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
- $InAl_xAs_{1-x}$/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

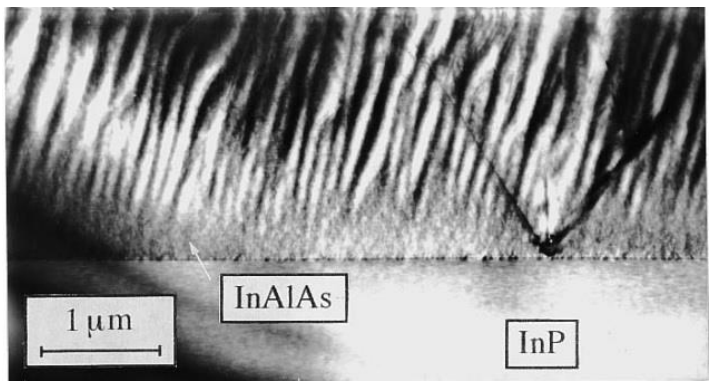
- ✓ Type-II interface in real space
- ✓ Strong and tunable photoluminescence
- ✓ Optical emission (ranging 1.1 - 1.3 eV) with a photon energy smaller than the gap energy of semiconductors forming the heterostructure
- ✓ Good structural quality of interface
- ✓ Application in microwave and optoelectronic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

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

InAlAs

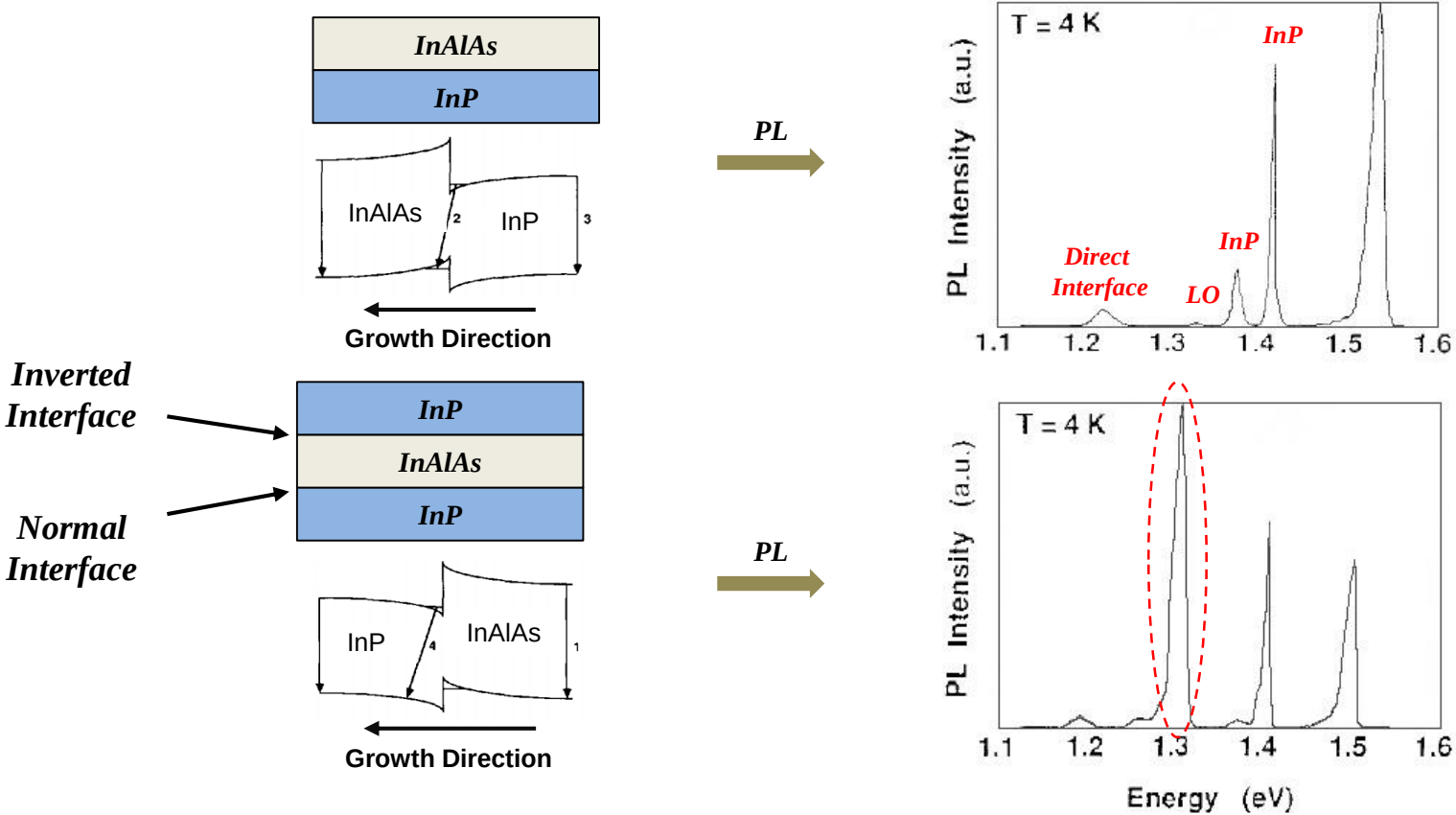
Normal Interface →

InP



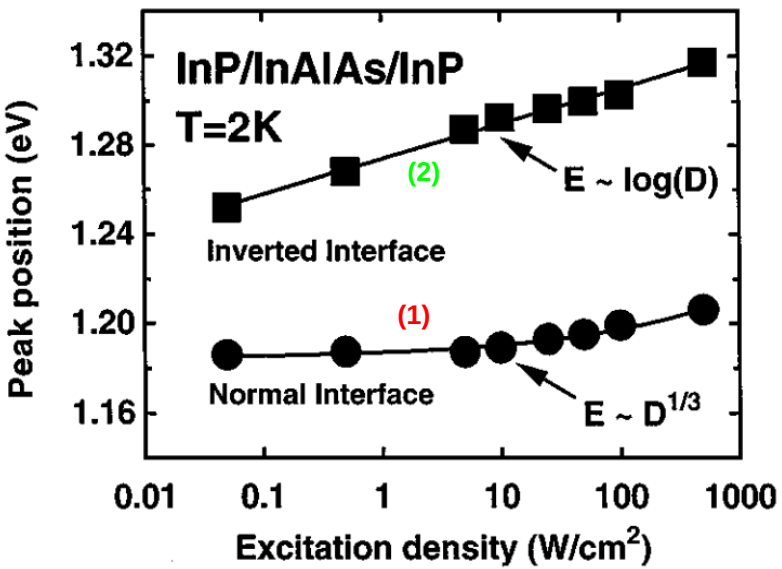
Peiró, F., et al., Applied physics letters 66.18 (1995): 2391-2393.

Normal and inverted interface for InP/InAlAs

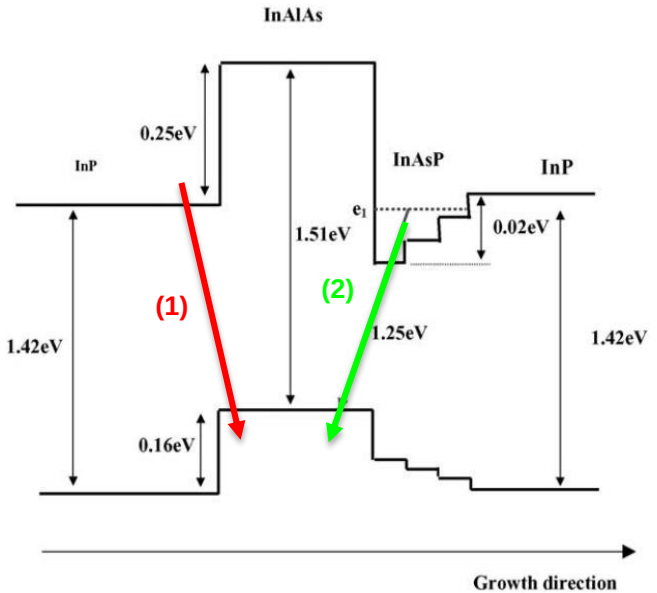


Benyattou, T., et al., *Applied surface science* 63.1-4 (1993): 197-201.

Normal and inverted interface for InP/InAlAs



Böhrer, J., et al., *Applied Physics Letters* 68.8 (1996): 1072-1074.



Hellara, J., et al., *Materials Science and Engineering: C* 21.1 (2002): 231-236.

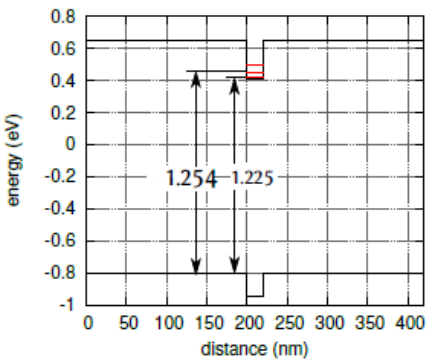
- ✓ The change of peak energy position as a function of excitation power is different between the normal and inverted interfaces.

Quantum well (QW) structures

InAlAs/InP QW

InP QW →

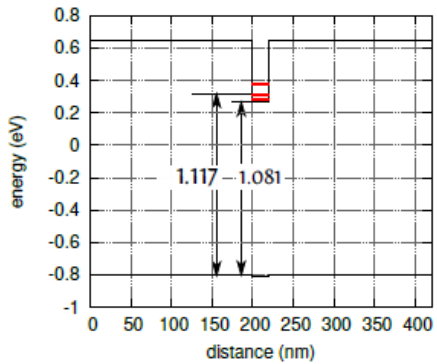
$In_{0.52}Al_{0.48}As/InP$ type II



InAlAs/InGaAsP QW

← *InGaAsP QW*

$In_{0.52}Al_{0.48}As/(In_{0.53}Ga_{0.47}As)_{0.4}(InP)_{0.6}$ quasi-type II



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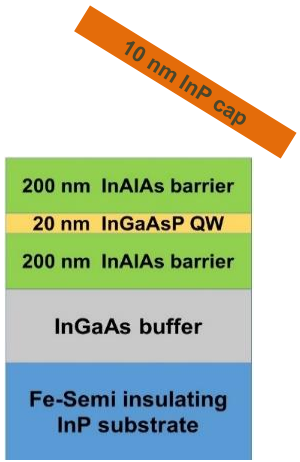
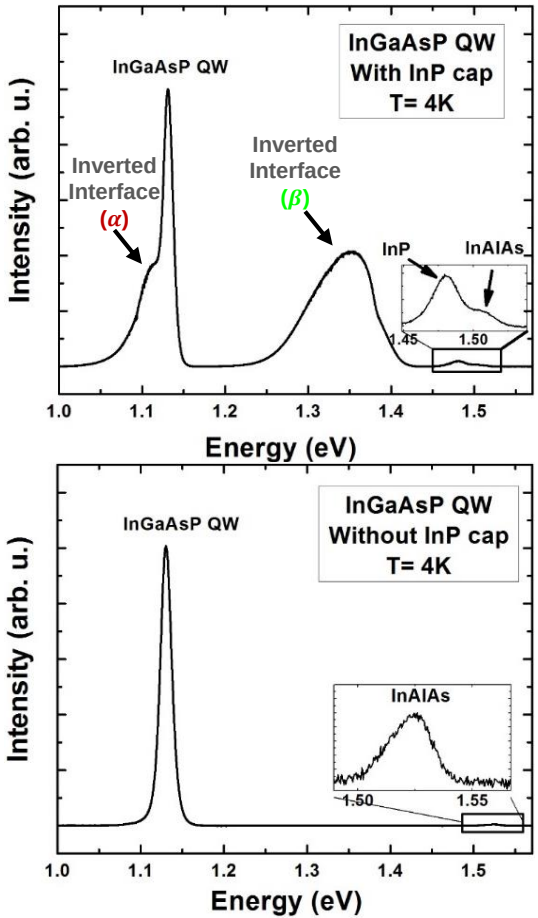
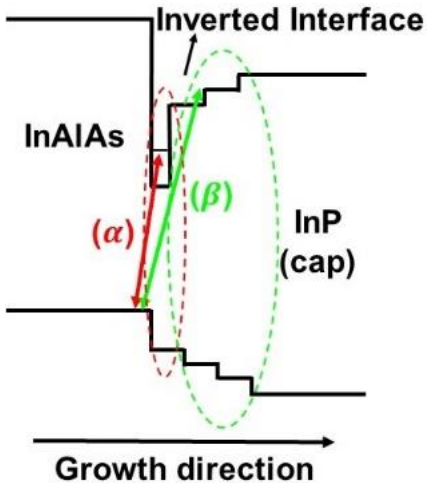
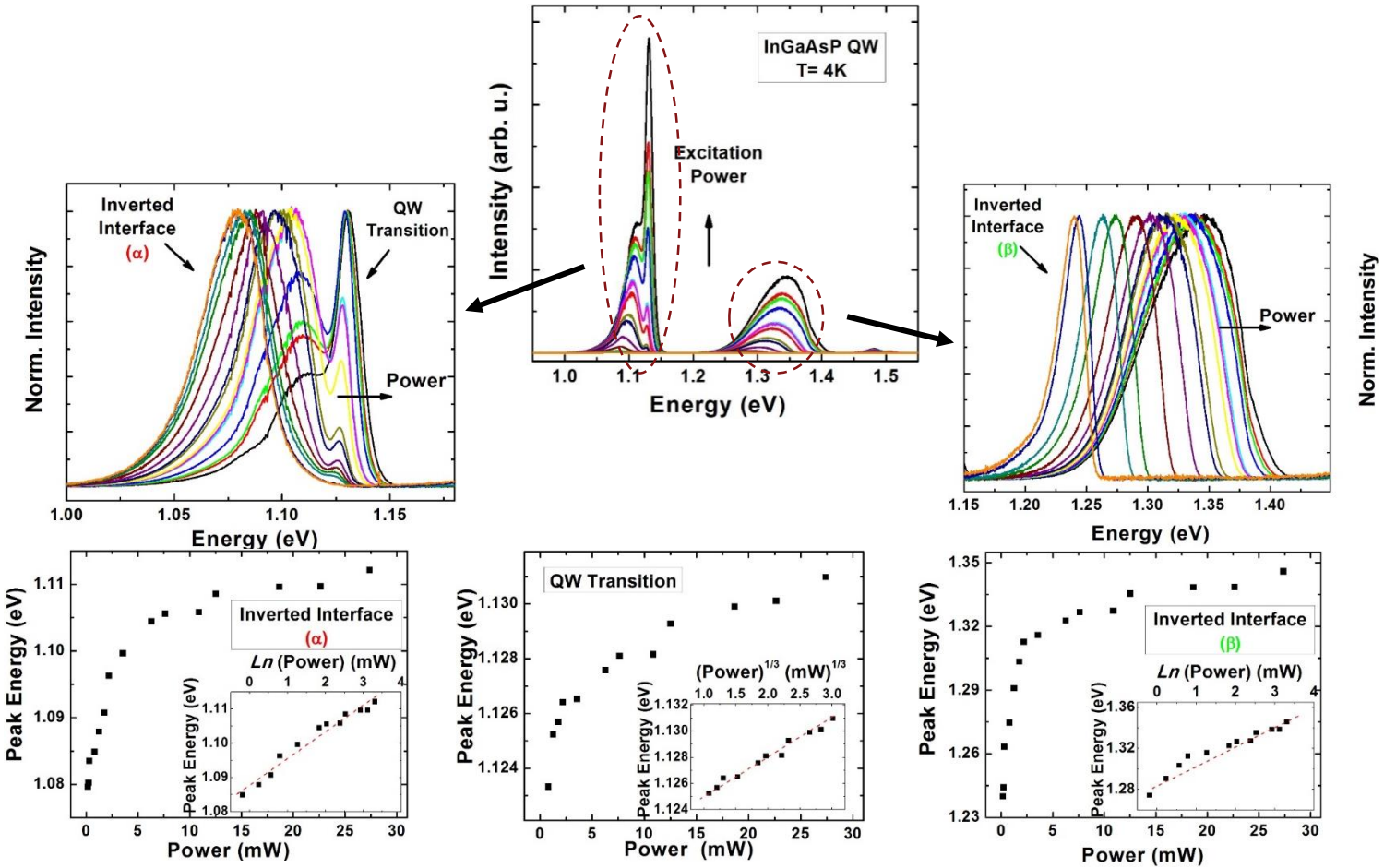
The effect of InP cap on the photoluminescence (PL) spectrum



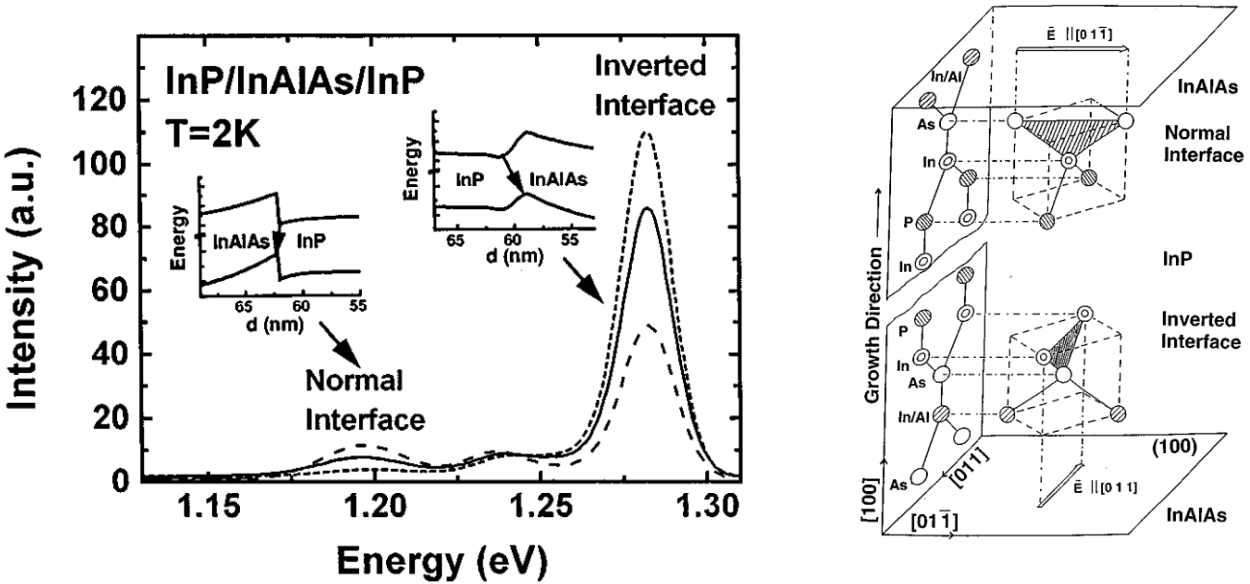




Photoluminescence of the InGaAsP QW



Polarization dependent of interface transition of InP/InAlAs

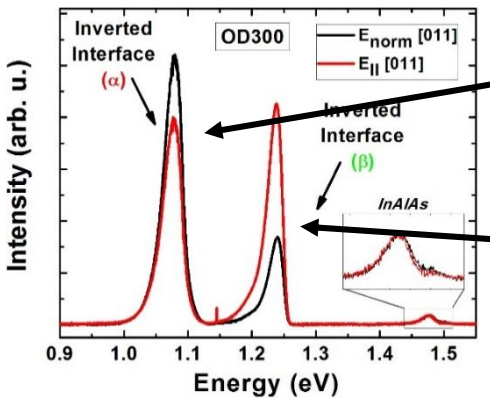


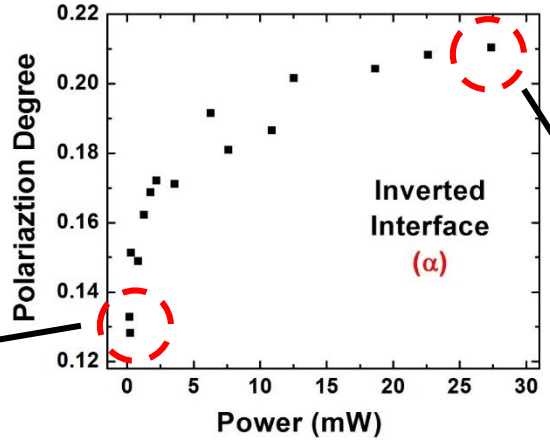
Böhrer, J., et al. *Applied Physics Letters* 68.8 (1996): 1072-1074.

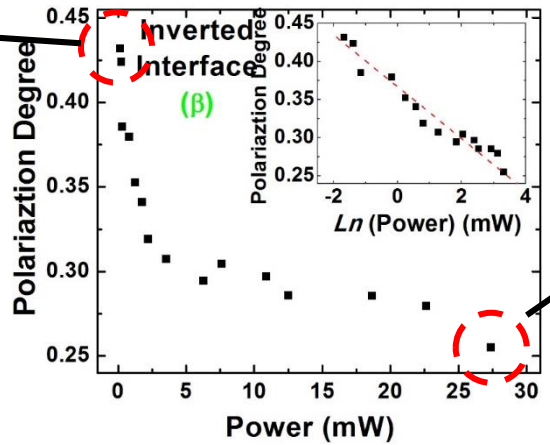
Polarization effects of the InGaAsP QW Photoluminescence

$$\rho = \frac{I_{\perp} - I_{\parallel}}{I_{\perp} + I_{\parallel}}$$ ***Polarization degree***

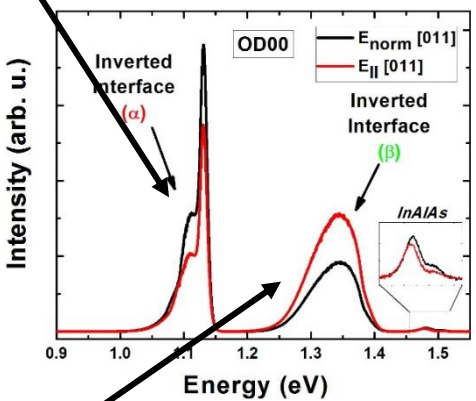
Low Power







High Power



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 α (β) coincides with the minimum (maximum) of the other inverted interface transition β (α) .

Thank you!