor dots, wires, or wells. Applications of our SAP to free-standing InSb dots yield very encouraging and interesting results, as shown in Fig. C15 where the confinement effects are found to be anomalously strong, and the emission wavelength shows a surprising linear dependence on size across the visible and infrared regions of the spectrum. (The fabrication and optoelectronic properties of InSb quantum dots present an intriguing possibility for joint study by IRG1 and IRG2.)

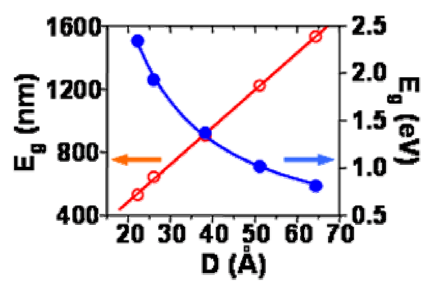


Fig. C15. Calculated band gap as a function of size of InSb quantum dot.

Encouraged by our initial results on narrow gap semiconductor quantum dots, we now propose to consider quantum wires and wells. In particular we intend to determine whether the carrier mobility in narrow gap nanowires can be further increased with respect to the already large values found in the bulk. More interestingly, we will determine how the *g*-factor in InSb dots and wires will depend on the dimensionality and size by calculating the response of individual states of these structures to external magnetic fields. These calculations will be particularly relevant to the proposed experiments on SET devices. Note that an approach to study the *g*-factor and magnetic-field effects in nanostructures has been developed by us [C122], and we also have experience in transport theory [C123]. In conjunction with Xie, we can also investigate the spin-polarized electronic states in wires to reveal important implications of using the prominent spin characteristics in InSb nanostructures for spintronics.

Optical Characterization of Spin Properties: The spin transport device development will benefit from far-infrared magneto-optical measurements on bulk and quantum well structures grown by Santos and Salamo. Doezema and Santos, as described in Pertinent Achievements have developed an electron spin resonance technique to directly measure the Rashba spin splitting. Even though it is the basis for many proposed spintronic structures, the specific layer structures that maximize the Rashba effect are not yet established. The Rashba effect originates from two physical mechanisms. One is a coupling between the spin of moving electrons in the *xy* plane and an electric field caused by an applied gate voltage or an asymmetry in the layer structure. The other mechanism arises from differences between the wavefunctions and step heights at the two well/barrier interfaces and is actually calculated to be the dominant effect in III-V quantum wells [C124]. Through electron spin resonance experiments on tailor made structures with asymmetric barriers and/or doping profiles, we will be able to distinguish the effect of an asymmetric electric field from the role of the barrier asymmetry and consequently maximize the Rashba spin splitting. In this way, these fundamental optical studies will contribute to success of the Rashba device efforts. These DC optical techniques will also prove useful in the study of how the *g*-factor depends on structure size and will be closely tied to the calculations performed by Fu and Bellaiche.

Spin-orbit effects are also evident in cyclotron resonance experiments that are spin-resolved due to the non-parabolicity of the conduction band [C125]. This enables the observation of subband Landau-level avoided level crossings [C126]. The Landau-level fan diagram in Fig. C16 shows the positions of the avoided level crossings. The energy gaps of the two anti-crossings of Landau levels with the same spin depend on the tilt of the magnetic field from the sample normal as reported in earlier studies of (non spin-resolved) subband Landau coupling in GaAs quantum wells [C127]. The gaps of the anti-crossings of levels with opposite spins, however, are essentially tilt-angle independent. Although spin-orbit effects are strong in InSb, the origin of the opposite-spin anti-crossings has not yet been definitively identified. We propose to probe the dependence of the anti-crossings on the Rashba effect by studying structures with different degrees of asymmetry. The ability to study spin interactions is important for understanding the intricacies of spin dynamics in semiconductors. Understanding spin-spin interactions may contribute to the ability to manipulate spins and to the identification of spin relaxation mechanisms.

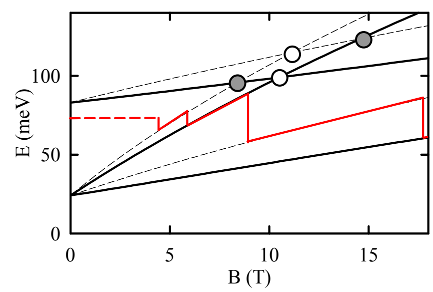


Fig. C16. Calculations of Landau levels for a 25-nm wide InSb quantum well with two subbands. The solid (dashed) lines are spin up (down) levels. The red line is the Fermi level. The grey (white) circles indicate crossings of levels with the opposite (same) spin.

In addition to significant spin tuning via external fields, a key issue for any spin experiment or device is a robust spin coherence that survives over an adequate time for spins to precess before decaying. While spin relaxation lifetimes of ~100ns at 5K and ~100ps at 300K have been reported for bulk GaAs (n~1x10^{16}cm^{-3}) [C128], this material has significantly smaller spin-orbit effects than the narrow gap systems. Indeed, it had been thought that strong Rashba and Dresselhaus mechanisms were incompatible with long spin relaxation times. However recent mid-infrared pump/probe measurements on bulk InAs and InSb samples (n~1-2x10^{17}cm^{-3}) have been reported with spin relaxation times (1.6ns and 300ps, respectively) at room temperature that are comparable to those of GaAs [C129,C130]. In systems with significant spin orbit coupling such as narrow gap materials, spin is not a good quantum number and spin scattering can occur even via spin-independent processes due to the coupling between the spin and orbital degrees of freedom. The losses of spin coherence in *n*-type semiconductors are modeled as due to Elliott-Yafet (EY) or Díyakonov-Perel (DP) mechanisms. In the EY mechanism, spin relaxation is related to the orbital relaxation since the eigenstates are not spin eigenstates. In contrast, spin relaxation is inversely proportional to the orbital relaxation for the DP mechanism. The recently reported long relaxation times have been attributed to a suppression of the DP mechanism by degeneracy in these more highly doped samples, with the resultant relaxation rate limited by the EY process.

While these results bode well for the spintronic application of narrow gap materials, understanding of spin relaxation in such systems is still rudimentary, hence we also propose to perform our own time resolved optical measurements. We propose to make use of Salamoís extensive experience in self-induced transparency (SIT), coherent optics, and pump-probe ultrafast lifetime measurement techniques, to measure spin relaxation times. These studies will be performed in concert with the growth efforts as high mobility materials will be essential. Experiments on quantum well structures, as well as bulk materials, will be crucial as the various asymmetries (bulk inversion vs. structural inversion) will also influence spin relaxation processes.

Interestingly, all optical polarization switches, which utilize optically induced circular dichroism or optical pumping, require very short spin relaxation times. These divergent requirements all point to the need to understand the mechanisms that determine spin relaxation times in order to develop the capability to tailor them to suit specific applications. For example, we are currently measuring the spin relaxation time in $Al_xIn_{1-x}Sb/InSb$ multiple quantum wells using the pump probe technique (Fig. C17a). In this approach, right circularly polarized light is used as a pump to excite one transition while a left circular polarized light is used as a probe to detect spin transfer (Fig. C17b). The requested upgrade of our pump-probe detection system will enable experiments to understand and control the absorption and refractive index of quantum wells made of InSb and other narrow gap semiconductors.

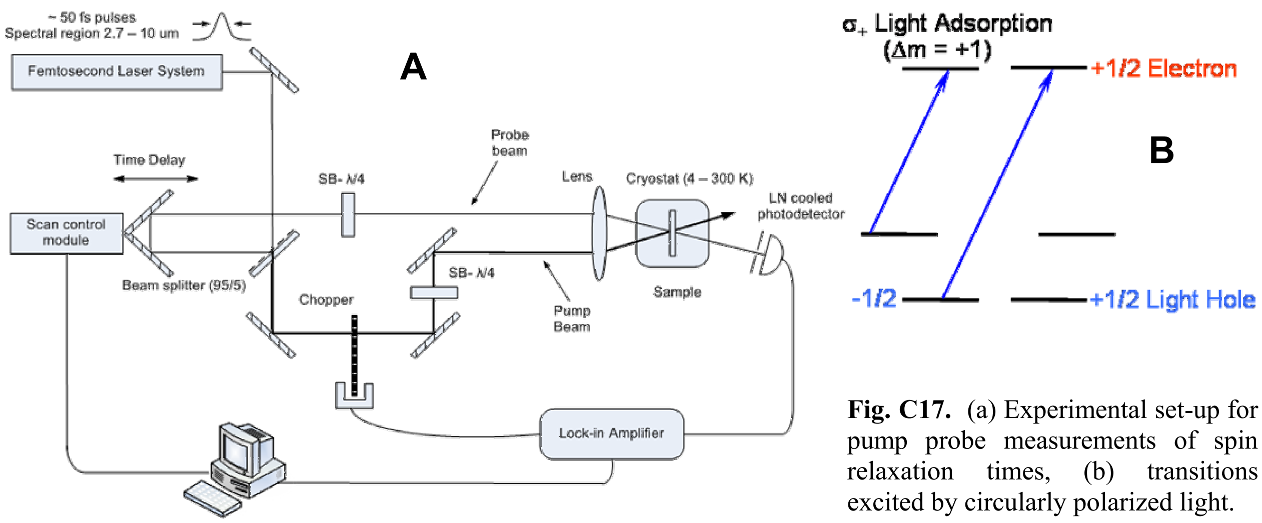


Fig. C17. (a) Experimental set-up for pump probe measurements of spin relaxation times, (b) transitions excited by circularly polarized light.

Coherent effects such as SIT, photon echoes, free induction decay, and hole burning make possible the determination of both T_1 and T_2 while electromagnetic induced transparency allows low absorption with a large index difference for right and left circularly polarized light - making for an effective optical switch. In addition to all optical switching, the excitonic optical nonlinearity is of interest for many nonlinear optical effects such as four wave mixing and phase conjugation. Meanwhile, uncovering the dependence of spin relaxation on parameters, such as well width at room temperature, makes it possible to tailor spin relaxation times for electronic devices.

Mesoscopic Magnetic Field Sensors: In addition to devices that operate close to the quantum limit, the improvements in narrow gap materials growth and characterization will also enhance the performance of magnetic field sensors that are based on classical principles. In the proposed effort to improve spatial resolution however, these sensors will shrink and be forced to operate closer to the ballistic regime. One focus of IRG2 is the fabrication of such devices and the study of their behavior as they approach the crossover threshold.

Ongoing efforts to increase the storage capacity of disk drives have led to commercially available drives that deliver areal densities of ~15Gb/in^2. A critical component of these storage systems is the read-head sensor, which is currently based on giant magnetoresistance (GMR) or tunneling magnetoresistance (TMR) in layered magnetic metals. Magnetic noise limits the scalability of such magnetic sensors to areal densities of <100Gb/in^2. As documented in a recent article in *Scientific American* [C131], Santos and collaborators at NEC demonstrated mesoscopic InSb based magnetic-field sensors that rely on the extraordinary magnetoresistance (EMR) effect [C132,C133]. The EMR effect is an enhanced geometrical magnetoresistance caused by a metallic shunt embedded within a narrow-gap semiconductor. The high room-temperature mobility of narrow gap quantum wells leads to the high sensitivity of these devices. Moreover, the relevant field required to read a magnetic bit with an EMR device (which can be placed horizontally above the magnetic medium) is an order of magnitude larger than required for GMR or TMR devices (which must be placed vertically above the magnetic medium). The higher relevant field results in a higher signal to noise ratio for the EMR device. In an InSb EMR device with characteristic dimensions of 30nm by 35nm (corresponding to a recording density of ~600 Gb/in^2), a ~35% change in resistance was measured at the relevant field of 0.05T. This sensitivity is better than the ~20% change in resistance in current sensors made of layered magnetic materials at a relevant field of 0.005T. The preliminary devices demonstrate that nonmagnetic narrow-gap semiconductors provide a viable route to ultra-high-density recording at densities approaching 1Tb/in^2 [C134].

In addition, magnetic sensors based on III-V semiconductors have found wide application in both physical and biological sciences. In contrast to read-head sensors, many scientific applications require detectivity in the nT range (rather than the mT range) where the Hall effect is more sensitive than the EMR effect. However, the size requirements are not as stringent (tens of microns rather than tens of nanometers). For example, sensors with micron-range lateral sizes and an absolute magnetic detectivity in the nT-range, have improved scanning techniques for scanning Hall probe microscopy [C135,C136] and magnetic force microscopy [C137]. Even more recently, a new method for the detection of nuclear magnetic resonance and electron spin resonance has been proposed, using advanced micro-Hall devices [C138]. Techniques using micro-Hall devices are of particular interest for biology and medicine where nondestructive and non-contact techniques, as well as room temperature operation are required. To date, the most sensitive magnetic sensor is the superconducting quantum interference device (SQUID). While the high sensitivity of the SQUID can open incredible medical opportunities, the drawback is that the operational temperature of the SQUID device is 4.2 K, limiting its potential for medical investigations. When room temperature operation or portability is required we may consider developing micro-Hall devices as a replacement for SQUIDs for biomedical applications.

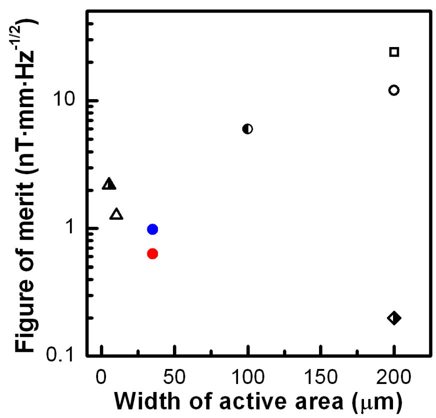


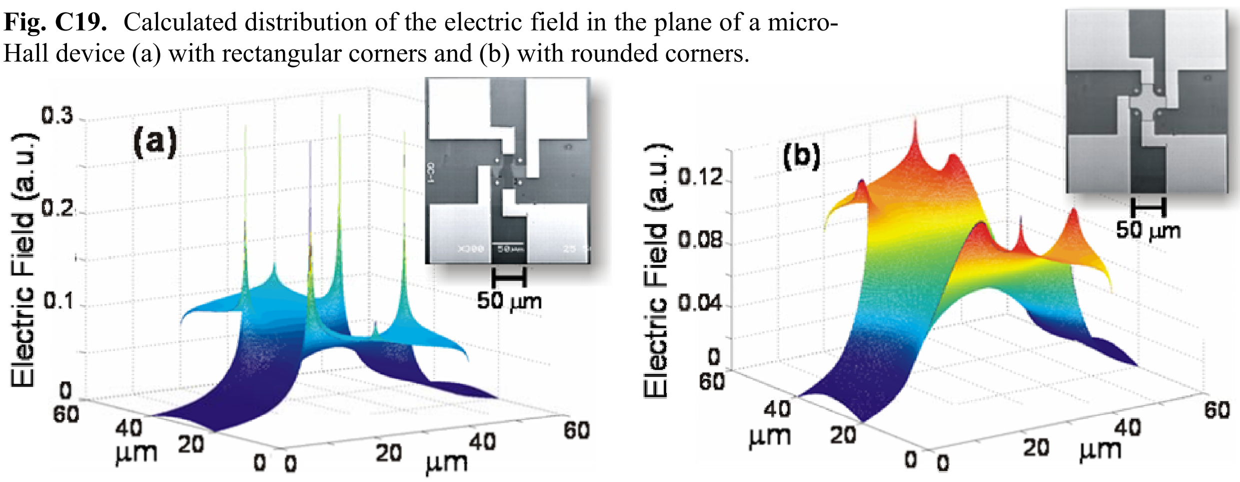
Fig. C18. Experimental measurements of the detection limit of micro-Hall devices fabricated from different semiconductors. The colored circles represent our InSb micro-Hall devices at 77K (red) and 300K (blue). See Refs. C139-C144 for details of the devices represented by the other symbols.

We propose to explore mesoscopic narrow gap devices for biological, read-head, and other magnetic sensor applications that require high sensitivity, low noise, and high thermal stability. The electron mobility, saturation velocity, doping profile and layer structure will all affect the performance of micro-Hall or EMR devices. We will pursue several materials combinations in parallel since it is not clear which narrow gap system will best meet all three requirements. We will continue the growth of InSb/$Al_xIn_{1-x}Sb$ structures on GaAs substrates, pseudomorphically-strained InAs/$Al_xGa_{1-x}Sb$ quantum wells on GaAs substrates, lattice-matched $In_{0.53}Ga_{0.47}As$/InP quantum wells, and pseudomorphically-strained $In_xGa_{1-x}As$/InP and $In_xAl_{1-x}As$/ $In_xGa_{1-x}As$ ($0.53<x<0.75$) wells on InP. Using InP-based heterostructures as a reference, we will then insert an InAs quantum well of different thicknesses into the optimized $In_xGa_{1-x}As$ channel of $In_xAl_{1-x}As$/$In_xGa_{1-x}As$ heterostructures to obtain even higher saturation velocities. These materials improvements should have a profound impact on the performance of magnetic field sensors.

Salamo has already initiated noise spectroscopy studies of micro-Hall bars made from InSb quantum wells grown in Santosís laboratory, allowing us to measure the detection limit over a broad frequency range. An important figure of merit is the detection limit scaled by the active size of a micro-Hall device at a high frequency where thermal noise dominates. The results shown in Fig. C18 indicate that our preliminary devices are already more sensitive than similarly-sized devices made from other semiconductors [C139-C144]. These encouraging results are obtained despite significant *1/f* noise resulting from crystalline defects. In devices with lateral electron transport [C145], noise spectroscopy can be a powerful tool for characterizing crystalline defects.

The detection limits will be improved in new structures with defect densities reduced through execution of the plan described earlier. More suitably tailored heterostructures and improved device geometries will also help. As shown in Fig. C19, our preliminary calculations based on the finite element method (FEM) indicate that the conventional Greek-cross geometry is not optimal. The rectangular corners result in a high electric field inhomogeneity that will increase undesirable *1/f* noise and device self-heating. As an alternative, geometries with rounded corners should be considered. Another important design issue is the balance between high mobility and ballistic transport. The Hall effect is known to quench when ballistic transport dominates [C146] but geometrical magnetoresistance, including EMR, appears to be less affected [C133,C134]. The quantitative effect of ballistic transport on the performance of micro-Hall and EMR sensors may prove to be a factor in determining the scalability and ultimate sensitivity of these devices.

Fig. C19. Calculated distribution of the electric field in the plane of a micro-Hall device (a) with rectangular corners and (b) with rounded corners.



To facilitate these efforts we have recently established collaborations with Humboldt Universit%to to develop micro-Hall sensors and with Hitachi Global Storage Technologies to continue the development of EMR devices. EMR and Hall effect devices with characteristic dimensions as small as ∀200 nm will be fabricated at Hitachi, Humboldt, and within C-SPIN from material grown by Santos and Salamo. Murphy will study device performance under ballistic transport conditions. The acquisition of electron beam lithography equipment through this renewal will facilitate the fabrication of the requisite mesoscopic devices locally; while the acquisition of a spectrum analyzer, will improve data acquisition for our low-frequency noise measurements. In this project, Hitachiís expertise in magnetic applications will supplement C-SPINís expertise in growth and transport.

Summary: IRG2 brings together a comprehensive array of expertise focused on fabricating narrow gap systems with characteristic dimensions that are at the border between the quantum and classical regimes. We will utilize these materials in fundamental and technologically motivated experiments on quantum confinement, spin transport, and magnetic field sensing. Our concentration on narrow gap materials places us in a strong position to make distinct advances in spintronics and semiconductor nanoscience.

4.D SEED FUNDING AND EMERGING AREAS

For C-SPIN to remain topical, we must respond to opportunities created within and outside of the Center. To this end, about 10% of the budget is set aside for seed funding. New areas to pursue will be determined annually by the Executive Committee from submissions by C-SPIN or other UA/OU faculty based on the quality of the proposal and overlap with Center interests. Seed areas will target higher risk projects and emerging areas of interdisciplinary research; however, industrial outreach or innovative educational ventures will also be considered. Seeds by junior faculty or that establish links with other disciplines have priority. Below we discuss candidates for funding in the first two years of the Center.

Inquiry Based Materials Science Modules
C. Hall, M. Johnson, K. Mullen (OU); P. Calleja (UA); 2 graduate students, 1 undergraduate student.

Focus: To unite faculty in science and education with principals, teachers, and students to bring materials science to the classroom.

Motivation: The states of Oklahoma and Arkansas do not have a strong technology base. Indeed, fewer than 10% of Oklahoma public school teachers and 5% of Arkansas teachers hold degrees with specific content area specialization in science [D1]. Teachers often enter the classroom lacking the background or resources to effectively teach inquiry-based physical science lessons, with the most acute needs being in rural and densely urban areas. In addition, traditional high school and middle school curricula deal with the material world only by focusing on atoms, reducing the complexity of nature to the periodic table. We wish to restore some of the wonder and richness of the material world by showing how the arrangements of atoms (often identical types) can yield a dazzling array of differing properties.

However, even if we develop the best possible materials, their adoption will be hampered if they do not fit in with the state mandated curriculum, if teachers are not aware of the materials and if they receive little support from their administration. These issues can best be addressed by partnering with Schools of Education. Sadly, there is no tradition of such partnering at UA or OU. While not ìnovel,î such a partnership is institutionally unprecedented, and thus risky. We need to seed a new collaboration, drawing faculty and students outside of their normal realms of expertise and comfort so as to understand and address this interdisciplinary need.

Proposed Activity: C-SPIN will form a new partnership between the Center and the Departments of Education at OU and UA and the Center for Educational and Community Renewal (CECR). We will form teams at each site that include two C-SPIN scientists, one faculty in the School of Education one graduate student in Science Education, and one undergraduate Education major who has expressed a desire to teach in rural or core urban areas. The effort will be promoted by awarding partial fellowships to the Education students. In concert with their scientist mentors, the students will create and develop inquiry-based modules designed to spark the interest of high school students in materials science, similar to existing kits such as Exploring the Nanoworld [D2] and Materials World Modules [D3]. CECR Director Mary John OíHair and her staff will work with these teams to ensure that activities will each address state curriculum objectives to ensure their usefulness in the classroom, yet will be designed with the broader goal of developing exciting, engaging lessons. To aid in promotion, C-SPIN will host workshops to distribute and demonstrate the newly developed kits to science education majors at both UA and OU. In addition, CECR, with its mission to train school principals, will promote the material to middle and high school principals, who may in turn mandate its adoption in the classroom. After two years, we conservatively estimate that this initiative will place stimulating activities in materials science within 40 public schools. C-SPIN will also facilitate kit placement in science classrooms at one Oklahoma City high school with a minority population of 97%, as well as four rural school districts in Northwest Arkansas which serve a Hispanic population upwards of 50%. We will further support each school with semi-annual C-SPIN-coordinated teacher training and in-classroom presentations. An evaluation component will be developed to assess the impact on the science

Exploring New Methods for Single-Molecule/Single-Nanoparticle Spectroscopy:
Combined Solid-State Nanopore Microscopy and Single-Molecule Spectroscopy

L. Bumm, W. Yip (OU), J. Li, X. Peng, S. Singh, and Z. Tian, (UA); 1 postdoc, 1 graduate student

***Focus**:* This seed project studies single lumophores (photoluminescent or electroluminescent, molecules and nanoparticles) transiently confined by a Si_3N_4 nanopore. The function of the nanopore is four fold: 1) to detect the presence of the lumophore via ion-channel conductance, 2) as a local photonic probe to enhance luminescence with plasmon resonant structures decorating the pore periphery, 3) to dielectrophoretically trap/manipulate single lumophores, and 4) to employ large electric fields within the nanopore to electric-field modulate the photoluminescence (PL) and to locally excite electroluminescence (EL) of the lumophores.

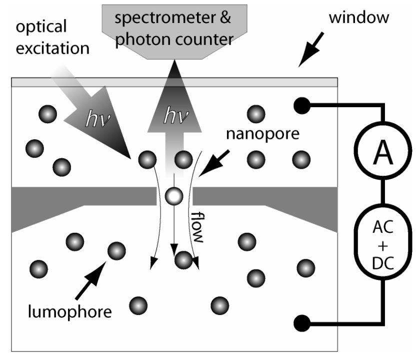


Fig. D1. The nanopore microscope combined with single-molecule optical measurements.

***Background**:* Our seed group is uniquely placed to explore the combination of nanopore microscopy with single-molecule spectroscopy [D4,D5] (Fig. D1). This effort builds on the work of Li [D6] and adds the expertise in nanotechnology, spectroscopy, and scanned probe microscopy of the other seed participants.

The jumping off point for this project is the nanopore microscope, a solution-based technique using a single nanopore (typically 3-50 nm diameter) fabricated in a 10 nm thick Si_3N_4 membrane. An ion current flows through the pore due to the DC bias across the membrane. Large molecules (DNA, nanoparticles, etc.) passing through the pore are easily detected by the temporarily drop in ion current.

The large electric-field gradients within nanopipette tips have been used as ìelectrodelessî dielectrophoretic (EDEP) traps for DNA and small molecules (dCTP) [D7,D8]. These traps are ìelectrodelessî because the field gradients are due to confinement of the ion-conduction channel, not an electrode structure. Thus trapping is not complicated by electrochemistry or adsorption on the electrodes.

***Proposed Research**:* While the ion current is not specific to the species in the nanopore, simultaneous optical measurements will provide a second channel of information. Our approach has the advantage that the lumophores can be probed and trapped under physiologic conditions. Thus the tumbling dynamics of molecules confined within the nanopore can be studied. Demonstration of EL excitation will have direct impact for sequencing and detection of single DNA strands using nanopore microscopy. More fundamentally our work will expand the tool set for studying single molecules.

Experiments with lumophores will explore the photophysics of the nanopore-lumophore system. The optical measurements of molecular and nanoparticle lumophores passing through the nanopores will be temporally correlated to the ion channel current. Strategies to select local nanopore-lumophore interactions include adding plasmon resonant structures near the pore [D9-D11] (ìsurface-enhancedî PL & EL), electric-field modulated PL, and direct electrical excitation (EL). If successful, EL has a huge advantage over PL because it is zero backgroundó ONLY lumophores in the pore are excited.

EDEP trapping of individual lumophores within the pore may be a fundamentally new way to do single lumophore experiments. The position of the trap is fixed and the species can be held for study, then electrophoretically ejected, and a new species trapped. The conductance signature confirms trapping, while the optical channel provides detailed characterization.

Model systems will be nanoparticles (CdSe, ZnS:Mn, etc.), molecular polyelectrolytes (PEI, DNA, dendrimers, etc.), and proteins (GFP, etc.). Non-luminescent polyelectrolytes (PEI, DNA, etc.) and proteins can be covalently tagged with lumophores. Small molecule lumophores (R6G, Di-4-ANEPPS, Alq_3, etc.) will also be investigated.

The Si_3N_4 nanopores for this work will be fabricated and characterized at UA (Li). The II-VI nanoparticle lumophores will be prepared and characterized at UA (Peng & Tian). The optical spectroscopic measurements will be performed at OU and UA (Bumm, Singh & Yip). EDEP trapping experiment will be carried out by investigators at OU and UA (Bumm, Li, Singh & Yip).

Nano-Textured Surfaces for Tribological and Opto-Electronic Applications

M. Zou, (UA Mechanical), H. Naseem (UA Electrical), and M. Johnson (OU Physics); 2 grad. students

Focus: The focus of this seed project is to fabricate nano-textured or nano-sculpted surfaces and to characterize their tribological, mechanical, and opto-electronic properties. The emphasis is on scalable fabrication processes that can lead to ordered structures. The overall emphasis is on the fundamental understanding of the effects of surface nano-texturing on friction/stiction, lubrication, and wear; and on the practical improvements for real-life problems and applications, for example, reduction of friction/stiction and wear in miniature systems.

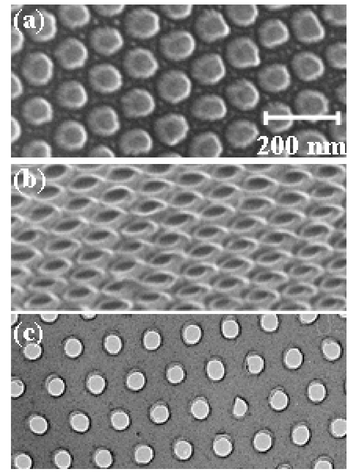


Fig. D2. SEM images of: (a) GaAs pillars on GaAs, 50 nm tall (top view) (b) Si nano-rings on Si (45^{o} view), 50 nm inner diameter, 10 nm thick, 50 nm tall (c) free-standing Si nano-hole array, 50 nm thick.

Motivation: The case for using nanostructures for opto-electronic applications is made earlier in this proposal, in short, nanostructures display electronic and optical properties that are revolutionizing many areas. On the other hand, nanostructures also demonstrate novel mechanical and tribological properties that hold promise for significantly reducing friction/stiction, wear, and energy consumption in computer hard drive head-disk interfaces, mechanical seals, MEMS/NEMS, and micro- and nano-fluidic applications. Recently it has been shown that NanoTurf (a nano-engineered surface with hydrophobic nano-posts) can produce a low flow friction surface with 40% drag reduction [D12]. A recent study also showed that mechanical properties of materials are size-dependent. The hardness of Si nanoparticles is 4 times that of bulk Si [D13]. These unique nano-scale properties provide tremendous potential for engineering surfaces to improve tribological properties, including friction/stiction, and wear, of moving components. Currently, micro-textured surfaces have been widely used in computer hard drives [D14-D16] and are very effective in increasing load carrying capacity and reducing friction in mechanical seals [D17-D19] and thrust bearings [D20, D21]. It is expected that nano-textured surfaces will bring in more benefit than micro-textured surfaces.

Proposed Research: In this seed we combine the fabrication techniques and structural characterization techniques at both OU and UA with the tribological and opto-electronic measurements and application interests at UA. The template fabrication techniques (Johnson) use anodized aluminum oxide templates in combination with more conventional etching and deposition techniques. The combination is a scalable process that results in ordered arrays of dots, pillars, rings, and pores in a range of materials (see Fig. D2). The spacing between dots can be tailored from about 20 to 200 nm, while the size of the dot, itself, can be varied somewhat independently. Combining these processes with the vapor-phase and metal induced crystallization techniques (Naseem, Zou) allows us to expand the geometries and materials available in our array structures. For example, we expect to fabricate well-ordered nano-fingers of crystalline silicon extending into an amorphous silicon layer. It is important to stress here the ability to fabricate ordered arrays is critical because it results in more structures with uniform size distributions and may even allow the individual structures to be individually addressed. These arrays will be structurally characterized using x-ray and electron microscopy techniques available at both campuses.

The mechanical and tribological properties of these nano-textured surfaces will be studied using state of the art nanomechanical and tribological characterization tools at UA (Zou). An initial example of study will be to investigate the expected frictional coefficient reduction associated with metal nano-arrays (related preliminary experiments show a large decrease). In addition, we can use the chemistry expertise in the center to see the effect of self assembled monolayers attached to such a surface on their trobological properties. The overall objective here is to develop a practical, robust process to reduce friction in real life applications. Opto-electronic properties will be studied in Electrical Engineering at UA (Naseem). An initial example of study will be to investigate the properties of the crystalline Si nano-fingers in amorphous silicon. The ability to tailor this structure on the nanoscale may lead to novel optical and electronic properties making this type of material useful as a photovoltaic an area of interest at UA.

4.E.1 EDUCATION AND HUMAN RESOURCES

Goals: To excite students in the K-12 arena, using inquiry based instruction, about the science in everyday life; to engage and aid teachers, principals and the community in improved science education; and to expose undergraduate and graduate students to the fascinating world of material science.

Rationale: Neither Oklahoma nor Arkansas has a tradition of high-technology industry and both states rank near the bottom in funding and resources for K-12 education, with Oklahoma ranking 50^{th} in teacher pay. Given these economic realities, CSPINís dual campus collaboration serves as a vital and powerful asset to regional science education. Moreover, in a time when standardized testing forces teachers to inundate students with rigid lecture-based curricula, our role has been to revitalize the natural curiosity that children have for the world around them by bringing them into contact with authentic research.

While we have had common goals, our previous strategy had been to design local programs for each campus tailored to the needs of the individual communities and to enhance and coordinate existing programs where possible. We plan to unify our existing programs in a ìStakeholdersî model that brings together all those who have vital interest in science education, including K-12 teachers, students, and principals; University faculty and students (at all levels) in science *and* education; members of business and industry, as well as the community at large. Through this model, we hope to evoke a *cultural shift* by providing meaningful, engaging experiences that would otherwise be unavailable in our region. It is our aim to attract greater numbers of young people to careers in science, to aid public schools in training and retaining quality science teachers, to offer leading-edge research opportunities for undergraduate and graduate students, hence building an even greater network of partnerships for improving science education. Below we describe our plan starting with our new bi-campus initiatives addressing the community at large, and then our ongoing efforts for K-12 students and teachers and our materials research programs for undergraduates and graduates. Recognizing a special obligation to improving opportunities for under-represented groups, we conclude this section with a Diversity Plan designed to build on past successes. (Additional outreach with colleges of education and local principals is in **Seed**).

New Bi-Campus Initiatives in Community Outreach

Inquiry-Based Learning through Museum collaborations: CSPIN proposes to increase the visibility of science through inquiry-based learning using Oklahoma and Arkansas museums. The Oklahoma Childrenís Discovery Network is comprised of four major science museums and works in close coordination with its Arkansas counterpart. In consultation with the network, the Center has agreed to provide museum shows developed by Penn State. These exhibits let children explore the wonders of nanoscale science through concrete, hands-on ìmanipulatives.î In addition to financial resources, CSPIN will also provide training while the network will enable museums to take these traveling displays to rural communities. Our eventual desire is to expose over a thousand Oklahoma and Arkansas children to materials science on an annual basis.

Nanotechnology Teaching Resources Digital Library: Helping K-12 teachers find, develop, and use learning resources that will excite their students about science is crucial both to create the next generation of scientists and to develop a public that is literate and interested in science. CSPIN is in a unique position to fill a void in regional science education. Through a new partnership with an NSF-funded national digital library and the OU/UA Colleges of Education, we propose to create a comprehensive web-based nanotechnology library for teaching resources which is peer reviewed and connected to state standards. Currently, there are a number of clearinghouses for science education resources; however, there is no organized process of ongoing peer review and dissemination of resources related exclusively to nanotechnology. We propose to follow five steps toward this end: 1) collection of materials from the literature, conferences/workshops, and web-based outreach programs to find nanoscience-related teaching resources; 2) professional peer review by scientists and experienced educators for scientific and pedagogical merit; 3) linkage of materials by Hall and Calleja to both state science education standards *and* to the National Academy of Science NCES standards, and compilation of material into sequenced, inquiry-based learning cycles for secondary physical science classrooms in collaboration with UAís Stewart; 4) publicity via ComPADRE (funded by the NSF National science Digital Library) and

MERLOT (an international consortium offering peer-reviewed evaluations of educational materials crossing 15 disciplines) in collaboration with OUís Mason; and 5) dissemination via in-school teacher training opportunities and campus-based nanotechnology workshops, in collaboration with OU and UA Colleges of Education, (see **Seed** section for greater detail.)

Continuing Efforts for K-12 students and teachers

As described in the EHR subsection of Pertinent Achievements, CSPIN has had great success in filling a local vacuum in science education by means of K-12 programs. The continuing programs with new enhancements are described below. (See EHR in Pertinent Achievements for supplemental information.)

SeeS, an OU-sponsored after-school K-5 science club, has been carefully crafted to attract girls at an age when many start to lose their interest in science[3] with six interactive science sessions per year boasting an attendance of 65 kids per session (>60% female). C-SPIN expanded this program to include a Title 1 school with a relatively large minority population for Norman (11% African-American, 8% Hispanic, and 14% Native American). C-SPIN will add a SeeS undergraduate staff position to improve organization, contribute to equipment and expendables, and provide CSPIN volunteers for all eight sites in the program.

GK-12 K.I.D.S_ is an NSF/UA program that pairs graduate fellows with middle school math and science teachers to develop inquiry-based science modules. Seven of the ten fellows accepted this year are from CSPIN labs who will use their backgrounds to develop and implement lessons with material science themes. To date, 25 fellows (32% minority) and 12 teachers (11 female) and have participated in the program. As the project enters its third year of six, the impact on the teachers, fellows and students has become apparent. Our evaluation team tracked 839 students in two middle schools on math standardized test scores. While the control group of 776 saw a 10% decrease in scores between 4^{th} and 6^{th} grade, consistent with the national trend [4], the 63 GK-12 students posted a 10% *increase*. Additionally, time devoted to inquiry activities increased in comparison to traditional direct instruction. We now propose to team GK-12 with the UA College of Education by including not only fellows and middle school teachers in summer training, but also pre-service science teachers. This collaboration will work in coordination with the outreach proposal described in the Seed Section.

BEST is a junior high and high school level robotics contest which CSPIN promotes through volunteer participation and financial support, sponsoring an average of 20 local teams per year comprised of 10 students each. Calleja and Vickers serve on the regional administrative committee that provides coordination for all facets of BEST. In addition, an enthusiastic group of Center faculty and student volunteers will continue to serve as BEST judges and assistants during kickoff, mall day, and game day.

Research Experience for Teachers: Over the past four years CSPIN has supported 25 middle and high school teachers in Center laboratories. We propose to continue to provide teachers a rich science experience, benefiting both teacher and their students. CSPIN will support Hall, a ten year veteran of middle school teaching, to provide recruiting and administrative infrastructure for both teachers directly supported by the Center and those on RET supplements in all Center related departments. CSPIN will provide teachers with individually tailored opportunities to develop science curriculum and design labs, while collaboratively working with MRSEC faculty to better understand the science. Several RETs will also be filmed while implementing each of their developed classroom lessons. Those recordings will be compiled into an educational DVD that can be downloaded from CSPINís site. We will also continue our summer meetings between REUs and RETs in which they exchange their personal observations and experiences about middle and high school science from the perspective of teacher and of student.

Continuing Efforts in Materials Research and Education for Undergraduates and Graduates

Research Experiences for Undergraduates: Both UA and OU Physics Departments have a history of successful NSF REU summer programs. The Center will continue to support an additional 3-4 students a year, using the existing REU site infrastructure. Students will be selected based on talent, lack of access to research at their home institution and geographic distribution. Over the last 4 years the UA REU has been particularly successful in recruiting under-represented groups (with 32% minority and 37% female participation); OUís REU has a 25% female participation). This success can be attributed to the Carver Project, an existing effort at UA that develops ongoing institutional partnerships with HBCUs. OU plans to adopt and emulate UAís successful diversity effort in the future.

Undergraduate and Graduate Training: In additional to our research experiences for students we have and will continue to make contributions to materials science pedagogy. Two graduate courses (*Advanced Nanomaterials Chemistry* and *Science of Nanodevices*) developed with CSPIN support will continue to be taught at both campuses using Internet II video-conferencing technology. Additionally, two new courses are under development at UA by Salamo and Vickers with the focus being photonic-electronic device design and prototyping and financial support provided by a Department of Education FIPSE grant. At the undergraduate level, OU offers an intercession freshman/sophomore level course in nanotechnology by Bumm and Johnson funded by NSF-NUE funding. This course will now become a regularly offered laboratory for lower division students.

Diversity Plan

Operating on the principle that enhancing diversity will enhance nanotechnology, our vision is to improve diversity in the U.S. nanotechnology workforce. We are proud of our progress on diversity (with one quarter of our C-SPIN graduate students female and one tenth members of minority groups), but aim to do even better. Our goal is to strive for half female and one third minority for our graduate population by 2010, reflecting percentages in the population at large. In order to meet this goal, C-SPIN will integrate a diversity plan throughout the Center structure in which we will be aided by Luz Martinez-Miranda, a new member of our External Review Board. It begins with identifying and recruiting underrepresented graduate students and reaches all the way to graduation and career placement. This plan is structured in four components: targeted recruitment, faculty and student mentors, exciting research opportunities, and career placement. While the latter three are applied to *all* CSPIN graduate students regardless of gender or ethnicity, we recognize that the effort requires special attention for underrepresented groups.

***Targeted Recruitment* -** We seek to attract a *critical mass* of minority students who are exceptionally academically qualified. Tactics include strengthening our established partnerships with the Louisiana and Oklahoma Louis Stokes Alliances for Minority Participation (LSAMP) programs; the Mississippi and Texas members of the UA George Washington Carver Project; and our NSF/REU programs on nanoscience, which just last year was nearly a third female (6/21) at OU, and half female (8/16) and one quarter minority (4/16) at UA. From last year, 4 students returned for graduate studies - two female and two minorities. We are also striving to improve our visibility and genuineness with minority partner institution administrators and faculty. Over the last several years, UA has sponsored two-day conferences for these individuals during which, the Chancellor, faculty, and students provide visitors with direct observations of our research and teaching facilities and engagement of minority students via a support group. This approach has proven successful and will be expanded to include both campuses next year.

***Exciting Research Opportunities* -** This is our strongest suit. We will continue to develop a team approach which enhances creativity and is proving to be a good fit to a broader spectrum of students.

***Faculty and Student Mentors* ñ** We help build community and foster understanding through our research and industrial work groups, where students share their different cultural perspectives on personal or professional issues. A new tactic is to have each student, on entering the program, have both a C-SPIN faculty mentor and a peer mentor with background and experiences closely matched to the new student.

***Career Placement* -** We recognize that our educational program must be part of an education -workforce continuum. Tactics include: a co-op experience, which overlaps with the studentís thesis work; external co-advisor from either industry or academia depending on student career interest; and annual student meetings with visiting industrialists. In the past we have supported students to attend the annual national meetings of minority scientific organizations such as the National Society of Black Physicists, in the future we will foster our relationships with industry minority researchers who can act as mentors.

Complimenting the above effort to increase student diversity we also plan to work to increase the number of minority faculty in nanotechnology at our universities. Murphy is spearheading a plan to bring an NSF Advance grant to OU to recruit and retain female academics in the sciences and engineering. We also propose to invite small groups of minority candidates to visit C-SPIN in the hope of interesting them in joining our faculty in nanoscience and engineering. Our universitiesí diversity initiatives will ensure that offers of faculty positions will be made to appropriate candidates to whom CSPIN will act as a support group to mentor success.

4.E.2 COLLABORATIONS WITH INDUSTRY AND/OR OTHER SECTORS

Collaborations with industry and other sectors are a vital part of the C-SPIN mission and operating structure. These interactions occur in several modes. First, the Center collaborates with scientists and engineers in industry, government, and national laboratories on many of the research projects within IRG1 and IRG2. Second, research from the Center has led to the founding of three small companies. Third, we will start an Industrial Affiliates Program that will further encourage interaction between C-SPIN researchers and industrial researchers. Fourth, we will continue to pursue industrial interaction fostered by the Oklahoma Network for Nanostructured Materials (Oklahoma NanoNet), which is a project funded by the NSF EPSCoR program, and the Oklahoma Nanotechnology Initiative. Finally, we will continue to coordinate our industrial outreach with those of local student programs with similar goals. The importance of these modes of collaboration to the success of the Center is described below:

Research Collaborations within IRG1: The ability to fabricate assemblies of nanostructures opens up a range of collaborative possibilities. Johnsonís AAO templates, for example, can be used to fabricate nanostructures from various materials. John Kirtley at IBM Research Laboratory (Yorktown Heights, NY) will perform scanning squid microscopy on nanorings and other nanostructures made at C-SPIN from metals and superconductors. AAO templates will also be used by C-SPIN to etch nanoholes in GaAs quantum wells grown at Sandia National Laboratories. The transport properties of the resulting nano-textured 2D electron system will be studied at Sandia by Michael Lilly. One of Salamoís students spent two months with Eric Stach at Lawrence Livermore Laboratory fabricating indented GaAs samples, characterizing by TEM, and is now using them as templates for organized MBE growth. The research results in the field of colloidal nanocrystals carried out by Peng, Xiao, and Johnson will be communicated to our industrial partners and collaborators (NN-Labs, Quantum Dots, Kovio, Kodak, GE) through existing channels.

The characterization facilities at C-SPIN also create opportunities for interaction. For example, Johnson will use C-SPINís x-ray diffraction, TEM, and XPS equipment to study silica coated magnetite nanoparticles for biological applications. The nanoparticles will be fabricated by Charles Sweeney at NanoBioMagnetics (Oklahoma City OK) and Kenneth Dormer at the OU Health Sciences Center.

Research Collaborations within IRG2: Industrial collaborations are also an important aspect of the proposed research on mesoscopic narrow gap systems. With MRSEC support, Santos and three students visited NTT Basic Research Laboratories (Japan) during the past three years. Each of the students stayed at NTT for ~10 weeks to fabricate and characterize ballistic transport devices made from heterostructures grown at C-SPIN. Murphy and Santos propose to continue to collaborate with Yoshiro Hirayamaís group on several of the proposed quantum confined and spin devices.

During 2004, a C-SPIN graduate student spent 10 weeks at Hitachi Global Storage Technologies (San Jose, CA). Under the guidance of Stephan Maat and Bruce Gurney, she performed experiments on prospective materials for read-head sensors. Santos, Murphy, and Salamo propose to collaborate with Hitachi on magnetic sensor applications for mesoscopic narrow gap devices. Narrow gap material will be grown at C-SPIN. Device fabrication and characterization will be carried out at Hitachi and C-SPIN.

Local industry initiatives: The research performed at C-SPIN has also had a significant impact on local industry through the founding of three small companies: Nanomaterials and Nanofabrication Laboratories (NN-Labs, founded by Peng), Nanoferr Inc. (founded Salamo and Bellaiche), and Minotaur Inc. (founded by Xiao). NN-Labs has licensed the intellectual property generated by Pengís research group and is actively commercializing colloidal nanocrystals. Since NN-Labs began an active phase in July 2002, it has received two Phase II SBIR awards. NN-Labs has already marketed two complete product lines and three partial product lines during the past year. With eight employees, NN-Labs is currently seeking three more full-time additions as they begin executing on Phase II programs. With support from the State of Arkansas and the University of Arkansas through its Genesis Technology Incubator, NN-Labs is rapidly growing into a significant high-tech startup in this traditionally rural state. NN-Labs also plans to interact with the new Innovation to Commercialization Incubator discussed below.

C-SPIN utilizes the infrastructure provided by the UA Innovation Incubator (I^2) to advance some of its research successes into commercialization. I^2 was launched in 2001 with funding from the NSF-Partnerships for Innovation (PFI) program. Its mission is to stimulate the creation of knowledge-based small businesses in the region by providing its clients with a graduate student for 12 months and $6K for materials or other expenses. This is supplemented by courses on entrepreneurship and proposal writing that are taken by C-SPIN supported students. I^2 also mentors client companies on how to write SBIR/STTR proposals and requires each company to submit at least one proposal during its year-long involvement with I^2.

I^2 has supported client proposals originating from C-SPIN research, including one from Nanoferr Inc. which focuses on the development of layered ferroelectric structures. I^2 has also worked on the commercialization of ten patents disclosures made by Salamo, Bellaiche, Fu, Peng, and Xiao. I^2 is eager to disseminate lessoned learned and has agreed to work in partnership with C-SPIN in adapting the developed success template. To this end, I^2 and C-SPIN will co-fund Oklahoma client companies with strategic linkages to C-SPIN.

During 2004, I^2 broadened its mission by adding the Innovation to Commercialization Incubator (ICI), which is separately funded by the NSF-PFI program. The objective of this new initiative is to build a complete pathway to commercialization. ICI will work with small companies that have already received an SBIR Phase I award to establish a new partnership with participants in the Walton College of Businessís MBA program. Combined business/technical student teams will be formed and assigned to client companies with the goal of accelerating these companies towards commercialization. Success is already evident through the tripling of the number of SBIR/STTR proposals both written and awarded within the state of Arkansas since the launch of the new programs. ICI will investigate the potential for broadening commercialization assistance to other regional companies. For instance, a relatively new relationship is with Northern Illinois Nanotech, Inc. (NIN), a company dedicated to commercialization of nanotechnology. NIN is interested in the possibilities of collaboration on development of products combining nanotechnology with electronics, overlapping strongly with research within IRG2.

In addition, I^2 partner Virtual Incubation, LLC, a private accelerator, has indicated a strong interest in expanding to work with Oklahoma companies through a relationship with C-SPIN. Virtual Incubation (VI) develops new companies by partnering technology entrepreneurs with business experts, technology experts and seed stage investors. The approach is to provide client companies with senior management experience, intimate knowledge of technology startup companies, and proven processes to execute business strategies. Applying modern communications technology in creating highly effective and efficient virtual teams, VI specializes in helping startup companies that are located near technology hot zones.

C-SPIN will continue to generate research commercialization activities in technology-based startup businesses. Progress is expected to accelerate as new research and technology parks are being launched at both campuses. In fact, on the OU campus, McCann and his company, Ekips Technologies, are charter participants in the newly planned research park just south of the main campus. C-SPIN also has relationships with area businesses that have achieved SBIR Phase I support, including NewMan Technologies, Inc. and NanoBioMagnetics, Inc. in Oklahoma.

Industrial Affiliates Program: Upon renewal, we will establish an Industrial Affiliates Program (IAP) to recognize companies that provide support to C-SPIN. The purpose is to foster closer relationships between the Center and companies in both our region and nationally. Membership is designed for organizations whose activities require the skills of nanoscientists and nanotechnologists. The benefits of membership will include use of C-SPIN facilities (e.g., cleanroom laboratory, molecular beam epitaxy, x-ray diffraction) at a reduced rate, on-site seminars and consultation by C-SPIN researchers, access to resumes of graduating students at the B.S., M.S., and Ph.D. levels for permanent positions or internships, distribution of technical reprints describing C-SPIN research, and an invitation to an annual meeting of all Industrial Affiliates.

Each Industrial Affiliate organization will be assigned a C-SPIN faculty liaison. The liaison will represent the Affiliate organizationís interests by providing assistance by: finding technical consultants within C-SPIN; identifying graduating students to fill positions at the Affiliate organization; suggesting C-SPIN researchers who might present on-site seminars of interest to the Affiliate organization; and serving as a host for visits by individual researchers from the Affiliate organization. At the annual Affiliates meeting, members will be updated on the research being conducted within C-SPIN and will meet with students who are supported by Program funds. The meetings will be excellent opportunities for members to meet students who may become candidates for future employment at their organizations.

The primary objective of the IAP will be to establish and nurture technical relationships between researchers at the Affiliate organizations and C-SPIN researchers in areas of mutual interest. This will lead to increased industrial support of C-SPIN research, joint projects, and graduate research being carried out at the Affiliate organizationís site. Another objective of the IAP is to facilitate the hiring of C-SPIN graduates by member organizations, as either full-time employees or interns.

We anticipate interest from organizations with whom we currently collaborate (Hitachi, NTT, IQE, Bell Labs, NanoBioMagnetics) and from those who have previously interacted (Nomadics, Eagle-Picher, Delphi Research Labs, IBM Microelectronics). In addition, we will solicit interest from small nanotechnology-related companies in Oklahoma (Ekips, SWeNT, NewMan Technologies) and Arkansas (Space Photonics, NN-labs, Nanoferr, Minotaur).

Oklahoma NanoNet and Nanotechnology Initiative: The Oklahoma NanoNet project provides infrastructure support for research on nanostructures made from semiconductors, carbon nanotubes, and other materials. Seven C-SPIN faculty members are also among the 39 faculty participants in Oklahoma NanoNet. A scientific symposium is organized annually by Oklahoma Nanonet with statewide participation by faculty, students, and researchers in industry. This is complemented by additional efforts by Oklahoma EPSCoR to foster statewide communication among researchers in universities and industry. In 2003, the Oklahoma state legislature established the Oklahoma Nanotechnology Initiative. When fully functional, it will develop mechanisms for attracting federal research monies and investment capital to Oklahoma to support nanotechnology research and industry growth. C-SPIN will actively pursue industrial collaborations fostered by Oklahoma NanoNet and the Oklahoma Nanotechnology Initiative.

Cooperation with Existing Student Programs: The Microelectronics-Photonics (! EP) degree program (funded by NSF-IGERT) at UA and the Engineering Physics (EPHYS) degree program at OU have educational goals that overlap with those of C-SPIN. EPHYS, ! EP, and C-SPIN all seek to promote greater interaction between students and industry. All three programs invite speakers from industry to campus and have advisory boards that include members from high-tech companies. During Summer 2003 and Summer 2004, ! EP and C-SPIN students organized field trips to Dallas-based companies (as shown in the Fig. E1 below). We will continue to coordinate activities among the programs to maximize student interaction with industry.

Fig. E1. Students from the OU Physics REU Program, the UA Physics REU Program, and the UA ! EP REU Program took a tour of Zyvex, a nanotechnology company in Richardson, TX. Zyvexís nanotechnology commercialization work was discussed by Dr. John Randall, Zyvexís Chief Technical Officer and a member of the ! EP Industrial Advisory Committee.

4.E.3 SHARED EXPERIMENTAL FACILITIES

Over the past five years the Universities of Oklahoma and Arkansas have made a large investment in developing interdisciplinary research in nanoscience. This has been a direct result of C-SPIN, our successful MRSEC funded in 2000, which raised the visibility of nanoscience on both campuses. As evidence of support, the administrations hired two new faculty members, provided matching funds for equipment proposals, prepared new and renovated space, supported technicians, and provided fellowships for graduate students. Such support has been essential to address the goals of the Center which requires an extensive array of equipment and manpower supporting molecular beam epitaxy, colloidal synthesis, electron and scanning tunneling microscopes, fabrication clean rooms, *etc.* available to all researchers. We are pleased that the administration is committed to continue this support, as demonstrated by the provision of **two new full-time technical staff positions**, one at each campus as match to this proposal.

Shared experimental facilities are much more than state-of-the-art equipment alone; equally important is the state-of-the-art expertise to run the equipment. C-SPIN in the past made a number of postdoc hires to improve the Centerís talent base and transfer this knowledge to the graduate students. We will continue this philosophy in the future. One of the direct results of this has been an expanded set of experimental facilities that are now conveniently available in our Center. For example associated with the TEM expertise at OU, we have now established links to the extensive Electron Microscopy facilities at Oak Ridge National Labs. This example and several others are discussed below.

C-SPIN Facilities: The table at the end lists the shared experimental facilities. The growth facilities at both institutions are central to many of the proposed collaborative experiments. The complementary arrays of structural characterization tools and set-ups for transport and optical experiments are used to study samples grown at both institutions. The Semiconductor Physics Fabrication Facility (SPiFF) at OU and the High Density Electronics Center (HiDEC) at UA are available for free to Center participants and on a fee use basis to other academic and external users. (For details on the C-SPIN facilities see http://www.nhn.ou.edu/cspin/facilities/overview.html .)

While the Center is currently well equipped, there will be an immediate impact made by adding pieces of equipment critical for the proposed pursuits. At OU a multi-user MBE system will be augmented, as will several pieces of equipment within the recently established SPiFF. Similarly, upgrades will be made to various chambers of the UA multi-user MBE system. The equipment to be purchased with NSF and matching funds are listed in italics in the table.

CSPIN Materials Staff: Staffing is undoubtedly one of the keys to the success in any analytical user facility because of the lack of experience of many of the end users and the wide variety of materials that need to be grown or analyzed. The overall operating philosophy and funding of CSPIN dictates staff responsibilities and, consequently, the staffís educational background. We have found that a balance between (1) technicians and (2) Ph.D. scientists is ideal for the function of our user facility.

With this philosophy in mind our technician and scientist Staff for the CSPIN user facility is:

Charles Kelley	Clean Room specialist	Physics, Ω supported by OU
Tetsuya Mishima	MBE and TEM specialist	Physics, Staff position by OU
Guoda Lian	TEM materials specialist	OU, Ω supported by OU
Frank Zhao	MBE specialist	Electrical, Ω supported by OU
New Position	Device specialist	Physics, match position by OU
John L. Shultz	MBE and Characterization	Physics, Staff position by UA
New Position	Optics Specialist	Physics, match position by UA
Zhiming Wang	MBE Specialist	Physics, Ω supported by UA
Yuriy Mazur	PL and PLE Specialist	Physics, Ω supported by UA
Vasyl Kunets	MBE and Hall Specialists	Physics, Ω supported by UA

(Fractions of staff salaries not supported by OU or UA are from grants.)

The new OU staff member will assist C-SPIN participants with electron beam lithography and other fabrication processes available within SPiFF. The new UA staff member will maintain existing optical equipment and help develop new optical facilities that are focused on exploring quantum dot and ring arrays and ferroelectric nanostructures.

Financial Support of Facilities: Initially the user base at OU and UA was insufficient to fully recoup staff salaries, maintenance and service contract costs entirely from user fees, instead grants and the Universities provided direct support. As the Center grows we are expanding the user base to include more internal academic and external users; however we are not yet self-sustaining. To pass this threshold, we need a larger internal and external user base. To achieve this we use a graded fee structure where academic users are charged one rate, startup-companies a higher rate and fully established companies a yet higher rate. We waive these fees for preliminary measurements for proposals in which cost schedules for continued use of the equipment are included. Similarly, we waive the initial use fee for technique evaluation and first time uses. Furthermore, we are establishing a web presence and pamphlets to disseminate information about our facilities to our state sister schools, out-of-state schools and industries. Over the duration of the first MRSEC grant, we have seen a marked increase in our facilities use and with our continued innovative efforts we are confident it will continue.

Collaborative Facilities:
In addition to activity within the Center there is considerable exciting research performed in the laboratories of our national and international collaborators. We have been very open within the Center to encourage cross-fertilization, encouraging Center PIs to network with each others collaborators. Examples include THz spectroscopy at the University of Alberta to measure anisotropic photoconductivity in MBE grown quantum wires, where initially the contact was with Johnson and is now also with Salamo. A second example is the new relationship between wherein OU TEM scientists are taking UA samples, prep them in-house and then image them at facilities all over the world. Over the past few years we have seen the number of such secondary collaborations grow. Furthermore, our students have benefited from personal travel to a number of our collaboratorsí facilities at Sandia, in Germany and in Japan. Below is a list of Center collaborators grouped by the facility or technique they provide.

1. Electron Microscopy: Oak Ridge National Lab, A. Blom, and L. F. Allard Jr., Metals and Ceramics Division (http://www.ms.ornl.gov/htmlhome/mauc/tempage/MAGTEM1.htm) , http://stem.ornl.gov/, Sematech, FEI and Philips 300 kV TEM/STEM http://atdf.com/analyticalservices/tem.htm , Arizona
2. TerraHertz Spectroscopy: Frank Hegmann, Physics, University of Alberta
3. Synchrotron X-ray Beam: M. Schmidbauer, Institut f¸r Physik, Humboldt-Universit‰t zu Berlin
4. NSOM: R. Pomraenke and C. Lienau, Max-Born-Institut, Berlin, Germany
5. Electron-beam-lithography (EBL): W.T. Masselink, Physics, Humboldt University Berlin, Germany
6. Fabrication Facilities for Optical Waveguides : M. Chauvet, University de Franche Comte, France
7. Nonlinear Optical Facilities: G. Stegeman, CREOL of the University of Central Florida
8. Brillouin Scattering: M. H. Kuok, Physics, National University of Singapore
9. Mesoscopic Device Fabrication, low-temperature/high B-field transport measurements. NTT, Japan
10. Mesoscopic Device Fabrication, Michael Lilly, Sandia National Labs
11. Novel optical scanning probe microscopy, V.I. Klimov http://cint.lanl.gov/about.html

General OU-UA Facilities: The OU Department of Physics and Astronomy maintains a first-class instrument shop staffed by three machinists with no charge for services from departmental PIs. Additionally, the department has a fee-free electronics shop staffed by one, and a full-time computer systems operator. The OU Department of Chemistry maintains a fee-free electronics shop staffed by three. Both the Physics and Chemistry instrument and electronics shops provide services to those outside the departments at cost. The UA Physics Department maintains a machine shop staffed by a full-time machinist and a electronics shop staffed by a electronics specialist. Also available at both OU and UA are and a glass-blowing shop with one full-time glass blower. Numerical studies can be done on either campus on scientific workstations.

University of Oklahoma (OU)	University of Arkansas (UA)
UHV Growth Systems: Intevac MBE Systems MBE #1: IV-VI (Pb, Eu, Se, Te) and Ba/CaF_2 MBE #2: III-V InSb related (In, Ga, Al; and Sb, As) Dopants Si and Be. *Requested As and Sb valved crackers.* Omicron: Electron beam evaporator FEI Field ion source VG AES & XPS with depth profiling Omicron AFM/STM	**UHV Growth Systems:** Riber MBE Systems MBE #1: MBE32 III-V AlGaIn AsP MBE #2: MBE32 III-V AlGaIn As *Requested atomic H source and AsB_3 source* MBE #3: Veeco Gen II Nitride MBE #4: Riber MBE32 Ferroelectrics VG Electron beam evaporator, ion etcher Omicron AFM/STM: *Add E-Field Sensitive head.* Omicron Low-Temperature STM/NSOM Omicron Multiscan STM/SEM/AES
Characterization: High Resolution TEMs JEOL 2000FX with EDS and PEELS JEOL 2010F (Field-Emission Source) SEM with EDS JEOL JSM-880 (LaB6) *Add field-emission SEM* *Add Precision Ion Polishing System* http://www.ou.edu/research/electron/ Topometrix In-Air AFM/STM with MFM head RHK Room-Temperature STM/STL: *Requested liquid He capability.*	**Characterization:** TEM JEOL 100CX, Environmental SEM FEI XL-30 FEG ESEM with Nabity EBL and Edax Phoenix EDS SQUID Magnetometer, Quantum Design MPMS Nuclear Magnetic Resonance Bruker DSX-400, Confocal Microscope, Leica Raman Spectroscopy, custom FTIRFT-Raman/PL Bruker IFS66 *Requested UV-Vis-IR spectrophotometer* SPM Digital Inst. Dimension 3000/Nanoscope III XPS Kratos His; Hitachi S2300 SEM (W-filament) w/ EDS
Common to both institutions: X-ray Diffractometers: high resolution (Philips MRD) and low angle systems (Scintag), Optical Microscopy (Nikon), Hall Effect System (Custom) FTIR (A Biorad FTS-60A and a Bruker Equinox 55 FTIR) and Photoluminescence (Custom)	
Transport: ^{3}He and ^{4}He cryostats with B up 9T **Optical Spectroscopy:** Photoluminescence (0.2 to 5 ! m) UV-Vis spectrophotometer ^{4}He cryostat with FIR laser for cyclotron resonance	**Transport:** *Requested Spectrum Analyzer* **Optical Spectroscopy:** CW/Pulsed Lasers (0.4 to 16 ! m), time-resolved spectroscopy: *Requested various systems to enhance polarization, photon counting and UV capabilities.*
SPiFF: III-V Processing Facility Photolithography, Karl Suss Model MJB-3with accessories. **Photoresist Spinner:** Laurel Tech. WS-200-4NPP **Deposition Systems:** Edwards thermal evaporator Kurt Lesker RF- DC-magnetron sputtering system CHA- 600 e-beam evaporator **Etching Systems:** Trion Mini-Lock II, For Si and III-V materials. **SPiFF Ball Bonder:** Kulicke & Soffa Model 4524. *Requested Plasma Enhanced CVD, electron beam lithography.*	**HiDEC: 5"- Multichip Module (MCM) Facility** Wide range of deposition and characterization techniques. http://www.hidec.uark.edu/

4.E.4 INTERNATIONAL COLLABORATIONS

C-SPIN is not only a partnership of talent between two universities, but also includes talent from other countries as integral parts of the proposed research plans of both IRGs. Examples of our ongoing and proposed international collaborations are described below. The equipment available in our collaboratorsí laboratories is described in Section 4.E.3, Shared Experimental Facilities.

IRG 1: The arrays of nanostructures fabricated in IRG1 enable several international collaborations. Salamo and Johnson will continue to collaborate with F.A. Hegmann of the University of Alberta (Canada) on terahertz pulse spectroscopy experiments that probe anisotropic photoconductivity and mobility in nanostructures. These contactless measurements of conductivity and mobility have already been performed on InGaAs quantum dot chains fabricated by Salamo. We will extend this collaboration to other nanostructures fabricated by C-SPIN. Johnson also proposes to collaborate with M.H. Kuok of the National University of Singapore and David Lockwood of the National Research Council (Canada) on Brillouin scattering of Nickel nano-ring arrays. The experiments will be carried out in Singapore on nano-rings fabricated by C-SPIN, with theory support from Canada.

Salamo collaborates with Mathieu Chauvet at the UniversitÈ de Franche Comte (France) on optical switching of spatial solitons in AlGaAs waveguides. We are working toward a reconfigurable optical interconnect device with quantum dots in the guiding slab. Xiao and Salamo also work with W. Ted Masselink and R. Kˆhler of Humboldt-Universit‰zu Berlin on the transport properties of self-organized quantum dots and wires and x-ray diffuse scattering by III-V quantum dot arrays, respectively. The latter work has confirmed that the vertical stacking of quantum dots is tilted, and we are currently developing a model to explain this behavior. Further work is also targeted toward Mn doped dot arrays with a focus on determining the nature and amount of Mn and on magneto-optical effects. Salamo and Xiao are also in partnership with J.W. Tomm and C. Linau of the Max-Born-Institut f¸r Nichtlineare Optik und Kurzzeitspektroskopie. We are working together on femtosecond time resolved spectroscopy and on near-field low temperature microscopy on the QD, QWR, and QR arrays. We are exploring excitation at one location in the array and examining emission at other locations due to tunneling of excited carriers. Salamo also has a started a collaboration with G. Tr‰nkle and H. Kissel of the Ferdinand-Braun-Institut f¸r Hˆchstfrequenztechnik. We will form a team together with Masselink on developing electron beam lithography on patterned substrates, which will then be used as substrates for self-assembled organized growth. We will use cathodoluminescence to explore individual nanosize elements of the array in order to observe their individual structure.

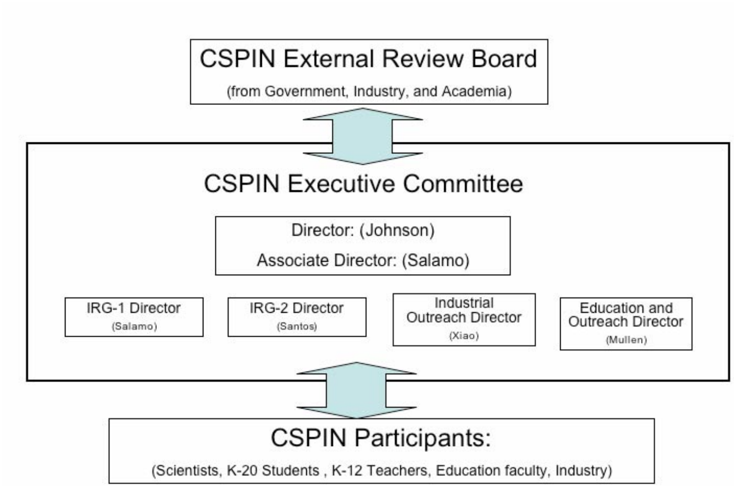
IRG 2: Salamo, Santos, and Murphy propose to collaborate with W. Ted Masselink of Humboldt-Universit‰zu Berlin on the development of micro-Hall sensors made from narrow gap material grown at C-SPIN. This project will be coupled to the collaboration with Hitachi on the development of mesoscopic read-head sensors. Santos, a graduate student and two undergraduates made several visits to NTT Basic Research Laboratories (Japan) during the past three years to collaborate on ballistic transport experiments with Yoshiro Hirayamaís group. Each student stayed in Japan for ~10 weeks. Most of the travel and lodging costs were funded by an AWARE (American Workforce and Research and Education) supplement from the NSF Office of International Science and Engineering. Murphy and Santos propose to continue to send students to NTT to fabricate mesoscopic devices from narrow gap material produced at C-SPIN. Experiments on these devices will be conducted at NTT and C-SPIN.

The collaboration with NTT has benefited participating students in both their scientific and cultural educations. The C-SPIN students worked closely with their Japanese hosts and lived in the same NTT-owned dormitories as Japanese employees. The results of their collaborative experiments have been presented at three international conferences and are described in three publications. Additionally, four C-SPIN students visited Japan for one week to participate in NTT Summer Schools on Quantum Computing (2002) and Transport Properties in Quantum Nanostructures (2004). We will explore similar opportunities with other international collaborators and plan to apply for appropriate supplemental funding from the NSF Office of International Science and Engineering.

4.E.5 MANAGEMENT

The CSPIN initiative grew out of a need at both institutions for a greater collaborative circle. Thus its management style and corresponding structure has been more democratic and collegial than autocratic. But a Center is more than just a collection of researchers and their projects; we have learned through experience that support staff and community activities are essential to forging a cohesive whole. A clear focus with articulated goals is required not only for the research efforts but for the Education and Industrial Outreach as well. Furthermore, having a Center equally split between two universities of adjacent states has some unique issues (the campuses are separated by a 4 hour car trip). As discussed below, we rely heavily on telephone conference calls, Internet-based meetings, frequent visits back and forth and summit meetings in Tulsa which is two hours from both universities. With this philosophy as a backdrop management issues are discussed below in more detail. This is followed by a timeline summarizing activities and new initiatives through out CSPIN.

Governance: Shown at right is CSPINís management structure. The MRSEC director is Matthew Johnson (OU) and associate director is Greg Salamo (UA). The Executive Committee (EC) consists of the Center Director, the two IRG Directors, and the Coordinators of Industrial and Educational Outreach. The External Review Board (ERB) is made up of members taken from industry, state government and academia. The role of each of these groups will be described below.



MRSEC Director and Associate Director: The Director and Associate Director are responsible for representing the MRSEC at all appropriate activities. They also provide overall supervision of the two IRGs, the Educational and Industrial Outreach components, the Seed Funding program, and the MRSEC budget. They are in charge of arranging joint teleconferencing seminars for reporting the scientific progress of Center participants. They are charged with maintaining the scientific integrity of the MRSEC. They will continue to have a weekly teleconference to review progress in the IRGs, education, industrial outreach, seed, and shared equipment programs. These meetings will also be attended by the Faculty outreach director (Mullen), UA outreach coordinator (Calleja) and the Project Administrator (Hall). In the event of personnel change, the director and associate director will always come from separate institutions in the collaboration.

Executive Committee: The Executive Committee consists of the IRG directors, the MRSEC director, and the two Directors for Industrial and Education Outreach. The Executive Committee meets every month by teleconference or whenever requested by a Director. They will convene a minimum of twice a year to formally review the progress and direction of each of the IRGs as well as the Centerís human resource development educational and industrial outreach, and shared equipment programs. Such review will have the potential for changed financial support. Evaluation criteria include: scientific merit, past productivity, the degree of collaborative activity, and past participation in Center outreach activities. Selection criteria for seed projects are slightly different and include: scientific merit, potential for absorption into an existing or new IRG, degree of interdisciplinarity, inclusion of new PIs into the Center; and mentorship of new faculty. The EC then makes a report and recommendations to the Directors. In addition the Executive Committee is the body that evaluates nanoscience curriculum. Finally the Executive Committee has the responsibility for writing the annual report, arranging the annual NSF review (both informal and formal), and for meeting with the External Review Board. They are also responsible for implementing NSF and ERB recommendations. The EC will continue to promote new research activities, new programs in education and outreach, better and more complete facilities, and most importantly, the careers of its young faculty.

External Review Board: The ERB is made up of members taken from industry, state government and academia. They will review the annual written report of the Executive Committee. The full ERB membership shall meet every two years with the Executive Committee. The Board will tour facilities, visit poster presentations by students, and listen to an overview of progress and discuss the future direction of the Center. The Board will also assess the graduate education provided by the Center, and its Outreach programs. In addition, individual ERC members shall meet with CSPIN on a regular basis to address specific issues within the range of their expertise or to participate in one of the workshops discussed below.

IRG Directors: The day-to-day operation of each of the two IRGs is the responsibility of the IRG directors. Each IRG will continue to meet regularly using Internet facilities, and once a semester at alternating campuses. They are also responsible for developing group meetings, research strategy, and new proposals. The IRG directors also coordinate equipment scheduling for maximum utilization and lowest cost of ownership. The IRG directors report progress to the Executive Committee. They are responsible for all IRG participants, including the investigators, students, postdocs and collaborators.

Industrial Outreach Director: The first priority for this Director will be to enhance existing partnerships. This will be accomplished by enlarging the circle of collaborating scientists and engineers with a given industrial partner. By presenting the broad experience and expertise of the Center faculty and students to a given industry, we will have a greater opportunity for successful outcomes. To carry this out, each faculty member will be expected to host, periodically, a visiting industrial scientist.

Education and Outreach Director: A faculty member of the Center (Mullen) is responsible for coordinating both the education program and outreach activities related to education. This individual works closely with a coordinator at the partner campus (Calleja), who is be responsible for implementing the outreach programs outlined earlier, and assisted by the Program Manager (Hall).

Meetings and Conferences: The Centerís administration will involve several types of meetings. The *managerial* meetings have been described above. They take place either via internet teleconferences using Center Polycom system or simple speakerphones. *Research* driven meetings are of several types. Small, informal meetings (*e.g.* to discuss TEM results or present theory) will continue to be scheduled as the need arises. Each IRG will hold monthly seminars as well as host seminars for invited speakers, most notably external collaborators. These will be jointly attended again using our existing teleconferencing tools. *Outreach* meetings will continue to be semi-monthly covering joint projects such as COMPADRE, museum exhibits and curriculum development. As in the past, *Nanoscience Classes* will meet twice a week over the semester via teleconferencing, with students earning credit at their home campus. During the summer, RET and REU participants at each institution meet weekly in separate lunchtime sessions to discuss their progress and attend lectures on nanoscience and graduate school admission where appropriate. The RETs and REUs meet at least once over the semester to exchange perspectives on middle and high school science.

In addition to the above, CSPIN will plan larger Center-wide meetings. These include: (1) annual graduate student/postdocs exchanges where one campus hosts the researchers from the other; (2) an annual outreach summit that brings together participants from schools of education, RET alumni, and Center participants to discuss best practices in science education; (3) a yearly conference and poster session for visiting NSF administrators; and (4) a biannual onsite conference for the ERB. These are included in the timeline below.

External Review Board Participants: The following people have agreed to serve as ERB members:

1. Sheri Stickley, Interim President, Oklahoma Center for the Advancement of Science and Technology
2. John Ahlen, President, Arkansas Science and Technology Authority
3. Mansour Shayegan, Department of Electrical Engineering, Princeton University
4. Moses Chan, Dept. Physics, Director Penn State MRSEC (2000-2005), Penn State University
5. Luz Martinez-Miranda, Materials Science and Engineering, University of Maryland.
6. Davis Baird, Chair, Dept. of Philosophy, Assoc. Director NanoCenter, University of South Carolina,

7. Richard E. Slusher, Dept. Head, Optical Physics Research, Lucent Technologies, Murray Hill, NJ
8. Bill Harsch, Director of Market and Business Development, Eagle-Picher, Joplin, MO
9. Charles Chalfant, President and CEO, Space Photonics Inc., Fayetteville, AR
10. Colin Cumming, President, Nomadics Inc., Stillwater, OK

The ERB was increased from five to ten members to address the issues of diversity, societal impact, and entrepreneurship. New ERB members include: Professor Luz Martinez-Miranda who was added not only because she is a nationally recognized Materials Scientist, but also because she has had considerable success in promoting diversity in science, Professor Davis Baird, an expert on the societal impact of nanotechnology; and Charles Chalfant and Colin Cumming, two highly successful local entrepreneurs.

Time Line: We summarize the research efforts over the length of the grant in the timeline below.

Year	2005	2006	2007	2008	2009	2010
Research: Purchase major equipment	!	!				
Personnel: Hire tech staff	!					
Hire Postdocs		!		!		!
Grad Student exchange	∀	#	∀	#	∀	#
SEED: *Outreach*						
Form teams	!		!		!	
Place in pilot schools		!		!		!
Large scale implementation			!	!	!	!
Scientific: Request proposals	!		!		!	
All seeds: Assess impact		!		!		!
EHR Classes (two course/ year)	!	!	!	!	!	!
Outreach summit with Sch. Of Ed.	!	!	!	!	!	!
BEST Robotic Competitions	#	#	#	#	#	#
GK-12: KIDs /SeeS Expansion		# /∀	# /∀	# /∀	# /∀	# /∀
NDL: Collect material/peer review.	!	!	!	!	!	!
Synthesis/Web publication		!	!	!	!	!
Teacher/Principal Training			!	!	!	!
Assess Impact			!			!
REU/RET	!	!	!	!	!	!
Diversity: 30% Female, 15% Min.			!			
50% Female, 33% Min						!
Industry:: Indust. Affiliates meeting	!	!	!	!	!	!
Coop. with Existing Student Prog.	!	!	!	!	!	!
Management: Evaluate IRG particip,	!	!	!	!	!	!
Solicit seed funding	!		!		!	
NSF Site Visits (formal and informal)	∀	#	!	#	∀	!
ERB Symposium		!		!		!

! : Both campuses; ∀: By or held at OU; # : By or held at UA.

Letters of Support: We have provided several letters of support limited by the allowed space.
1. John A. White, Chancellor of the University of Arkansas
2. David Boren, President of the University of Oklahoma
3. Yoshiro Hirayama, Leader, Quantum Solid-State Physics Research Group, NTT, Japan
4. Mathieu Chauvet, Laboratoire díOptique P.M. Duffieux, Universite∃Franche Comte, France
5. As well as 1,2, and 9 from the ERB list above.

4.F SYNOPSIS OF ORGANIZATIONAL AND OTHER COMMITMENTS

The University of Arkansas and the University of Oklahoma are committed to the success of the MRSEC proposal and to the success of the resulting Center for Semiconductor Physics in Nanostructures. Besides the standard institutional contributions of faculty and staff time the universities and states have made the major financial commitments listed below.

1. **Matching Funds:** The Universities of Oklahoma and Arkansas have committed \$3.7M match to the proposal for capital equipment, two new technicians, and other needs. The OU matching funds include \$642,000 in equipment funds from the Vice President for Research, \$600,000 in cash from the Oklahoma State Regents for Higher Education, \$96,000 in cash from the Department of Physics and Astronomy, and \$30,000 in cash from the School of Electrical and Computer Engineering. The UA matching funds include \$630,000 for equipment and \$642,190 in cash from the Provost The salary for a new technician at OU and at UA accounts for \$265,000 in salary match from each university over the six year grant period. The total represents 37.8% of the NSF request over six years as a match to the requested NSF support**.**
2. **Staff Positions**: The University of Arkansas and the University of Oklahoma have **each committed a new technician line item in the university budget** to a successful MRSEC. Personnel hired in these positions will provide continuous maintenance and guidance to users of the MRSEC facilities at each institution and also provide training for growth and device fabrication for graduate and undergraduate students.
3. **Space:** The University of Oklahoma recently completed a \$5.3M office addition to the building housing the Department of Physics and Astronomy. A complete renovation of the present building, totaling about \$4M, is planned and designed to expand and improve research space. The University of Arkansas is also completing a \$1 million dollar addition to the molecular beam epitaxy facility which will allow further expansion of its growth and imaging capability. These additions insure that there will be space available for the growth needs of the MRSEC.
4. **Access to Existing Facilities:** The University of Arkansas and the University of Oklahoma each have outstanding MBE-STM facilities whose personnel and equipment will be available to Center participants and collaborators. Major cleanroom facilities at each university will also be available, at Arkansas through HiDEC and at Oklahoma with the SPiFF facility which was completed in Spring 2000. Other existing scanning probe equipment, magneto-transport and magneto-optical facilities, and computing capabilities to be used for the MRSEC are available and have been detailed within the proposal.
5. **Commitments for Collaboration and Outreach Programs:** The proposed MRSEC will greatly benefit from the existing REU programs in physics at both the University of Arkansas and the University of Oklahoma. It will also benefit from university supported graduate student undergraduate student fellowships at both institutions. In addition, using the Internet 2 network, both Universities will make available facilities that will provide shared writing boards, video conferencing, shared designing, fabrication and testing equipment, and a shared classroom. This equipment will continue to be used for shared courses and weekly meetings. Last year, for example, a course in nanoscience was presented to students at both the University of Arkansas and the University of Oklahoma and was broadcast from the University of Arkansas and taught by Professor Salamo. The course was taken by 20 students and was rated by students at 4.8 on a scale of 5 being excellent.

4.G STUDIES OF SOCIETAL INTERACTIONS

While we have presented what we hope is a compelling case for exciting research in nanotechnology we do so with a careful eye on the societal issues discussed below that accompany such optimistic possibilities.

! ***Environmental Impact*** **ñ** If the ultimate goal of nanotechnology is to build novel materials and devices from scratch, atom by atom, such new materials may adversely impact the environment.

! ***Social Interactions*** **ñ** The emerging fields of nanoscience and nanoengineering are leading to unprecedented understanding and control over the fundamental building blocks of all things. This is likely to change the gadgets we use in everyday life - computers to automobile tires to objects not yet imagined. New things like e-mail and cell phones have brought social change and controversy (*i.e.* cell phones in public), hence nanotechnology will very likely raise public apprehension.

! ***Ethical Interactions*** **ñ** It is easy to imagine discussions about how tiny sensors and huge data banks can add up to a loss of individual privacy. The ethical challenges ahead need to be clearly understood by ourselves, our students, and the general public.

! ***Economic Issues*** **ñ** Given that many nanotechnology breakthroughs may revolutionize our industries, and that in the process other countries may develop into strong high-technology competitors, nanotechnology will likely rearrange the world economic landscape.

These issues have brought apprehension to the general public but can be addressed by a nanotechnology community with a clear and balanced view. Our approach is as follows.

Environmental Impact: At the nanoscale new, highly desirable, properties are created due to size confinement, surface, and interfacial phenomena. As these new and unique properties lead to exciting benefits we can anticipate that the use of nanotechnology will multiply. Along with this development, emissions to the environment may increase and a whole new class of toxins and corresponding environmental problems may be created.

For example, the field of colloidal semiconductor nanocrsytals has been mostly focused on CdSe and other cadmium chalcogenides nanocrystals in the recent years because they offer exciting applications in biomedical labeling, optoelectronics, nanoelectronics, etc. However, as these quantum dots are manufactured what waste is produced and what toxicity does it have? Importantly, what happens to these materials when they get into the air, soil, ground water, food supply, or skin? This situation is exemplified by cadmium based nanocrystals, which despite the environmental threat, have become the main stream for the research and development of high quality semiconductor nanocrystals in both academic and industrial settings due to the attractive economic possibilities. Applications of cadmium based nanocrystal emitters are under consideration by professionals in the fields of bio-medical, optoelectronic, solar, and sensing sciences. If the expected industrial benefits of cadmium based nanocrystal are fully exploited, one can anticipate that cadmium could soon be wide spread throughout the environmentó possibly without careful investigation or broad discussion of the potential harmful effects on our health.

While we do not have the expertise to study these important questions within C-SPIN there are some ways in which the Center can make a difference. We have taken measures that can minimize or even avoid the negative impact that nanostructures will have on the environment. For example, as discussed in Pertinent Achievements, we have already concentrated on the development of ìgreener approachesî for the synthesis of high quality cadmium-based semiconductor nanocrystals. Additionally, we have studied proper surface modifications, creating dendron-nanocrystals and box-nanocrystals, which certainly reduces the toxicity by enhancing the stability of the nanocrystals. These efforts have greatly reduced the environmental impact of these nanomaterials, and the ìgreener approachesî have thus been regarded as the standard methods for production of the cadmium chalcogenides in the field.

Nevertheless, it is the element cadmiumó regardless of oxidation stateó that is extremely toxic and highly carcinogenic; rather it would be better if a non-cadmium based nanocrystal emitter could be developed. This is part of what is proposed as the research effort of IRG1. In particular we propose to use transition metal doped ZnSe and ZnS nanocrystals as alternatives to cadmium chalcogenide nanocrystals. The zinc element is much more environmental friendly in comparison to cadmiumó one of the known toxic effects of cadmium is caused by the replacement of zinc by cadmium in living organs. Moreover, our results indicate that high quality zinc chalcogenide host nanocrystals can also be synthesized *via* ìgreen approachesî. While the bulk bandgap of ZnSe (2.7 eV) and ZnS (3.5 eV) are too high for such nanocrystals to emit in most of the visible and NIR windows for optoelectronics and bio-medical labeling, transition metal doped ZnSe and ZnS nanocrystals can emit at visible and near infrared wavelengths. Our preliminary results for Cu-doped and Mn-doped ZnSe and ZnS nanocrystals supports this possibility with emission in the 400 to 600 nm range. In addition to research and development of ìgreenerî semiconductor nanostructure materials we have also committed ourselves to a similar effort in ferroelectrics. Our plans are to begin our ferroelectric studies with the deposition of $BaTiO_3$, $SrTiO_3$ and then to focus on the non-toxic material, $BaZrTiO_3$. Currently, the most used ferroelectric in industry is the highly toxic lead zirconate titanate or as it is more commonly known, PZT. Our work has the potential to result in replacing PZT with an equal or better performer - $BaZrTiO_3$.

In general, our commitment is to stay focused on the discovery and development of non-toxic materials so that the applications we have discussed in our proposal may be accomplished in a way that is watchful of the impact on the environment.

Social Interactions: Given the potential impact of nanotechnology on our way of life it is easy to understand the concerns that exist in our communities. Nanotechnology is already being incorporated into products such as sunscreens, plastics, car parts, clothing, sensors, and new generation batteries. It is certainly possible that nanotechnology could lead to societal changes that influence transportation, urban development, information management, and other activities of our society that directly or indirectly affect the quality of life. The arena of medicine alone might bring social change by providing wider access to quality health care with automated diagnosis sensors and early detection of trouble.

Although at times the general public concerns may be exaggerated by publications by Crichton's novel "*Prey*" and Drexler's ì*Engines of Creation*î, resulting in a response from the nanotechnology community. It is generally true that neither the nanotechnology community nor those who shape its academic and public understanding are truly engaged in the new challenges and opportunities that society will face. With this in mind, our MRSEC has devoted effort to public awareness through a series of general audience talks (of the nature *Gray Goo vs. Reality* and *Compilers vs. Reality)* in which the impact of nanotechnology on society were discussed. To reach an even greater number of people we plan to add a regional newsletter and work on special programs for our local PBS radio station to present the facts and open dialogue. We plan to expand this effort in collaboration with Davis Baird, Professor of Philosophy at the University of South Carolina and a new member of our MRSEC Board of Visitors. He is P.I. of a NSF NIRT award, ì*From Laboratory to Society: Developing an Informed Approach to Nanoscale Research*î. Professor Baird and his colleagues have developed a spectrum of nano-literacy projects (a few listed below) to provide a more balanced education on nanotechnology. In collaboration with Professor Baird we will implement appropriate versions of these initiatives along with jointly designed new ideas for Arkansas and Oklahoma.

! Workshop on ìReading Nanoscienceî that brings the community together to discuss existing ideas;
! Courses on societal and ethical implications of nanotech, like ìNanotechnology: Promises and Perilsî, ìNano Philosophyî, or ìEnhancing Humansî;
! The Nano Semester which is a repertoire of five or six coordinated, interdisciplinary courses, each concentrating on a different aspect of nanotechnology;
! The South Carolina Citizens' School of Nanotechnology which is a program of presentations and discussions, supported by background readings, for curious non-experts who want to know more;
! USC conference on ìImaging and Imagining Nanoscience and Engineeringî designed to give students and faculty from all disciplines on campus an opportunity to discuss societal issues.

Ethical Interactions: As Einstein noted, "science tells us what is, not what should be". Science uncovers the facts and society puts them to use. Nano won't be either a goodie or baddie. Itó like everything elseó will have multiple and mixed effects. On the one hand, there is the possibility that nanotechnology might bring the solution to an array of challenges that currently face our society. On the other hand, there are the possibilities of terrible outcomesó like bioterrorism or loss of privacy. Indeed, the claims for the potential impact of nanotechnology are immense while the ethical challenges are also profound. We need to start a careful analysis of the multiple ways new nanotechnological spin-offs might engage society and take appropriate steps to ameliorate negative consequences and promote positive consequences.

The ethical issues and challenges of nanotechnology include: who will be the first to benefit from biological developments; will tiny sensors and the proliferation of powerful computers make it easier to compile and process databases of personal information and intrude on personal privacy; and what will happen to the people in jobs that quickly become obsolete? As expected, these are more complex to answer than just a simple yes or no to nanotechnology. While these issues are outside the expertise of our MRSEC we can certainly make a difference by understanding the potential ìimpact on valuesî to enable us to more clearly articulate, the ethical challenges and dilemmas, to both our students and to the public.

For this reason C-SPIN has kept the question of ethics at the forefront. For example, last year we tested a new summer course, MEPH 5821, Ethics for Scientists and Engineers, which was presented to our graduate students at Arkansas by Professor Ken Vickers of Physics and Professor Doug Adams of Sociology. The course is based on a textbook by Caroline Whitbeck entitled "*Ethics in Engineering Practice and Research*". During the course, we tried to prepare the student for ethical behavior by having discussions on issues that often have no perfect (or even preferred) answer. The idea was that when they are faced with a real ethical conflict in their personal or professional lives they may already have the thought patterns in place to help them successfully negotiate the problem. Based on our initial response from students, we plan to continue to offer this class, *via* the internet, to all MRSEC students.

In addition to the course, we tested a new effort with an invited speaker, Professor Vicki Colvin, Director of the Center for Biological and Environmental Nanotechnology at Rice University, who spoke in Oklahoma on ì*Biomedical and Environmental Nanoscience and Ethics*î. This talk generated a lot of discussion among students and faculty. Next year we hope to expand the effort to impact all MRSEC students *via* internet and to the general public by broadcasting on public radio (time committed by local PBS).

Economic Issues: As nanotechnology begins to pervade every sector of our economy, the profile of the world economy may dramatically change. For example, what would happen if the world became less dependent on oil or if some other part of the world became the leader in nanotechnology?

While the potential changes may be so great as to be unpredictable there are some ways that C-SPIN has found to make a difference on the economic impact of our work. Both Arkansas and Oklahoma have limited high-technology industry. As noted earlier, C-SPIN has had a significant impact on local industry through the founding of several startups: Nanomaterials and Nanofabrication Laboratories (NN-Labs), Nanoferr, Minotaur, and EKIPS. Nanoferr Inc. (Salamo, Fu, Xiao, and Bellaiche) focuses on the development of layered ferroelectric structures. Minotaur Inc. (Xiao) focuses on development of sensing technologies. NN-Labs (Peng) is actively commercializing colloidal nanocrystals and EKiPS (McCann) is commercializing IV-VI lasers for medical diagnosis. By spinning-off small businesses C-SPIN is playing a growing role in the states economic development plans. Additionally our director has interacted with Nanobiomagnetics, the OK Nano Initiative and regional entrepreneurial agencies to promote venture capital. C-SPIN is also working with both UA and OU, state, and local representatives to develop industrial parks. These efforts are beyond the discussion stages and both industrial parks are planning to attract and support nanotechnology economic growth. Our plan is for C-SPIN to continue to generate research commercialization possibilities in nanotechnology and with student manpower, to provide Arkansas and Oklahoma with an opportunity to be prepared to compete in the new economy.

PATENTS WITH PARTIAL MRSEC SUPPORT

For items 1-9 under heading Patents Filed (not yet published): *This information is considered: "confidential and proprietary -- University of Arkansas."*

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4.I Summary Table of Requested NSF Support

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Summary Table of Requested NSF Support		
ACTIVITY	**YEAR 1**	**6 YEAR TOTAL**
IRG 1 Collective Properties of Nanostructure Arrays	$ 542,847	$ 3,752,573
IRG 2 Mesoscopic Narrow Gap Systems	$ 439,447	$ 3,037,797
Seed Funding and Emerging Areas	$ 151,000	$ 980,000
Shared Experimental Facilities	$ 117,000	$ 268,000
Education and Human Resources	$ 62,000	$ 413,600
Collaboration with Industry and Other Organizations	$ 51,700	$ 357,388
Administration	$ 146,000	$ 992,800
TOTAL	$ 1,509,994	$ 9,802,158

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2 SUMMARY

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C100. ìT-shaped spin filter with ring resonator,î A.A. Kiselev and K.W. Kim, *J. Appl. Phys*. **94**, 4001 (2003).

C101. ìAntisymmetric spin filtering in one-dimensional electron systems with uniform spin-orbit coupling,î P. Streda and P. Seba, *Phys. Rev. Lett*. **90**, 256601 (2003).

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C103. ìSpontaneous spin-polarized current in a nonuniform Rashba interaction system,î Qing-feng Sun and X.C. Xie, preprint.

C104. ìGate control of spin-orbit interaction in an inverted $In_{0.53}Ga_{0.46}As/In_{0.52}Al_{0.48}As$ heterostructure,î J. Nitta, T. Akazaki, H. Takayanagi, and T. Enoki, *Phys. Rev. Lett*. 7**8**, 1335 (1997).

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C109. ìDo intradot electron-electron interactions induce dephasing?,î Z.T.Jiang, Q.F. Sun, X.C. Xie, Y.P. Wang, *Phys. Rev. Lett*. **93**, 076802 (2004).

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C112. ìQuantum conductance and magnetic focusing in InSb heterostructures,î D.A. Deen, A.R. Dedigama, S.Q. Murphy, N. Goel, J. Keay, M.B. Santos, K. Suzuki, S. Miyashita, and Y. Hirayama, *Bull. Am. Phys. Soc.*, 2005.

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C114. ìAllowed and forbidden transitions in artificial hydrogen and helium atomsî, Toshimasa Fujisawa, David Guy Austing, Yasuhiro Tokura, Yoshiro Hirayama and Seigo Tarucha, *Nature* **419**, 278 (2002).

C115. ìCoherent manipulation of electronic states in a double quantum dotî, T. Hayashi, T. Fujisawa, H. D. Cheong, Y. H. Jeong, and Y. Hirayama, *Phys. Rev. Lett.* **91**, 226804 (2003).

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C122. ìSpin-polarized transitions in InP quantum dots under magnetic fields,î H. Fu, *Bull. Am. Phys. Soc.* **48**, 1085 (2003).

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C124. ìSpin splitting of conduction subbands in III-V heterostructures due to inversion asymmetry,î P. Pfeffer and W. Zawadzki, *Phys. Rev.* **B59**, R5312 (1999).

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C126. ìObservation of spin-mediated subband Landau-level coupling in a two-dimensional electron gas,î X.H. Zhang, R.C. Meyer, T. Kasturiarachchi, N. Goel, R.E. Doezema, S.J. Chung, M.B. Santos, Y.J. Wang, submitted to *Phys. Rev.* **B**.

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C133. ìNonmagnetic semiconductors as read-head sensors for ultra-high-density magnetic recording,î S.A. Solin, D.R. Hines, A.C.H. Rowe, J.S. Tsai, Yu. A. Pashkin, S.J. Chung, N. Goel, and M.B. Santos, *Appl. Phys. Lett.* **80**, 4012 (2002).

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C145. ìGeneration-recombination noise in doped-channel $Al_{0.3}Ga_{0.7}As/GaAs/In_{0.2}Ga_{0.8}As$ quantum well micro-Hall devices,î Vas.P. Kunets, U. M¸ller, J. Dobbert, R. Pomraenke, H. Kissel, H. Kostial, G.G. Tarasov, Yu.I. Mazur, W.T. Masselink, *J. Appl. Phys.* **94** (7590) 2003.

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4.D SEED FUNDING AND EMERGING AREAS

D01. Statistical data for 2003 obtained from: Oklahoma State Department of Education, Data Services, 2500 N. Lincoln Blvd., Room 111, Oklahoma City, Oklahoma, http://www.sde.state.ok.us and Arkansas State Department of Education, #4 Capitol Mall, Room 405-B, Little Rock Arkansas 72201.

D02. <u>Exploring the Nanoworld</u>**,** developed by George C. Lisensky, Karen J. Nordel, S. Michael Condren, Diana Malone, and Arthur B. Ellis Institute for Chemical Education(ICE) Publication 20-001. In conjunction with the University of Wisconsin MRSEC http://mrsec.wisc.edu/edetc/supplies/index.html.

D03. <u>Materials World Modules</u>**,** an NSF-funded inquiry-based science and technology educational program based at Northwestern University. Materials World Modules, Northwestern University, 2220 Campus Drive , Cook Hall, Room 2078, Evanston, IL 60208 http://materialsworldmodules.org/.

D04. ìMembrane surface dynamics of DNA-thread nanopores revealed by simultaneous single-molecule optical and ensemble electrical recording,î L. Chandler, A.L. Smith, L.M. Burden, J.J. Kasianowicz, and D.L. Burden, *Langmuir* **20,** 898 (2004).

D05. ìZero-mode waveguides for single-molecule analysis at high concentrations,î M. J. Levene, J. Korlach, S. W. Turner, M. Foquet, H. G. Craighead, and W. W. Web, *Science* **299,** 682 (2003).

D06. ìDNA molecules and configurations in a solid-state nanopore microscope,î J. Li, M. Gershow, D. Stein, E. Brandin, and J. A. Golovchenho, *Nature Materials* **2,** 611 (2003).

D07. ìFrequency and Voltage Dependence of the Dielectrophoretic Trapping of Short Lengths of DNA and dCTP in a Nanopipette,î L. Ying, S. S. White, A. Bruckbauer, L. Meadows, Y. E. Korchev, D. Klenerman , *Biophys. J.* **86,** 1018 (2004).

D08. ìElectrodeless Dielectrophoresis of Single- and Double-Stranded DNA,î C.-F. Chou, J. O. Tegenfeldt, O. Bakajin, S. S. Chan, E. C. Cox, N. Darnton, T. Duke, R. H. Austin, *Biophys. J.* **83,** 2170 (2002).

D09. ìRadiative Decay Engineering 2. effects of silver island films on fluorescence intensity, lifetimes, and resonance energy transfer,î J. R. Lakowicz, Y. Shen, S. D'Aurita, J. Malicka, J. Fang, Z. Gryczynski, and I. Gryczynski, *Anal. Biochem.* **301,** 261 (2002).

D10. ìSpectral analysis of strongly enhanced visible light transmission through single C-shaped nanoapertures,î *Appl. Phys. Lett.* **85,** 648 (2004).

D11. ìGap-Dependent Optical Coupling of Single Bowtie Nanoantennas Resonant in the Visible,î *NanoLett.* **4,** 957 (2004).

D12. ìNanostructured surfaces for dramatic reduction of flow resistance in droplet-based microfluidics,î J. Kim and C.-J. Kim, *Technical Digest, IEEE Conference on MEMS,* Las Vegas, NV, Jan. (2002).

D13. ìSuperhard silicon nanospheres,î Gerberich, W.W., Mook, W.M.; Perrey, C.R.; Carter, C.B.; Baskes, M.I.; Mukherjee, R.; Gidwani, A.; Heberlein, J.; McMurry, P.H.; Girshick, S.L., *J. Mech. and Phys. Solids*, **51,** 979 (2003).

D14. ìOptimization of asperity for laser-textured magnetic disk surface,î K. Chilamakuri, and B. Bhushan, *Tribology Transactions* **40,** 303 (1997).

D15. ìOptimization of laser texture for the head-disk interface,î J. Liu, *IEEE Transactions on Magnetics* **33,** 3202 (1997).

D16. ìLaser zone texture on alternative substrate disks,î E. Teng, W. Goh, and A. Eltoukhy, *IEEE Transactions on Magnetics* **32,** 3759 (1996).

D17. ìA laser surface textured hydrostatic mechanical seal,î I. Etsion, and G. Halperin, *Tribology Transactions* **45,** 430 (2002).

D18. ìAnalytical and experimental investigation of laser-textured mechanical seal faces,î I. Etsion, Y. Kligerman, and G. Halperin, *Tribology Transactions* **42,** 511 (1999).

D19. ìLaser surface micro-texturing on the mechanical seal rings for enhancing the tribological properties,î D. Allegretti, G. Daurelio, and F. Guerrini, *Proceedings of SPIE - The International Society for Optical Engineering* **4184,** 512 (2001).

D20. ìA laser surface textured parallel thrust bearing,î V. Brizmer, Y. Kligerman, and I. Etsion, *Tribology Transactions* **46,** 397 (2003).

D21. ìExperimental Investigation of Laser Surface Textured Parallel Thrust Bearings,î I. Etsion, G. Halperin, V. Brizmer, and Y. Kligerman, *Tribology Letters* **17,** 295 (2004).

Biographical Sketch

Laurent Bellaiche Associate Professor of Physics

(a) Professional Preparation

University of Paris VI:	Physics	B.Sc., 1988 (with Summa Cum laude honors)
University of Paris VI:	Materials Science	M.S., 1990 (with Summa Cum laude honors)
University of Paris VI:	Materials Science	Ph.D., 1994 (with Summa Cum laude honors)
University of Paris XI:	Semiconductors	1994-1995 (teaching and research award)
N.R.E.L (CO):	Semiconductors	1995-1997 (postdoctoral fellow)
Rutgers University (NJ):	Ferroelectrics	1997-1998 (postdoctoral fellow)

(b) Appointments

Associate Professor, Physics	2003-Present	University of Arkansas
Assistant Professor, Physics	1999-2003	University of Arkansas

(c) Recent Publications

1) ``Ferroelectricity in barium titanate quantum dots and wires,"
H. Fu and L. Bellaiche, *Physical Review Letters* 91, 257601 (2003).
2) ``First-principles determination of electromechanical responses of solids under finite electric fields,"
H. Fu and L. Bellaiche, *Physical Review Letters* 91, 057601 (2003).
3) ``Strained hexagonal ScN: A material with unusual structural and optical properties",
V. Ranjan, L. Bellaiche and E.J. Walter, *Physical Review Letters* 90, 257602 (2003).
4) ``Piezoelectric Coefficients of Complex Semiconductor Alloys from First-Principles: The Case of Ga(1-x)In(x)N," A. Al-Yacoub, L. Bellaiche, and S.-H. Wei, *Physical Review Letters* 89, 057601 (2002).
5) ``Electronic and magnetic properties of MnN versus MnAs,"
A. Janotti, S.-H. Wei and L. Bellaiche, *Applied Physics Letters* 82, 766 (2003).

(d) Synergistic Activities

- Development of an *ab-initio* technique leading to the determination of localized electronic orbitals in solids [PRB 54, 1575 (1996); PRL 80, 5576 (1998)].

- Demonstration that conventional *ab-initio* techniques fail in reproducing experimental inelastic X-ray scattering profile. Development of a computational procedure that overcomes this failure [PRB 55, 5006 (1997)].

- Discovery that nitrogen alloys behave in such an unusual way that common beliefs on semiconductor alloys have to be revised entirely. [PRB 54, 17568 (1996); PRL 80, 4725 (1998)].

- Refinement of a computational technique to solve the Schrodinger equation in complex semiconductor systems [APL, 75, 2578 (1999)].

- Development of a first-principles-based scheme allowing the determination of finite-temperature properties in complex ferroelectric alloys [PRL 84, 5427 (2000)].

(e) Collaborators:

- Dr Alberto Garcia, Universidad Del Pais Vasco, Spain
- Dr Jorge Iniguez, NIST, MD
- Dr Jean-Michel Kiat, Ecole Centrale, Paris, France
- Dr Kevin Leung, Sandia National Laboratories, NM
- Dr Beatrix Noheda, University of Groningen, The Netherlands
- Dr Su-Huai Wei, National Renewable Energy Laboratory, CO

Graduate and Postdoctoral Advisors:

- Dr Karel Kunc, Universite Pierre et Marie Curie, France
- Dr Bernard Levy, Universite Paris-Sud, France
- Prof. David Vanderbilt, Rutgers University, NJ
- Dr Alex Zunger, National Renewable Energy Laboratory, CO

Thesis Advisor and Postgraduate-Scholar Sponsor:

Current graduate student advisees 6, Current postdoctoral scholars sponsored 3.

Biographical Sketch

Lloyd A. Bumm Assistant Professor of Physics

(a) Professional Preparation

Clarkson University	Chemistry	B.S. 1982
Northwestern University	Physical chemistry	Ph.D. 1991
Postdoc, Pacific Northwest National Laboratory	Physical chemistry	1991-1993
Postdoc, Pennsylvania State University	Physical chemistry	1993-1998

(b) Appointments

Assistant Professor of Physics, University of Oklahoma	2001-present
Research Professor, Pennsylvania State University	1998-2001

(c) Publications

1. "Conductance Switching in Single Molecules through Conformational Changes," Z. J. Donhauser, B. A. Mantooth, K. F. Kelly, L. A. Bumm, J. D. Monnell, J. J. Stapleton, D. W. Price Jr., A. M. Rawlett, D. L. Allara, J. M. Tour, P. S. Weiss, *Science* 292(5525), 2303–2307 (22 Jun 2001).

2. "Electron Tunneling through Organic Molecules," L.A. Bumm, J.J. Arnold, T.D. Dunbar, D.L. Allara, P.S. Weiss, *Journal of Physical Chemistry B*, 83 (38), 8122-8127 (1999).

3. "Directed Self-Assembly to Create Molecular Terraces with Molecularly Sharp Boundaries in Organic Mololayers," L.A. Bumm, J.J. Arnold, L.F. Charles, T.D. Dunbar, D.L. Allara, P.S. Weiss, *Journal of the American Chemical Society*, 121 (35) 8017-8021 (1999).

4. "Are Single Molecular Wires Conducting?" L.A. Bumm, J.J. Arnold, M.T. Cygan, T.D. Dunbar, T.P. Burgin, l. Jones II, D.L. Allara, J.M. Tour, P.S. Weiss, *Science* 271 (5256), 1705-1707 (1996).

5. "Phase Separation within a Binary Self-Assembled Monolayer on Au{111} Driven by an Amide-Containing Alkanethiol," R. K. Smith, S. M. Reed, P. A. Lewis, J. D. Monnell, R. S. Clegg, K. F. Kelly, L. A. Bumm, J. E. Hutchison, P. S. Weiss, *Journal of Physical Chemistry B* **105**(6), 1119–1122 (15 Feb 2001).

6. "Probing Electronic Properties of Conjugated and Saturated Molecules in Self-Assembled Monolayers," P. S. Weiss, L. A. Bumm, T. D. Dunbar, T. P. Burgin, J. M. Tour, D. L. Allara In *Molecular Electronics: Science and Technology;* A. Aviram, M. Ratner, Eds.; Annals of the New York Academy of Sciences, vol. 852, (New York Academy of Sciences, New York, 1998), pp 145-168. (ISBN 1–57331–155–3).

7. "Small Cavity Nonresonant Tunable Microwave-Frequency Alternating Current Scanning Tunneling Microscope," L. A. Bumm, P. S. Weiss, *Review of Scientific Instruments* **65**(8), 4140–4145 (Aug 1995).

(d) Synergistic Activities

1. Co-developed a new course, NanoLab – A Hands-on Introduction to Nanoscience for Scientists and Engineers funded through NSF-NUE (Nanotechnology Undergraduate Education).
2. Developed a new curriculum for our Sophomore Lab Electronics Class.
3. Supervised 4 Senior Capstone Projects and 3 summer REU students in the last three years.

(e) Collaborators & Other Affiliations

Professors Wai Tak Yip, Daniel T. Glatzhofer, Ronald L. Halterman, University of Oklahoma.

Graduate and Postdoctoral Advisors.

Postdoctoral Advisor:	Professor Paul S. Weiss, Pennsylvania State University
Postdoctoral Advisor:	Professor James P. Cowin, Pacific Northwest National Laboratory
Graduate Advisor:	Professor Richard P. Van Duyne, Northwestern University

Thesis Advisor and Postgraduate-Scholar Sponsor.

Current graduate students advisees 2

Biographical Sketch

Paul C. Calleja	Director, Education Outreach	
(a) Professional Preparation:		
San Jose State University	Kinesiology; Pedagogy	B.S. 1994
University of Arkansas	Kinesiology, Adapted Movement Science	M.S. 2000
University of Arkansas	Kinesiology, Pedagogy	Ph.D. 2004

(b) Appointments:

Education Outreach Director,	University of Arkansas C-SPIN	9/03 - Present
Project Director,	GK12 KIDS program	6/03 - Present

(c) Publications:

1. Kern, J. C., Hunt, S. B., & Calleja, P. C. (2003, January). "Enhancing the physical education internship experience," Published in the *Arkansas AHPERD Journal*.
2. Kern, J. C. & Calleja, P. C. (2003, January). "Teacher satisfaction within a school partnership," Presented at the annual *NAPEHE conference*, Long Beach, CA.
3. Kern, J. C. & Calleja, P. C. (2002, November). "Student teaching experiences in the state of Arkansas," Presented at the annual Arkansas *AHPERD conference*, Russellville, AR.
4. Kern, J. C. & Calleja, P. C. (2002, October). "Collaborative Mentoring,". Presented at the annual *Southeastern Regional Association of Teacher Educators conference*, Hot Springs, AR.
5. Kern, J. C., Hunt, S. B., & Calleja, P. C. (2002, July/August). "Ten ways for teachers to enhance student teaching experiences*," AAHPERD Update*, p. 7.

(d) Synergistic Activities:

1. BEST (Boosting Engineering, Science, and Technology), 2003-present, Northwest Arkansas, organizer and volunteer for six-week program that involves introduction and competition within a technical/interactive environment.
2. Advisory Committee Member, 2001-present, The University of Arkansas, Fayetteville, AR., Committee formed to improve integration and retention of persons who are of Latino background into the University of Arkansas community.
3. Data Usage Workshop, 2003, The University of Arkansas, One hour workshop for training education professionals on data usage with the Arkansas Department of Education online educational database.
4. Special Olympics Workshops, 2000-01, Northwest Arkansas, Volunteer in assisting participants during Special Olympics sports clinics.

(e) Collaborators and Co-Editors

See Publications list above

Biographical Sketch

Ryan E. Doezema	Regents' Professor and Chair	

(a) Professional Preparation

Calvin College	Physics	B.S. 1964
University of Maryland	Physics	Ph.D. 1971
Research Associate, Univ. of Maryland	Alloy Optical Properties	1971-1973

(b) Appointments

Chair, Department of Physics and Astronomy	1990-present	University of Oklahoma
Regents' Professor	2004-present	University of Oklahoma
Professor	1987-2004	University of Oklahoma
Associate Professor	1979-1987	University of Oklahoma
Visiting Associate Professor	1984-1985	University of Maryland
Wissenschaftlicher Angestellter	1973-1979	Technical University Munich

(c) Publications

1. "Observation of excitonic transitions in InSb Quantum Wells," N.Dai, F. Brown, P. Basic, G.A. Khodaparast, R.E. Doezema, M.B. Johnson, S.J. Chung, K.J. Goldammer, and M.B. Santos*, Appl. Phys. Lett*. **73**, 1101, (1998).
2. "Band Offset Determination in the Strained-Layer InSb/AlInSb System," N. Dai, G.A. Khodaparast, F. Brown, R.E. Doezema, S.J. Chung, and M.B. Santos, *Appl. Phys. Lett.* **76**, 3905 (2000)
3. "Temperature Dependence of Exciton Linewidths in InSb Quantum Wells," N. Dai, F. Brown, R.E. Doezema, S.J. Chung, and M.B. Santos, *Phys. Rev.* B**63**, 115321 (2001).
4. "Spectroscopy of Rashba Spin Splitting in InSb Quantum Wells," G.A. Khodaparast, R.E. Doezema, S.J. Chung, K.J. Goldammer, and M.B. Santos, *Phys. Rev.* B, to be published (2004).
5. "Observation of Spin-Mediated Subband-Landau-Level Coupling in InSb Quantum Wells," X.H. Zhang, R.C. Meyer, T. Kasturiarachchi, N. Goel, R.E. Doezema, M.B. Santos, and Y.J. Wang, submitted to *Phys. Rev. Lett.*
6. "Electrical Properties of InSb Quantum Wells Remotely-Doped with Si," K.J. Goldammer, W.K. Liu, G.A. Khodaparast, S.C. Lindstrom, M.B. Johnson, R.E. Doezema, and M.B. Santos, *J. Vac. Sci. Tech.* B**16**, 1367 (1998).
7. "Determination of the Concentration and Temperature Dependence of the Fundamental Energy Gap in $Al_xIn_{1-x}Sb$," N. Dai, R. Brown, R.E. Doezema, S.J. Chang, K.J. Goldammer, and M.B. Santos, *Appl. Phys. Lett.* **73**, 3132 (1998).
8. "Electronic Characterization of InSb Quantum Wells," S.J. Chung, N. Dai, G.A. Khodaparast, J. Hicks, K.J. Goldammer, F. Brown, W.K. Liu, R.E. Doezema, S.Q. Murphy, and M.B. Santos, *Physica* E**7**, 809 (2000).
9. "Spin Effects in InSb Quantum Wells," G.A. Khodaparast, R.C. Meyer, X.H. Zhang, T. Kasturiarachchi, R.E. Doezema, S.J. Chung, N. Goel, M.B. Santos, and Y.J. Wang, *Physica* E**20,** 386 (2004).
10. "Spin-Flip Subband-Landau-Level Coupling in InSb Heterostructures," X.H. Zhang, R.C. Meyer, T. Kasturiarachchi, N. Goel, R.E. Doezema, S.J. Chung, M.B. Santos, and Y.J. Wang, Proc. 27th Int. Conf. Phys. Semicond., AIP Conf. Proc., to be published (2004).

(d) Synergistic Activities

1. Chair of the University of Oklahoma Department of Physics and Astronomy. As Chair I am particularly proud to have helped establish and develop the Solid State and Applied Physics group, which is at the core of the MRSEC program's C-SPIN.
2. NSF Summer Workshop Lecturer for Middle and High School Teachers (U. of Tulsa), 1991-1996.

(e) Collaborators and Co-Editors

M.B. Johnson (Univ. of Oklahoma), S.Q. Murphy (Univ. of Oklahoma), M.B. Santos (Univ. of Oklahoma), Y.J. Wang (National High Magnetic Field Laboratory, Tallassee, FL)

• Graduate and Postdoctoral Advisors.

Postdoctoral advisor:	H.D. Drew	University of Maryland
Graduate Advisor:	J.F. Koch	Univ. of Maryland (currently T.U. Munich)

• Thesis Advisor and Postgraduate-Scholar Sponsor.

Thesis advisees: G.A. Khodaparast (Virginia Tech), F. Brown (Boeing Corp., Oklahoma City), Taroshani Kasturiarachchi (current grad student)

Post-doc advisees: N. Dai (Chinese Academy of Sciences, Shanghai), Xinhui Zhang (through 8/2004)

Total number of Ph.D.graduate students at the University of Oklahoma: 7

Total number of post-docs supervised: 2

Mr. Ron Foster Research Professor

(a) Professional Preparation

University of Arkansas	Physics	B.A. 1977
University of Arkansas	Physics	M.S. 1980

* Thesis work was on Ultrasonic Properties of Solid Electrolyte Materials

(b) Appointments

Research Professor, University of Arkansas Microelectronics-Photonics July 2001-to date
Current job as Director of Innovation Incubator

Honeywell, Manager of I.C. Design and Design for Fabrication	Jan 2000 – July 2001
Honeywell, Manager of New Product Launch	Sept 1998 – Jan 2000
Honeywell, Various Assignments, including management	Feb 1983 – Sept 1998
Texas Instruments, Diffusion Engineer	May 1980 – Feb 1983

Mr. Foster was employed at Texas Instruments from 1980 to 1983. During this time, he worked in a silicon wafer fab as a Diffusion engineer. In 1983, Mr. Foster moved to Honeywell, starting as a Metal engineer in a silicon and III-V wafer fabrication center. In 1986, Mr. Foster was promoted to Engineering Manager. With some interruptions for other assignments, this position was retained until his departure in 2001. Starting in January 2000, Mr. Foster was Manager over two departments with combined annual budgets of about $2.5M. The first department was Design for Fabrication of silicon-based sensors, and the second department was Integrated Circuit Design and Layout. The product sets were magnetic geartooth sensors, silicon micromachined pressure sensors, micromachined pH ISFET sensors, capacitive humidity sensors, resistive temperature detectors, and micromachined mass air-flow sensors. Integrated circuits were predominantly Analog Bipolar, although some CMOS was also employed.

In July 2001, Mr. Foster left Honeywell to join the University of Arkansas. In the capacity of Director of Innovation Incubator, Mr. Foster has launched efforts to encourage small businesses within the state. This has included a variety of mentoring and project management activities.

Mr. Foster has unique and varied experience as an individual contributor in design and fabrication of silicon-based integrated circuits, MEMS and electrochemical sensors, coupled with strong leadership and management skills in product development areas.

(c) Publications

“Bidirectional surge suppressor zener diode circuit with guard rings”, Walter T. Matzen, Ronald Foster, U.S. Patent 5,130,760, issued July 14, 1992

“Modular Proton Exchange Membrane Unit Fuel Cell Assembly and Fuel Stack”, Ronald Foster, patent 6,500,577 issued 12/31/2002.

“Planar Substrate-Based Fuel Cell Membrane Electrode Assembly and Integrated Circuitry”, Ronald Foster, patent pending filed 2001.

“Silicon Carbide Bipolar Digital Logic Circuitry”, Ronald Foster, patent pending filed 2004.

(d) Synergistic Activities

Graduate advisor, microelectronics-Photonics graduate program
Director, Innovation to Commercialization Incubator

Biographical Sketch

Huaxing Fu	Assistant Professor of Physics	

(a) Professional Preparation

University of Science and Technology of China	Low-Temperature Solid State Physics	B.S., 1988
Fudan University, China	Theoretical Surface Physics	M.S., 1991
Fudan University, China	Condensed Matter Physics	Ph.D., 1994

(b) Appointment

Asst. Prof., Department of Physics	University of Arkansas	9/02-present
Asst. Prof., Department of Physics	Rutgers University	2000-2002
Research Associate	Carnegie Institution of Washington	1999-2000
Postdoctoral Fellow	National Renewable Energy Laboratory Golden, Colorado	1995-1998

(c) Selected Publications

(1) H. Fu and L. Bellaiche, "First-principle determination of electromechanical responses in solids under finite electric fields," *Physical Review Letters* 91 (2003) 057601.
(2) H. Fu and L. Bellaiche, "Ferroelectricity in $BaTiO_3$ quantum dots," *Physical Review Letters* 91 (2003) 257601.
(3) H. Fu and R.E. Cohen, "Polarization rotation mechanism for ultrahigh electromechanical response in single-crystal piezoelectrics," *Nature* (London) 403 (2000) 281.
(4) H. Fu and A. Zunger, "Quantum-size effects on the pressure-induced direct-to-indirect band gap transition in InP quantum dots," *Physical Review Letters* 80 (1998) 5397.
(5) X. Huang, J. Li, and H. Fu, "The first covalent organic-inorganic networks of hybrid Chalcogenides: structures that may lead to a new type of quantum wells," *Journal of American Chemical Society* 122 (2000) 8789.
(6) W. Su, X. Huang, J. Li, and H. Fu, "Crystal of semiconducting quantum dots built on covalently bonded T5 [InCdS]: the largest supertetrahedral cluster in solid state," *Journal of American Chemical Society*, 124 (2002) 12944.
(7) H. Fu and J. Li, "Density-functional study of organic-inorganic hybrid single crystal $ZnSe(C_2H_8N_2)_{1/2}$," *Journal of Chemical Physics* 120 (2004) 6721.
(8) H. Fu, "Electrical-field effect in InP quantum films," *Physical Review B* 64, 075303 (2001).
(9) H. Fu and O. Gulseren, "Piezoelectric $Pb(Zr_{0.5}Ti_{0.5})O_3$: interplay of atomic ordering, ferroelectric soft modes, and pressure," *Physical Review B* 66, 214114 (2002).
(10) H. Fu, "Stark shifts, band-edge transitions, and intrinsic optical dipoles in spherical InP quantum dots under electric fields," *Physical Review B* 65, 045320 (2002).

(d) Synergistic Activities

(1) Developed and taught new curriculum courses when needed, in addition to other regular courses.
(2) Serving regularly as referee for scientific journals such as Physical Review Letters, Physical Review B, Journal of American Chemical Society, Nano Letters et al.
(3) Development of computation methodologies and codes, including first-principles mix-basis codes, implementation of modern theory of polarization, LDA-derived screened atomic pseudopotential, linearly scaled method to solve the Schrodinger equation of very large system, first-principles method for studying finite electric fields.

(e) Collaborators and Co-Editors

See publications list above and:

A. Franceschetti	Oak Ridge National Lab
A.J. Nozik	National Renewable Energy Lab
L.W. Wang	Lawrence Berkeley National Lab

Graduate and Postdoctoral Advisors

Thesis advisor:	Professor Xide Xie, Fudan University, PR China
Postdoctoral advisor:	Dr. A. Zunger, National Renewable Energy Lab, Colorado, USA; Dr. R. E. Cohen, Carnegie Institution of Washington, DC, USA.

Thesis Advisor and Postgraduate-Scholar Sponsor

Thesis advisor and postgraduate-scholar sponsor of: Graduate student Dileep Karanth
Supervisor of undergraduate students: 8; Supervisor of high-school teachers: 1

Biographical Sketch

Julio R. Gea-Banacloche	Professor of Physics	

(a) Professional Preparation

Universidad Autonoma de Madrid	Physics	B.S. 1980
Universidad Autonoma de Madrid	Physics	M.S. 1981
University of New Mexico	Physics-Quantum Theory	Ph.D. 1985
University of New Mexico	Center for Advanced Studies	Postdoc 1985-1986

(b) Appointments

Professor of Physics	2000-Present	University of Arkansas
Associate Professor of Physics	1994-2000	University of Arkansas
Assistant Professor of Physics	1990-1994	University of Arkansas
Staff Researcher	1988-1991	Institute de Optica, Spain
Visiting Assistant Professor	1987-1988	University of Miami, Oxford, Ohio
Visiting Scientific Collaborator	1987-1988	Max Planck Institut fur Quantenoptic, Munich

(c) Publications

1. "Quantum error correction against correlated noise," J.P. Clemens, S. Siddiqui, and J. Gea-Banacloche, *Phys. Rev. A* 69, 062313 (2004).
2. "Comparison of energy requirements for classical and quantum information processing," J. Gea-Banacloche and L.B. Kish, *Fluctuations and Noise Letters,* 3, C3-C7 (2003).
3. Reply II to "Comment on 'Some implications of the quantum nature of laser fields for quantum computations," J. Gea-Banacloche, *Phys. Rev. A* 68, 046303 (2003).
4. "Addendum: Extracting an entangled state of *n-t* qubits from an *n*-qubit entangled state after errors at *t* sites," M.A. Teplitsky and J. Gea-Banacloche, *Phys. Rev.* A 67, 014307 (2003).
5. "Minimum energy requirements for quantum computation," J. Gea-Banacloche, *Phys. Rev. Lett.* 89, 217901 (2002).
6. "Hiding messages in quantum data," J. Gea-Banacloche, *J. Math. Phys.* 43, 4531-4536 (2002).
7. "Splitting the wavefunction of a particle in a box," J. Gea-Banacloche, *Am. J. Phys,* 70, 3070312 (2002).
8. "Some implications of the quantum nature of laser fields for quantum computations," J. Gea-Banacloche, *Phys. Rev.* A 65, 022308 (2002).
9. "Teleportation of rotations and receiver-encoded secret sharing," C.P. Yang and J. Gea-Banacloche, *J. Opt.* B: Quantum Semiclass. 3, 407-411 (2001).

(d) Synergistic Activities

1. Associate editor, *Physical Review A* (Section: Quantum Information)
2. Creator: *Kinetic Theory Applet*: http://comp.uark.edu/~jgeabana/mol_dyn/. Improved, enhanced versions developed jointly with Melinda Freeze, an NSF REU student, summer, 2003, can be found at www.uark.edu/misc/julio/kinth/ This applet has been incorporated in a large number of educational sites and projects, including Jones and Childers' *Contemporary College Physics,* McGraw-Hill; the World Chemistry website, and the Laboratoire Virtuel de Science of the Universite Laurentienne, Ontario, Canada.
3. Co-chair, "Fluctuations and Noise in Photonics and Quantum Optics Conference," in the second SPIE International Symposium on "Fluctuations and Noise," Gran Canaria, Spain, 2004.
4. Freeware program for plotting data on the Macintosh: www.uark.edu/misc/julio/tplot/.

(e) Collaborators

See publications and synergistic activities above and:

Marlan O. Scully	Texas A&M University
Gerd Leuchs	Universitat Erlangen-Nurnberg, Erlangen, Germany
Richard E. Slusher	Lucent Technologies-Bell Labs, Murray Hill, N.J.
Jonathan P. Dowling	California Institute of Technology

∉ Graduate and Postdoctoral Advisors

Dissertation advisor	M.O. Scully	University of New Mexico
Postdoctoral advisor:		University of New Mexico

Biographical Sketch

Caroline Hall	Project Manager of C-SPIN	
(a) Professional Preparation		
University of Oklahoma	Journalism/Mass Communications	B.A. 1978
University of Dayton	Education	M.S. 2001
(b) Appointments		
Project Manager, C-SPIN	University of Oklahoma	2004-Present
Gifted/talented education	Springboro, Ohio (middle school)	2001-2003
Language Arts teacher	Middletown, Ohio (middle school)	1999-2001
Language Arts/Math teacher	Centerville, Ohio (middle/high schools)	1993-1999
Manager of Internal Communications	Miami Valley Hospital , Dayton, Ohio	1983-1984
Chief Investigator, Economic Crime	Sedgwick County District Attorney, Wichita, Kansas	1979-1983
Associate News Producer	KAKE-TV, Wichita, Kansas	1978-1979

(c) Publications

"The Effects of a Collaborative Learning Strategy on Reading Comprehension in Middle School Learners," C. H. Hall, *The University of Dayton Press*, 2001.

(d) Synergistic Activities

Invited to serve as a statewide planning committee member for the Ohio Bar Association's Council for Law-Related Education (LRE) from 2002-2003. The committee planned and implemented a regional conference to train secondary teachers to integrate the disciplines of language arts, social studies, and science within the classroom.

In concert with the Kettering, Ohio, Police Department and the Ohio Bureau of Investigation, created and implemented an interdisciplinary Crime Scene Investigation (CSI) activity in three middle school classrooms (2001-2003).

Designed and collaborated with teaching colleague to introduce a quasi-experimental research project at a Middletown, Ohio, middle school to assess the effects of one collaborative learning strategy on reading comprehension in struggling learners (1999-2000).

In collaboration with four team teachers and two administrators, designed and implemented an historic mock trial based upon the event known as the "Boston Massacre". The module integrated the disciplines of history, forensic science, language arts, speech communications, and law (2001-2003).

Member of Warren County, Ohio, consortium on Gifted/Talented education (2001-2003).

Co-directed Little Theater, an initiative to bring total theater experiences to middle school students (1999-2002).

Invited to serve as member of Curriculum Advisory Council for Centerville, Ohio, a district with 12,000+ students (1993-1995). During this time, language arts and mathematics K-12 curricula were fully redesigned/updated.

(e) Collaborators

Jared Reitz	Director, Ohio Council for Law-Related Educ., Columbus, OH
Lt. Steve Driscoll	Detective, Kettering Police Department, Kettering, Ohio
Yolande Grizinski, Ph.D.	Director, Warren County Gifted Education, Lebanon, Ohio
Tim Tepe	Attorney at Law, Springboro, Ohio
Georgia Lang	Gifted Ed. Coordinator, Columbus Schools., Columbus, Ohio
Terry Riley	Curriculum Coordinator, Centerville Schools, Centerville, OH.

Matthew B. Johnson Associate Professor of Physics

(a) Professional Preparation

University of Waterloo, Ontario	Physics	B.Sc., 1979
California Institute of Technology	Physics	M.S., 1984
California Institute of Technology	Applied Physics	Ph.D. 1989
Post-Doc, IBM, Research Division, NY	Silicon Technology	1988-1991
Post-Doc, IBM, Research Division, Switzerland	Physical Science	1991-1994

(b) Appointments

Associate Professor, Condensed Matter Experiment	2000-present	University of Oklahoma
Assistant Professor, Condensed Matter Experiment	1995-2000	University of Oklahoma

(c) Publications

1. "InGaAs/GaAs three-dimensionally-ordered array of quantum dots," Y.I. Mazur, W.Q. Ma, X. Wang, Z.M. Wang, G.J. Salamo, M. Xiao, T.D. Mishima and M.B. Johnson, *Appl. Phys. Lett.* 83, 987 (2003).
2. "Large-Scale Synthesis of Nearly Monodisperse CdSe/CdS Core/Shell Nanocrystals Using Air-Stable Reagents via Successive Ion Layer Adsorption and Reaction." J.J. Li, Y.A. Wang, W. Guo, J.C. Keay, T.D. Mishima, M.B. Johnson, and X. Peng, *J. Am. Chem. Soc.* 125, 12567 (2003).
3. "Fabrication of Nanoring Arrays by Sputter Redeposition Using Porous Alumina Templates," K.L. Hobbs, P.R. Larson, G.D. Lian, J.C. Keay, and M.B. Johnson, Nanoletters 4, 167 (2004).
4. "Observation of excitonic transitions in InSb QWs," N.Dai, F. Brown, P. Basic, G.A. Khodaparast, R.E. Doezema, M.B. Johnson, S.J. Chung, K.J. Goldammer, and M.B. Santos, *Appl. Phys. Lett*. 73, 1101, (1998).
5. "Near-field scanning optical nanolithography using amorphous silicon photoresists," M.K. Herndon, R.T. Collins, R.E. Hollingsworth, P.R. Larson, and M.B. Johnson, *Appl. Phys. Lett.* 74, 141, (1999).
6. "Study of factors limiting electron mobility in InSb QWs," S.J. Chung, S.C. Lindstrom, N. Dai, K.J. Goldammer, F. Brown, M.B. Johnson, R.E. Doezema, and M.B. Santos, *J. Vac. Sci. Technol.*.B 17, 1151 (1999).
7. "Atomic fluorine beam etching of silicon related materials," P.R. Larson, K.A. Copeland, G. Dharmasena, R.A. Lassel, M. Keil, and M.B. Johnson, *J. Vac. Sci. Technol* B 18, 307 (2000).
8. "Unambiguous observation of subband transitions from longitudinal valley and oblique valleys in IV-VI multiple quantum wells" H.Z. Wu, N. Dai, M.B. Johnson, and P.J. McCann, App. Phys. Lett.78, 2199 (2001).
9. "Mobility anisotropy in InSb/$Al_xIn_{1-x}Sb$ single quantum wells" M. A. Ball, J. C. Keay, S. J. Chung, M. B. Santos, and M. B. Johnson, App. Phys. Lett. 80, 2138 (2002).
10. "Be delta-doped layers in GaAs imaged with atomic resolution using STM," M.B. Johnson, P.M. Koenraad, W.C. van der Vleuten, H.M.W. Salemink and J.H. Wolter, *Phys. Rev. Lett.* 75, 1606 (1995).

(d) Synergistic Activities

1. Run OU's Society for Physics Students Society (SPS), which is involved in an outreach program bringing hands on science experiments to local primary schools.
2. Co-developed a new course, NanoLab – A Hands-on Introduction to Nanoscience for Scientists and Engineers funded through NSF-NUE (Nanotechnology Undergraduate Education).
3. Over the last 4 years hosted more than five high school and middle school teachers through the NSF-RET.
4. Over the last 6 years hosted more than 10 undergraduate students through the NSF-REU.
5. Developed a new curriculum for our Advanced or Junior Lab and Capstone or Senior Thesis Class. The second involves modules on scientific ethics.

(e) Collaborators and Co-Editors

See Publications list above and:

Kenneth J. Dormer	University of Oklahoma Health Sciences
M H Kuok	National University of Singapore
David J. Lockwood	National Research Council (Canada)
Oscar Komla Awitor	Université d'Auvergne
John Kirtley	IBM Research, NY
Michael Lilly	Sandia National Labs

• Graduate and Postdoctoral Advisors.

Postdoctoral advisor:	H.W.M. Salemink	T.U. Eindhoven
Postdoctoral advisor:	J.-M. Halbout	IBM Research
Graduate Advisor:	T.C. McGill	Caltech

• Thesis Advisor and Postgraduate-Scholar Sponsor.

Current graduate students advisees 4, Current postdoctoral scholars sponsored 2.

BIOGRAPHICAL SKETCH

Jiali Li Assistant Professor of Physics

(a) PROFESSIONAL PREPARATION

INSTITUTION	FIELD	DEGREE	YEAR
Hei Long Jiang University	Theoretical Physics	BS	1985
Univ. of Sci. & Tech. of China	Solid-state Physics	MS	1988
The City Univ. of New York	Biophysics	Ph.D.	1999
Harvard University	Nanofabrication & Biotechnology	Postdoctoral	1999-2002

(b) APPOINTMENTS

Assistant Professor, Physics	2002-Present	University of Arkansas
Postdoctoral Fellow, Physics/DEAS	1999-2002	Harvard University

(c) PUBLICATIONS

1. **Jiali Li**, Marc Gershow, Derek Stein, Eric Brandin and J. A. Golovchenko. "DNA Molecules and Configurations in a Solid-state Nanopore Microscope" ***Nature Materials*** Vol.2, 611-615, 2003
2. D. Stein, **J. Li** and J.A. golovchenko. "Ion Beam Sculpting Time Scales" ***Physical Review Letters***, Vol. 89, 276106-1-276106-4, 2002.
3. **Jiali Li**, Derek Stein, Ciaran McMullan, Daniel Branton, Michael J. Aziz, and Jene Golovchenko. Ion Beam Sculpting at nanometer length scales. ***Nature*** 412, 166-169 (2001).
4. Golovchenko, J.A., D. Branton, D. Stein, C. McMullan, and **J. Li**. Control of solid state dimensional features. **PATENT,** U.S. Serial Number **09/599**, 137.
5. Golovchenko, J.A., D. Branton, T. Denison, D. Stein, and **J. Li**. Molecular and atomic scale evaluation of biopolymers. **PATENT,** U.S. Serial Number **09/602**,650.
6. Derek M. Stein, Ciaran J. McMullan, **Jiali Li**, Jene A Golovchenko, *Feedback-controlled Ion Beam Sculpting Apparatus* Reviews of Scientific Instruments, Vol.75, Number 4, April 2004
7. **Li, J**., Coleman, W. J., Youvan, D. C. and Gunner, M. R. Characterization of a symmetrized mutant RC with 42 residues from the Q_A site replacing residues in the Q_B site. ***Photosynthesis Res.*** 64, 41-52 (2001).
8. **Li, J**., Takahashi, E. and Gunner, M.R. -÷G°AB and pH Dependence on the Electron Transfer from P^+QA^- QB to P^+QAQB^- in Rhodobacter sphaeroides RCs. ***Biochemistry***, 39(25), 7445-7454 (2000).
9. **4. Li, J**., Gilroy, D., Tiede, D.M, and Gunner, M. R. Kinetic phases in the electron transfer from $D^+QA^-Q_B$ to $D^+Q_AQ_B^-$ and the associated processes in R-26 RCS. ***Biochemistry,*** 37, (9), 2818-2829 (1998).
10. Stallworth, P.E., **Li, J**., Greenbaum, S.G., Groce, F., Slane, S. and Salomon, M. " Sodium-23 NMR and Impedance Studies of Gel Electrolytes on Poly Acrylonitrile" ***Solid State Ionics*** 73,119-126 (1994).

(d) Synergistic Activities

1. Participated the invention of Ion Beam Sculpting technique at Harvard University, Prof. Golovchenko's lab, this technique was patented and later transferred to the Agilent Technology.
2. Volunteered to train a high school teacher from NSF's RET program in the summer of 2002

(e) Collaborators & Other Affiliations

Prof. **David McNabb**, Biology	University of Arkansas
Prof. **Greg Salamo**, Physics	University of Arkansas
Prof. **Daniel Branton**, Molecular and Cellular Biology	Harvard University
Prof. **Michael J. Aziz**, Engineering & Applied Sciences,	Harvard University
Prof. **Jene Golovchenko**, Applied Physics and Physics	Harvard University

• Graduate and Postdoctoral Advisors

Postdoctoral Advisor	Jene Golovchenko	Harvard University
Graduate Advisor	Marilyn Gunner	the City College of the City University of New York

• Thesis Advisor and Postgraduate-Scholar Sponsor

Current graduate students **4** Current postdoctoral scholars sponsored **1**

BIOGRAPHICAL SKETCH

M. Omar Manasreh	Professor of Electrical Engineering	

(a) Professional Preparation

University of Jordan, Amman, Jordan	Physics	B.Sc., 1976
University of Puerto Rico, Rio Piedras, PR	Solid State Physics	M.S.,1980
University of Arkansas, Fayetteville, AR	Solid State Physics	Ph.D.,1984
University of Arkansas, Fayetteville, AR	Electrical Eng.	1984-1985
NRC Fellow, Wright-Patterson AFB	Electrical Eng.	1986-1989

(b) Appointments

Professor, Electrical Engineering	June 2003 – present	University of Arkansas
Professor of Electrical & Computer Eng.	1999 –2003	University of New Mexico
Electronics Engineer	1989 –1999	Air Force Research Lab

(c) Publications:

1. "Y.C. Chua, E.A. Decuir, Jr., B.S. Pass"Tuning $In_{0.3}Ga_{0.7}As/GaAs$ multiple quantum dots for long wavelength infrared detectors," more, K.H. Sharif, and M.O. Manasreh, Z.M. Wang and G.J. Salamo, *Appl. Phys. Lett*. ***85***, 1003 (2004).
2. "Infrared Optical Absorbance of Intersubband Transitions in GaN/AlGaN Multiple Quantum Well Structures." Q. Zhou, B. Pattada, J. Chen, M.O. Manasreh, F. Xiu, S. Puntigan, L. He, K.S. Ramaiah, and Hadis Morkoç, J. *Appl. Phys*. **94**, 10140 (2003)
3. "Phonon Modes of GaN/AlN Heterojunction Field Effect Transistor Structures Grown on Si(111) Substrates." B. Battada, J. Chen, M.O. Manasreh, S. Guo, and B. Peres, J. *Appl. Phys*. **93**, 5826 (2003).
4. "Photoluminescence of Metalorganic Chemical Vapor Deposition Grown GaInNAs/GaAs Single Quantum Wells." M.O. Manasreh, D.J. Friedman, W.Q. Ma, C.L. Workman, C.E. George, and G.J. Salamo, *Appl. Phys.* Lett. **82**, 514 (2003).
5. "Structural Disorder in Ion-Implanted AlGaN." S. O. Keucheyev, S.J. Williams, J. Zou, G. Li, C. Jagadish, M.O. Manasreh, P. Pophristic, S. Guo, and I.T. Ferguson. *Appl. Phys. Lett*. **80**, 787 (2002).
6. "Ion-Beam-Produced Damage and its Stability in AlN Films." S.O. Kucheyev, J. S. Williams, J. Zhou, C. Jagadish, M. Pophristics, S. Guo, I.T. Ferguson, and M.O. Manasreh J. *Appl. Phys*. **92**,3554 (2002).
7. "Observation of Nitrogen Vacancy in $Al_xGa_{1-x}N$ thin films." Q. Zhou, M.O. Manasreh, M. Pophristic, and I. Ferguson, *Appl. Phys. Lett*. **79**, 2901-2903 (2001).
8. "Thermal Annealing Effect on Nitrogen Vacancy in Proton Irradiated AlGaN." Q. Zhou and M. O. Manasreh, *Appl. Phys. Lett*. **80**, 2072 (2002).
9. "Optical Absorption of Intersubband Transitions in $In_{0.3}Ga_{0.7}As/GaAs$ Multiple Quantum Dots." B. Pattada, J. Chen, Q. Zhou, M.O. Manasreh, M. Hussien, W. Ma, and G.J. Salamo, *Appl. Phys. Lett*. **82**, 2509 (2003)
10. "Intersubband Transitions in Proton Irradiates InGaAs/InAlAs Multiple Quantum Wells Grown on Semi-insulating InP Substrates." Q. Zhou, M.O. Manasreh, B.D. Weaver, and M. Missous, *Appl. Phys. Lett*. **81** (4 Nov 2002).
11. "Thermal Annealing Effect on Intersublevel Transitions in InAs Quantum dots." Y. Berhane, M. O. Manasreh, H. Yang, and G. J. Salamo, *Appl. Phys. Lett.* **78**, 2196 (2001).

(d) Synergistic Activities

1. The PI is a member of IEEE (senior member), APS, and MRS.,
2. Editor of two book series, one on optoelectronic properties of Semiconductors (21 volumes) and the other on **nanoscience and technology** (10 volumes in preparations and still growing).
3. Established a course on Semiconductor Nanostructure and wrote the textbook of the course, which will be published by McGraw-Hill in May 2005.
4. Organize and co-edit 12 symposia for the MRS.

(e) Current Collaborators:

All of our current collaborators are mentioned in the list of publications

Ph.D. Adviser: Professor Dan O. Pederson

Students: current graduate student advisees: 7

BIOGRAPHICAL SKETCH

Bruce Mason Associate Professor of Physics and Astronomy

(a) PROFESSIONAL PREPARATION

Oberlin College	Physics	B.A. 1980
University of Maryland	Physics	Ph.D. 1985
University of Illinois	Physics and Engineering	PostDoc 1985-89

(b) APPOINTMENTS

Electronic Publications Editor, 2004 – present	AAPT
Faculty Fellow, Advisor to the CIO, 2000 – present	University of Oklahoma
Associate Professor, Physics and Astronomy, 1995 – present	University of Oklahoma Assistant Professor,
Physics and Astronomy, 1989 – 1995	University of Oklahoma

(c) PUBLICATIONS

1. "Report and Recommendations on Available Multimedia Material for Teaching Mechanics at School and University Level", H.J. Jodl, B.A. Mason et al., Proceedings of the 9th Workshop on Multimedia in Physics Teaching and Learning, Accessed online 1/24/2005, http://physik.uni-graz.at/MPTL9/proceedings/ProcSporkenMason.pdf
2. "On the Use of Classical Transport Analysis of e-H2 Scattering Experiments", R.D. White, M.A. Morrison, and B.A. Mason, Jour. Phys. B, **35**, 605 (2002).
3. "Optimizing and Engineering EuSe/PbSe0.78Te0.22/EuSe Multiple Quantum Well Laser Structures", M.F. Khodr, P.J. McCann, and B.A. Mason, IEEE Jour Opt Elect, **34**, 1604(1998).
4. "Gain and Current Density Calculations in IV-VI Quantum Well Lasers", M.F. Khodr, P.J. McCann, and B.A. Mason, Jour Appl Phys, **77**, 4927 (1995).
5. "Phase Diagram Study of the Half-Integer Quantum Hall Effect", G. Dev, X.C. Xie, and B.A. Mason, Phys Rev **B51**, 10905 (1995)
6. "Calculations of the Spin Dependence of Transport and Optical Properties of Wide Parabolic Quantum Wells", C.H. Hembree, B.A. Mason, J.T. Kwiatkowski, J.E. Furneaux, and J.A. Slinkman, Phys Rev **B50**, 15197 (1994)

(d) SYNERGISTIC ACTIVITES

- Editor, MERLOT/Physics Collection, 1999 – Present
- Advisory Board Member, MERLOT, 2001 – Present
- "Workshops for Faculty in Technology", 1999 – 2000, Organizer and presenter. Funded in part by the Oklahoma State Regents for Higher Education
- Invited Speaker, Oklahoma Workshop on Technology in Education, 2001
- Invited Speaker, "Simulations in the Sciences", 1st MERLOT International Conference, 2001
- Plenary Speaker, Austin Community College Faculty Development Day, 2002
- Invited Speaker, EUPEN 2003, Uppsala Sweden, 2003
- Invited Speaker, MPTL 8, Prague, Czech Republic, 2003
- Invited Speaker, MPTL 9, Graz, Austria, 2004
- Invited Speaker on Digital Libraries, AAPT, Summer 2002, Summer 2003, Summer 2004
- Workshops on Digital Libraries, AAPT, Summer 2003, Winter 2004, Summer 2004
- Workshop, Peer Review of Learning Effectiveness for Digital Teaching Resources, MERLOT International Conference, 2003

(e) COLLABORATORS (other than those cited in the publication list):

Gerard Hanley	Surajit Sen	Patrick Tam
Charles Bennett	Flora McMartin	Tom Colbert
Ron Greene	Trevor Melder	Joel Rauber
Peter Sheldon	Louis Keiner	Terry Bradfield

Graduate Students Advised: J.T. Kwiatkowski (1999)

Graduate Advisor: Prof. Sankar Das Sarma, Phys. Dept., University of Maryland.

Postdoctoral Advisor: Prof. Karl Hess, Beckman Institute, University of Illinois.

Biographical Sketch

Patrick J. McCann Professor of Electrical and Computer Engineering

(a) Professional Preparation

University of California at Berkeley	Engineering Physics	B.S. 1981
Process Development Engineer, IBM, Burlington, VT	DRAM/SRAM Technology	1981-1984
Device Design Engineer, IBM, Burlington, VT	DRAM/SRAM Technology	1981-1984
Massachusetts Institute of Technology	Electronic Materials	Ph.D. 1990

(b) Appointments

Professor, Solid State Electronics	2001-Present	University of Oklahoma
Associate Professor, Solid State Electronics	1996-2001	University of Oklahoma
Assistant Professor, Solid State Electronics	1990-1996	University of Oklahoma

(c)Selected Publications

[1] P. J. McCann, "IV-VI Semiconductor Materials, Devices, and Applications", State-of-the-Art Program on Compound Semiconductors and Narrow Bandgap Optoelectronic Materials and Devices, p. 218, edited by D. Buckley et al., The Electrochemical Society (ISBN 1-56677-407-1), New Jersey (2004).

[2] U. P. Schiessl, J. John, and P. J. McCann, "Lead-Chalcogenide-based Mid-Infrared Diode Lasers", Long-Wavelength Infrared Semiconductor Lasers, p. 145, edited by H. K. Choi, Wiley (ISBN 0-471-39200-6), New Jersey (2004).

[3] J. D. Jeffers, C. B. Roller, K. Namjou, M. A. Evans, L. McSpadden, J. Grego, and P. J. McCann, "Real-time diode laser measurements of vapor phase benzene", *Analytical Chemistry* **76**, 424 (2004).

[4] P. H. O. Rappl and P. J. McCann, "Development of a Novel Epitaxial Layer Segmentation Method for Optoelectronic Device Fabrication", *IEEE Photonics Technology Letters* **15**, 374 (2003).

[5] C. B. Roller, K. Namjou, J. Jeffers, M. Camp, P. J. McCann, and J. Grego, "Nitric Oxide Breath Testing Using Tunable Diode Laser Absorption Spectroscopy: Application in Respiratory Inflammation Monitoring", *Applied Optics* **41**, 6018 (2002).

[6] H. Z. Wu, N. Dai, and P. J. McCann, "Experimental determination of deformation potentials and band nonparabolicity parameters for PbSe", *Physical Review B* **66**, 045303 (2002). [Also selected to appear in *Virtual Journal of Nanoscale Science & Technology* **6** (4), www.vjnano.org, July 22, 2002]

[7] W. Z. Shen, H. Z. Wu, and P. J. McCann, "Excitonic line broadening in PbSrSe thin films grown by molecular beam epitaxy", *J. Applied Physics* **91**, 3621 (2002).

[8] C. B. Roller, K. Namjou, J. Jeffers, W. Potter, P. J. McCann, and J. Grego, "Simultaneous NO and CO_2 Measurements in Human Breath Using a Single IV-VI Mid-Infrared Laser", *Optics Letters* **27**, 107 (2002).

[9] S. Krishna, P. Bhattacharya, J. Singh, T. Norris and J. Urayama, P.J. McCann and K. Namjou, "Intersubband Gain and Stimulated Emission in Long Wavelength (ς=13 σm) Intersubband Quantum Dot Emitters", *IEEE. J. Quantum Electronics* **37**, 1066 (2001).

[10] H. Z. Wu, N. Dai, M. B. Johnson, P. J. McCann, and Z. S. Shi, "Unambiguous Observation of Subband Transitions from Longitudinal Valley and Oblique Valleys in IV–VI multiple Quantum Wells", *Applied Physics Letters* **78**, 2199 (2001).

(d) Synergistic Activities

[1] Founder of OU spin-out company Ekips Technologies, Inc. (www.breathmeter.com)

[2] Mentor to Oklahoma School for Science and Mathematics (OSSM) high school students.

[3] Faculty mentor for undergraduate and graduate student volunteers for elementary school science and engineering outreach program "Cool Science Investigations (CSI)"

(e) Collaborators and Co-Editors

Peter Möck, Portland State University;
Pallab K. Bhattacharya, University of Michigan;
Ivan Zasavitskii and Yurii Selivanov, Lebedev Physical Institute, Moscow, Russia.
Also see publications list above

• Graduate Advisor

Ph.D. Thesis Advisor: Clifton G. Fonstad, Electrical Engineering and Computer Science Department, MIT

• Thesis Advisor and Postgraduate-Scholar Sponsor.

Current graduate student advisees	7
Current postdoctoral scholars sponsored	2

Biographical Sketch

Kieran Mullen	Associate Professor of Physics	
(a) Professional Preparation		
Georgetown University	Physics	B.S. 1982
University of Michigan	Physics	Ph.D. 1989
Post-Doc, University of Illinois at Urbana-Champaign	Solid State Physics	1989-1991
Post-Doc, Indiana University	Cond. Matter Theory	1991-1994
(b) Appointments		
Associate Professor, Condensed Matter Theory	2001-Present	University of Oklahoma
Assistant Professor, Condensed Matter Theory	1994-2001	University of Oklahoma

(c) Publications

1. "Theory of tunneling resonances of bilayer electron systems in a strong magnetic field," M. Abolfath, R. Khomeriki, and K. Mullen, *Phys. Rev. B* 69, 165321 (2004).
2. "Atomic-scale observation of temperature and pressure driven preroughening and roughening," Z. Ding, D.W. Bullock, P.M. Thibado, V. LaBella, and K. Mullen, *Phys. Rev. Lett.* 90, 216109 (2003).
3. "Solitons in polarized double layer quantum Hall systems," R. Khomeriki, M. Abolfath, and K. Mullen, *Phys. Rev.* B 65, 121310 (2002).
4. "Massive skyrmions in quantum Hall ferromagnets," M. Abolfath, K. Mullen, and H.T.C. Stoof, *Phys. Rev.* B, 63, 75315 (2001).
5. "Quantum Driving Forces," K. Mullen and T. Nance, *Bull. Of the American Physical Society* 44, 1871 (1999).

(d) Synergistic Activities

- ∉ Co-director of OU Physics REU site since 1999, including personal supervision of 13 undergraduates in theoretical research.
- ∉ Adjunct faculty member in Religious Studies program at OU, providing scientific perspective to discussions of faith and society.
- ∉ Serve as MRSEC Faculty Outreach Coordinator for CSPIN's RET program, working closely with high school and middle school teachers.
- ∉ Provide public lectures and high school talks on "Nanoscience and You", to illustrate the importance of math skills in the pursuit of future careers.
- ∉ Teach introductory courses on Modern Physics, which incorporate and test lesson plans, software, and demonstrations of nanotechnology.

(e) Collaborators and Co-Editors

See Publications list above and:

Xincheng Xie	Oklahoma State University
M. Wallin	Royal Institute for Technology, Stockholm, Sweden
H.T.C. Stoof	Utrecht University, The Netherlands

∉ Graduate and Postdoctoral Advisors

Postdoctoral Advisor:	S.M. Girvin	Indiana University
Postdoctoral Advisor	A.J. Leggett	University of Illinois at Urbana-Champaign
Graduate Advisor	Eshel Ben-Jacob	Tel Aviv University

∉ Thesis Advisor and Postgraduate-Scholar Sponsor

Current graduate students advisees	3
Current postdoctoral scholars sponsored	1

Biographical Sketch

Sheena Q. Murphy	Associate Professor of Physics	

(a) Professional Preparation

MIT	Physics	B.S., 1984
Cornell University	Physics	M.S., 1987
Cornell University	Physics	Ph.D., 1991
Post-Doc., IBM Research, Yorktown Heights, N.Y.	Physics	1991-1992
Post-Doc.,AT&T Bell Laboratories, Murray Hill, N.J.	Physics	1992-1994

(b) Appointments

Associate Professor, Condensed Matter Experiment	2001-Present	University of Oklahoma
Assistant Professor, Condensed Matter Experiment	1995-2001	University of Oklahoma

(c) Publications

1. "Quantum point contact fabricated by optical near field lithography", C. Veauvy, M.A. Treaster, R.T. Collins, R.E. Hollingsworth, J.L. Hicks, and S.Q. Murphy, Submitted *Appl. Phys. Letters.*
2. "Lithographic patterning using Near Field Scanning Optical Microscopy (NSOM)," C. Veauvy, R.E. Hollingsworth, J.D. Beach, A.A. Khandekar, T.F. Kuech, J. Hicks, S.Q. Murphy, and R.T. Collins, *Mat. Res. Soc. Symp. Proc.* Vol EXS-2, M6.10.1 (2004).
3. "Ising quantum Hall ferromagnetism in InSb-based two-dimensional electronic systems," J.C. Chokomakoua, N. Goel, S.J. Chung, M.B. Santos, J.L. Hicks, J.B. Johnson, and S.Q. Murphy, *Phys. Rev.* B 69, 235315 (2004).
4. "Studies of the quantum Hall to quantum Hall insulator transition in InSb-based 2DEXs", S.Q. Murphy, J. Hicks, W.K. Liu, S.J. Chung, K.J. Goldammer, and M.B. Santos, *Physica* E6, 293-296 (2000).
5. "Electronic Characterization of InSb Quantum Wells," S.J. Chung, N.Dai, G.A. Khodaparast, J. Hicks, K.J. Goldammer, F. Brown, W.K. Liu, R.E. Doezema, S.Q. Murphy, and M.B. Santos, *Physica* E7, 809 (2000).

(d) Synergistic Activities

1. Co-director, Physics and Astronomy REU Program. 1996-2002
2. Committee member, National High Magnetic Field Laboratory Research Program Committee, 2004-present
3. Chair, Physics and Astronomy Undergraduate Studies Committee, 2000-present
4. Member, Dean's Advisory Council on Women's Issues, 2000-2001

(e) Collaborators and Co-Editors

See publications list above and:

M. Lilly	Sandia National Labs
B.A. Gurney, S. Maat, E.E. Marinero	Hitachi Global Storage Tech. (San Jose, CA)
Y. Hirayama, K, Suzuki	NTT Basic Research Laboratories (Japan)

∉ Graduate and Postdoctoral Advisors

Postdoctoral advisor:	James P. Eisenstein	Caltech
Postdoctoral advisor:	Alan Fowler	IBM (retired)
Graduate advisor:	John Reppy	Cornell University

∉ Thesis Advisor and Postgraduate-Scholar Sponsor

J.L. Hicks	University of Iowa
Current graduate student advisees	2

Biographical Sketch

HAMEED A. NASEEM Professor of Electrical Engineering

(a) Professional Preparation:

Guru Nanak Dev University, Amritsar, India	Physics	B.Sc. 1974
Panjab University, Chandigarh, India,	Physics	B.Sc. Hons.1975
Panjab University, Chandigarh, India,	Physics	M.Sc. 1976
Virginia Polytechnic Institute	Physics	M.S. 1980
Virginia Polytechnic Institute	Materials Science Eng.	Ph.D., 1984
Postdoctoral: Southern Methodist University	Electrical Eng.	1984-1985

(b) Appointments:

Professor	Dept. of EE, University of Arkansas	1995 - Present.
Adjunct Professor	Dept. of Physics, University of Arkansas	2000 - Present.
Associate Professor	Dept. of EE, University of Arkansas	1990-1995.
Assistant Professor	Dept. of EE, University of Arkansas	1985-1990

(c) Related Publications/Patents:

1. "A Novel Technique for Manufacturing Silicon Solar Cells using Low Temperature Metal-Induced Crystallization and Doping of Amorphous Silicon," M. S. Haque, H. A. Naseem, and W. D. Brown, Awarded Jan. 15, 2002, **U. S. Patent No. 6,339,013**.
2. "TEM of Aluminium-Induced Crystallization of Amorphous Silicon," Ram Kishore, A. A. Naseem, and W. D. Brown, *Microscopy*, Sept. 2001, p.11.
3. "Aluminum-Induced Crystallization of Amorphous Silicon (ζ-Si:H) at 150∀C," Ram Kishore, Chris Hotz, H. A. Naseem, W. D. Brown, Electrochemical and Solid-State Letters, Vol. 4, No. 2, p. G14, 2000.
4. "In-Situ Analysis of Aluminum Enhanced Crystallization of Hydrogenated Amorphous Silicon (a-Si:H) Using X-ray Diffraction, F. A. Khalifa, H. A. Naseem, J. L. Shultz, and W. D. Brown, Thin Solid Films, Vol. 355/356, p. 343, 1999.
5. "Effect of Early Methane Introduction on the Properties of Nano-Seeded MPCVD-Diamond Films," A. A. Shaikh, H. A. Naseem, and W. D. Brown, Thin Solid Films, Vol. 355-356, p. 139, 1999.

(d) Synergistic Activities:

I was awarded NASA funding for research on amorphous silicon thin films in 1987, which led to continuous funding from NASA, ultimately culminating in the creation of a Photovoltaics Research Center at the University of Arkansas. At this center a low cost method of fabricating solar cells using metal induced crystallization of amorphous silicon at as low as 150∀C was invented. British Technology Group, a company pushing viable technologies to the market, has adopted our technology and is aggressively marketing our patented technology. A Japanese company has also shown keen interest in our technology.
I have received multiple awards for excellence in the field of teaching: Arkansas Academy of Electrical Engineering Outstanding Faculty Award, 1988, 1993, 1996, 2000; Phillips Petroleum Company Outstanding Faculty Award, 1994; Texas Instruments Outstanding Researcher Award, 1996, 1998; Outstanding Researcher Award, 1989; Haliburton Outstanding Teacher Award, 1992; and Arkansas Teaching Academy, College of Engineering Teaching Award, 1994. I have stablished one-day symposiums for Coordinated efforts among students in Semiconductor Electronics classes to present an educational outreach exhibit titled "So, What is inside Intel?" This outreach provided high school students throughout the region with hands-on experiences, and elicited remarkable public response

(e) Collaborations and Other Affiliations:

Collaborators: S. Lal, S. Liu,and S. Gangopadhyay (Texas Tech, Lubbock, TX), A. M. Al-Dhafiri (King Saud University, Riyadh), Ram Kishore and K. N. Sood (National Physical Laboratories, New Delhi, India), D. Nelms (Integral Wave Technologies, Fayetteville, AR), R. A. Railkar (Conexant), T. G. Lenihan, P. A. Molian, and Mike Shirk (Iowa State University), K. Y. Chen (Texas Instruments), Sergio Afonso (Texas Instruments), Carlton Ollison (Atmel, Dallas)

Graduate and Post Doctoral Advisors

Dr. Larry Burton	Penn State University
Dr. Ting Chu (retired)	Southern Methodist University

Biographical Sketch

Xiaogang Peng Associate Professor of Chemistry

Professional Preparation:

Jilin University, China	Polymer Chemistry	B.S., 1987
Jilin University, China	Physical & Polymer Chemistry	Ph.D., 1992
University of California-Berkeley	Chemistry	Post-doctoral fellow

(b) Appointments

Associate Professor, Chemistry	2004-present	University of Arkansas
Assistant Professor, Chemistry	1999-2003	University of Arkansas
Staff Scientist	1996-1999	U.C. Berkeley/Lawrence Berkeley National Labs

(c) Related Publications:

1 "Luminescent CdSe/CdS Core/Shell Nanocrystals in Dendron Boxes: Superior Chemical, Photochemical and Thermal Stability", Guo, W.; Li, J.; Wang, Y. A.; Peng, X. J. Am. Chem. Soc., 2003, vol 125, p 3901. (*Hightlighted in "Heart Cut", an E-journal of ACS; also in Materials Today*)

2 "Large-Scale Synthesis of Nearly Monodisperse CdSe/CdS Core/Shell Nanocrystals Using Air-Stable Reagents via Successive Ion Layer Adsorption and Reaction", J. Li, Y. A. Wang, W. Guo, J. Keay, T. D. Mishima, M. B. Johnson, X. Peng, J. Am. Chem. Soc., 2003, vol 125, p 12567.

3 "Colloidal Two-Dimensional Systems, CdSe Quantum Shells and Wells", D. Battaglia, J. J. Li, Y. Wang, X. Peng, Angew. Chem. Int. Ed., 2003, vol 43, p 5035.

4 "Formation of High Quality CdS and Other II-VI Semiconductor Nanocrystals in Non-Coordinating Solvent, Tunable Reactivity of Monomers", Yu W., Peng X., Angew. Chem. Int. Ed., 2002, vol 41, p 2368. (*Announced as a "hot paper" by the journal*)

5 "Control of Photoluminescence Properties of CdSe Nanocrystals in Growth", Qu L., Peng, X., J. Am. Chem. Soc., 2002, vol 124, p 2049.

6 "Stabilize Inorganic Nanocrystals by Organic Dendrons", Wang, Y. A., Li, J. J., Chen, H., Peng, X., J. Am. Chem. Soc., **2002**, vol 124, p 2293.

7 "Nearly Monodisperse and Shape-Controlled CdSe Nanocrystals via Alternative Routes: Nucleation and Growth" Peng, Z.; Peng, X., J. Am. Chem. Soc., 2002, vol 124, p 3343.

8 "Synthesis of High Quality Cadmium Chalcogenides Semiconductor Nanocrystals Using CdO as precursor", Peng Z. A., Peng X., J. Am. Chem. Soc., 2001, vol 123, p 168. (*highlighted in C&En News*)

9 "Mechanisms of the Shape Evolution of CdSe Nanocrystals", Peng Z. A., Peng X., J. Am. Chem. Soc., 2001, 123, 1389.

10 "Photochemical Instability of CdSe Nanocrystals Coated by Hydrophilic Thiols", Aldana J., Wang, Y. A., Peng, X., J. Am. Chem. Soc., 2001, 123, p 8844.

(d) Synergistic Activities:

- Editorial Advisory Board, Chemistry of Materials, starting in January 2004
- Scientific Advisor Board & Technical Consultant: NN-Labs, AR; Kovia, CA; Quantum Dot, CA
- Panelist, NSF NSEC center, NIRT, NIH Nano-initiative
- Symposium organizer, MRS Spring meeting, 2005, San Francisco
- The first course of materials chemistry in the history of the University of Arkansas, "*Advanced Materials Chemistry, with an Emphasis on Nanomaterials and Nanofabrication*"

(e) Collaborators and Other Affiliations:

Collaborators (other than those appeared in the publication and proposal):

UCSB: David Awshelam

Graduate and Postdoctoral Advisors:

Postdoctoral advisor:	Alivisatos A. P.,	Department of Chemistry, UC Berkeley
Graduate advisor:	Li, T. & Shen, J.	Department of Chemistry, Jilin University

Thesis Advisor and Postdoctoral Sponsor:

Dr. Z. Adam Peng, *Evident Technologies*; Dr L. Qu, *Bioplex;* Dr. W. Guo, *Kovia*; Dr. W. Yu, *Rice University*; Dr. Linsong Li, *NN-Labs;* Dr. Jack Li, *UCLA*

Biographical Sketch

Gregory J. Salamo University Professor of Physics at the University of Arkansas

(a) Professional Preparation

Brooklyn College	B.S.	1966	Physics
Purdue University	M.S.	1968	Solid State
CUNY/Bell Labs	Ph.D.	1973	Optics
Rochester	Post-Doc	1973-5	Optics

(b) Appointments

University Professor of Physics	1995-present	University of Arkansas
Professor	1987-1995	University of Arkansas
Associate Professor, Physics	1981-1986	University of Arkansas
Assistant Professor, Condensed Matter Experiment	1975-1981	University of Arkansas

(c) Publications

1. "Experimental Observation of Discrete Modulational Instability," J. Meier, G. I. Stegeman, D. N. Christodoulides, Y. Silberberg, R. Morandotti, H. Yang, G. Salamo, M. Sorel, and J. S. Aitchison, *Phys. Rev. Lett*. 92, 163902 (2004)
2. "Fabrication of (In,Ga)As quantum-dot chains on GaAs(100)," Z.M.Wang, K. Holmes, Yu. I. Mazur, and G.J.Salamo, *Appl. Phys. Lett*. 84, 1931 (2004).
3. "Atom-resolved scanning tunneling microscopy of (In,Ga)As quantum wires on GaAs(311)A," H.Wen, Z.M.Wang, and G.J.Salamo, *Appl. Phys. Lett*. 84, 1756, (2004).
4. "Persistence of (In,Ga)As quantum-dot chains under index deviation from GaAs(100)," Z. M. Wang, Yu. I. Mazur, G. J. Salamo, P. M. Lytvin, V. V. Strelchuk, and M. Ya. Valakh , *Appl. Phys. Lett.* **84**, 4681 (2004)
5. B. Pattada, J Chen, Q Zhou, M.O. Manasreh, M.L. Hussein, W. Ma, and G.J. Salamo, "Optical absorption of intersubband transitions in InGaAs/GaAs multiple quantum dots", *Appl. Phys. Lett*. 82, 2509 (2003).
6. V. R. Yazdanpanah, Z. M. Wang, and G. J. Salamo, "Highly anisotropic morphologies of GaAs (331) surfaces" *Appl. Phys. Lett*. 82, 514 (2003).
7. Yu. I. Mazur, W.Q.Ma, Z. M. Wang, G. J. Salamo, and M. Xiao, "InGaAs/GaAs three-dimensionally-ordered array of quantum dots" *Appl. Phys. Lett*. 83, 987 (2003).
8. Yu. I. Mazur, W.Q.Ma, Z. M. Wang, G. J. Salamo, and M. Xiao, "Hidden resonant excitation of photoluminescence in bilayer arrays of InAs/GaAs quantum dots" *Appl. Phys. Lett*. 83, 1866 (2003).
9. Z. M. Wang, V. R. Yazdanpanah, J. L. Shultz, and G. J. Salamo, "Strain-driven facet formation on self-assembled InAs Islands on GaAs (311)A" *Appl. Phys. Lett.* 82, 1688 (2003).
10. Z. M. Wang, J. L. Shultz, and G. J. Salamo, "Morphology evolution during strained (In,Ga) epitaxial growth on GaAs vicinal (100) surfaces", *Appl. Phys. Lett*. 83, 1749 (2003).

(d) Synergistic Activities

. Gregory J. Salamo received the Ph.D. in physics from City University of New York in 1973, where he also worked as an intern student at Bell Laboratories in Murray Hill, New Jersey. His postdoctoral work was at the Institute of Optics of University of Rochester in New York. He joined the faculty of the University of Arkansas in January of 1975, where he is now University Professor of Physics. He has carried out research in the areas of optical communications, optical image processing, and the optical properties of semiconductors. His research is currently focused on growing III-V semiconductors and ferroelectrics using molecular beam epitaxy (MBE) and scanning tunneling microscopy (STM). He has published over one hundred papers in referred journals, given numerous contributed and invited talks, and contributed several book chapters. He also pursues the development of interdisciplinary research and education through the establishment of HiDEC and a new degree program to provide greater career opportunities for students and faculty. He is also involved in the development of an educational course and laboratory in nanotechnology. He is a Fellow of the Optical Society of America.

(e) Collaborators and Co-Editors

Yariv, M. Segev, G. C. Valley, B. Crosignani, P. Di Porto, and R. R. Neurgaonkar.

Á **Graduate and Postdoctoral Advisors**

Graduate advisor: Prof. Hyatt Gibbs, Optical Science Center, University of Arizona

Post-doctoral supervisor: Prof. L. Mandel, Physics Department, University of Rochester

Biographical Sketch

Michael B. Santos Professor of Physics

(a) Professional Preparation

Cornell University	Electrical Engineering, Materials Science	B.S., 1986
Princeton University	Electrical Engineering	M.A., 1989
Princeton University	Electrical Engineering	Ph.D., 1992
AT&T Bell Labs, Holmdel NJ	Advanced Photonics Research Department	Post-Doc, 1992-1993

(b) Appointments

Professor, Condensed Matter Experiment	2004-present	University of Oklahoma
Invited Professor (while on sabbatical leave)	2000-2001	NTT Basic Research Labs (Japan)
Associate Professor, Condensed Matter Experiment	1999-2004	University of Oklahoma
Assistant Professor, Condensed Matter Experiment	1993-1999	University of Oklahoma

(c) Publications (130 total from 1988 to present)

1. "Spectroscopy of Rashba Spin Splitting in InSb Quantum Wells," G.A. Khodaparast, R.E. Doezema, S.J. Chung, K.J. Goldammer, and M.B. Santos, *Physical Review* **B70**, 155322 (2004).
2. "Effect of Buffer Layer on InSb Quantum Wells Grown on GaAs (001) Substrates," T.D. Mishima and M.B. Santos, *Journal of Vacuum Science and Technology* **B22**, 1472 (2004).
3. "Ballistic Transport in InSb/AlInSb Antidot Lattices," Hong Chen, J.J. Heremans, J.A. Peters, N. Goel, S.J. Chung, and M.B. Santos, *Applied Physics Letters* **84**, 5380 (2004).
4. "Effect of Temperature on Ballistic Transport in InSb Quantum Wells," N. Goel, K. Suzuki, S. Miyashita, S.J. Chung, M.B. Santos, and Y. Hirayama, *Physica* **E21**, 761 (2004).
5. "Spin Effects in InSb Quantum Wells," G.A. Khodaparast, R.C. Meyer, X.H. Zhang, T. Kasturiarachchi, R. E. Doezema, S.J. Chung, N. Goel, and M. B. Santos, and Y.J. Wang, *Physica* **E20**, 386 (2004).
6. "Anisotropic Structural and Electronic Properties of InSb/$Al_xIn_{1-x}Sb$ Quantum Wells Grown on GaAs (001) Substrates," T.D. Mishima, J.C. Keay, N. Goel, M.A. Ball, S.J. Chung, M.B. Johnson, and M.B. Santos, *Journal of Crystal Growth* **251**, 551 (2003).
7. "Room Temperature Extraordinary Magnetoresistance of Non-Magnetic Narrow-Gap Semiconductor/Metal Composites: Application to Read-Head Sensors for Ultra High Density Magnetic Recording," S.A. Solin, D.R. Hines, J.S. Tsai, Yu. A. Pashkin, S.J. Chung, N. Goel and M.B. Santos, *IEEE Trans. Magnetics* **38**, 89 (2002).
8. "Mobility anisotropy in InSb/AlInSb single quantum wells," M.A. Ball, J.C. Keay, S.J. Chung, M.B. Santos, and M.B. Johnson, *Applied Physics Letters* **80**, 2138 (2002).
9. "Electronic Characterization of InSb Quantum Wells," S. J. Chung, N. Dai, G.A. Khodaparast, J. Hicks, K.J. Goldammer, F. Brown, W. K. Liu, R. E. Doezema, S. Q. Murphy, and M. B. Santos, *Physica* **E7**, 809 (2000).
10. "High-mobility electron systems in remotely-doped InSb quantum wells," K.J. Goldammer, S.J. Chung, W.K. Liu, M.B. Santos, J.L. Hicks, S. Raymond, and S.Q. Murphy, *Journal of Crystal Growth* **201/202**, 753 (1999).

(d) Synergistic Activities

1. Supervised 10 senior capstone projects and 5 NSF-REU students (1996 to present)
2. Chair, Program in Engineering Physics, University of Oklahoma (1994 to present)
3. Consortium Team, Pre-Engineering Program, Moore Norman Technology Center (2004 to present)
4. Program Committee, International Conference on Narrow Gap Semiconductors (2002-2003, 2004 to present)
5. Co-editor (with W.K. Liu), *Heteroepitaxy: Thin Film Systems* (World Scientific Publishing Co., 1999)

(e) Collaborators

See publications list above and:

P. Debray	CEA Saclay (France), University of Cincinnati
B.A. Gurney, S. Maat, E.E. Marinero	Hitachi Global Storage Technologies (San Jose CA)
J.J. Heremans	Ohio University
Y. Hirayama, K. Suzuki	NTT Basic Research Laboratories (Japan)
J. Kono	Rice University
S.A. Solin	Washington University, St. Louis

• Graduate and Postdoctoral Advisors.

Postdoctoral advisor:	J.E. Cunningham	Lucent Technologies, Bell Labs
Graduate Advisor:	Mansour Shayegan	Princeton University

• Thesis Advisor and Postgraduate-Scholar Sponsor.

W.K. Liu (IQE plc), K.J. Goldammer (TestChip Technologies), S.J. Chung (Agilent Laboratories), G.A. Khodaparast [co-advised] (Virginia Tech), N. Goel (University of Notre Dame)

Current graduate students advisees 3, Current postdoctoral scholars sponsored 1.

Biographical Sketch

Zhisheng Shi	Associate Professor of Electrical Engineering	

(a) Professional Preparation

University of Jilin, China	Physics	B.Sc., 1984
University of Jilin, China	Electrical Engineering	M.S., 1987
Fraunhofer Institute **IpM** & University of Freiburg, Germany	Applied Physics	Ph.D. 1995
Post-Doc, Swiss Federal Institute of Technology (***ETH***),	Applied Physics	1995-1997

(b) Appointments

Associate Professor, Electrical Engineering	2002-present	University of Oklahoma
Assistant Professor, Electrical Engineering	1997-2002	University of Oklahoma
Research Staff, Chinese Academy of Since	1987-1992	Physics Institute,

(c) Publications

1. H. Z. Xu and Z. Shi, Comment on “Effects of the localized state inside the barrier on resonant tunneling in double-barrier quantum wells”, Physical Review B **69**, 237201 (2004).
2. F. Zhao, X. Lv, A. Majumda and Z. Shi, “Influence of mounting on continuous-wave photoluminescence from mid-infrared PbSrSe/PbSe multiple quantum-wells”, Appl. Phys. Lett., **84**, 1251(2004).
3. A. Majumdar, H. Z. Xu, F. Zhao, J. C. Keay, L. Jayasinghe, S. Khosravani, X. Lu, V. Kelkar, and Z. Shi, “Bandgap energies and refractive indices of $Pb_{1-x}Sr_{x}Se$”, J. Appl. Phys., **95**, 939(2004)
4. F. Zhao, H. Wu, A. Majumdar and Z. Shi,“Continuous wave optically pumped lead-salt mid-infrared quantum-well vertical-cavity surface-emitting lasers”, Appl. Phys. Lett., **83**, 5129 (2003).
5. H. Z. Xu, F. Zhao, A. Majumdar and Z. Shi, “High power mid-infrared lasing from optically pumped vertical-cavity surface-emitting PbSe/PbSrSe multiple quantum well lasers operating at 325K”, *Electron. Lett*. **39**, 661(2003).
6. Majumdar, H. Xu, S. Khosravani, F. Zhao, and Z. Shi, “High power light emission of IV-VI lead salt MQW structure grown by MBE on <111> BaF_2 substrate”, Appl. Phys. Lett., . **82**, 493(2003).
7. H. Wu, F. Zhao, L. Jayasinghe, and Z. Shi, “Molecular beam epitaxy of IV-VI mid-infrared vertical cavity surface-emitting quantum well laser structures”, J. Vac. Sci. Technol. B. 20(4), 1356(2002).
8. H. Z. Xu and Z. Shi, “Strong Wave-Vector Filtering and Nearly 100% Spin-Polarization Through Resonant Tunneling Anti-Symmetrical Magnetic Structure”, Appl. Phys. Lett., **81**, 691 (2002).
9. F. Zhao, H. Wu, L. Jayasinghe and Z. Shi ,“Above-Room-Temperature Optically Pumped 4.12 σm Mid-Infrared Vertical-Cavity Surface-Emitting Lasers”, Appl. Phys. Lett., **80**, 1129 (2002).
10. L. Felix, W. W. Bewley, I. Vurgaftman, J. R. Lindle, and J. R. Meyer, H. Z. Wu, G. Xu, S. Khosravani, and Z. Shi “Low-Threshold Optically-Pumped ς=4.4σm Vertical-Cavity Surface-Emitting Laser with PbSe Quantum Well Active Region”, Appl. Phys. Lett., **78**, 3771 (2001).

(d) Synergistic Activities

1. Developed a new course at OU, IC Fabrication
2. Developed a solid state Teaching Lab.

(e) Collaborators and Co-Editors

See Publications list above and:

Prof. Laurie McNeil	Univ. of North Carolina
Kenneth Zanio	MOSET, Inc.
Armin Lambrecht	Fraunhofer Institute, IpM (Germany)

• Graduate and Postdoctoral Advisors.

Postdoctoral advisor:	Ursula Keller	ETH
Ph.D Advisor:	M. Tacke	Fraunhofer Institute **IpM**

• Thesis Advisor and Postgraduate-Scholar Sponsor

Current graduate student advisees	6,	Current postdoctoral scholars sponsored	1.

Biographical Sketch

Surendra P. Singh	Associate Professor of Physics	

(a) Professional Preparation

Banaras Hindu University	Phys.,Chem., Math	B.Sc. 1973
Banaras Hindu University	Physics	M.Sc. (1975)
CSIR (India) Fellow, Banaras H. University	Physics	1975-1976
University of Rochester	Physics	Ph.D. (1982)

(b) Appointments

Professor of Physics	1992–present	University of Arkansas
Chair of Physics	1995–2002	University of Arkansas
Visiting Fellow of JILA	1989–1990	University of Colorado
Associate Professor of Physics	1987–1992	University of Arkansas
Assistant Professor	1982–1987	University of Arkansas

(c) Publications

1. "Conditional measurements as probes of quantum dynamics," S. Siddiqui, D. Erenso, R. Vyas and S. Singh, Phys. Rev. A **67**, 063808 (2003).
2. "Measurements of intensity fluctuations in a laser with a saturable absorber," M. Mortazavi, F. Rawwagah, and S. Singh, Phys. Rev. A **65**, 025803 (2002).
3. "Measurements of higher order photon bunching of light beams," Y. Qu, S. Singh, and C. D. Cantrell, Phys. Rev. Lett. **76**, 1236 (1996).
4. "Measurements of photon statistics in second harmonic generation," Y. Qu and S. Singh, Phys. Rev. A **51**, 2530 (1995).
5. "Second harmonic generation with multimode beams," Y. Qu and S. Singh, Phys. Rev. A **47**, 3259 (1993).

1. "Entanglement, interference, and measurement in a degenerate parametric oscillator," H. Deng, D. Erenso, R. Vyas, and S. Singh, Phys. Rev. Lett. **86**,, 2770 (2001).
2. "Antibunching and photoemission waiting times," R. Vyas and S. Singh, J. Opt. Soc. Am B **17**, 634 (2000).
3. "Higher order nonclassical effects in a parametric oscillator," R. Vyas and S. Singh, Phys. Rev. A **62**, 033803 (2000).
4. "Exact quantum distribution for the parametric oscillators," R. Vyas and S. Singh, Phys. Rev. Lett. **74**, 2208 (1995).
5. "Photon counting statistics of the degenerate parametric oscillator," R. Vyas and S. Singh, Phys. Rev. A **40**, 5147 (1989).

(d) Synergistic Activities

1. Developed Jr./Sr. level optics laboratory and a laboratory manual with support from NSF-ILI grant. The manual is available to interested parties from the Optical Society of America. Currently working on a graduate level text on electromagnetic theory.
2. I initiated the reform of our undergraduate program (BS) as Department Chair. As a result of these reforms we have a growing undergraduate physics program graduating above average 10-15 majors each year.
3. Established annual series of privately funded public lectures (Maurer Lecture Series) by prominent scientists to promote public understanding of science and its role in our culture. Past lecturers have included Steven Chu, William D. Phillips, Lawrence Krauss, Phillip Morrison, and Richard Zare and John Wheeler.
4. The PIs research has resulted in the training of 12 graduate students and 3 postdoctoral research associates. Students graduating from this program have accepted positions at U.S. universities/colleges and industrial research labs thus contributing to the education and training of the nation's technical work force. One former student has started his own telecommunications company. We have also had undergraduate students and faculty from historically black colleges participate in research during summer.
5. Referee and/or panel member for more than a dozen scientific journals and funding agencies.

(e) Collaborators and Co-Editors

See Publications list above and:

• **Graduate and Postdoctoral Advisors.**

Graduate Advisor:	Prof. L. Mandel (deceased)	University of Rochester

• **Thesis Advisor and Postgraduate-Scholar Sponsor.**

Thesis Advisor: M. Mortazavi, W. L. Erikson, Y. Qu, and M. Schillaci, Fuad Rawwagah,
Postgraduate Sponsor: Samir Bali, Baolong Lu, and Hua Deng

Current graduate student advisees	1,	Current postdoctoral scholars sponsored	0

GAY B. STEWART Associate Professor

(a) PROFESSIONAL PREPARATION:

University of Arizona	Physics	B.S., 1988
University of Illinois, Urbana-Champaign	Physics	M.S., 1990
University of Illinois, Urbana-Champaign	Physics	Ph.D., 1994

(b) APPOINTMENTS:

2000-present Associate Professor, Department of Physics, University of Arkansas, Fayetteville
1994-2000 Assistant Professor, Department of Physics, University of Arkansas, Fayetteville

(c) PUBLICATIONS:

1. Gay B. Stewart, "Part I: Toward a System of Educational Engineering for Traditional Class Elements in Introductory Physics Courses." *Journal of Science Education and Technology,* **6**:173 (1997).
2. Gay B. Stewart and John C. Stewart, "Part II: A Computationally Based Modeling System for Class Elements Using Formal Observer-Based Experimental Connections." *Journal of Science Education and Technology,* **6**:193 (1997).
3. Gay B. Stewart, John C. Stewart, Sean Slape and Jon Osborn, "Optimally Engineering Traditional Introductory Physics Classes." *Journal of Science Education and Technology*, **6**:297 (1997).
4. Gay B. Stewart and Jon Osborn, "Closing the Gender Gap in Student Confidence: Results from a University of Arkansas Physics Class." *Journal of Women and Minorities in Science and Engineering.* **4**:27 (1998)
5. Gay B. Stewart, John C. Stewart, Stephen Skinner and Crystal Bailey, "Using Linguistic References to Characterize Class Integration," *Physics Education*, **34**:266 (1999).
6. "Practicing What We Preach," APS Forum on Education Newsletter, Summer 2004.
7. "Enhancing the Student-Instructor Interaction Frequency," *The Physics Teacher*, Vol 40, pp. 535-541, D.W. Bullock, V.P. LaBella, T. Clingan, Z. Ding, G. Stewart and P.M. Thibado. (2002)
8. Submitted to *The Physics Teacher*: "Using Student Behavior Data to Better Understand Class Performance" Jennifer McGee, John C. Stewart and Gay B. Stewart.
9. Submitted to *The American Journal of Physics*: "Context sensitivity of the Force Concept Inventory" Heather Griffin, John C. Stewart and Gay B. Stewart

I have given many colloquia, contributed talks, and chaired many sessions, below lists only the relevant invited talks.

∉ *APDL, a part of the National Science Digital Library,* July 2004, 3rd National Forum on Advanced Placement.
∉ *Intro Courses that Entice Majors and Improve Student Performance*, April 2004 APS meeting, Denver.

National Service: PKAL F21 Academic Administrators Advisory Task Force, Chair, APS Forum on Education , Member, APS Committee on Education, Chair, College Board Science Academic Advisory Committee, Member, College Board Academic Assembly Council, Editorial Board, *Journal of Science Education and Technology,* Reviewer for *Journal of Women and Minorities in Science and Engineering*, Begell House

(d) SYNERGISTIC ACTIVITIES:

∉ Began research into improved methods of intro physics education after attending the NSF sponsored 1993 UFE Conference *Teaching Introductory Physics Using Interactive Methods and Computers* at Dickinson College.
∉ Development of a new degree to improve the background of educators at the high school and community college level. Development of our departmental TA training program. Chosen as Cluster Leader for the Preparing Future Faculty Program in Physics (one of four campuses chosen nationwide to pilot this program), and to be included as one of 6 Primary Program Institutions in PhysTEC.
∉ Development of the highly successful UPII course, with supporting materials. Recognition from our efforts here has resulted in being chosen for 1) content reviewer for the Advanced Placement Digital Library project, and 2) the Advanced Placement Physics Curriculum Development Committee to promote results of physics education reform in the model for high school physics. She served as chair of the committee for three years, starting Fall 2000, she is now Chair of the Science Academic Advisory Committee. It also resulted in a nomination and election to the APS Forum on Education Executive Committee, of which she is currently chair.

(e) COLLABORATORS: Crystal Bailey, University of Indiana; Ditta Gallai, Hungary; Jon Osborn, Butler University; Steven Sandh, Lockheed Martin in Texas; Stephen Skinner, University of Arkansas; Sean Slape, University of Arkansas; John C. Stewart, University of Arkansas

GRADUATE ADVISOR: Bob Eisenstein*, University of Illinois, Urbana-Champaign.

MASTERS THESIS ADVISOR for 15

POST GRADUATE SPONSOR for 2

Biographical Sketch

Z. Ryan Tian

(a) Professional Preparation

Fudan University, Shanghai, China	Chemistry	B. S. 1982
University of Connecticut, Storrs, CT	Chemistry	Ph.D. 1998
University of California, Davis, CA	Materials Thermochemistry	1998 – 2000
Sandia National Labs, NM	Nanostructure Syntheses	2002 – 2004

(b) Appointments

- 2004-Present	Assistant Professor, University of Arkansas
2002 – 2004	Postdoctoral Fellow, Sandia National Labs
2000 – 2001	R&D Manager, AXT, Inc.
1998 – 2000	Postdoctoral Associate, University of California, Davis
1992 – 1998	Graduate Assistant, University of Connecticut

(c) Publications

(1). Complex and oriented ZnO nanostructures, **Z. R. Tian**, J. A. Voigt, J. Liu, B. Mckenzie, M. J. Mcdermott, M. A. Rodriguez, H. Konishi, H. Xu, *Nature Mater.* 2003, 2, 821

(2). Manganese oxide mesoporous structures: Mixed-valent semiconducting catalysts, **Z. R. Tian**, W. Tong, J. Y. Wang, N. G. Duan, V. V. Krishnan, S. L. Suib, *Science* 1997; 276 (5314), 926

(3). Hierarchical and self-similar growth of self-assembled crystals, **Z. R. Tian**, J. Liu, J. A. Voigt, B. Mckenzie, H. Xu, *Angew. Chem. Int. Ed.* 2003, 42 (4), 413 (Feature Article)

(4). Large oriented arrays and continuous films of TiO_2-based nanotubes, **Z. R. Tian**, J. A. Voigt, J. Liu, B. Mckenzie, H. Xu *J. Am. Chem. Soc.* 2003, 125, 12384

(5). Directed Spatial Organization of Zinc Oxide Nanorods, J. Hsu, **Z. R. Tian**, N. C. Simmkons, C. M. Matzke, J. A. Voigt, J. Liu, *Nano Lett*. (5(1), 83-86, 2005.

(6). Biomimetic arrays of oriented helical ZnO nanorods and columns, **Z. R. Tian**, J. A. Voigt, J. Liu, B. Mckenzie, M. J. Mcdermott, *J. Am. Chem. Soc.* 2002, 124, 12954

(7). Dendritic growth of cubically ordered nanoporous metariels through self-assembly, **Z. R. Tian**, J. Liu, J. A. Voigt, H. Xu, M. J. Mcdermott, *Nano Lett.* 2003, 3(1), 89

(8). Shape-selective growth, patterning, and alignment of cubic nanostructured crystals via self-assembly, **Z. R. Tian**, J. Liu, H. Xu, J. A. Voigt, B. Mckenzie, C. M. Matzke, *Nano Lett.* 2003, 3(2), 179

(9). Teplateless assembly of molecularly aligned conductive polymer nanowires: A new approach for oriented nanostructures, J. Liu, Y. Lin, L. Liang, J. A. Voigt, D. L. Huber, **Z. R. Tian**, E. Coker, B. B. Mckenzie, M. J. Mcdermott, *Chem. Eur. J.* 2003, 9(3), 604 (Invited Article)

(d) Synergistic Activities

1. Teaching of "Nanomaterials Chemistry" course (Fall, 04') was evaluated by students as "Really Enjoyed It"
2. Development of nanoseeding and microcontact-printing methods for aligning nanorods (2002-2004)
3. Ultrasensitive biosensing on Self-Assembled Monolayer (2004)
4. Hierarchically building complex structures in both nano- and micron-scales (2002-2004)
5. First user of Density Normalized Surface Area for porous materials of heavy elements (*Science* 1997).

(e) Collaborators and Other Affiliations

Dr. Jing Li	NASA Ames Research Center
Dr. D. Huang	Air Force Research Lab
Prof. M. Xiao	University of Arkansas
Dr. K. Carrado	Argoune National Lab

Graduate and Post Doctoral Advisors

Prof. S. L. Suib, University of Connecticut
Prof. A. Navrotsky, University of California, Davis
Dr. J. Liu, Sandia National Labs

Thesis Advisor and Postgraduate-Scholar Sponsor

None

Biographical Sketch

Ken Vickers	Director of Microelectronics-Photonics Graduate Program		
(a) PROFESSIONAL PREPARATION			
University of Arkansas	Physics	BS - High Honors	1976
University of Arkansas	Physics	MS	1978
Southern Methodist University	12 hours toward MS Applied Science		1977-80

(b) APPOINTMENTS

Director, Microelectronics-Photonics Graduate Prog./ Research Professor, Physics and Electrical Eng.	1998-Present	University of Arkansas
Engineering Manager-Process/Equipment	1991-1998	Texas Instruments, Sherman Wafer Lab
Co-Director, 0.8 micron BiCMOS startup	1989-1990	Texas Instruments, Freising, Germany
Engineering Section Manager	1980-1989	Texas Instruments, Sherman Wafer Lab
Process Engineer	1977-1980	Texas Instruments, Sherman Wafer Lab

(c) PUBLICATIONS

1. Vickers, Salamo, Foster; ASEE Annual Conf, Jun 04; *"Microelectronics-Photonics Interdisciplinary Science/Engineering Graduate Program Startup – Lessons Learned at the Five Year Point"*; Conf Proceedings
2. Vickers, Salamo, Collier, Wolff; ASEE Annual Conf, Jun 02; *"Land Grant Research University Partnerships with HBCUs for Enhanced Undergraduate Research Opportunities"*; Conf Proceedings
3. Vickers, Salamo, Foster; ASEE Annual Conf, Jun 02; *"Graduate Student Practice of Technology Management: The Cohort Approach to Structuring Graduate Programs"*; Conf Proceedings
4. Vickers, Todd; Decision Sciences Institute Annual Conference, Nov 01; "*Intra/Entrepreneurship of Technology – An Interdisciplinary Approach to Teaching Commercialization of Research*" (Winner – National Instructional Innovation Award); Conf Proceedings
5. Vickers, Salamo, Loewer, and Ahlen; "*Creation of an Entrepreneurial University Culture, The University of Arkansas as a Case Study*"; J. Engineering Education, p617, Vol. 90, No. 4, Oct 01

1. Foster, Vickers, Salamo, Ahlen; ASEE Annual Conf, June 04; *"Early Progress Indicators: an Innovation Incubator"*; Refereed Conference Proceedings
2. John Todd, Ken Vickers; International Council for Small Business World Conference; Puerto Rico; June 2002; *"Business + Physics = Entrepreneurship Education*", Conf Proceedings
3. Vickers; National Collegiate Inventors and Innovators Alliance Annual Conference, March 2002; Invited Panel Member: "*Current State of Technology Entrepreneurship Education".*
4. Vickers, Salamo, Turner; American Society for Engineering Education Annual Conference, June 2001; *"Graduate Physics Education – Industrial Style",* Conf Proceedings
5. Vickers; Invited Panel Member: American Society for Engineering Education Annual Conference, June 2001; *"University of Arkansas Innovation Incubator: Flaming the Sparks of Creativity*".

(d) SYNERGISTIC ACTIVITIES

1. Director of 2001 – 2003 microEP NSF REU site and 2004 – 2008 microEP NSF REU site
2. Membership Chairman, ASEE Entrepreneurship Division, June 2000 to June 2002
3. Thirty total patents issued (fourteen sole author, four principle author, and twelve contributing author)
4. Elected Texas Instruments Member Group Technical Staff (1987), Senior Member Technical Staff (1989), and Technical Manager (1991)
5. Chaired Texas Instruments' world-wide team for silicon usage reduction between integrated circuit factories 1996-1998. $15M in cost reduction accomplished over the last two years of the program.

(e) COLLABORATORS

Dr. John Ahlen, Ark. Sci and Tech Authority	Dr. Greg Salamo, University of Arkansas
Dr. Kathy Allen, U Southern Califonia	Dr. Ed Sobey, Northwest Invention Center
Prof. Ron Foster, University of Arkansas	Dr. John Todd, University of Arkansas
GRADUATE ADVISOR	Member of all microEP committees
THESIS ADVISOR	Dr. Don Pederson, University of Arkansas

Biographical Sketch

Min Xiao Distinguished Professor of Physics

(a) Professional Preparation

Nanjing University, Nanjing, P.R. China	Physics	B.S. 1982
University of Texas at Austin	Physics	Ph.D. 1988
Massachusetts Institute of Technology	Atomic Physics	Postdoc 1988-90

(b) Appointments

2004-present	Distinguished Professor of Physics	University of Arkansas
1998-present	Professor of Electrical Engineering	University of Arkansas
1998-2004	Professor of Physics	University of Arkansas
1995-1998	Associate Professor, Department of Physics	University of Arkansas
1990-1995	Assistant Professor, Department of Physics	University of Arkansas

Honors and Awards:

National Science Foundation Young Investigator Award	1994
Alumni Distinguished Faculty Research Achievement Award by the University of Arkansas Alumni Association	1998
Master Researcher Award, Fulbright College of Arts and Sciences, UA	2002

(c) Recent Publications

(1) "Optical Multistability in Three-Level Atoms inside an Optical Ring Cavity", A. Joshi and Min Xiao, *Phys. Rev.* Lett., **91**, 143904 (2003).
(2) "Controlling Steady-State Switching in Optical Bistability", A. Brown, A. Joshi, and Min Xiao, *Appl. Phys*. Lett., **83**,1301 (2003).
(3) "Hidden Resonant Excitation of Photoluminescence in Bi-Layer Arrays of InAs/GaAs Quantum Dots", Y. Mazur, Z.M. Wang, G.J. Salamo, and Min Xiao (with G.G. Tarasov, Z.Y. Zhuchenko, W.T. Masselink, and H. Kissel), *Appl. Phys*. Lett., **83**, 1866 (2003).
(4) "InGaAs/GaAs Three-Dimensionally-Ordered Array of Quantum Dots", Y. Mazur, W. Ma, X. Wang, Z.M. Wang, G.J. Salamo, and Min Xiao, T.D. Mishima and M.B. Johnson, *Appl. Phys*. Lett., **83**, 987 (2003).
(5) "Controlled Optical Bistability in a Three-Level Atomic System", A. Joshi, A. Brown, H. Wang, and Min Xiao, *Phys. Rev*. A **67**, Rapid Communications, 041801(R) (2003).

(d) Synergistic Activities:

∉ Created and taught several new undergraduate and graduate classes in the past few years.
∉ Received one US patent (US Patent Number: 5,821,546, "Method and System for Fecal Detection", by Min Xiao, D. Zhuang, G. Zheng, and M.F. Slavik, Oct., 1998).
∉ Serving as Co-Chair of the Quantum Optics Sub-Committee at the *2004' International Quantum Electronics Science Conference*, May, 2004
∉ Elected as Program Co-Chair for the *2005' Quantum Electronics and Laser Science Conference*

(e) Collaborations & Other Affiliations:

∉ Yongqing Li — Department of Physics, East Carolina University, NC, USA
∉ David Carroll — Department of Physics, Wake Forest University, NC, USA

Graduate and Postdoctoral Advisors:

Graduate advisor: Professor H. Jeff Kimble, California Institute of Technology
Postdoctoral advisor: Professor David E. Pritchard, Massachusetts Institute of Technology

Thesis Advisor and Postgraduate-Scholar Sponsor:

Graduate Students: (total graduate students in last five years: 11)
Graduated in last five years: 4 Ph.D. and 4 M.S.
Current graduate students in progress: 3 Ph.D.

Postdoctoral Scholars: (total postdoctoral scholars in last five years: 7)
Past: 5 Current: 2

Biographical Sketch

Xincheng Xie	Regents Professor	

(a) Professional Preparation

University of Science and Technology of China	Physics	B.Sc., 1982
University of Maryland	Physics	Ph.D., 1988
Post-Doc, University of Washington	Physics	1988-1989
Post-Doc, University of Maryland	Physics	1990-1991

(b) Appointments

Regents Professor,	Condensed Matter Theory	2004-present	Oklahoma State University
Professor,	Condensed Matter Theory	2000-2004	Oklahoma State University
Associate Professor,	Condensed Matter Theory	1996-2000	Oklahoma State University
Assistant Professor,	Condensed Matter Theory	1991-1996	Oklahoma State University

(c) Recent Publications

1. "Theory for high spin systems with orbital degeneracy," S.Q. Shen, X.C. Xie, and F.C. Zhang, Phys. Rev. Lett. 88, 027201 (2002).
2. "The Droplet State and the Compressibility Anomaly in 2D Electron Systems," J.R. Shi and X.C. Xie, Phys. Rev. Lett. 88, 086401 (2002).
3. "Coulomb-Enhanced Dynamic Localization and Bell-State Generation in Coupled Quantum Dots," P. Zhang, Q.K. Xue, X.G. Zhao, and X.C. Xie, Phys. Rev. A66, 022117 (2002).
4. "Spin-Dependent Transport Through An Interacting Quantum Dot," P. Zhang, Q.K. Xue, Y.P. Wang and X.C. Xie, Phys. Rev. Lett. 89, 286803 (2002).
5. "Low Temperature Saturation of Variable Range Hopping and Delocalization of Electron States by Entanglement with Phonons in Two Dimensions," Xiong, X.C. Xie, S.J. Xiong, Phys. Rev. B67, R140201 (2003) (Rapid Communications).
6. "Spin Current in the Kondo Lattice Model," S.Q. Shen and X.C. Xie, Phys. Rev. B67, 144423 (2003).
7. "Surface Phase Transitions Induced by Electron Mediated Adatom-Adatom Interaction," Junren Shi, Biao Wu, X.C. Xie, E.W. Plumer, Zhenyu Zhang, Phys. Rev. Lett. 91, 076103 (2003).
8. "Radiation-induced "Zero-resistance State" and the Photon-assisted Transport, Junren Shi and X.C. Xie, Phys. Rev. Lett. 91, 086801 (2003).
9. "Spin Current through a Quamtum Dot in the Presence of an Oscillating Magnetic Field," Ping Zhang, Q.K. Xue and X.C. Xie, Phys. Rev. Lett. 91, 196602 (2003).
10. "Generation of Spatially-separated Spin Entanglement in a Triple Quantum Dot System," Ping Zhang, Q.K. Xue, X.G. Zhao, and X.C. Xie, Phys. Rev. A69, 042307 (2004).
11. "Resonant spin Hall conductance in two-dimensional electron systems with Rashba interaction in a perpendicular magnetic field," S.Q. Shen, M. Ma, X.C. Xie, and F.C. Zhang, Phys. Rev. Lett. 92, 256603 (2004).
12. "Do intradot electron-electron interactions induce dephasing?" Z.T. Jiang, Q.F. Sun, X.C. Xie, and Y.P. wang, Phys. Rev. Lett. 93, 076802 (2004).

(d) Synergistic Activities

1. Serve as Coordinator for Condensed Matter Physics for "Oversea Chinese Physicists Association".
2. Member of Editorial Board for the journal "Chinese Physics".

(e) Collaborators and Co-Editors

See Publications list above and:

Qian Niu	University Of Texas
J.K. Jain	Penn State University

• Graduate and Postdoctoral Advisors.

Postdoctoral advisor:	E. Riedel	University of Washington
Postdoctoral advisor:	M. den Nijs	University of Washington
Postdoctoral advisor:	D.J. Thouless	University of Washington
Postdoctoral advisor:	S. Das Sarma	University of Maryland
Graduate Advisor:	S. Das Sarma	University of Maryland

• Thesis Advisor and Postgraduate-Scholar Sponsor.

Current graduate students advisees	2

Biographical Sketch

Wai Tak Yip	Assistant Professor of Chemistry	

(a) Professional Preparation

University of Hong Kong, Hong Kong	Chemistry	B.Sc., 1989
University of Chicago, IL	Physical Chemistry	Ph.D., 1996
Post-Doc, University of Minnesota, MN	Physical Chemistry	1996-1998
Post-Doc, University of Minnesota, MN	Biophysical Chemistry	1998-2000

(b) Appointments

Assistant Professor, Single Molecule Spectroscopy	2000-present	University of Oklahoma

(c) Publications

1. Ye Li and Wai Tak Yip, "Coulombic Interactions on the Deposition and Rotational Mobility Distributions of Dyes in Polyelectrolyte Multilayer Thin Films", *Langmuir* **2004**, *submitted.*
2. James W. Gilliland, Kazushige Yokoyama, Wai Tak Yip, "Effect of Coulombic Interactions on Rotational Mobility of Guests in Sol-Gel Silicate Thin Films", *Chemistry of Materials* **2004**, *in press*.
3. C. Ricardo Viteri, James W. Gilliland, Wai Tak Yip, "Probing the Dynamic Guest-Host Interactions in Sol-Gel Films Using Single Molecule Spectroscopy", *J. Am. Chem. Soc.* **2003**, 125, 1980-1987.
4. Wai-Tak Yip, Dehong Hu, Ji Yu, David A. Vanden Bout, Paul F. Barbara, "Classifying the Photophysical Dynamics of Single- and Multiple-Chromophoric Molecules by Single Molecule Spectroscopy", *J. Phys. Chem. A* **1998**, 102, 7564-7575.
5. David A. Vanden Bout, Wai-Tak Yip, Dehong Hu, Dian-Kui Fu, Timothy M. Swager, Paul F. Barbara, "Discrete Intensity Jumps and Intramolecular Electronic Energy Transfer in the Spectroscopy of Single Conjugated Polymer Molecules", *Science* **1997**, 277, 1074-1077.
6. Barden Chan, Kristin Weidemaier, Wai-Tak Yip, Paul F. Barbara, Karin Musier-Forsyth, "Intra-tRNA Distance Measurements for Nucleocapsid Protein-Dependent tRNA Unwinding During Initiation of HIV Reverse Transcription", *Proc. Natl. Acad. Sci.* **1999***,* 96, 459-464.
7. Wai-Tak Yip, Donald H. Levy, Renata Kobetic, Piotr Piotrowiak, "Energy Transfer in Bichromophoric Molecules: The Effect of Symmetry and Donor/Acceptor Energy Gap", *J. Phys. Chem. A* **1999***,* 103, 10-20.
8. Wai-Tak Yip and Donald H. Levy, "Excimer/Exciplex Formation in van der Waals Dimers of Aromatic Molecules", *J. Phys. Chem.* **1996**, 100, 11539-11545.
9. Wai-Tak Yip and Ronald S. Tse, "A Polarograph Built on an APPLE II", *Lab. Rob. Autom.* **1994**, 6, 5-13 (1994).
10. Wai-Tak Yip and Ronald S. Tse, "An Inexpensive Optical Multichannel Analyzer Built on an AT-Compatible Computer", *Rev. Sci. Instrum.* **1992**, 63, 3777-3780.

(d) Synergistic Activities

1. Over the last 4 years hosted 2 open-lab visits to elementary school students.
2. Over the last 4 years hosted 4 undergraduate students through the NSF-REU.

(e) Collaborators and Co-Editors

Kazushige Yokoyama SUNY Geneseo, NY

• Graduate and Postdoctoral Advisors.

N.A.

• Thesis Advisor and Postgraduate-Scholar Sponsor.

Current graduate students advisees 3, Current postdoctoral scholars sponsored 2.

Biographical Sketch

Min Zou Assistant Professor of Mechanical Engineering

(a) Professional Preparation

Northwestern Polytechnical University, China	Aerospace Engineering	B.S.	1988
Northwestern Polytechnical University, China	Aerospace Engineering	M.S.	1991
Georgia Institute of Technology	Mechanical Engineering	M.S.	1996
Georgia Institute of Technology	Mechanical Engineering	Ph.D.	1999

(b) Appointments

Assistant Professor, Department of Mechanical Engineering	2003-present	University of Arkansas
Senior Engineer / Staff Engineer, Mechanical R&D	1999-2003	Seagate Technology, LLC.
Engineer / Manager, Structural Strength Department	1991-1994	Shanghai Aircraft Research Institute

(c) Publications

1. Dayan, J., Green, I., and Zou, M., ìControl of the Rotordynamic Behavior of Mechanical Face Seals - Analytical and Experimental Results,î *10th International Symposium on Rotating Machinery* (ISROMAC), Honolulu, Hawaii, March 7-11, 2004.
2. Cai, L., Zou, M., Brown, W., ìNano Aluminum Film Induced Crystallization of Amorphous Silicon,î *The Electrochemical Society International Semiconductor Technology Conference*, Shanghai, China, September, 15 - 17, 2004.
3. Zou, M., Cai, L., Wang, Y. A., Mallette, N. D., and Peng, X., ìMechanical Properties of Au Nanocontacts on a Silicon Substrate,î Applied Physics Letters, submitted.
4. Tang, H., Zou, M., Stoebe, T., Rao, M., Ryun S., Li, X., and Gui, J., ìExperimental Verification of Drive Stiction Model,î *4th International Conference on Tribology of Information Storage Devices*, Monterey, CA, December 1-3, 2003.
5. Dayan, J., Zou, M., and Green, I., "Contact Elimination in Mechanical Face Seals Using Active Control," *IEEE Transactions on Control Systems Technology*, Vol. 10, No. 3, pp. 344-354, 2002.
6. Zou, M., Dayan, J., and Green, I., "Feasibility of Contact Elimination of a Mechanical Face Seal through Clearance Adjustment," *ASME Transactions, Journal of Engineering for Gas Turbines and Power*, Vol. 122, No. 3, pp. 478-484, 2000.
7. Zou, M., Dayan, J., and Green, I., "Dynamic Simulation and Monitoring of a Non-contacting Flexibly Mounted Rotor Mechanical Face Seal," Proceedings of the Institution of Mechanical Engineers, Part C: *Journal of Mechanical Engineering Science*, Vol. 214, No. 9, pp. 1195-1206, 2000.
8. Zou, M., and Green, I., "Clearance Control of a Mechanical Face Seal," *STLE Tribology Transactions*, Vol. 42, No. 3, pp. 535-540, 1999.
9. Dayan, J., Zou, M., and Green, I., "Sensitivity Analysis for the Design and Operation of a Noncontacting Mechanical Face Seal," Proceedings of the Institution of Mechanical Engineers, Part C: *Journal of Mechanical Engineering Science*, Vol. 214, No. 9, pp. 1207-1218, 2000.
10. Cai, L., Rohatgi, A., Han, S., May, G., and Zou, M., ìInvestigation of the Properties of Plasma-enhanced Chemical Vapor Deposited Silicon Nitride and Its Effect on Silicon Surface Passivation,î *Journal of Applied Physics*, Vol. 83, No. 11 pt 1, pp. 5885-5889, 1998.

(d) Synergistic Activities

1. Members of the Editorial Advisory Board, International Journal of Multidiscipline Modeling in Materials and Structures.
2. Reviewer, Journal of Tribology, Tribology Transactions, IEEE Transactions on Automation Science and Engineering.
3. Member, Society of Tribologists and Lubrication Engineers (STLE), ASME, ASEE.
4. Developed nanomechanical characterization module for mechanical engineering lab course.

(e) Collaborators and Co-Editors

Dr. Li Cai, Professor Xiaogang Peng	University of Arkansas
Professor Joshua Dayan	Technion - Israel Institute of Technology
Professor Itzhak Green	Georgia Institute of Technology
Dr. Y. Andrew Wang	NN-Labs, LLC.

ï Graduate and Postdoctoral Advisors.

Graduate Advisor:	Professor Itzhak Green	Georgia Institute of Technology

ï Thesis Advisor and Postgraduate-Scholar Sponsor.

Current graduate student	Hengyu Wang	University of Arkansas

Biographical Sketch

Gregory J. Salamo University Professor of Physics at the University of Arkansas

(a) Professional Preparation

Brooklyn College	B.S.	1966	Physics
Purdue University	M.S.	1968	Solid State
CUNY/Bell Labs	Ph.D.	1973	Optics
Rochester	Post-Doc	1973-5	Optics

(b) Appointments

University Professor of Physics	1995-present	University of Arkansas
Professor	1987-1995	University of Arkansas
Associate Professor, Physics	1981-1986	University of Arkansas
Assistant Professor, Condensed Matter Experiment	1975-1981	University of Arkansas

(c) Publications

1. "Experimental Observation of Discrete Modulational Instability," J. Meier, G. I. Stegeman, D. N. Christodoulides, Y. Silberberg, R. Morandotti, H. Yang, G. Salamo, M. Sorel, and J. S. Aitchison, *Phys. Rev. Lett*. 92, 163902 (2004)
2. "Fabrication of (In,Ga)As quantum-dot chains on GaAs(100)," Z.M.Wang, K. Holmes, Yu. I. Mazur, and G.J.Salamo, *Appl. Phys. Lett*. 84, 1931 (2004).
3. "Atom-resolved scanning tunneling microscopy of (In,Ga)As quantum wires on GaAs(311)A," H.Wen, Z.M.Wang, and G.J.Salamo, *Appl. Phys. Lett*. 84, 1756, (2004).
4. "Persistence of (In,Ga)As quantum-dot chains under index deviation from GaAs(100)," Z. M. Wang, Yu. I. Mazur, G. J. Salamo, P. M. Lytvin, V. V. Strelchuk, and M. Ya. Valakh , *Appl. Phys. Lett.* 84, 4681 (2004)
5. "Optical absorption of intersubband transitions in InGaAs/GaAs multiple quantum dots," B. Pattada, J Chen, Q Zhou, M.O. Manasreh, M.L. Hussein, W. Ma, and G.J. Salamo, *Appl. Phys. Lett*. 82, 2509 (2003).
6. "Highly anisotropic morphologies of GaAs (331) surfaces," V. R. Yazdanpanah, Z. M. Wang, and G. J. Salamo, *Appl. Phys. Lett*. 82, 514 (2003).
7. "InGaAs/GaAs three-dimensionally-ordered array of quantum dots," Yu. I. Mazur, W.Q.Ma, Z. M. Wang, G. J. Salamo, and M. Xiao *Appl. Phys. Lett*. 83, 987 (2003).
8. "Hidden resonant excitation of photoluminescence in bilayer arrays of InAs/GaAs quantum dots," Yu. I. Mazur, W.Q.Ma, Z. M. Wang, G. J. Salamo, and M. Xiao, *Appl. Phys. Lett*. 83, 1866 (2003).
9. "Strain-driven facet formation on self-assembled InAs Islands on GaAs (311) A," Z. M. Wang, V. R. Yazdanpanah, J. L. Shultz, and G. J. Salamo, *Appl. Phys. Lett.* 82, 1688 (2003).
10. "Morphology evolution during strained (In,Ga) epitaxial growth on GaAs vicinal (100) surfaces," Z. M. Wang, J. L. Shultz, and G. J. Salamo, *Appl. Phys. Lett*. 83, 1749 (2003).

(d) Synergistic Activities

. Gregory J. Salamo received the Ph.D. in physics from City University of New York in 1973, where he also worked as an intern student at Bell Laboratories in Murray Hill, New Jersey. His postdoctoral work was at the Institute of Optics of University of Rochester in New York. He joined the faculty of the University of Arkansas in January of 1975, where he is now University Professor of Physics. He has carried out research in the areas of optical communications, optical image processing, and the optical properties of semiconductors. His research is currently focused on growing III-V semiconductors and ferroelectrics using molecular beam epitaxy (MBE) and scanning tunneling microscopy (STM). He has published over one hundred papers in referred journals, given numerous contributed and invited talks, and contributed several book chapters. He also pursues the development of interdisciplinary research and education through the establishment of HiDEC and a new degree program to provide greater career opportunities for students and faculty. He is also involved in the development of an educational course and laboratory in nanotechnology. He is a Fellow of the Optical Society of America.

(e) Collaborators and Co-Editors

Yariv, M. Segev, G. C. Valley, B. Crosignani, P. Di Porto, and R. R. Neurgaonkar.

Graduate and Postdoctoral Advisors

Graduate advisor: Prof. Hyatt Gibbs, Optical Science Center, University of Arizona
Post-doctoral supervisor: Prof. L. Mandel, Physics Department, University of Rochester

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Oklahoma Norman Campus

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Matthew B Johnson

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Matthew B Johnson - PI	0.00	0.00	1.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (3) POST DOCTORAL ASSOCIATES	36.00	0.00	0.00	105,000	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	43,700	
3. (6) GRADUATE STUDENTS				120,000	
4. (2) UNDERGRADUATE STUDENTS				10,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				278,700	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				61,139	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				339,839	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Equipment $ 117,000					
TOTAL EQUIPMENT				117,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 10,000 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				10,000	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				750,772	
6. OTHER				15,600	
TOTAL OTHER DIRECT COSTS				818,372	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,300,211	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) IDC on REU stipend (Rate: 25.0000, Base: 10000) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				209,783	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,509,994	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,509,994	$

M. COST SHARING PROPOSED LEVEL $ 578,039 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Matthew B Johnson

ORG. REP. NAME*
Leslie flenniken

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

**** I- Indirect Costs**
MTDC (Rate: 48.0000, Base 431839)

SUMMARY PROPOSAL BUDGET YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Oklahoma Norman Campus

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Matthew B Johnson

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Matthew B Johnson - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (4) POST DOCTORAL ASSOCIATES	48.00	0.00	0.00	147,000	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	45,885	
3. (6) GRADUATE STUDENTS				126,000	
4. (2) UNDERGRADUATE STUDENTS				10,500	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				329,385	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				77,793	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				407,178	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Equipment $ 42,000					
TOTAL EQUIPMENT				42,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 10,500 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				10,500	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				775,982	
6. OTHER				16,380	
TOTAL OTHER DIRECT COSTS				844,362	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,319,040	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) IDC on REU Stipend (Rate: 25.0000, Base: 10500) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				230,230	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,549,270	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,549,270	$

M. COST SHARING PROPOSED LEVEL $ 592,872 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Matthew B Johnson

ORG. REP. NAME*
Leslie flenniken

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 2

** I- Indirect Costs
MTDC (Rate: 48.0000, Base 474178)

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION **University of Oklahoma Norman Campus**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Matthew B Johnson**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Matthew B Johnson - PI	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (4) POST DOCTORAL ASSOCIATES	48.00	0.00	0.00	154,350		
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	48,179		
3. (6) GRADUATE STUDENTS				132,300		
4. (2) UNDERGRADUATE STUDENTS				11,025		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				345,854		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				81,683		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				427,537		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Equipment $ 37,000						
TOTAL EQUIPMENT				37,000		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 11,025 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				11,025		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				50,000		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				802,182		
6. OTHER				17,199		
TOTAL OTHER DIRECT COSTS				871,381		
H. TOTAL DIRECT COSTS (A THROUGH G)				1,361,943		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) IDC on REU Stipend (Rate: 25.0000, Base: 11025) (Cont. on Comments Page)						
TOTAL INDIRECT COSTS (F&A)				240,134		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,602,077		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,602,077	$	
M. COST SHARING PROPOSED LEVEL $ 608,250	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Matthew B Johnson**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION					
ORG. REP. NAME* **Leslie flenniken**	Date Checked	Date Of Rate Sheet	Initials - ORG			

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

**** I- Indirect Costs**
MTDC (Rate: 48.0000, Base 494537)

SUMMARY PROPOSAL BUDGET

YEAR 4

ORGANIZATION **University of Oklahoma Norman Campus**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Matthew B Johnson**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Matthew B Johnson - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (4) POST DOCTORAL ASSOCIATES	48.00	0.00	0.00	162,068	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	50,588	
3. (6) GRADUATE STUDENTS				138,915	
4. (2) UNDERGRADUATE STUDENTS				11,576	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				363,147	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				85,767	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				448,914	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Equipment $ 30,000					
TOTAL EQUIPMENT				30,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 11,577 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				11,577	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				829,414	
6. OTHER				18,059	
TOTAL OTHER DIRECT COSTS				899,473	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,404,964	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) IDC on REU Stipend (Rate: 25.0000, Base: 11577) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				250,533	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,655,497	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,655,497	$

M. COST SHARING PROPOSED LEVEL $ 624,198 AGREED LEVEL IF DIFFERENT $

PI/PD NAME **Matthew B Johnson**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Leslie flenniken**	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 4

** I- Indirect Costs
MTDC (Rate: 48.0000, Base 515914)

SUMMARY PROPOSAL BUDGET

YEAR 5

ORGANIZATION	FOR NSF USE ONLY		
University of Oklahoma Norman Campus	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR	AWARD NO.		
Matthew B Johnson			

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Matthew B Johnson - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (4) POST DOCTORAL ASSOCIATES	48.00	0.00	0.00	170,171	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	53,118	
3. (6) GRADUATE STUDENTS				145,861	
4. (2) UNDERGRADUATE STUDENTS				12,155	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				381,305	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				90,056	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				471,361	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
Equipment $ 25,000					
TOTAL EQUIPMENT				25,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 12,155					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				12,155	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				857,721	
6. OTHER				18,962	
TOTAL OTHER DIRECT COSTS				928,683	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,452,199	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
IDC on REU Stipend (Rate: 25.0000, Base: 12155) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				261,452	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,713,651	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,713,651	$

M. COST SHARING PROPOSED LEVEL $ 640,730 AGREED LEVEL IF DIFFERENT $

PI/PD NAME	FOR NSF USE ONLY		
Matthew B Johnson	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
Leslie flenniken			

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 5

** I- Indirect Costs
MTDC (Rate: 48.0000, Base 538361)

SUMMARY PROPOSAL BUDGET — YEAR 6

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Oklahoma Norman Campus

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Matthew B Johnson

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Matthew B Johnson - PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (4) POST DOCTORAL ASSOCIATES	48.00	0.00	0.00	178,680	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	55,774	
3. (6) GRADUATE STUDENTS				153,154	
4. (2) UNDERGRADUATE STUDENTS				12,763	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				400,371	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				94,559	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				494,930	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) Equipment $ 17,000					
TOTAL EQUIPMENT				17,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 12,764 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (2) TOTAL PARTICIPANT COSTS				12,764	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				2,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				887,148	
6. OTHER				19,910	
TOTAL OTHER DIRECT COSTS				959,058	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,498,752	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) IDC on REU Stipend (Rate: 25.0000, Base: 12764) (Cont. on Comments Page)					
TOTAL INDIRECT COSTS (F&A)				272,917	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,771,669	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,771,669	$

M. COST SHARING PROPOSED LEVEL $ 657,882 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Matthew B Johnson

ORG. REP. NAME*
Leslie flenniken

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET COMMENTS - Year 6

** I- Indirect Costs
MTDC (Rate: 48.0000, Base 561930)

SUMMARY PROPOSAL BUDGET — Cumulative

ORGANIZATION University of Oklahoma Norman Campus			FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Matthew B Johnson			AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Matthew B Johnson - PI	0.00	0.00	1.00	$ 0	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (23) POST DOCTORAL ASSOCIATES	276.00	0.00	0.00	917,269	
2. (6) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	72.00	0.00	0.00	297,244	
3. (36) GRADUATE STUDENTS				816,230	
4. (12) UNDERGRADUATE STUDENTS				68,019	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				2,098,762	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				490,997	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				2,589,759	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 268,000					
TOTAL EQUIPMENT				268,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				90,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 68,021 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (12) TOTAL PARTICIPANT COSTS				68,021	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				300,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				12,000	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				4,903,219	
6. OTHER				106,110	
TOTAL OTHER DIRECT COSTS				5,321,329	
H. TOTAL DIRECT COSTS (A THROUGH G)				8,337,109	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				1,465,049	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				9,802,158	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 9,802,158	$

M. COST SHARING PROPOSED LEVEL $ 3,701,971	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME Matthew B Johnson	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Leslie flenniken	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

7. BUDGET JUSTIFICATION

A. SENIOR PERSONNEL

One month of summer salary for the PI (M.B. Johnson at OU) is requested from the NSF. One month of summer salary for OU's Faculty Outreach Coordinator (K. Mullen) will be part of the OU cost share. Fifty percent of the salaries for UA's Educational and Industrial Outreach Directors' salaries will be part of the UA cost share.

B. OTHER PERSONNEL

NSF funds are requested for post-doctoral researchers at UA (6 per year) and OU (4 for the first year, 5 for the other years) at $35,000 per year. NSF funds are also requested for graduate students at UA (7 per year) at $14,933 per 12 months and at OU (7 per year) at $20,000 per 12 months. The UA participants will compete for incentive funds from UA's Graduate College, on a case by case basis, to add to the stipends provided by the NSF. OU requests $10,000 from the NSF for 2 undergraduate research assistants.

OU's budget includes two 0.5 FTE Other Professionals. One is the CSPIN Project Manager ($23,700) and the other is the OU-CSPIN Outreach Liaison ($20,000). The Project Manager will aid the Director in managing the Center by providing record keeping, organizing annual exchanges and site visits and aiding in the production of the annual reports. The Outreach Liaison will help in interfacing with teachers, K-12 students and museum staff. UA's budget includes one 1.0 FTE Program Management Specialist ($50,000) who is responsible for accounting and purchasing at UA connected with the MRSEC, and who will assist with meetings and other events.

All salaries are benchmarked at year 2005 values, with salaries during subsequent years incremented by an inflation factor of 4% for postdoctoral researchers, 3% (limited by university rules) for graduate assistants, and 5% for the project manager, outreach liaison, and program management specialist.

C. FRINGE BENEFITS

The current rates for fringe benefits at UA are 23.675% for faculty, postdoctoral researchers, and staff members; and 3.594% for graduate assistants. The current rates for fringe benefits at OU are 37% for faculty, postdoctoral researchers, and staff members; 5% for graduate assistants; and 1.2% for undergraduate assistants.

D. EQUIPMENT

The OU equipment budget is $910,000, including $268,000 requested from the NSF and $642,000 from OU matching funds. The UA equipment budget is $630,000, which will be from UA matching funds.

The following equipment will be purchased by the OU participants:

1. Field-Emission Scanning Electron Microscope (SEM) with lithography package – for high-resolution electron microscopy and electron-beam lithography
2. Plasma Enhanced Chemical Vapor Deposition (PECVD) system – for gate oxide deposition
3. As and Sb Valved Cracker Cells – for existing MBE system to improve Group-V flux regulation
4. Optical Microscope Camera – for more user-friendly image processing on existing microscopes
5. Precision Ion Polishing System (PIPS) – for improved TEM specimen preparation
6. Unix Workstation – for modeling phase transitions in nanostructures
7. Profilometer – for characterizing etched features during device processing
8. Custom Built Low-temperature STM/STL – for high-efficiency detection of light from nanostructures

The following equipment will be purchased by the UA participants:

1. Optical Cryostat with Magnetic Field – to split states for proposed electromagnetic induced transparency studies
2. Compact UV laser: – to extend PL studies to the UV region
3. White Light Source: – for photoluminescence electron spectroscopy

4. Time Resolved Photon Counting – for improved PL detection
5. Optical Pulse Picker – for optical pump-probe studies.
6. Laser Beam Profiler - to characterize the spatial intensity distribution of a laser spot on a sample
7. PL Spectrometer – for UV PL measurements
8. Atomic H source – for low temperature oxide-layer removal from patterned GaAs substrates
9. $AsBr_3$ source (to be designed and fabricated with help from Veeco) – for in-situ etching, layer-by-layer, for growth on patterned substrates
10. Electric Field Sensitive SPM Head – to measure electric field and piezoelectric character of ferroelectric nanostructures
11. UV-Vis-IR Absorption Spectrophotometer (200 nm to 3500 nm) – to characterize nanoparticles with direct or indirect bandgaps
12. PL Polarization System for Existing Bomem FTIR – for polarization sensitive measurements of nanostructure arrays
13. Growth and Preparation System for Colloidal Clusters
14. Spectrum Analyzer (Agilent E4448A) – for noise measurements used in defect studies
15. Pump-Probe Detection System – for spin lifetime measurements

E. TRAVEL

The annual travel budget of $15,000 per year (NSF request) and $14,000 per year (UA match) at UA and $15,000 per year (NSF request) at OU will support conference participation of students, postdoctoral researchers and senior investigators. It will also support extended stays of students and faculty at partner institutions and participation in meetings with the other NSF MRSEC directors.

F. PARTICIPANT SUPPORT COSTS

OU requests $10,000 per year for 2 undergraduate REU participants. The requested REU students will work on interdisciplinary projects with the Department of Chemistry and Biochemistry or the School of Electrical and Computer Engineering. Successful REU site programs are in place at OU's Department of Physics and Astronomy and at UA's Physics Department and MicroEP Program (a multidisciplinary program). Typically, 8 to 10 REU students per year have been involved with CSPIN research over the last five years. We will continue this level of participation.

G. OTHER DIRECT COSTS

1. MATERIAL and SUPPLIES

NSF funds ($50K per year for OU, $50K per year for UA) are requested for laboratory supplies. OU is providing an average of $18,886 per year in matching funds and UA is providing $100,000 per year in matching funds. These funds will cover supplies consumed in the MBE (OU and UA) and colloidal growth facilities (UA). The supplies include source material, liquid nitrogen, substrate wafers, and repairs. In addition, supplies for optical and electrical measurements, such as mirrors, lenses, mounts, and liquid helium, and cleanroom materials will be purchased. The difference in the operating budgets for OU and UA reflects the fact that UA supports more MBE growth chambers as well as a colloidal growth system.

2. PUBLICATION COSTS

OU requests $2,000 per year from the NSF, while UA proposes an $8,800 per year cash match for publication costs.

3. CONSULTANT SERVICES

UA will provide $10,000 per year in cost share for two consultants who will each run a three-day workshop for CSPIN students. The topics of the workshops are team building and starting a small business.

6. TUITION

Tuition for seven graduate students each at UA and OU is based on the university fixed rates of 43.642% and 32%, respectively, of salary. OU will provide a waiver of 59.4% of the tuition.

M. COST SHARING
UA and OU have committed $3.7M in matching funds (37.8% of the NSF request) for capital equipment, materials and supplies. This includes the salaries of *two new full-time technicians*. In addition, 50% of the salaries for directors of UA education outreach and UA industrial outreach (see bios below) are included as match.

Education Outreach Director - Dr. Paul Caleja recently received his Ph.D in physical education on a thesis project work with handicapped children. Paul has developed and implemented the Arkansas MRSEC education outreach program for more than one year. He has been involved in the NSF GK-12 program since it began two years ago and now directs the entire program which involves five MRSEC faculty and seven MRSEC graduate students. He also directs the MRSEC RET program at UA. As coordinator, he is responsible for overseeing all K-12 activities including scheduling, creative activity development, implementation and evaluation.

Industry Outreach Director - Ron Foster was a manager at Honeywell for 20 years. He is now the MRSEC industrial outreach director at Arkansas. He has been responsible for an NSF program called partnerships for Innovation or PFI. This program has supported the three spin-off companies from the MRSEC based on nanomaterials and their optical behavior. He brings companies to campus to encourage and attract collaboration on MRSEC-related research; support for visiting scientists to work at our Center; support for students and postdoctoral fellows by industry doing MRSEC research; and the use by MRSEC researchers of external facilities. He will work half time for the MRSEC and half time for PFI.

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University of Arkansas**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory J Salamo**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Gregory J Salamo - Co-PI**	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (6) POST DOCTORAL ASSOCIATES	72.00	0.00	0.00	210,000		
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	50,000		
3. (7) GRADUATE STUDENTS				104,533		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				364,533		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				65,312		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				429,845		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				49,998		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				45,620		
TOTAL OTHER DIRECT COSTS				95,618		
H. TOTAL DIRECT COSTS (A THROUGH G)				540,463		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 42.5000, Base: 494843)**						
TOTAL INDIRECT COSTS (F&A)				210,308		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				750,771		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 750,771	$	
M. COST SHARING PROPOSED LEVEL $ 359,735	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Gregory J Salamo**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION					
ORG. REP. NAME* **Leslie flenniken**	Date Checked	Date Of Rate Sheet	Initials - ORG			

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **University of Arkansas**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory J Salamo**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Gregory J Salamo - Co-PI**	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (6) POST DOCTORAL ASSOCIATES	72.00	0.00	0.00	218,400		
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	52,500		
3. (7) GRADUATE STUDENTS				107,669		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				378,569		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				68,005		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				446,574		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				50,000		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				46,989		
TOTAL OTHER DIRECT COSTS				96,989		
H. TOTAL DIRECT COSTS (A THROUGH G)				558,563		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 42.5000, Base: 511574)**						
TOTAL INDIRECT COSTS (F&A)				217,419		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				775,982		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 775,982	$	
M. COST SHARING PROPOSED LEVEL $ 369,373	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Gregory J Salamo**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION					
ORG. REP. NAME* **Leslie flenniken**	Date Checked	Date Of Rate Sheet	Initials - ORG			

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION **University of Arkansas**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory J Salamo**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory J Salamo - Co-PI**	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (6) POST DOCTORAL ASSOCIATES	72.00	0.00	0.00	227,136	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	55,125	
3. (7) GRADUATE STUDENTS				110,899	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				393,160	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				70,811	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				463,971	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				48,399	
TOTAL OTHER DIRECT COSTS				98,399	
H. TOTAL DIRECT COSTS (A THROUGH G)				577,370	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 42.5000, Base: 528971)**					
TOTAL INDIRECT COSTS (F&A)				224,813	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				802,183	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 802,183	$
M. COST SHARING PROPOSED LEVEL $ 379,295	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gregory J Salamo**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Leslie flenniken**	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 4

ORGANIZATION **University of Arkansas**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory J Salamo**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Gregory J Salamo - Co-PI	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (6) POST DOCTORAL ASSOCIATES	72.00	0.00	0.00	236,221		
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	57,881		
3. (7) GRADUATE STUDENTS				114,226		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				408,328		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				73,734		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				482,062		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				50,000		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				49,851		
TOTAL OTHER DIRECT COSTS				99,851		
H. TOTAL DIRECT COSTS (A THROUGH G)				596,913		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 42.5000, Base: 547062)**						
TOTAL INDIRECT COSTS (F&A)				232,501		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				829,414		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 829,414	$	
M. COST SHARING PROPOSED LEVEL $ 389,517	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Gregory J Salamo**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Leslie flenniken**				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET
YEAR 5

ORGANIZATION **University of Arkansas**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory J Salamo**				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Gregory J Salamo - Co-PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (6) POST DOCTORAL ASSOCIATES	72.00	0.00	0.00	245,670	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	60,775	
3. (7) GRADUATE STUDENTS				117,653	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				424,098	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				76,779	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				500,877	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				51,346	
TOTAL OTHER DIRECT COSTS				101,346	
H. TOTAL DIRECT COSTS (A THROUGH G)				617,223	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 42.5000, Base: 565877)					
TOTAL INDIRECT COSTS (F&A)				240,498	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				857,721	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 857,721	$
M. COST SHARING PROPOSED LEVEL $ 400,034	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gregory J Salamo**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Leslie flenniken**	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 6

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Arkansas

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Gregory J Salamo

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Gregory J Salamo - Co-PI	0.00	0.00	0.00	$ 0	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (6) POST DOCTORAL ASSOCIATES	72.00	0.00	0.00	255,497	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	12.00	0.00	0.00	63,814	
3. (7) GRADUATE STUDENTS				121,183	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				440,494	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				79,952	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				520,446	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				52,887	
TOTAL OTHER DIRECT COSTS				102,887	
H. TOTAL DIRECT COSTS (A THROUGH G)				638,333	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) MTDC (Rate: 42.5000, Base: 585446)					
TOTAL INDIRECT COSTS (F&A)				248,815	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				887,148	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 887,148	$

M. COST SHARING PROPOSED LEVEL $ 410,871 AGREED LEVEL IF DIFFERENT $

PI/PD NAME	FOR NSF USE ONLY		
Gregory J Salamo	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
Leslie flenniken			

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET   Cumulative

ORGANIZATION University of Arkansas				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Gregory J Salamo				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Gregory J Salamo - Co-PI	0.00	0.00	0.00	$ 0	$	
2.						
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (36) POST DOCTORAL ASSOCIATES	432.00	0.00	0.00	1,392,924		
2. (6) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	72.00	0.00	0.00	340,095		
3. (42) GRADUATE STUDENTS				676,163		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				2,409,182		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				434,593		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				2,843,775		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				90,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				299,998		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				295,092		
TOTAL OTHER DIRECT COSTS				595,090		
H. TOTAL DIRECT COSTS (A THROUGH G)				3,528,865		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				1,374,354		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				4,903,219		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 4,903,219	$	
M. COST SHARING PROPOSED LEVEL $ 2,308,825	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME Gregory J Salamo				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Leslie flenniken				Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

7. BUDGET JUSTIFICATION

A. SENIOR PERSONNEL

One month of summer salary for the PI (M.B. Johnson at OU) is requested from the NSF. One month of summer salary for OU's Faculty Outreach Coordinator (K. Mullen) will be part of the OU cost share. Fifty percent of the salaries for UA's Educational and Industrial Outreach Directors' salaries will be part of the UA cost share.

B. OTHER PERSONNEL

NSF funds are requested for post-doctoral researchers at UA (6 per year) and OU (4 for the first year, 5 for the other years) at $35,000 per year. NSF funds are also requested for graduate students at UA (7 per year) at $14,933 per 12 months and at OU (7 per year) at $20,000 per 12 months. The UA participants will compete for incentive funds from UA's Graduate College, on a case by case basis, to add to the stipends provided by the NSF. OU requests $10,000 from the NSF for 2 undergraduate research assistants.

OU's budget includes two 0.5 FTE Other Professionals. One is the CSPIN Project Manager ($23,700) and the other is the OU-CSPIN Outreach Liaison ($20,000). The Project Manager will aid the Director in managing the Center by providing record keeping, organizing annual exchanges and site visits and aiding in the production of the annual reports. The Outreach Liaison will help in interfacing with teachers, K-12 students and museum staff. UA's budget includes one 1.0 FTE Program Management Specialist ($50,000) who is responsible for accounting and purchasing at UA connected with the MRSEC, and who will assist with meetings and other events.

All salaries are benchmarked at year 2005 values, with salaries during subsequent years incremented by an inflation factor of 4% for postdoctoral researchers, 3% (limited by university rules) for graduate assistants, and 5% for the project manager, outreach liaison, and program management specialist.

C. FRINGE BENEFITS

The current rates for fringe benefits at UA are 23.675% for faculty, postdoctoral researchers, and staff members; and 3.594% for graduate assistants. The current rates for fringe benefits at OU are 37% for faculty, postdoctoral researchers, and staff members; 5% for graduate assistants; and 1.2% for undergraduate assistants.

D. EQUIPMENT

The OU equipment budget is $910,000, including $268,000 requested from the NSF and $642,000 from OU matching funds. The UA equipment budget is $630,000, which will be from UA matching funds.

The following equipment will be purchased by the OU participants:

1. Field-Emission Scanning Electron Microscope (SEM) with lithography package – for high-resolution electron microscopy and electron-beam lithography
2. Plasma Enhanced Chemical Vapor Deposition (PECVD) system – for gate oxide deposition
3. As and Sb Valved Cracker Cells – for existing MBE system to improve Group-V flux regulation
4. Optical Microscope Camera – for more user-friendly image processing on existing microscopes
5. Precision Ion Polishing System (PIPS) – for improved TEM specimen preparation
6. Unix Workstation – for modeling phase transitions in nanostructures
7. Profilometer – for characterizing etched features during device processing
8. Custom Built Low-temperature STM/STL – for high-efficiency detection of light from nanostructures

The following equipment will be purchased by the UA participants:

1. Optical Cryostat with Magnetic Field – to split states for proposed electromagnetic induced transparency studies
2. Compact UV laser: – to extend PL studies to the UV region
3. White Light Source: – for photoluminescence electron spectroscopy

4. Time Resolved Photon Counting – for improved PL detection
5. Optical Pulse Picker – for optical pump-probe studies.
6. Laser Beam Profiler - to characterize the spatial intensity distribution of a laser spot on a sample
7. PL Spectrometer – for UV PL measurements
8. Atomic H source – for low temperature oxide-layer removal from patterned GaAs substrates
9. $AsBr_3$ source (to be designed and fabricated with help from Veeco) – for in-situ etching, layer-by-layer, for growth on patterned substrates
10. Electric Field Sensitive SPM Head – to measure electric field and piezoelectric character of ferroelectric nanostructures
11. UV-Vis-IR Absorption Spectrophotometer (200 nm to 3500 nm) – to characterize nanoparticles with direct or indirect bandgaps
12. PL Polarization System for Existing Bomem FTIR – for polarization sensitive measurements of nanostructure arrays
13. Growth and Preparation System for Colloidal Clusters
14. Spectrum Analyzer (Agilent E4448A) – for noise measurements used in defect studies
15. Pump-Probe Detection System – for spin lifetime measurements

E. TRAVEL

The annual travel budget of $15,000 per year (NSF request) and $14,000 per year (UA match) at UA and $15,000 per year (NSF request) at OU will support conference participation of students, postdoctoral researchers and senior investigators. It will also support extended stays of students and faculty at partner institutions and participation in meetings with the other NSF MRSEC directors.

F. PARTICIPANT SUPPORT COSTS

OU requests $10,000 per year for 2 undergraduate REU participants. The requested REU students will work on interdisciplinary projects with the Department of Chemistry and Biochemistry or the School of Electrical and Computer Engineering. Successful REU site programs are in place at OU's Department of Physics and Astronomy and at UA's Physics Department and MicroEP Program (a multidisciplinary program). Typically, 8 to 10 REU students per year have been involved with CSPIN research over the last five years. We will continue this level of participation.

G. OTHER DIRECT COSTS

1. MATERIAL and SUPPLIES

NSF funds ($50K per year for OU, $50K per year for UA) are requested for laboratory supplies. OU is providing an average of $18,886 per year in matching funds and UA is providing $100,000 per year in matching funds. These funds will cover supplies consumed in the MBE (OU and UA) and colloidal growth facilities (UA). The supplies include source material, liquid nitrogen, substrate wafers, and repairs. In addition, supplies for optical and electrical measurements, such as mirrors, lenses, mounts, and liquid helium, and cleanroom materials will be purchased. The difference in the operating budgets for OU and UA reflects the fact that UA supports more MBE growth chambers as well as a colloidal growth system.

2. PUBLICATION COSTS

OU requests $2,000 per year from the NSF, while UA proposes an $8,800 per year cash match for publication costs.

3. CONSULTANT SERVICES

UA will provide $10,000 per year in cost share for two consultants who will each run a three-day workshop for CSPIN students. The topics of the workshops are team building and starting a small business.

6. TUITION

Tuition for seven graduate students each at UA and OU is based on the university fixed rates of 43.642% and 32%, respectively, of salary. OU will provide a waiver of 59.4% of the tuition.

M. COST SHARING

UA and OU have committed $3.7M in matching funds (37.8% of the NSF request) for capital equipment, materials and supplies. This includes the salaries of *two new full-time technicians*. In addition, 50% of the salaries for directors of UA education outreach and UA industrial outreach (see bios below) are included as match.

Education Outreach Director - Dr. Paul Caleja recently received his Ph.D in physical education on a thesis project work with handicapped children. Paul has developed and implemented the Arkansas MRSEC education outreach program for more than one year. He has been involved in the NSF GK-12 program since it began two years ago and now directs the entire program which involves five MRSEC faculty and seven MRSEC graduate students. He also directs the MRSEC RET program at UA. As coordinator, he is responsible for overseeing all K-12 activities including scheduling, creative activity development, implementation and evaluation.

Industry Outreach Director - Ron Foster was a manager at Honeywell for 20 years. He is now the MRSEC industrial outreach director at Arkansas. He has been responsible for an NSF program called partnerships for Innovation or PFI. This program has supported the three spin-off companies from the MRSEC based on nanomaterials and their optical behavior. He brings companies to campus to encourage and attract collaboration on MRSEC-related research; support for visiting scientists to work at our Center; support for students and postdoctoral fellows by industry doing MRSEC research; and the use by MRSEC researchers of external facilities. He will work half time for the MRSEC and half time for PFI.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Laurent Bellaiche	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIRT: Ferroelectric Nanomaterials and Devices

Source of Support: NSF

Total Award Amount: $1,247,992 Total Award Period Covered: 08/01/05 – 07/31/09

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Properties of Ferroelectric Nanostructures: A Combined Theoretical and Experimental Approach

Source of Support: U.S. Dept. of Energy

Total Award Amount: $448,842 Total Award Period Covered: 01/01/05 – 12/31/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Modeling and Designing Ferroelectrics with Defects and in Two-Dimensional Forms (CAREER Renewal)

Source of Support: NSF

Total Award Amount: $240,000 Total Award Period Covered: 05/15/04 – 05/14/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.7 (yrs 2 & 3 only)

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Understanding and Designing Complex Ferroelectrics from First Principles

Source of Support: Office of Naval Research

Total Award Amount: $189,000 Total Award Period Covered: 04/01/04 – 05/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Laurent Bellaiche

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A New Era in Ferroelectrics: Nanostructures and Devices

Source of Support: Army Research Office

Total Award Amount: $3,000,000 Total Award Period Covered: 06/19/03 – 06/18/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: REU Site: Modern Optics and Optical Materials

Source of Support: NSF

Total Award Amount: $240,000 Total Award Period Covered: 04/01/03 – 03/30/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A Virtual Laboratory for the First-Principles Design of Piezoelectrics for Transducers

Source of Support: College of William and Mary

Total Award Amount: $227,920 Total Award Period Covered: 12/31/01 – 01/30/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Finite-Temperature Properties of Ferroelectric Alloys from First Principles

Source of Support: Office of Naval Research (DEPSCoR)

Total Award Amount: $272,421 Total Award Period Covered: 04/01/01 – 03/30/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRSEC: Center for Semiconductor Physics in Nanostructures

Source of Support: University of Oklahoma

Total Award Amount: $2,170,000 Total Award Period Covered: 09/01/00 – 08/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Laurent Bellaiche

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: CAREER: Towards a Deep Microscopic Understanding of Ferroelectric Alloys

Source of Support: NSF
Total Award Amount: 200,000 Total Award Period Covered: 02/15/00 – 01/31/06
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.7 (sumr 2005)

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Lloyd A. Bumm (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NUE: NanoLab – A Hands-On Introduction to Nanoscience for Scientists and Engineers

Source of Support: NSF DMR

Total Award Amount: $ 100,000 Total Award Period Covered: 05/01/03 – 05/01/05

Location of Project: The University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CAREER: Single-Molecule Optoelectronics and Nanometer Scale Photonics

Source of Support: NSF CHE

Total Award Amount: $ 510,00 Total Award Period Covered: 03/01/03 – 08/01/08

Location of Project: The University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Paul Calleja

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: 12 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Other agencies (including NSF) to which this proposal has been/will be submitted.

Investigator: R.E. Doezema (One of 22 Scientists)

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: InSb Heterostructures for Spin and Quantum Confinement Experiments (PI: M.B. Santos, Co-PIs: R.E. Doezema and S. Murphy)

Source of Support: NSF

Total Award Amount: $ 628,495 Total Award Period Covered: 7-1-05 to 6-31-08

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Acquisition of Fourier Transform Infrared Spectrometer for Research and Education on Spintronics and Semiconductor Nanostructures (PI: M.B. Santos, Co-PI: R.E. Doezema)

Source of Support: NSF

Total Award Amount: $91,000 Total Award Period Covered: 8-1-04 to 7-15-05

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Spin and Other Electronic Properties of InSb Quantum Wells (PI: M.B. Santos, Co-PIs: R.E. Doezema and S. Murphy)

Source of Support: NSF

Total Award Amount: $453,000 Total Award Period Covered: 7-15-02 to 6-30-05

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRSEC: Center for Semiconductor Physics in Nanostructures (16 senior investigators)

Source of Support: NSF

Total Award Amount: $4,500,000 Total Award Period Covered: 9-1-00 to 3-31-05

Location of Project: University of Arkansas and University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Ron B. Foster**	Other agencies (including NSF) to which this proposal has been/will be submitted. N/A

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR-Materials Research Science and Engineering Centers

Total Award Amount: $ 9,802,158 Total Award Period Covered: 09/01/2005 – 08/31/2011

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: 6 Acad: 4.5 Sumr: 1.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Revitalizing Undergraduate Engineering - A Holistic Approach

Connections

Source of Support: NSF

Total Award Amount: $ 100,000 Total Award Period Covered: 01/1/2004-08/31/2005

Location of Project: University of Arkansas Fayetteville

Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: PFI: Building a Pathway Connecting Innovation to Commercialization

Source of Support: NSF Partnerships for Innovation

Total Award Amount: $ 600,000 Total Award Period Covered: 10/15/2004-10/15/2007

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 5 Acad: 4.5 Sumr: 0.5

Support: ☐ Current ☐ Pending ☒ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Acquisition of Focused Ion Beam

Source of Support: NSF – Major Research Instrumentation

Total Award Amount: $1,250,000 Total Award Period Covered: 07/01/2005-07/01/2008

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.5 Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Huaxiang Fu

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIRT: Ferroelectric Nanaomaterials and Devices

Source of Support: NSF

Total Award Amount: $1,247,992 Total Award Period Covered: 08/01/05 – 07/31/09

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Properties of Ferroelectric Nanostructures: A Combined Theoretical and Experimental Approach

Source of Support: DOE

Total Award Amount: $448,842 Total Award Period Covered: 12/01/04 – 11/30/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRI: Acquisition of a Computing Cluster for High-end Applications in Science and Engineering

Source of Support: NSF

Total Award Amount: $498,597 Total Award Period Covered: 08/01/04 – 07/30/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Modeling and Designing Complex Ferroelectrics

Source of Support: ONR

Total Award Amount: $699,579 Total Award Period Covered: 06/01/04 – 05/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Huaxiang Fu

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Modeling and Designing Complex Ferroelectrics from First-principles

Source of Support: Office of Naval Research

Total Award Amount: $90,000 Total Award Period Covered: 05/01/04 – 04/30/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Piezoelectrics by Design

Source of Support: Office of Naval Research thru College of William & Mary

Total Award Amount: $27,000 Total Award Period Covered: 01/01/03 – 12/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Other agencies (including NSF) to which this proposal has been/will be submitted.

Investigator: Julio Gea-Banacloche

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Low-Power, Ultrafast Optical Switches Based on Coherence Optical Effects in Arrayed Semiconductor Nanostructures

Source of Support: DoD/DEPSCoR:ARO

Total Award Amount: $466,326 Total Award Period Covered: 06/01/05 – 05/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Cavity Quantum Electrodynamics of Cold Atoms in Periodic Potentials

Source of Support: NSF

Total Award Amount: $208,370 Total Award Period Covered: 06/01/05 – 05/31/08

Location of Project: Universtiy of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Quantum Error Correction in the Presence of Environmental Noise

Source of Support: ARO EPSCoR

Total Award Amount: $308,225 Total Award Period Covered: 06/01/02 – 05/31/2005

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2.0

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Matthew Johnson (1 of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Oklahoma Nano Materials

(OU Co-ordinator, includes about 25 Scientists)

Source of Support: Oklahoma State Regents for Higher Education

Total Award Amount: $1,500,000 Total Award Period Covered: : 06/1/05-05/31/08

Location of Project: OU, OSU and U. of Tulsa

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NSF EPSCoR Research Infrastructure Initiative

(OU Co-ordinator, includes about 25 Scientists)

(Budget below is for NanoMaterials effort, includes 25 scientists)

Source of Support: NSF

Total Award Amount: $849,000 Total Award Period Covered: 06/1/05-05/31/08

Location of Project: OU, OSU and U. of Tulsa

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NUE: NanoLab – A Hands-On Introduction to Nanoscience for Scientists and Engineers

(with Lloyd Bumm)

Source of Support: NSF DMR

Total Award Amount: $100,000 Total Award Period Covered: 05/01/03 – 05/01/05

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: EPSCoR Research Infrastructure Improvement Award

(Materials component of award is $4M for 20 researchers at U of Oklahoma, Oklahoma State and U. of Tulsa)

Source of Support: NSF-EPSCoR

Total Award Amount: $9,000,000 Total Award Period Covered: 06/01/02 to 05/31/05

Location of Project: University of Oklahoma, OSU and U. of Tulsa

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Matthew Johnson

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures (with 8 others at Oklahoma and 9 others at Arkansas)

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $4,500,000 Total Award Period Covered: 09/01/00 to 08/30/05

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CAREER: Scanning Probe Microscopy of Photonic and Electronic Materials

Source of Support: NSF ECS

Total Award Amount: $440,000,000 Total Award Period Covered: : 4-15-98 to 12-31-04

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Jiali Li**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Fabrication of Solid-state Nanopores for Developing Single Biopolymer Detector

Source of Support: MRSEC Seed

Total Award Amount: $25,000 Total Award Period Covered:

Location of Project: UA

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Single DNA and protein characterization with a solid-state nanopore sensor

Source of Support: Arkansas Bioscience Institute

Total Award Amount: $71,000 Total Award Period Covered: 1/1/04-5/30/05

Location of Project: UA

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Solid-state Nanopore Identification for Proteins

Source of Support: NIH

Total Award Amount: $517,133 Total Award Period Covered: 6/1/04-4/30/07

Location of Project: UA

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Omar Manasreh

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Infrared Applications of III-V Semiconductor Nanostructures

Source of Support: AFOSR (DOD DEPSCoR)

Total Award Amount: $678,817 Total Award Period Covered: 06/01/05 – 05/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 2 (Yr1 Sumr: 3.0 (Yr 2 & 3)

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Fabrication and Characterization of GaN-based HFET Devices

Source of Support: AFOSR (DOD DEPSCoR)

Total Award Amount: $606,189 Total Award Period Covered: 06/01/05 – 05/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1.0 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: III-V Semiconductor Nanostructures for Infrared Detectors

Source of Support: NSF

Total Award Amount: $413,689 Total Award Period Covered: 05/01/05 – 04/30/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Yr1-2 Sumr: 1

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Photoresponse Measurements of Long Wavelength Infrared Photodetectors

Source of Support: AFOSR (DURIP)

Total Award Amount: $128,765 Total Award Period Covered: 05/01/05 – 04/30/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Omar Manasreh

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: NIRT: Multifunctional Semiconductor Quantum Structures

Source of Support: NSF
Total Award Amount: $1,374,053 Total Award Period Covered: 05/01/05 – 04/31/09
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 2.0 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: NIRT: Ferroelectric Nanomaterials and Devices

Source of Support: NSF
Total Award Amount: $1,247,992 Total Award Period Covered: 08/01/05 – 07/31/09
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 2.0 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Infrared Detectors Based on Dilute Nitrides

Source of Support: ARO
Total Award Amount: $292,462 Total Award Period Covered: 01/01/05 – 12/31/07
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 2.0 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Optical Properties of III-V Semiconductor Nanostructures and Quantum Wells

Source of Support: AFOSR
Total Award Amount: $380,720 Total Award Period Covered: 10/01/03 – 12/31/06
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 3.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Infrared Application of III-Nitride Quantum Dots

Source of Support: NSF
Total Award Amount: $420,002 Total Award Period Covered: 08/01/03 – 07/31/06
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Bruce Mason**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **MERLOT/Physics Editor**

Source of Support: **Oklahoma State Regents for Higher Education**

Total Award Amount: $ **75,500** Total Award Period Covered: **07/01/99 - 06/30/04**

Location of Project: **University of Oklahoma**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **1.00** Sumr: **1.00**

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **ComPADRE: Communities for Physics and Astronomy Digital Resources in Education**

Source of Support: **NSF-DUE**

Total Award Amount: $ **900,000** Total Award Period Covered: **10/01/02 - 09/30/04**

Location of Project: **University of Oklahoma, College Park Maryland**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **4.50** Sumr: **1.00**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **ComPADRE: Pathway for Physics and Astronomy Education**

Source of Support: **NSF-DUE**

Total Award Amount: $ **3,000,000** Total Award Period Covered: **01/01/05 - 12/31/08**

Location of Project: **University of Oklahoma, College Park Maryland**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **4.50** Sumr: **1.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Patrick McCann (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Multi-Band/Multi-Threat Warning System with a Single Sensor

Source of Support: Agiltron, Inc.

Total Award Amount: $21,000 Total Award Period Covered: 7/1/2004 to 4/30/2005

Location of Project: Norman, OK

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Rapid Detection of Chemical Compounds

Source of Support: State of Oklahoma, Center for the Advancement of Science and Technology

Total Award Amount: $240,000 Total Award Period Covered: 3/1/2003 to 3/28/2006

Location of Project: Norman, OK

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Semiconductor Lasers with Improved Heat Dissipation

Source of Support: State of Oklahoma, Center for the Advancement of Science and Technology

Total Award Amount: $300,000 Total Award Period Covered: 2/1/2002 to 1/31/2005

Location of Project: Norman, OK

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: State of Oklahoma (NSF-EPSCoR)

Total Award Amount: $350,000 Total Award Period Covered: 9/1/2000 to 8/31/2005

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Patrick McCann (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Excimer Laser System for Semiconductor Device Processing

Source of Support: U.S. Department of Defense

Total Award Amount: $588,000 Total Award Period Covered: 5/1/2005 to 12/31/2005

Location of Project: Norman, OK

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: UV Emitters for Handheld Chemical and Biological Sensors

Source of Support: State of Oklahoma, Center for the Advancement of Science and Technology

Total Award Amount $240,000 Total Award Period Covered: 3/1/2005 to 2/29/2008

Location of Project: Norman, OK

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr: 1

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Kieran Mullen (1 of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Physics REU Site at the University of Oklahoma

(OU Co-PI)

Source of Support: NSF

Total Award Amount: $165,000 Total Award Period Covered: : 07/1/02-06/30/05

Location of Project: OU Norman campus

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NSF EPSCoR Research Infrastructure Initiative

(One of about 25 Scientists)

(Budget below is for NanoMaterials effort, includes 25 scientists)

Source of Support: NSF

Total Award Amount: $849,000 Total Award Period Covered: 06/1/05-05/31/08

Location of Project: OU, OSU and U. of Tulsa

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Physics REU Site at the University of Oklahoma

(Co-PI)

Source of Support: NSF

Total Award Amount: $90,000 Total Award Period Covered: 07/1/05-06/30/08

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: EPSCoR Research Infrastructure Improvement Award

(Materials component of award is $4M for 20 researchers at U of Oklahoma, Oklahoma State and U. of Tulsa)

Source of Support: NSF-EPSCoR

Total Award Amount: $9,000,000 Total Award Period Covered: 06/01/02 to 05/31/05

Location of Project: University of Oklahoma, OSU and U. of Tulsa

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Kieran Mullen

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

(with 8 others at Oklahoma and 9 others at Arkansas)

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $4,500,000 Total Award Period Covered: 0909/01/00 to 08/30/05

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: S. Murphy (One of 22 Scientists)	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: InSb Heterostructures for Spin and Quantum Confinement Experiments
(PI: M.B. Santos, Co-PIs: R.E. Doezema and S. Murphy)

Source of Support: NSF

Total Award Amount: $ 628,495 Total Award Period Covered: 7-1-05 to 6-31-08

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Spin and Other Electronic Properties of InSb Quantum Wells
(PI: M.B. Santos, Co-PIs: R.E. Doezema and S. Murphy)

Source of Support: NSF

Total Award Amount: $453,000 Total Award Period Covered: 7-15-02 to 6-30-05

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRSEC: Center for Semiconductor Physics in Nanostructures (16 senior investigators)

Source of Support: NSF

Total Award Amount: $4,500,000 Total Award Period Covered: 9-1-00 to 3-31-05

Location of Project: University of Arkansas and University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Hameed A. Naseem

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Low Temperature Solid Phase Crystallization and Doping of Amorphous Silicon for Solar Cells and Other Micro/Nano-electronic Applications

Source of Support: DOE

Total Award Amount: $4,500,000 Total Award Period Covered: 03/01/04 – 02/28/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 3.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: International Cooperation for Investigating Metal Induced Crystallization Behavior of Thin Film Amorphous Silicon

Source of Support: NSF/Int – Africa, Near East, So Asia Program

Total Award Amount: $35,400 Total Award Period Covered: 03/01/04 – 02/28/07

Location of Project: University of Arkansas and National Physical Lab, New Delhi

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Investigation of Low Temperature Metal Induced Crystallization and Doping of Silicon Using Various Excitation Sources for Solar Cells and Other Microelectronic Applications

Source of Support: DOE

Total Award Amount: $495,000 Total Award Period Covered: 03/01/02 – 02/28/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Xiaogang Peng

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures, PI: Johnson (OH), Co-PI: Salamo (UA)

one of 22 faculty senior personnel

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Growth Mechanism, Synthesis and Applications of High Quality Semiconductor Nanocrystals, CAREER (with a sup-

Source of Support: NSF

Total Award Amount: $560,000 + $73,877 Total Award Period Covered: 3/1/01-2/28/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr: 1

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Large Scale Formation of High Quality Nanocrystals from Metal Oxides

Source of Support: NSF

Total Award Amount: $334,000 Total Award Period Covered: 8/15/01-7/31/04 (extended to 7/31/05)

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr: 1

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Subcontracts from NN-labs for industrial development of the nanocrystals developed by Peng's group

Source of Support: NN-Labs

Total Award Amount: about $245,000 in total Total Award Period Covered: 7/1/03-7/1/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr:

Support: X Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Colloidal Nanocrystals as Standard Biomedical reagents

Source of Support: Arkansas Bioscience Institute

Total Award Amount: $49,000 Total Award Period Covered: 8/15/04-7/1/05

Location of Project: U of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Investigator: Xiaogang Peng

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Bandgap and composition engineering of semiconductor nanocrystals

Source of Support: NSF

Total Award Amount: $496.787 Total Award Period Covered: 11/1/04-/11/1/07

Location of Project: university of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1 Sumr: 1

Support: Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Non-Cadmium Based Semiconductor Nanocrystals as a New Generation of Chromophores

Total Award Amount: $331,628

Total Awar

Location of Project: University of Arkansas Total Award Period Covered: 09/01/05 – 08/31/11

Person-Months Per Year Committed to the Project.

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers
Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11
Location of Project: University of Oklahoma and University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 1.0 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: NIRT: Ferroelectric Nanomaterials and Devices

Source of Support: NSF
Total Award Amount: $1,247,992 Total Award Period Covered: 08/01/05 – 07/31/09
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: NIRT: Multifunctional Semiconductor Quantum Structures

Source of Support: NSF
Total Award Amount: $1,285,539 Total Award Period Covered: 06/01/05 – 05/31/09
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Infrared Applications of III-V Semiconductor Nanostructures

Source of Support: AFOSR (DOD DEPSCoR)
Total Award Amount: $668,626 Total Award Period Covered: 06/01/05 – 05/31/08
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: III-V Semiconductor Nanostructures for Infrared Detectors

Source of Support: NSF
Total Award Amount: $415,534 Total Award Period Covered: 05/01/05 – 04/30/08
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0. 5 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Cooperative Activity in Materials Research: Behavior of Organized Quantum Dot and/or Wire Arrays

Source of Support: NSF

Total Award Amount: $119,103 Total Award Period Covered: 04/01/05 – 03/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIRT: GOALI – Development of Nano Electronchemical Machining (Nano-ECM) for Advanced Biomedical Manufacturing

Source of Support: NSF

Total Award Amount: $1,686,280 Total Award Period Covered: 04/01/05 – 03/31/09

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Building a Pathway Connecting Innovation to Commercialization

Source of Support: NSF

Total Award Amount: $600,000 Total Award Period Covered: 10/15/04 – 09/30/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Laser Tweezers for Manipulation of Single Cells

Source of Support: Arkansas Biosciences Institute

Total Award Amount: $28,000 Total Award Period Covered: 06/01/04 – 05/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: URC: Studio Concept to Enable Students to Uncover the Rules of Nature at the Small Scale

Source of Support: NSF

Total Award Amount: $50,000 Total Award Period Covered: 06/01/04 – 05/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Developing Nitride Material and Optical Devices I

Source of Support: Oklahoma State University

Total Award Amount: $184,938 Total Award Period Covered: 04/01/04 – 12/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: .05

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Developing nitride Material and Optical Devices II

Source of Support: Oklahoma State University

Total Award Amount: $105,939 Total Award Period Covered: 04/01/04 – 12/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.42 Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: REU Site: University Undergraduate Research in Nanodevices

Source of Support: NSF

Total Award Amount: $125,000 Total Award Period Covered: 03/15/04 – 02/28/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Arkansas EPSCoR Research Infrastructure

Source of Support: NSF EPSCoR

Total Award Amount: $2,082,250 Total Award Period Covered: 11/15/03 – 10/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Spatial Solitons

Source of Support: US-Israel Binational Science Foundation

Total Award Amount: $23,275 Total Award Period Covered: 10/01/03 – 09/30/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Spatial Solitons and Their Applications

Source of Support: NSF
Total Award Amount: 358,096 Total Award Period Covered: 08/15/03 – 07/31/06
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: A New Era in Ferroelectrics: Nanostructures and Devices

Source of Support: U.S. Army Research Laboratory
Total Award Amount: $3,000,000 Total Award Period Covered: 06/19/03 – 06/18/08
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0. 5 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: GK-12: Teaching the Sciences in Everyday Life

Source of Support: NSF
Total Award Amount: $1,549,477 Total Award Period Covered: 06/01/02 – 05/31/06
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Innovation Incubator: Flaming the Sparks of Creativity

Source of Support: NSF
Total Award Amount: $499,657 Total Award Period Covered: 02/01/02 – 01/31/05
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: MRSEC: Center for Semiconductor Physics in Nanostructures

Source of Support: University of Oklahoma
Total Award Amount: $2,170,000 Total Award Period Covered: 09/01/000 – 08/31/2005
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Reconfigurable Waveguides Using Spatial Solitons in AlGaAs

Source of Support: NSF

Total Award Amount: $21,000 Total Award Period Covered: 05/21/00 – 04/30/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MURI: Solitonic Gateless Computing

Source of Support: University of Central Florida (DoD Flow-Through)

Total Award Amount: $796,901 Total Award Period Covered: 05/04/00 – 04/29/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: IGERT: A new Era in Electronics Education

Source of Support: NSF

Total Award Amount: $2,439,786 Total Award Period Covered: 08/01/99 – 07/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: M.B. Santos (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: InSb Heterostructures for Spin and Quantum Confinement Experiments (PI: M.B. Santos, Co-PIs: R.E. Doezema and S. Murphy)

Source of Support: NSF

Total Award Amount: $ 628,495 Total Award Period Covered: 7-1-05 to 6-31-08

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Acquisition of Fourier Transform Infrared Spectrometer for Research and Education on Spintronics and Semiconductor Nanostructures (PI: M.B. Santos, Co-PI: R.E. Doezema)

Source of Support: NSF

Total Award Amount: $91,000 Total Award Period Covered: 8-1-04 to 7-15-05

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Spin and Other Electronic Properties of InSb Quantum Wells (PI: M.B. Santos, Co-PIs: R.E. Doezema and S. Murphy)

Source of Support: NSF

Total Award Amount: $453,000 Total Award Period Covered: 7-15-02 to 6-30-05

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRSEC: Center for Semiconductor Physics in Nanostructures (16 senior investigators)

Source of Support: NSF

Total Award Amount: $4,500,000 Total Award Period Covered: 9-1-00 to 3-31-05

Location of Project: University of Arkansas and University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Zhisheng Shi

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NOVEL TUNABLE LEAD SALT MID-INFRARED DIODE LASERS

Source of Support: DoD DEPSCoR

Total Award Amount: $451,694 Total Award Period Covered: 6/1/04 – 5/31/07

Location of Project: University of Oklahoma

Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: High Temperature Mid-Infrared Microcavity Light Emitting Devices

Source of Support: ARO

Total Award Amount: $315,073 Total Award Period Covered: 10/1/03 – 9/30/06

Location of Project:

Person-Months Per Year Committed to the Project. Cal: 2 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Surendra Singh

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers
Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11
Location of Project: University of Oklahoma and University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Quantum and chaotic dynamics in nonlinear optics

Source of Support: NSF
Total Award Amount: $378,903 Total Award Period Covered: 06/01/05 – 05/31/08
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: 2.25 Sumr: 2.00

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Investigations of phase and polarization properties of optical beams

Source of Support: NASA
Total Award Amount: $20,500 Total Award Period Covered: 02/01/05 – 01/31/06
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator**: Gay Stewart** (1 of 22 Scientists)	Other agencies (including NSF) to which this proposal has

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $ 9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Cal: 0 Acad: 0 Sumr: 0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Rural PTRA Site

Source of Support: NSF-subaward from American Association of Physics Teachers

Total Award Amount: $ cost Total Award Period Covered: 06/01/05-05/31/07

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Cal: 0.5 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Physics Teacher Education Coalition

Source of Support: American Physical Society (Subaward from NSF and FIPSE)

Total Award Amount: $ 450,000 Total Award Period Covered: 08/15/01-08/14/07

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Cal: 1.5 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Cal: Acad: Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Z. R. Tian (One of 22 Scientists) tuian

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current x Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Integrating Nanostructured Thin-Films for Real-time, Selective, Label- and Reagent-Free Zeptomolar Biosensing

Source of Support: DIA-MASINT

Total Award Amount: $139,939 Total Award Period Covered: FY2005

Location of Project: UA

Person-Months Per Year Committed to the Project. 12 Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending xSubmission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Hierarchical syntheses of ordered and oriented 3D catalytic nanostructures

Source of Support: **Experimental Program to Stimulate Competitive Research (EPSCoR); Building EPSCoR-State/National**

Total Award Amount: $120,000 Total Award Period Covered: FY 2005

Location of Project: UA, Sandia National Labs, and Argonne National Lab

Person-Months Per Year Committed to the Project. 12 Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Ken Vickers**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: NSF through University of Oklahoma

Total Award Amount: $ 2,170,000 Total Award Period Covered: 09/01/00 – 08/31/05

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: GK-12: Inquiry and Innovative Thinking by Design

Source of Support: NSF

Total Award Amount: $ 1,549,477 Total Award Period Covered: 06/01/01 – 05/31/06

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Revitalizing Undergraduate Engineering – A Holistic Approach

Source of Support: NSF

Total Award Amount: $ 100,000 Total Award Period Covered: 09/01/03 – 08/31/05

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.12 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Undergraduate Research on Nanodevices REU Site

Source of Support: NSF

Total Award Amount: $ 625,000 Total Award Period Covered: 03/15/04 – 02/28/09

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Ken Vickers**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: PFI: Building a Pathway Connecting Innovation to Commercialization

Source of Support: NSF

Total Award Amount: $ 600,000 Total Award Period Covered: 10/15/04 – 09/30/07

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: Sumr:

Support: ☐ Current ☐ Pending ☒ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: IGERT: A Pilot Program to Attract Under Represented Group Students into the Ph.D. Path

Source of Support: NSF

Total Award Amount: $ 3,200,000 Total Award Period Covered: 06/01/06 – 05/31/11

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRI: Development of In-situ Sensors for Molecular Beam Epitaxial Growth of III-Nitride Nanostructures

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 0.25 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: IGERT: A NEW ERA IN ELECTRONICS EDUCATION – Fellowships for Students

Source of Support:

Total Award Amount: $ 2,320,175 Total Award Period Covered: 07/01/99 – 07/31/05

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: 1.5 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project: University of Arkansas, Fayetteville

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Min Xiao (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures (current proposal)

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Novel Nonlinear Dynamic and Quantum Statistical Effects in Multi-Level Atomic Systems and Semiconductor Nanostructures

Source of Support: NSF

Total Award Amount: $338,201 Total Award Period Covered: 06/01/04—05/31/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Enhancing Nonlinear Optical Processes at Low Light Level with Atomic Coherence

Source of Support: NSF

Total Award Amount: $290,070 Total Award Period Covered: 09/01/01—08/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

REU Supplement: Enhancing Nonlinear Optical Processes at Low Light Level with Atomic Coherence

Source of Support: NSF

Total Award Amount: $10,000 Total Award Period Covered: 07/01/03—08/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Laser Tweezers for Manipulation of Single Cells

Source of Support: Arkansas Biosciences Institute

Total Award Amount: $28,000 Total Award Period Covered: 07/01/04—6/15/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Min Xiao

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

A New Era in Ferroelectrics: Nano-Structures & Devices (PI: G. Salamo; Xiao's share $50,000 per year)

Source of Support: Army Research Laboratory

Total Award Amount: $4.0 M Total Award Period Covered: 06/19/03—06/18/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Quantum Information Processing in Multi-Level Electromagnetically Induced Transparency Systems

Source of Support: NSF

Total Award Amount: $357,051 Total Award Period Covered: 07/01/05—06/30/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Low-Power, Ultrafast Optical Switches Based on Coherence Optical Effects in Arrayed Semiconductor Nanostructures

Source of Support: DoD/DEPSCoR: ARO

Total Award Amount: $466,326 Total Award Period Covered: 06/01/05—05/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

NIRT: Ferroelectric nanomaterials and devices (PI: H. Fu)

Source of Support: NSF

Total Award Amount: $1,106,607 Total Award Period Covered: 8/01/2005—7/31/2009

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

NER: Building Efficient Nanoscale All-Optical Switches with Engineered Semiconductor Nanostructures

Source of Support: NSF

Total Award Amount: $119,438 Total Award Period Covered: 7/1/05—6/31/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: X. Xie (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Spin and charge transport in low-dimensional systems

Source of Support: DOE

Total Award Amount: $180,000 Total Award Period Covered: 2004-2006

Location of Project: Oklahoma State University

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Wai Tak Yip | Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR – Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Probing Layer-By-Layer Structural Variations in Polyelectrolyte Multilayer Films

Source of Support: CHE – Analytical and Surface Chemistry

Total Award Amount: $485,768 Total Award Period Covered: 08/01/05 – 07/31/08

Location of Project: University of Oklahoma – Norman Campus

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A Generic Silica Sol-Gel Bio-Encapsulation for Sensor Development

Source of Support: CHE – Approach to Combat Terrorism

Total Award Amount: $200,000 Total Award Period Covered: 10/01/04 – 09/30/06

Location of Project: University of Oklahoma – Norman Campus

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 2.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: The Development of Protein/Sol-gel Composite Biosensors

Source of Support: Oklahoma Center for the Advancement of Science & Technology

Total Award Amount: $135,000 Total Award Period Covered: 07/01/03 – 06/30/06

Location of Project: University of Oklahoma – Norman Campus

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support
(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Min Zou** (One of 22 Scientists)

Other agencies (including NSF) to which this proposal has

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Center for Semiconductor Physics in Nanostructures (This proposal)

Source of Support: DMR – Materials Research Science and Engineering Centers
Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 – 08/31/11
Location of Project: University of Oklahoma and University of Arkansas
Person-Months Per Year Committed to the Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Fabrication and Characterization of Patterned Silicon Nanowires

Source of Support: NSF
Total Award Amount: $283,704 Total Award Period Covered: 06/01/05 – 05/31/08
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Cal: Acad: Sumr: 1

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: NER: Exploration of a Nano-engineered Flagellar Motor Based TNT Detection System

Source of Support: NSF
Total Award Amount: $159,680 Total Award Period Covered: 05/01/2005 – 04/30/2006
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Cal: Acad: Sumr: 1

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Nano-textured Surface for Tribological Applications in Miniature Systems

Source of Support: NSF
Total Award Amount: $293,871 Total Award Period Covered: 07/01/05 – 06/30/08
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Cal: Acad: Sumr: 1

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Center for Semiconductor Physics in Nanostructures

Source of Support: DMR ñ Materials Research Science and Engineering Centers

Total Award Amount: $9,802,158 Total Award Period Covered: 09/01/05 ñ 08/31/11

Location of Project: University of Oklahoma and University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 1.0 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIRT: Ferroelectric Nanomaterials and Devices

Source of Support: NSF

Total Award Amount: $1,247,992 Total Award Period Covered: 08/01/05 ñ 07/31/09

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIRT: Multifunctional Semiconductor Quantum Structures

Source of Support: NSF

Total Award Amount: $1,285,539 Total Award Period Covered: 06/01/05 ñ 05/31/09

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Infrared Applications of III-V Semiconductor Nanostructures

Source of Support: AFOSR (DOD DEPSCoR)

Total Award Amount: $668,626 Total Award Period Covered: 06/01/05 ñ 05/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: III-V Semiconductor Nanostructures for Infrared Detectors

Source of Support: NSF

Total Award Amount: $415,534 Total Award Period Covered: 05/01/05 ñ 04/30/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0. 5 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Cooperative Activity in Materials Research: Behavior of Organized Quantum Dot and/or Wire Arrays

Source of Support: NSF

Total Award Amount: $119,103 Total Award Period Covered: 04/01/05 ñ 03/31/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIRT: GOALI ñ Development of Nano Electronchemical Machining (Nano-ECM) for Advanced Biomedical Manufacturing

Source of Support: NSF

Total Award Amount: $1,686,280 Total Award Period Covered: 04/01/05 ñ 03/31/09

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Building a Pathway Connecting Innovation to Commercialization

Source of Support: NSF

Total Award Amount: $600,000 Total Award Period Covered: 10/15/04 ñ 09/30/07

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Laser Tweezers for Manipulation of Single Cells

Source of Support: Arkansas Biosciences Institute

Total Award Amount: $28,000 Total Award Period Covered: 06/01/04 ñ 05/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: URC: Studio Concept to Enable Students to Uncover the Rules of Nature at the Small Scale

Source of Support: NSF

Total Award Amount: $50,000 Total Award Period Covered: 06/01/04 ñ 05/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Developing Nitride Material and Optical Devices I

Source of Support: Oklahoma State University
Total Award Amount: $184,938 Total Award Period Covered: 04/01/04 ñ 12/31/05
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: .05

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Developing nitride Material and Optical Devices II

Source of Support: Oklahoma State University
Total Award Amount: $105,939 Total Award Period Covered: 04/01/04 ñ 12/31/05
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.42 Sumr: 0.5

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: REU Site: University Undergraduate Research in Nanodevices

Source of Support: NSF
Total Award Amount: $125,000 Total Award Period Covered: 03/15/04 ñ 02/28/08
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Arkansas EPSCoR Research Infrastructure

Source of Support: NSF EPSCoR
Total Award Amount: $2,082,250 Total Award Period Covered: 11/15/03 ñ 10/31/05
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: Spatial Solitons

Source of Support: US-Israel Binational Science Foundation
Total Award Amount: $23,275 Total Award Period Covered: 10/01/03 ñ 09/30/05
Location of Project: University of Arkansas
Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Spatial Solitons and Their Applications

Source of Support: NSF

Total Award Amount: 358,096 Total Award Period Covered: 08/15/03 ñ 07/31/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A New Era in Ferroelectrics: Nanostructures and Devices

Source of Support: U.S. Army Research Laboratory

Total Award Amount: $3,000,000 Total Award Period Covered: 06/19/03 ñ 06/18/08

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0. 5 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: GK-12: Teaching the Sciences in Everyday Life

Source of Support: NSF

Total Award Amount: $1,549,477 Total Award Period Covered: 06/01/02 ñ 05/31/06

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Innovation Incubator: Flaming the Sparks of Creativity

Source of Support: NSF

Total Award Amount: $499,657 Total Award Period Covered: 02/01/02 ñ 01/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MRSEC: Center for Semiconductor Physics in Nanostructures

Source of Support: University of Oklahoma

Total Award Amount: $2,170,000 Total Award Period Covered: 09/01/000 ñ 08/31/2005

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Greg Salamo	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Reconfigurable Waveguides Using Spatial Solitons in AlGaAs

Source of Support: NSF

Total Award Amount: $21,000 Total Award Period Covered: 05/21/00 ñ 04/30/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.25 Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: MURI: Solitonic Gateless Computing

Source of Support: University of Central Florida (DoD Flow-Through)

Total Award Amount: $796,901 Total Award Period Covered: 05/04/00 ñ 04/29/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: IGERT: A new Era in Electronics Education

Source of Support: NSF

Total Award Amount: $2,439,786 Total Award Period Covered: 08/01/99 ñ 07/31/05

Location of Project: University of Arkansas

Person-Months Per Year Committed to the Project. Cal: Acad: 0.5 Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

4.E.3 Shared Experimental Facilities

Over the past five years the Universities of Oklahoma and Arkansas have made an investment in developing interdisciplinary research in nanoscience. For example, they hired two new faculty members, provided matching funds for equipment proposals, prepared new and renovated space, supported technicians, and provided fellowships for graduate students. Such support has been essential since addressing the goals of the Center requires an extensive array of equipment and manpower supporting molecular beam epitaxy, colloidal synthesis, electron and scanning tunneling microscopes, fabrication clean rooms, etc. that must be available to all researchers.

The table below lists the shared experimental facilities. The growth facilities at both institutions are central to many of the proposed collaborative experiments. The complementary arrays of structural characterization tools and set-ups for transport and optical experiments are used to study samples grown at both institutions. The Semiconductor Physics Fabrication Facility (SPiFF) at OU and the High Density Electronics Center (HiDEC) at UA are available to both internal and external users on a fee use basis.

While the Center is well equipped, there will be an immediate impact made by adding pieces of equipment critical for the proposed pursuits. At OU for example, a multi-user MBE system will be augmented, as will several pieces of equipment within the recently established SPiFF. Similarly, upgrades will be made to various chambers of the UA multi-user MBE system. The pieces of equipment to be purchased with NSF and matching funds are listed in italics in the table below.

As part of the matching commitment, OU and UA are **each providing a new full-time technical staff position**. The OU staff member will assist CSPIN participants with electron beam lithography and other fabrication processes available within SPiFF. The UA staff member will maintain existing optical equipment and help develop new optical facilities that are focused on exploring quantum dot and ring arrays and ferroelectric nanostructures.

University of Oklahoma (OU)	**University of Arkansas (UA)**
Growth : MBE #1: IV-VI (Pb, Eu, Se, Te) and Ba/CaF_2 MBE #2: III-V InSb related (In, Ga, Al; and Sb, As) *Add As and Sb valved crackers.* Electron beam evaporator, field ion source Auger Electron Spectroscopy and X-ray Photoemission Spectroscopy with depth profiling AFM/STM	**Growth:** MBE #1: III-V AlGaIn AsP MBE #2: III-V AlGaIn As *Add atomic H source and AsB_3 source* MBE #3: Ferroelectrics Electron beam evaporator, ion etcher AFM/STM: *Add Electric Field Sensitive SPM head.* SIAM, Low-Temperature STM/NSOM
Characterization: High Resolution TEM and SEM *Add field-emission (FE) TEM and SEM* *Add Precision Ion Polishing System* In-Air AFM/STM with MFM head Room-Temperature STM/STL: *Add liquid He capability*.	**Characterization:** TEM, Environmental SEM SQUID Magnetometer, Nuclear Magnetic Resonance, Confocal Microscope, Raman Spectroscopy *Add UV-Vis-IR spectrophotometer*
Common to both institutions: X-ray Diffractometers: high resolution and low angle systems, Optical Microscopy, Hall Effect System, FTIR and Photoluminescence	
Transport: ^{3}He and ^{4}He cryostats with B up 9T **Optical Spectroscopy:** Photoluminescence (0.2 to 5 μm) UV-Vis spectrophotometer ^{4}He cryostat with FIR laser for cyclotron resonance	**Transport:** *Add Spectrum Analyzer for noise measurements* **Optical Spectroscopy:** CW/Pulsed Lasers (0.4 to 16 μm), time-resolved spectroscopy: *Add various systems to enhance polarization, photon counting and UV capabilities.*
SPiFF: III-V Processing Facility Photolithography, oxide/metal deposition, Reactive Ion Etcher and ball bonder. *Add electron beam evaporator, Plasma Enhanced CVD, electron beam lithography.*	**HiDEC: 5"- Multichip Module (MCM) Facility** Wide range of deposition and characterization techniques.

UNIVERSITY of ARKANSAS
1871

Office of the Chancellor

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January 20, 2005

Dr. Ulrich Strom
Program Director
Materials Research Science and Engineering Centers
Division of Materials Research
National Science Foundation
4201 Wilson Blvd., Suite 585
Arlington, VA 22230

Dear Dr. Strom:

I am writing to convey my full support for a proposal to continue the development of a Materials Research Science and Engineering Center on the subject of Semiconductor Physics in Nanostructures. The proposed MRSEC is a collaboration between the University of Arkansas and the University of Oklahoma. Under prior MRSEC support the research team has collaborated successfully and achieved significant progress towards the Center's goal of growing novel nanostructures and understanding their underlying optical and electronic properties. One tangible measure of the research productivity of the Center is having 196 manuscripts published by faculty supported by the Center in such publications as *Physical Review Letters*, *Nature*, and *Science*.

While the Center has been incredibly successful in discovery, I believe its greatest impact has been on the transformative effect it has had on our campus. The Center serves as a model of interdisciplinary research and education. The faculty supported by the Center are among the most successful integrated scholars at the University. From the Center, a new interdisciplinary Ph.D program has been established; it currently enrolls more than 50 graduate students in at least 10 different academic disciplines. Additionally, it is the most diverse academic program at the University when measured by gender and race/ethnicity. It has also played a major role in creating an entrepreneurial cultural on the campus, having spun off three companies.

Clearly, the Center provides a strong attraction for excellent new students and faculty. An essential reason for its success is the strong leadership provided by Dr. Greg Salamo. Plus, the

faculty who are actively involved in the Center are broadly recognized among the "best and brightest" at the University of Arkansas. Coupling the human resources with our unique nanotechnology facilities, the international collaborations that exist, and the Center's programs aimed at K-12 and undergraduate students, it is not surprising to find the strong impact it has had on our graduate students. Working in the Center results in a deeper interest in and understanding of science for our students; it also gives them a greater understanding of the opportunities and responsibilities of being a scientist.

Drawing on the talents of our very best faculty and students, the MRSEC addresses three of the seven focus areas of our university – nanoscience, optical communications, and advanced materials. The long-term goal is for the University of Arkansas and the University of Oklahoma to become national resources in mid-America in these three critical subject areas.

As you might surmise, I am very proud of the accomplishments of the Center. I am especially pleased with the successful collaboration with our neighbor, the State of Oklahoma, and sister institution, the University of Oklahoma. In fact, I would challenge any other set of institutions to match the research productivity, commitment to diversity, and outreach success of the MRSEC you have supported at the University of Arkansas and the University of Oklahoma.

The National Science Foundation has a rich portfolio of programs. Many appear to be aimed at making strong research scientists and engineers even stronger; others seem to have as their goal broadening and strengthening the nation's research capacity; and still others are focused on enriching the pipeline. No doubt, the MRSEC program has multiple goals.

Based on the impact the initial MRSEC funding had on the University of Arkansas, it is clear that the pipeline is being enriched and the nation's research capacity has been expanded. In addition, the University of Arkansas' strongest researchers have been made stronger through the support of the National Science Foundation. By any measure, NSF's investment is yielding incredible returns for the State of Arkansas and the nation. Largely due to NSF's support, The University of Arkansas is rapidly emerging as a national competitive research university. Several "centers of excellence" are viewed externally as world class in their areas.

Due to the strategic significance of nanostructures to our vision for the University of Arkansas, the proposed MRSEC has the full support of Governor Mike Huckabee, Dr. B. Alan Sugg, President of the University of Arkansas System, and myself. I am confident that with state and

Dr. Ulrich Strom
January 20, 2005
Page 3

NSF support the proposed MRSEC will continue to be the brightest of our crown jewels and will accelerate our emergence as a nationally competitive research university.

Although our resources are quite limited in comparison with our national peers, because of the strategic significance of the MRSEC and the need for resources that exceed what the National Science Foundation can provide, we will to commit to matching NSF's investment one-for-two. In addition, we will commit the University to hiring one new technician in the area of optics and nanotechnology to support the Center and make substantial investments in equipment Fortunately, we are not starting from scratch, since approximately $10 million has already been invested in fabrication and analytical equipment in our Molecular Beam Epitaxy, Colloidal Growth, Atomic Imaging Laboratory, and our Laser Facilities.

In closing, thank you for the support you have provided to date to the University of Arkansas and the MRSEC. Your continued support is critical to the future of the two universities and to the states and region we serve. If you have any questions regarding the proposal, or if I may be of further assistance in your decision making process, please do not hesitate to contact me.

Very truly yours,

John A. White
Chancellor

The University of Oklahoma

OFFICE OF THE PRESIDENT
January 21, 2005

Program Director
Materials Research Science and Engineering Centers
Division of Materials Research
National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230

Dear Director:

The University of Oklahoma is excited to have been selected to prepare a full proposal for a NSF Materials Research Science and Engineering Center in collaboration with the University of Arkansas. In this letter I outline the very strong commitment that the University has made to materials science research and education and to this proposal, as well as the strong record on research and education established with our currently funded center.

There are ten University of Oklahoma faculty participating in this re-competing MRSEC proposal entitled, "Center for Semiconductor Physics in Nanostructures." Two faculty members are from our School of Electrical and Computer Engineering, seven are from our Department of Physics and Astronomy and one is from Chemistry and Biochemistry. This OU component of the MRSEC started with the interdisciplinary Laboratory for Electronic Properties or Materials (LEPM), which was initiated in 1991 with funding through the NSF EPSCoR program. The University and the Oklahoma State Regents have contributed substantial funding, as cost sharing and as new positions, since the inception of LEPM. Our efforts have paid off in the quality of our faculty and of the added world-class infrastructure. We are particularly proud of the success of the current MRSEC regarding their large scientific output, as well as the strong collaborative ties within OU and ties to the University of Arkansas.

The semiconductor group in the Department of Physics and Astronomy is also a beneficiary of the University's current and planned steps to enlarge and improve the building which houses this dynamic department. In the recent past a $4.8M addition containing two lecture halls was completed and this spring a $5.3M second addition (including some renovation of the original building) will be completed. It, together with the planned complete renovation of the original building, will assure first-class research space for the Department's future expansion.

For this re-competing proposal the University of Oklahoma and the Oklahoma State Regents have targeted $1.368M as match. Additional evidence of the University's long-term commitment is provided by the technician line promised by the Vice President for Research if the proposal is funded. These new commitments of support, in addition to our strong support in the past of this outstanding group of faculty are evidence of the University's dedication to promoting materials science research in Oklahoma.

Sincerely,

David L. Boren
President

660 Parrington Oval, Room 110, Norman, Oklahoma 73019-0390 (405) 325-3916, FAX (405) 325-7605

ARKANSAS SCIENCE & TECHNOLOGY AUTHORITY

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January 21, 2005

Gregory J. Salamo, Ph.D.
Physics Professor
University of Arkansas
Physics Department
Fayetteville, Arkansas 72701

Dear Dr. Salamo:

This is a letter of support for the Center for Semiconductor Physics in Nanostructures and for the renewal of funding from the National Science Foundation for this collaborative effort between the University of Arkansas and the University of Oklahoma. The advances made by NSF's Arkansas/Oklahoma Materials Research Science and Engineering Center in basic science – and their potential in commercial applications – are significant and should be continued. Supporting your effort fits nicely with the mission and strategic plan of the Arkansas Science & Technology Authority, and also with the Research and Development Plan adopted by the Authority's Board of Directors. Furthermore, I have benefited from my association with CSPIN and look forward to continuing that relationship under the renewal.

You and I have previously discussed the significance of a MRSEC to Arkansas in terms of research infrastructure and support of the knowledge-based economy in Arkansas. The presence of this Center has contributed to the Authority's understanding of the importance of nanostructures and has enabled our staff to do things that we otherwise might not have been able to do. One example is that CSPIN propelled the effort to plan a statewide research and development network in Arkansas, with one significant point being the linkage between research and entrepreneurship.

I am again pleased – as I was in 2000 – to accept your invitation to serve on CSPIN's External Review Board. Such involvement affords the opportunity to interact with the Center's faculty and students, which is always an enriching experience. I also enjoy working with colleagues from Oklahoma – a sister state in the Southern Growth Policies Board region – with whom I serve on the Southern Technology Council.

In 2000, I wrote a letter of support for CSPIN and stated that the Center's proposal was important. It is now clear that the Center significantly contributes to the metrics that we use to measure Arkansas' performance in the 21st Century economy; the Center influences federal research and development funding, the creation of intellectual property, and the preparation of scientists and engineers in the workforce.

Thank you for the leadership you provide to this effort and for giving me the opportunity to be a part of this important work. If I can provide anything else to support renewal of the MRSEC proposal, please let me know.

Sincerely,

John W. Ahlen

John W. Ahlen, Ph.D.
President

OCAST

OKLAHOMA CENTER FOR THE ADVANCEMENT OF SCIENCE AND TECHNOLOGY

January 20, 2005

Professor Matthew B. Johnson
Department of Physics and Astronomy
The University of Oklahoma
440 West Brooks Street
Norman OK 73019-0225

Dear Matthew:

I am excited that you and your colleagues at both the University of Oklahoma and the University of Arkansas have been invited to re-compete at the full proposal stage for a continuation of a NSF Materials Research Science and Education grant. And I am pleased to keep an OCAST presence associated with the Center for Semiconductor Physics in Nanostructures (C-SPIN).

The progress that has been made at both universities is very impressive. The "critical mass" of personnel is in place and the cooperative arrangement will produce more excellent results in this very important area of science and engineering. I understand that this materials research science and engineering center will provide much of the semiconductor talent of Oklahoma and Arkansas with a value added opportunity and the possibility of increased collaboration with industry in the region and nationally.

I am also pleased that you are considering a broad approach to educational outreach within the states and will build on programs such as the National Science Foundation funded Lewis Stokes Alliance for Minority Participation effort in Oklahoma. The number of underrepresented minorities in both states is significant and the ability to channel young people with talent, who happen to be underrepresented minorities, in the direction of materials science, especially nanostructures, is very important. I am particularly excited about the impact of this center on education, research, and industrial participation. Of course, one lasting outcome will be the education of Oklahoma students in high tech research. This will be a key for future growth of high tech industry in Oklahoma which, as you know, is one of the goals of the Oklahoma Center for the Advancement of Science and Technology program. I look forward to the possibility of OCAST and SBIR proposals based on applied or device aspects of this work.

I am certainly an enthusiastic supporter of the proposal and look forward to working with you over the long term. I look forward to the role of OCAST and to joining the Board of Visitors for C-SPIN.

Sincerely,

Sherilyn Stickley
Interim Executive Director

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SPACE PHOTONICS

Jan. 21, 2005

Professor Greg Salamo
Dept. of Physics
Univ. of Arkansas
Fayetteville, AR 72701

Dear Dr. Salamo,

I am very happy to hear that the Oklahoma-Arkansas proposal for a material research science and engineering center or MRSEC was selected for the next level of competition. I want to offer my strongest possible endorsement and support for your program and I am looking forward to participating in the center's activities.

Our company is actively involved in developing optical communications products for a wide range of markets, specifically advanced components for high speed optical communications on board aircraft and spacecraft. Access to research that will be carried out at the MRSEC and our relationship with you and the University is essential in our endeavor to maintain a leading edge in advanced communications technologies.

I look forward to the continued success of the MRSEC, and to working with you in this challenging and exciting area.

Sincerely,

Chuck Chalfant
President/CEO
Space Photonics, Inc.

Chuck Chalfant, President/CEO
(479) 575-5221 phone
www.spacephotonics.com

700 Research Center Blvd.
Fayetteville, AR 72701
(479) 575-7446 fax

femto-st
sciences & technologies

DEPARTEMENT D'OPTIQUE P.M. DUFFIEUX

Besançon, January, 21, 2005.

Dear Greg,

To now our international partnership has been very fruitful. Indeed during the last 5 years we have been able to establish efficient joint research programs between our labs. It has first been possible thanks to the funding we obtained from our respective national foundation for science, namely NSF for USA and CNRS for France. This award essentially made for travel between the Département d'Optique from the FEMTO-ST Institute at the Université of Franche-Comté and the Physics Department at the University of Arkansas has facilitated numerous exchanges for students and faculties. Most of the work realized inside these joint international programs would not have been successfully achieved without the creation of the Oklahoma-Arkansas NSF-MRSEC center. The unique molecular beam epitaxy (MBE) facility present in this center especially opened up greater opportunity between us.

I hope this collaboration between our respective labs can continue and even be reinforced in the future. The work realized toward the development of ultra-fast reconfigurable optical interconnects still needs developments. In addition new concepts for realization of pioneering 3-D integrated optical circuits using spatial solitons are emerging. These projects would benefit from the complimenting talents of both teams. That is the extensive experience in the study of nonlinear optical properties of the French team and the Oklahoma/Arkansas know-how in waveguide growth by MBE and structure characterization.

Our future work will focus on semiconductor compound and structures exhibiting enhanced nonlinear properties. One project consists in growing waveguides with embedded quantum dots and quantifying their Kerr optical properties. Another project aim at studying the semi-insulating CdTe II-VI compound in order to reveal strong nonlinear photorefractive properties near the band edge. Both these projects aspire to find nonlinear material suitable for realization of all optical components. But achievement necessitates equipment and expertise from both the French and American labs. I hope prolongation of the MRSEC proposal will be approved unless it would jeopardize our promising projects.

Mathieu Chauvet

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January 20, 2005

Program Director
Materials Research Science and Engineering Centers
Division of Materials Science
National Science Foundation
4201 Wilson Blvd.
Arlington, VA 22230 USA

Dear Program Director:

This letter expresses my intention to continue collaborating with the Center for Semiconductor Physics in Nanostructures on studies of mesoscopic narrow gap systems. All the necessary resources for fabricating and studying narrow gap structures are available in our laboratories or those of the Center. Since 2002, three students from Oklahoma have visited our institute for ~10 weeks each. The funding for most of their travel and living costs was provided by an AWARE supplement to the NSF MRSEC grant. We worked with the students on the fabrication of mesoscopic InSb devices and on low-temperature experiments that study bend resistance and quantized conductance. We have recently begun experiments on structures for ballistic electron focusing and single electron tunneling. We are excited about the scientific opportunities that will be enabled by a renewal of the MRSEC project.

The mission of NTT Basic Research Laboratories is to seek new concepts, knowledge, and scientific results in the fields of device physics, materials science, quantum optics/optical materials and quantum electron physics. We believe that basic research benefits from communication and cooperation with other researchers and other laboratories, both in Japan and abroad. We look forward to continuing the collaboration with the Center for Semiconductor Physics in Nanostructures on the study of mesoscopic structures fabricated from narrow gap semiconductors.

Sincerely,

Dr. Yoshiro Hirayama
Executive Manager, Physical Science Laboratory
Group Leader, Quantum Solid State Physics Research Group
NTT Basic Research Laboratories