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Structural & Spectroscopic Study of InAs/InP Quantum Dots for Dual-Frequency Laser Engineering

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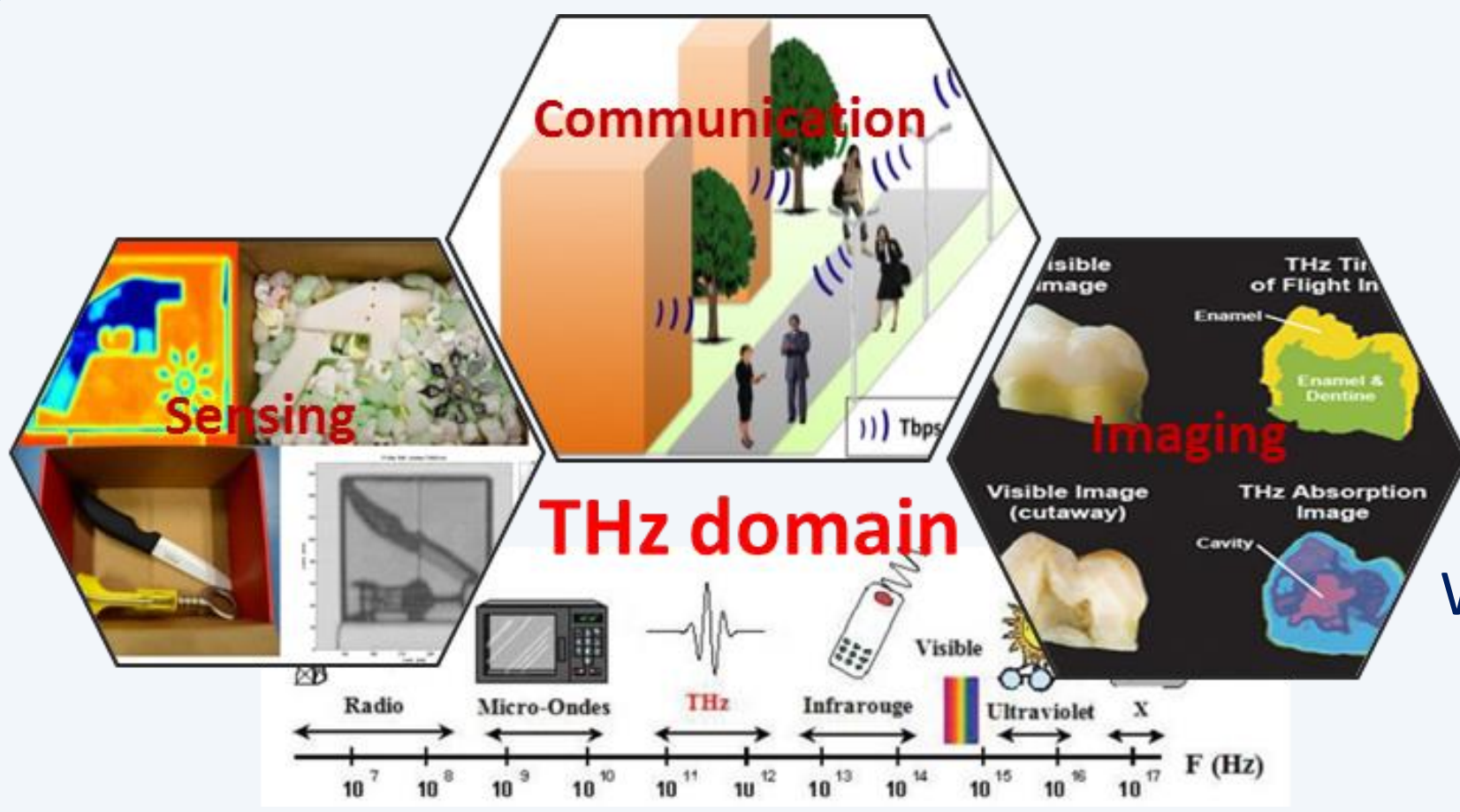


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Structural & Spectroscopic Study of InAs/InP Quantum Dots for Dual-Frequency Laser Engineering

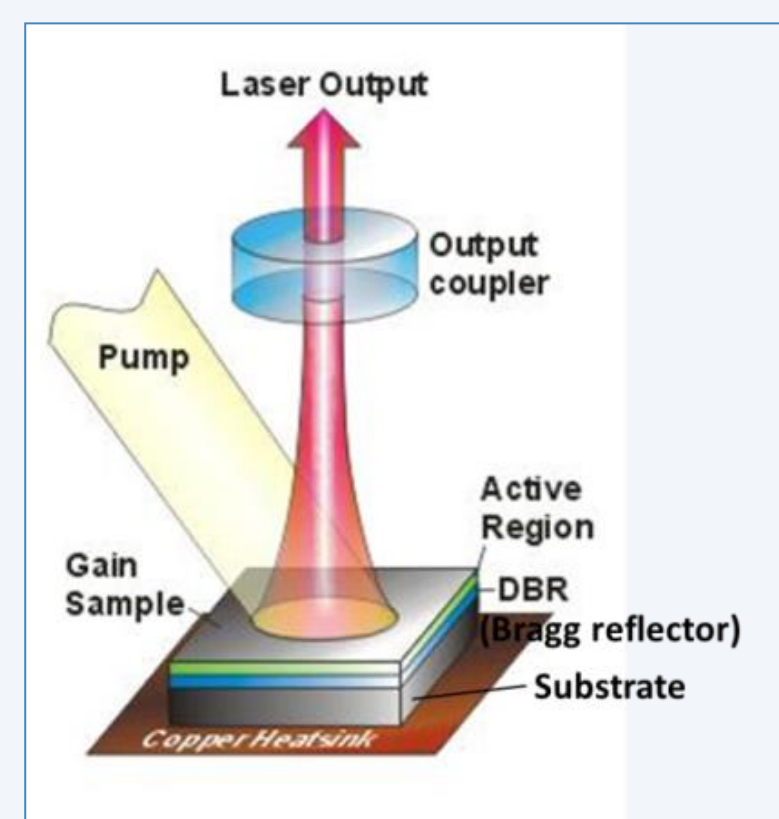
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Introduction



Problem
Few efficient compact tunable room temperature THz sources available

Wavelength beating from a Coherent dual wavelength Quantum Dots (QDs) based Vertical External Cavity Surface Emitting Laser (VECSEL)



Why VECSEL ?

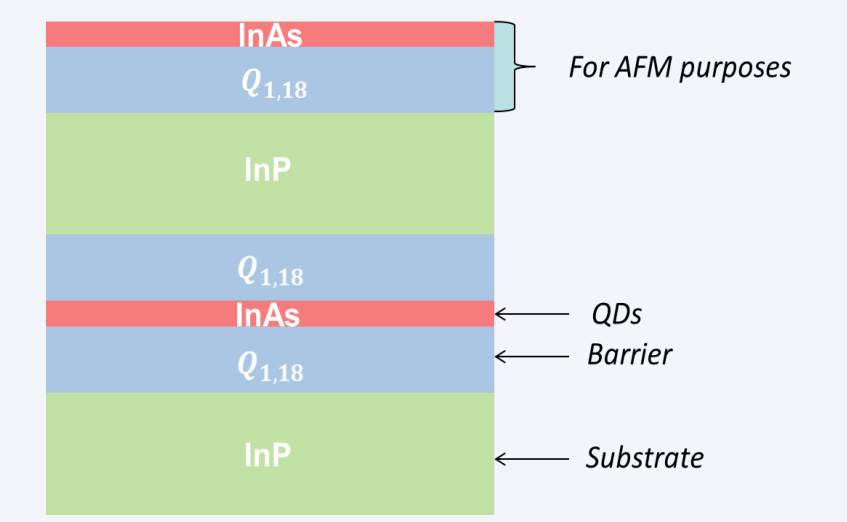
- Low intensity and phase noise
- Dual-wavelength regime possible

Why QDs ?

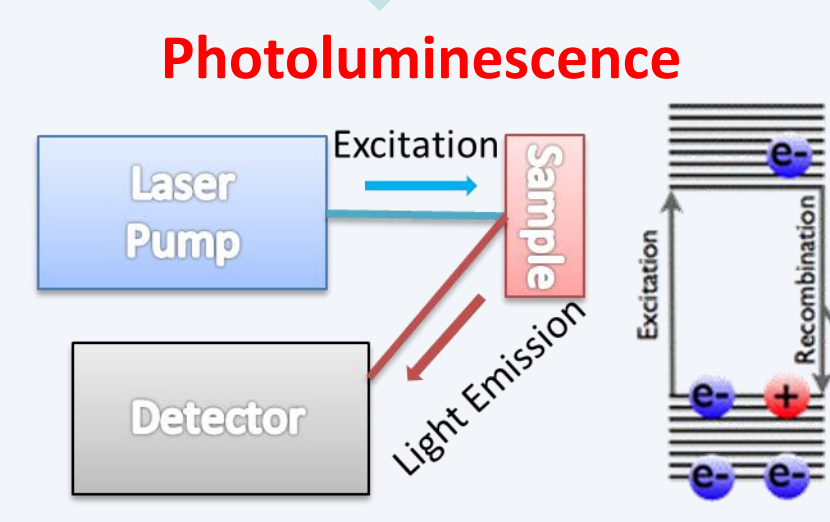
- Weak coupling (inhomogeneous medium)
- Possible electrical injection

Requirements for the QDs

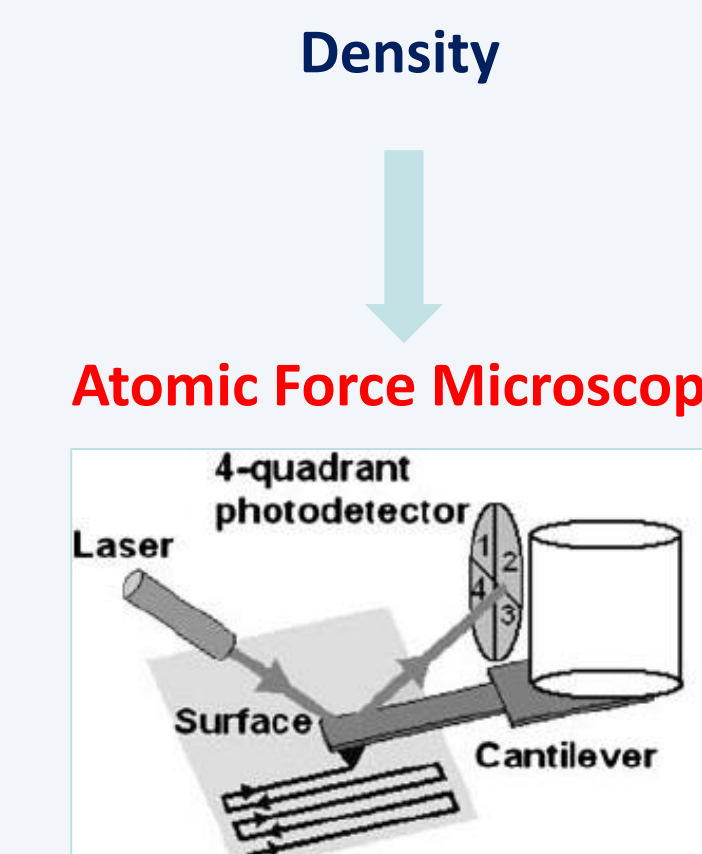
InAs/InP QDs
Molecular Beam Epitaxy Growth parameters:
• AsH₃ Flow
• Quantity of deposited InAs



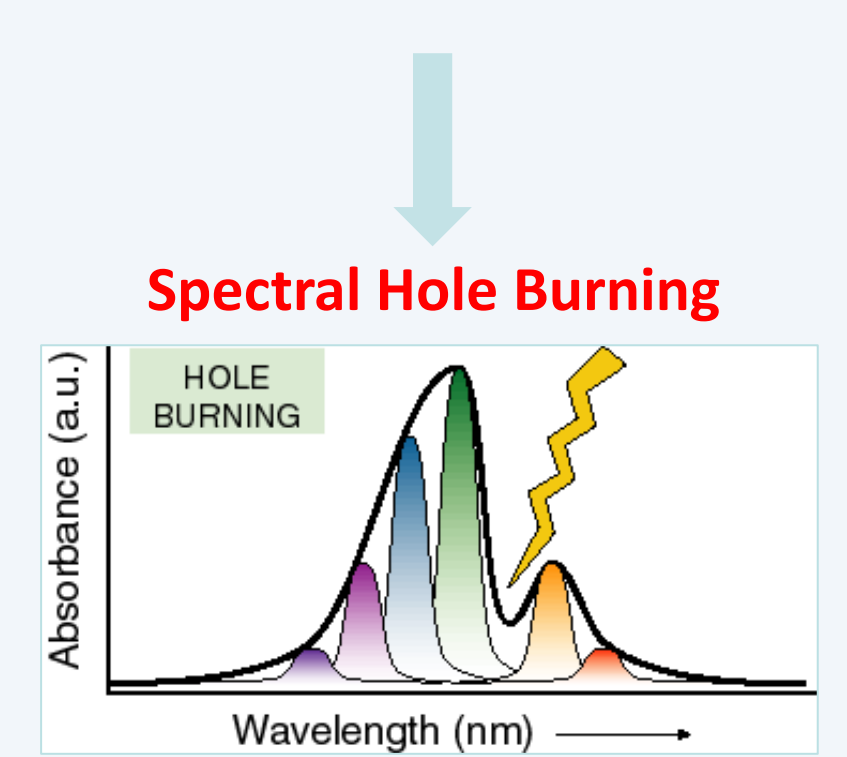
Telecom wavelength



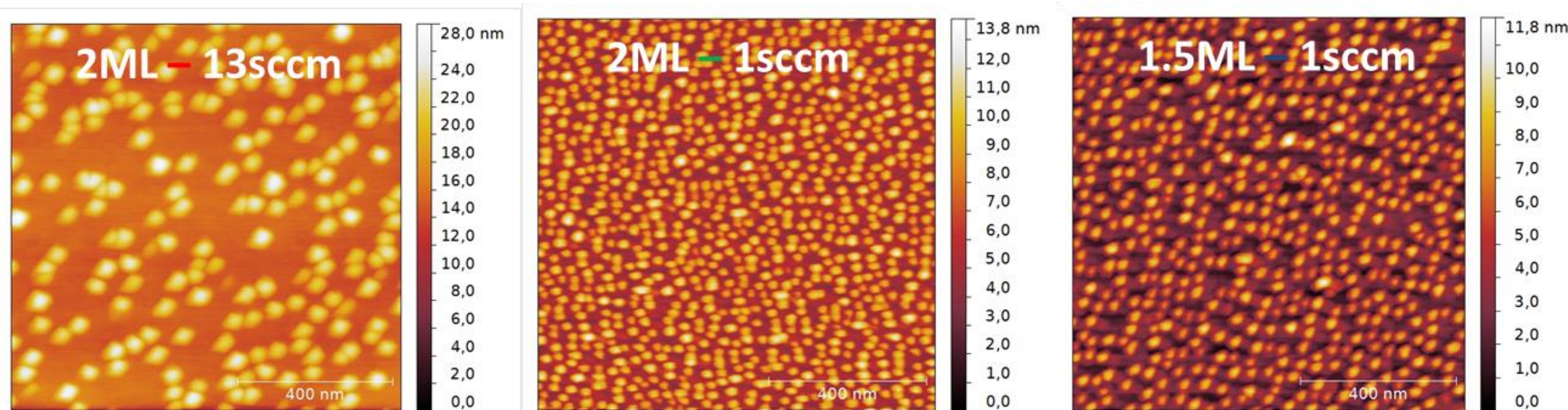
Weak Coupling



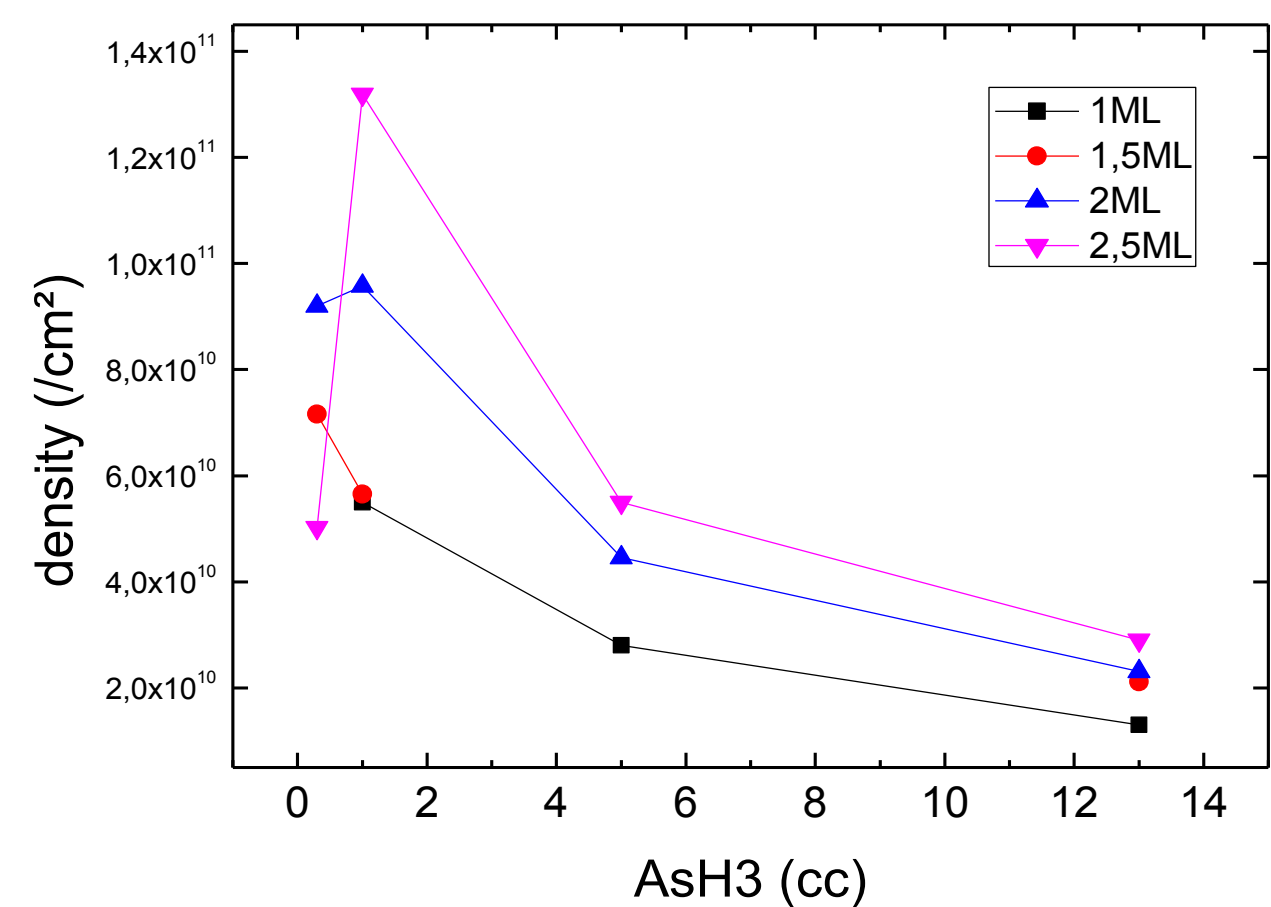
Homogeneous linewidth



Tuning of the QDs density - AFM

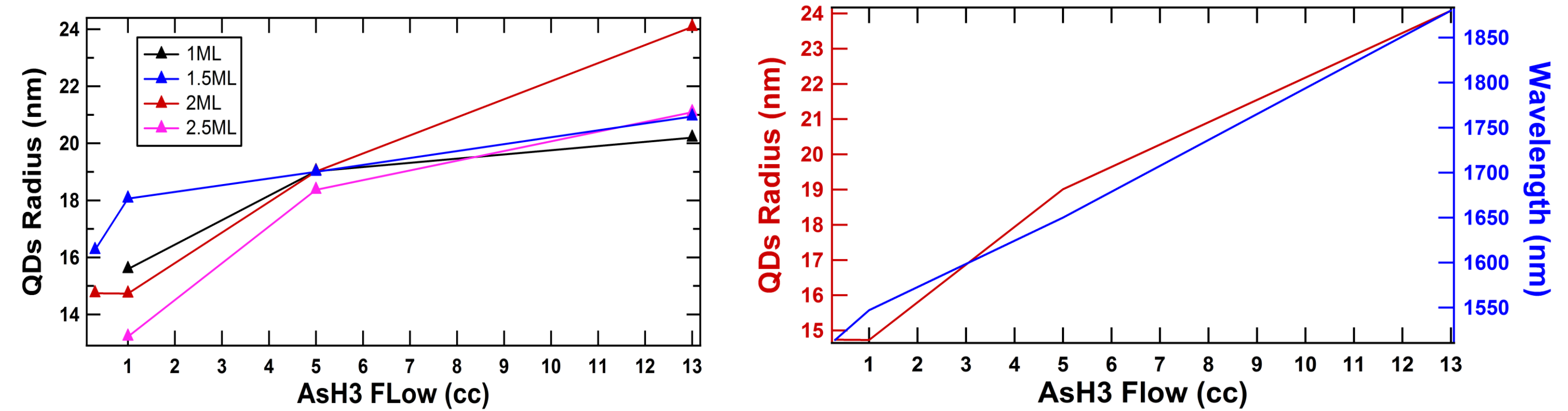


AFM images (1x1 μm²) of the InAs/InP Quantum Dots which have different growth parameters



QDs density as a function of AsH₃ Flow
When the AsH₃ Flow increases, the QDs get bigger and the density greatly decreases (x10)

QDs size and emission wavelength

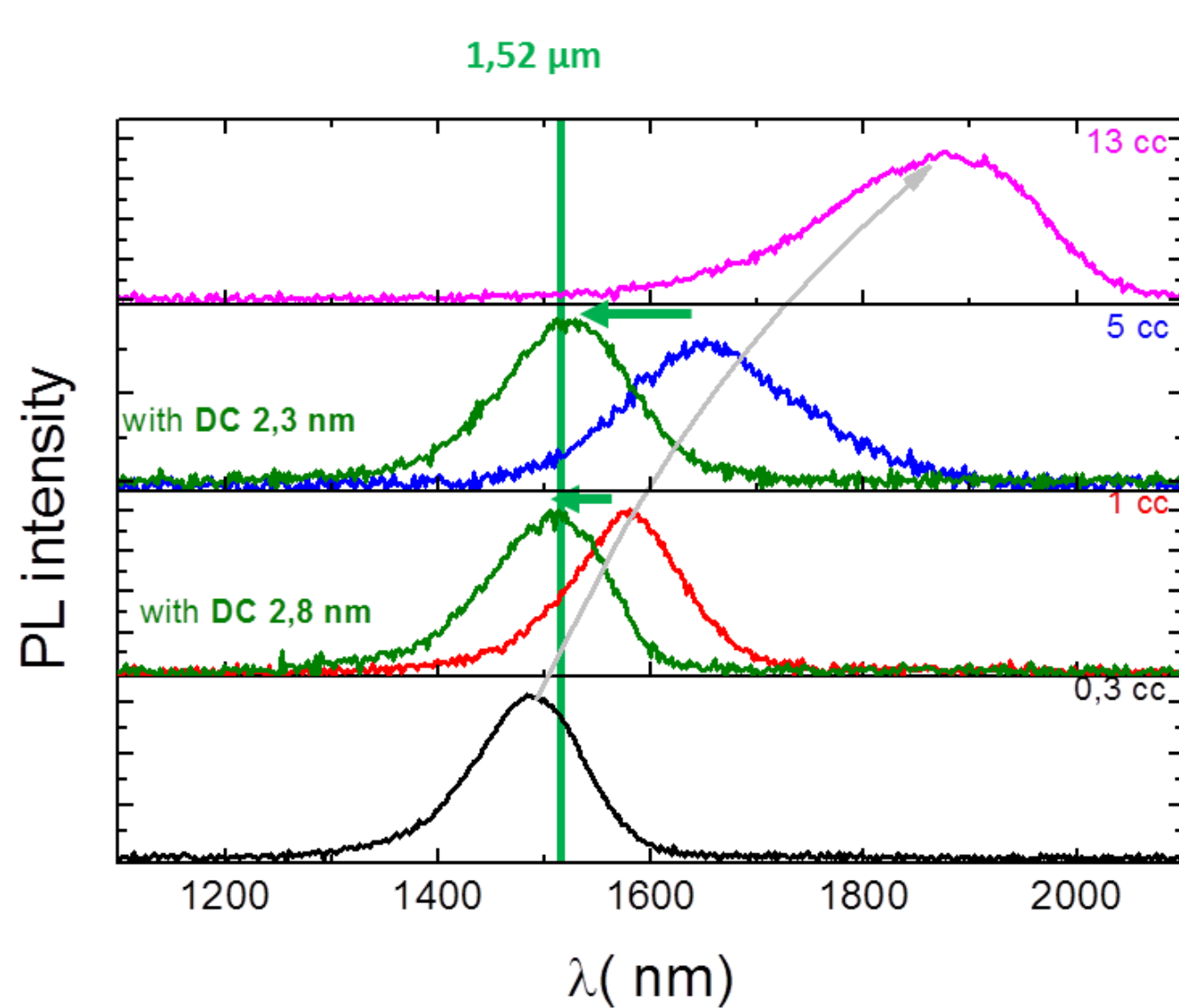


The radius of the QDs is bigger for higher flow

For 2ML: QDs radius and wavelength as a function of As Flow
Bigger QDs → Higher emission wavelength

QDs = self-assembled nanostructure → impossible to control the size and consequently the wavelength

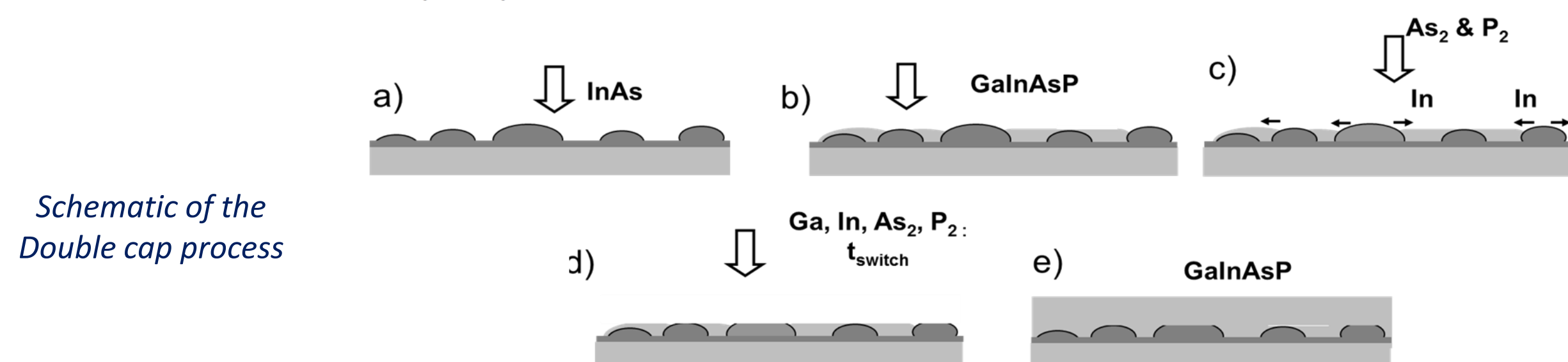
Control of the wavelength – Double Cap



Emission Wavelength for different AsH₃ flow

QDs Wavelength: Tendency with growth parameters but impossibility to control it by only the growth

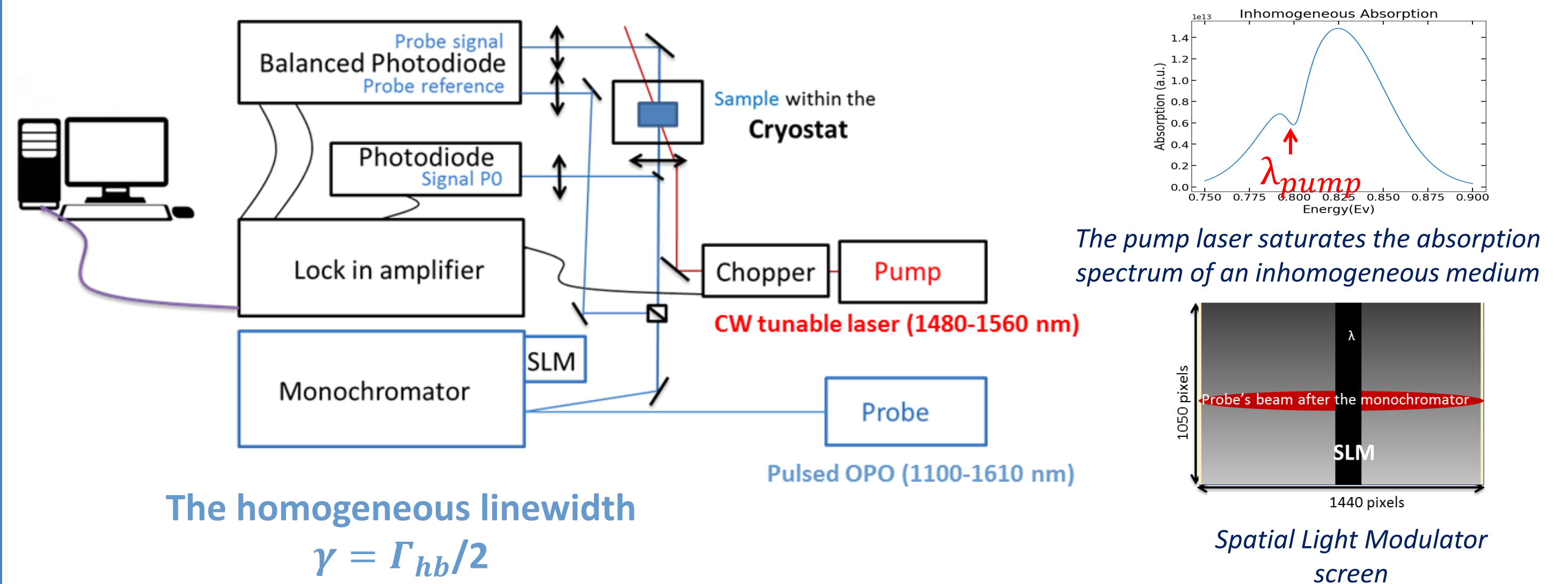
Double cap process



Schematic of the Double cap process

Spectral Hole Burning

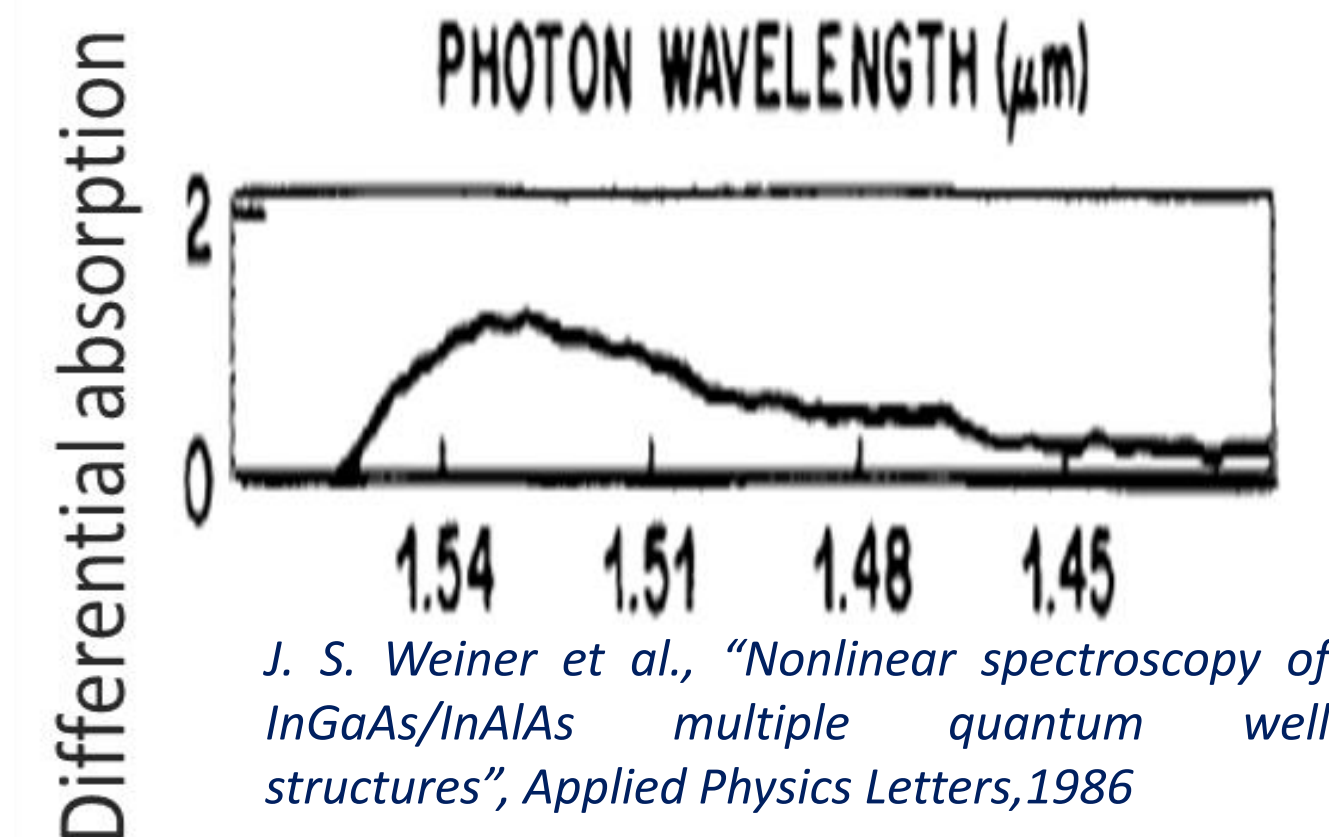
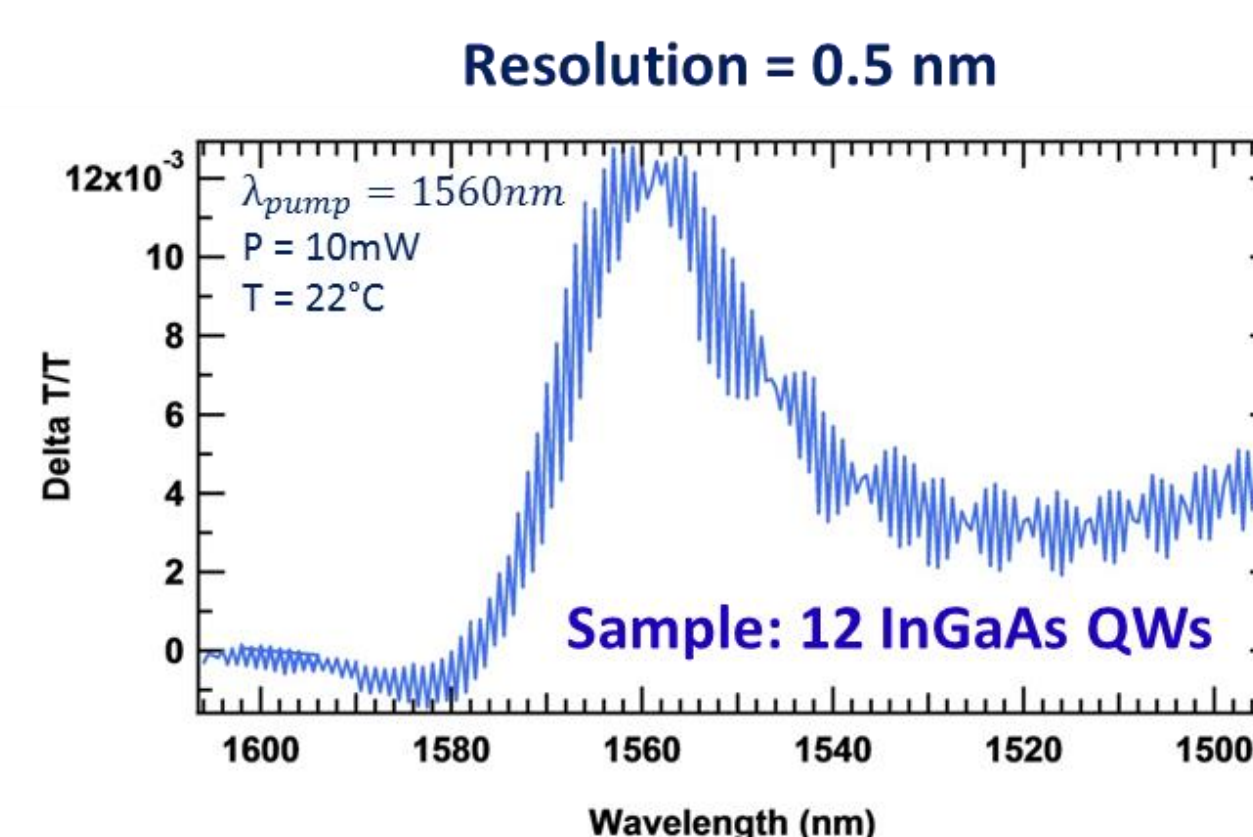
Experimental Setup



The pump laser saturates the absorption spectrum of an inhomogeneous medium

The homogeneous linewidth
 $\gamma = \Gamma_{hb}/2$

Preliminary Results (on QWs)



Experimental SHB spectrum and Reference

Same shape, good resolution (visible interferences due to the sample), higher spectral range
Typical characteristics of QWs: thermal carriers exponential decline, exciton photo-bleaching

Conclusion

- QDs density (and coupling) mainly controlled by the As flow: changed from 10¹¹ down to 10¹⁰ cm⁻², with a strong effect on the wavelength emission: from 1500 nm to 1945 nm
- Independent control of the density and wavelength (double cap)
- SHB experimental setup ready with good resolution (<0.5nm) and high spectral range (500 nm)
- Results on QWs correspond well with the bibliography

Perspectives

- Achievement of SHB in order to get the homogeneous linewidth broadening as a function of QDs density, temperature, input power
- Optimisation of QDs density to get the weaker coupling
- VECSEL characterisation