Power dependent photoluminescence investigation of the linear polarization at normal and inverted interface transitions in InP/InAlAs and InGaAsP/InAlAs QW structures

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Outline

• Introduction and motivation of InAlAs/InP
• Normal and inverted interfaces of InAlAs/InP
• InAl$_x$As$_{1-x}$/InP quantum well (QW) structures and its optical property
• Excitation power dependent photoluminescence (PL) spectrum
• Polarization effects of the QW photoluminescence
Introduction: InAlAs/InP heterostructure

- Type-II interface in real space
- Strong and tunable photoluminescence
- Optical emission (ranging 1.1 - 1.3 eV) with a photon energy smaller than the gap energy of semiconductors forming the heterostructure
- Good structural quality of interface
- Application in microwave and optoelectronic devices
- High electron mobility

- InAlAs needs to be isolated from atmosphere to avoid oxidation of Al.

Normal and inverted interface for InP/InAlAs

Normal and inverted interface for InP/InAlAs


✓ The change of peak energy position as a function of excitation power is different between the normal and inverted interfaces.
Quantum well (QW) structures

InAlAs/InP QW

10 nm InP cap
200 nm InAlAs barrier
200 nm InAlAs QW
InGaAs buffer
Fe-Semi insulating InP substrate

InP QW

InAlAs/InGaAsP QW

10 nm InP cap
200 nm InAlAs barrier
200 nm InAlAs QW
InGaAs buffer
Fe-Semi insulating InP substrate

InGaAsP QW


The effect of InP cap on the photoluminescence (PL) spectrum

![Graph showing the effect of InP cap on PL spectrum.](image)
Photoluminescence of the InGaAsP QW

- Graphs showing the relationship between energy and peak intensity for InGaAsP QW at various excitation powers.
- Inverted interface and QW transition highlighted in the graphs.
- The data is presented for an excitation temperature of 4K.

Photovoltaics Materials & Device Group, University of Oklahoma: http://www.nhn.ou.edu/~sellers/group/index.html
Polarization dependent of interface transition of InP/InAlAs

Polarization effects of the InGaAsP QW Photoluminescence

\[ \rho = \frac{I_{\perp} - I_{\parallel}}{I_{\perp} + I_{\parallel}} \]  

Polarization degree

**Low Power**

**High Power**

\[ \text{Intensity (arb. u.)} \]

\[ \text{Energy (eV)} \]

\[ \text{Power (mW)} \]

\[ \text{Energy (eV)} \]

\[ \text{Power (mW)} \]

\[ \text{Polarization Degree} \]

\[ \text{Polarization Degree} \]

\[ \text{Inverted Interface} \]

\[ \text{Inverted Interface} \]

\[ \text{Inverted Interface} \]

\[ \text{Inverted Interface} \]
Conclusion

• The growth of InP on InAlAs adds features to the PL spectrum of this structure which can degrade the quality of the emission from the sample.
• By removing the InP cap, the features due to the inverted interface are eliminated.
• There are two transitions from the inverted interface of the InGaAsP QW which change linearly with the natural logarithm of the excitation power.
• Power dependent study shows that polarization maximum (minimum) for one inverted interface transition $\alpha$ ($\beta$) coincides with the minimum (maximum) of the other inverted interface transition $\beta$ ($\alpha$).

Thank you!