Electric Field in Hot Carrier Solar Cells

By Tanner Legvold with Dr. Sellers' group

Current State

- Solar cells efficiencies are currently stuck at the Shockley-Queisser limit, which is about 33%
- Primary loss mechanisms are thermalization and lack of absorption
- **Hot carrier solar cells reduce the rate of thermalization without sacrificing absorption**

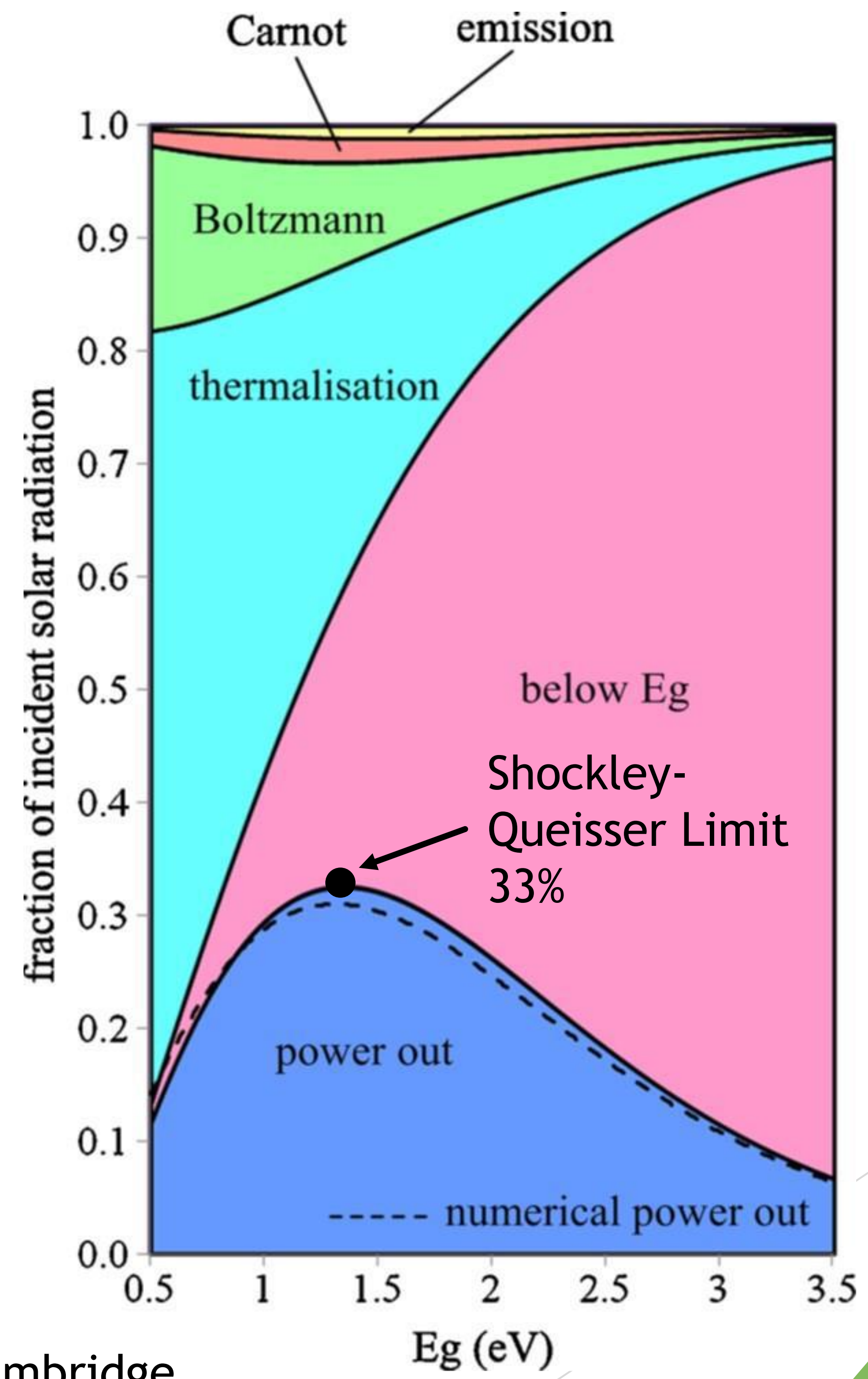
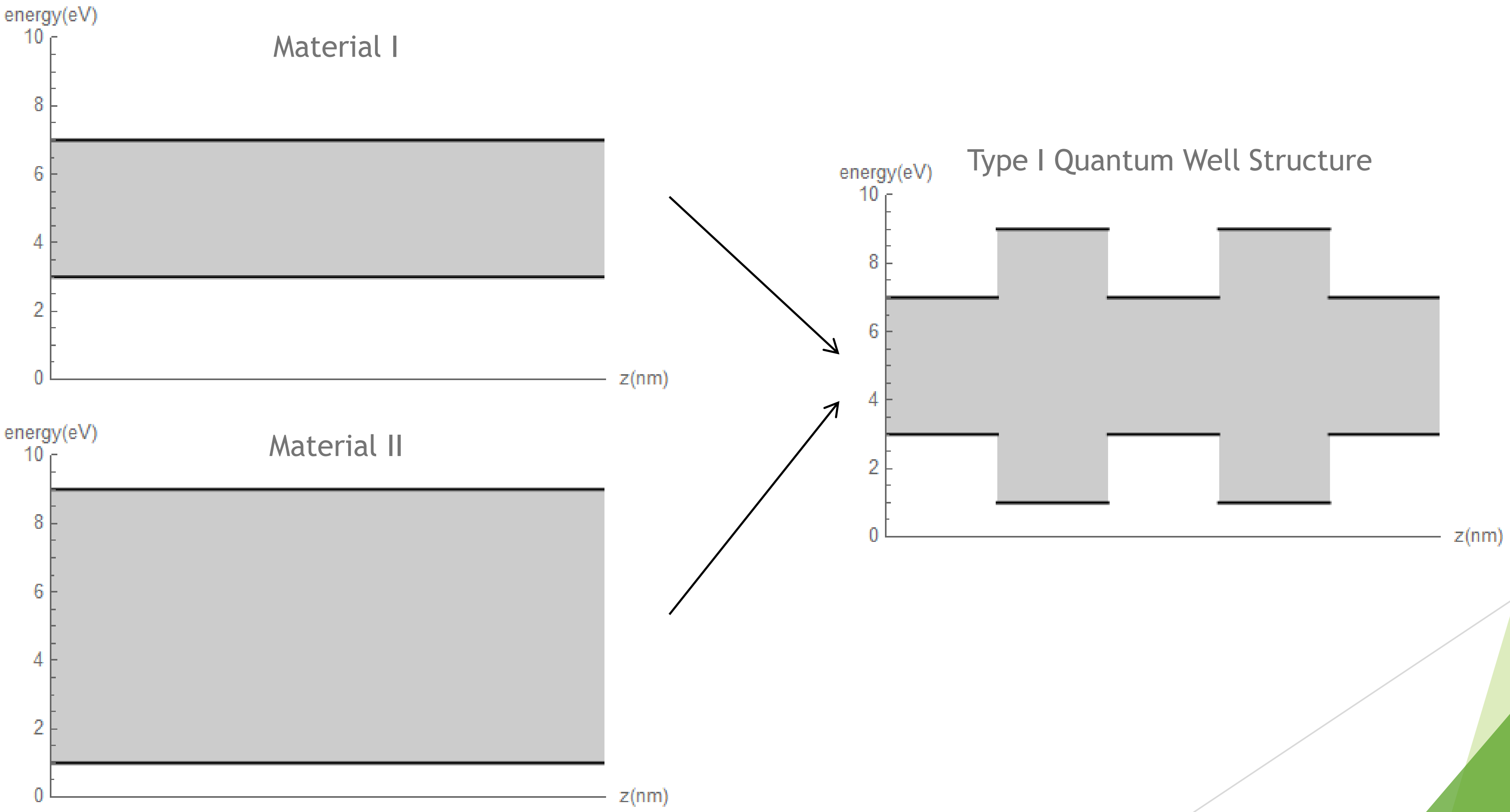


Image credit: Louise Hirst, University of Cambridge

Band Structure Diagrams

- To understand what is special about hot carrier solar cells, we need a basic knowledge of the "band structure" of a semiconductor device



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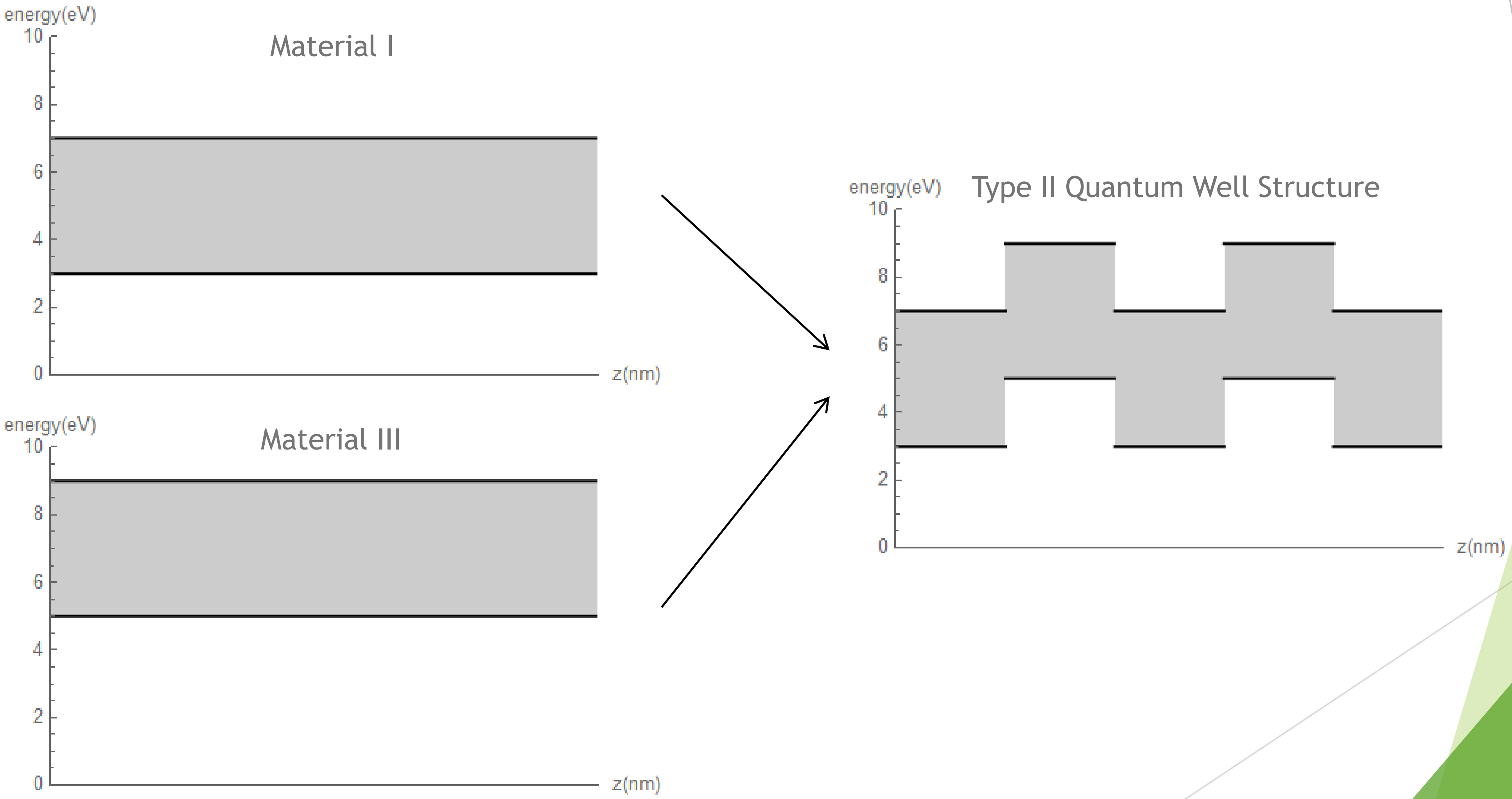
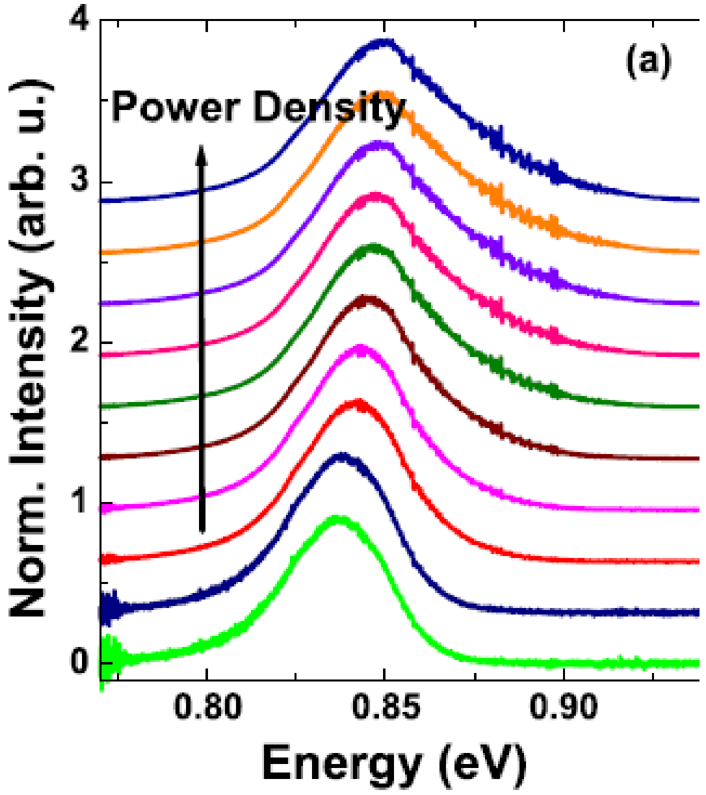
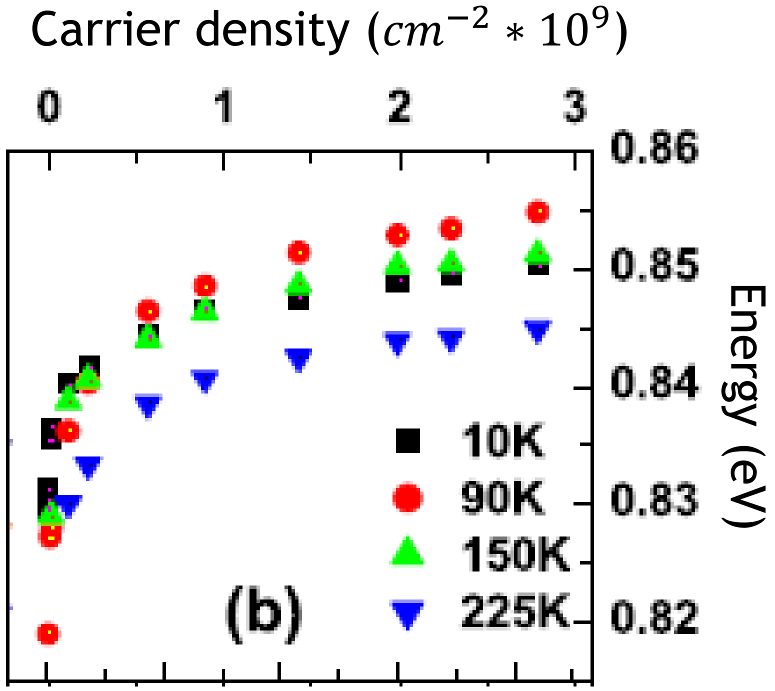


Blueshift emission in Type-II Quantum Wells



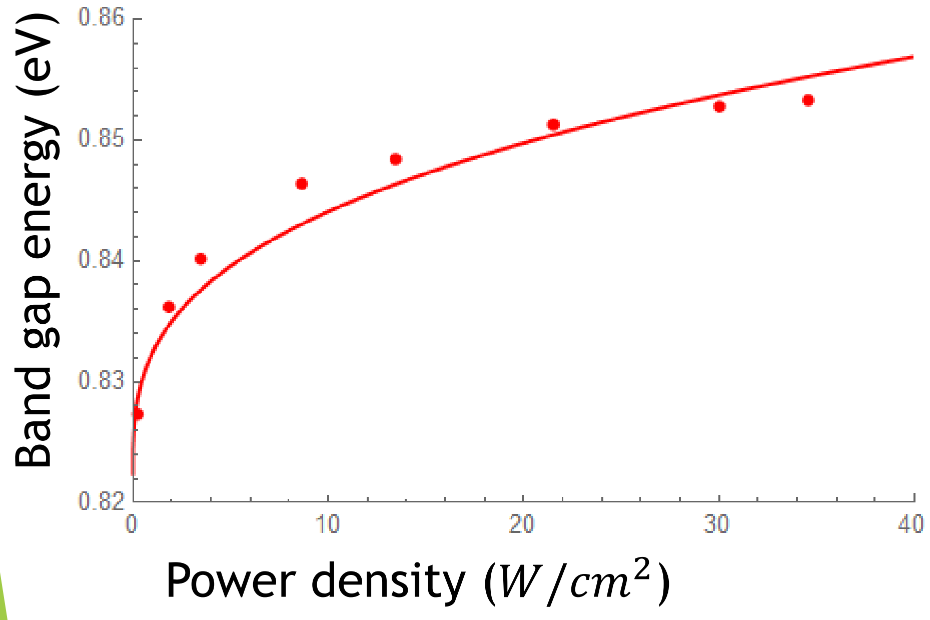


- The blueshift in emitted light is due to the electric field changing the band structure itself (widening the band gap)

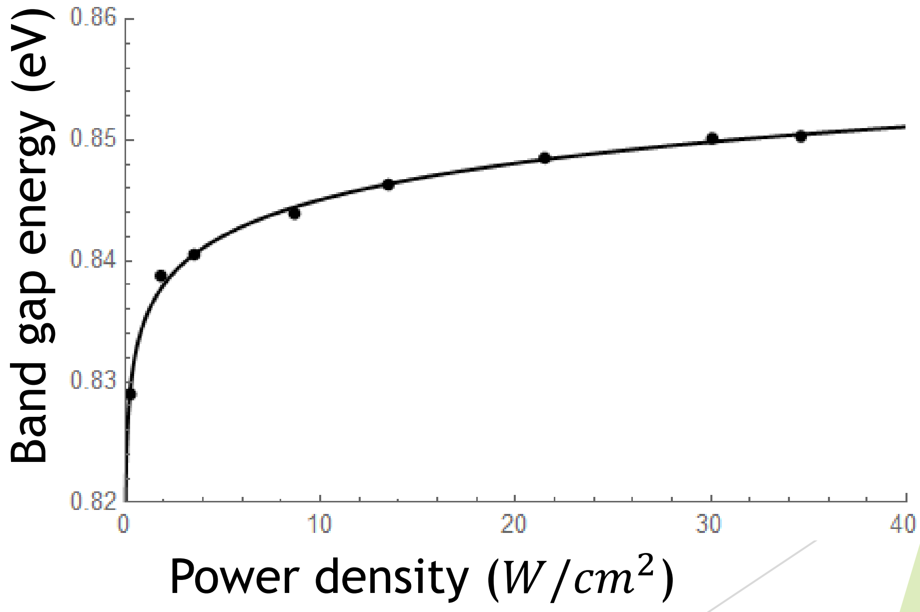
Image credit: [1]

Localization of Carriers

- There are many small impurities at the atomic scale in these materials. These cause localization of electrons which causes a “Type-II” dependence at low temperatures. This is drowned out at higher temperatures, becoming “Type-I”
- We believe the electric field produced by the carriers themselves may be causing more electrons to become localized in these local minimums of the band structure.

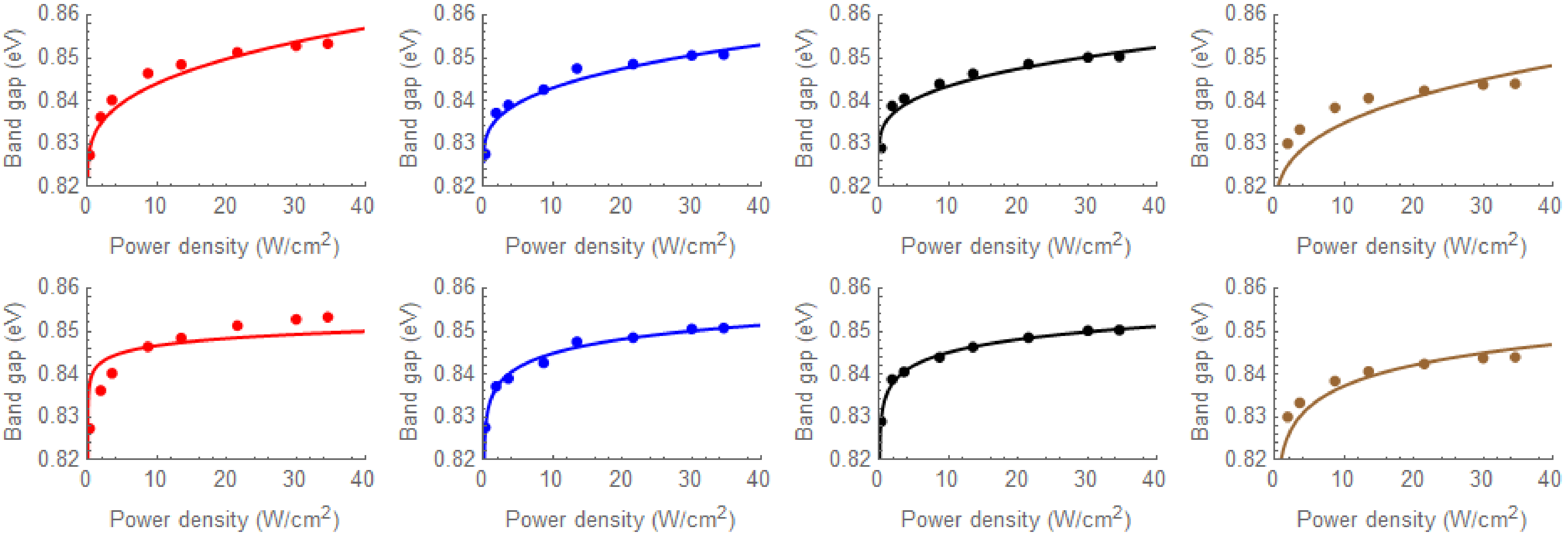


Example of Type-II $P^{1/3}$dependence



Example of Type-I ln(P) dependence

Localization of Carriers



$Power^{1/3}$

$\ln(Power)$

90 Kelvin

130 Kelvin

150 Kelvin

225 Kelvin

- As the temperature increases, we see the system become more Type-I, indicating localization due to non-idealities in the lattice have an important effect for hot carriers at low temperatures

Conclusion

- Solar cells are an important technology for the future of energy creation
- The current "generation" of cells cannot break the Shockley-Queisser limit of 33% efficiency
- Hot carrier solar cells are a potential technique to make cells of greater efficiency by reducing thermalization of carriers
- The electric field produced in these systems has an important effect, related to localization of electrons, for hot carrier solar cells

Sources

- Louise Hirst, University of Cambridge
- [1] H. Esmaielpour. (2018) *Type-II Quantum Well Hot Carrier Solar Cells*. University of Oklahoma, Norman, Oklahoma.

Acknowledgements

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Questions?