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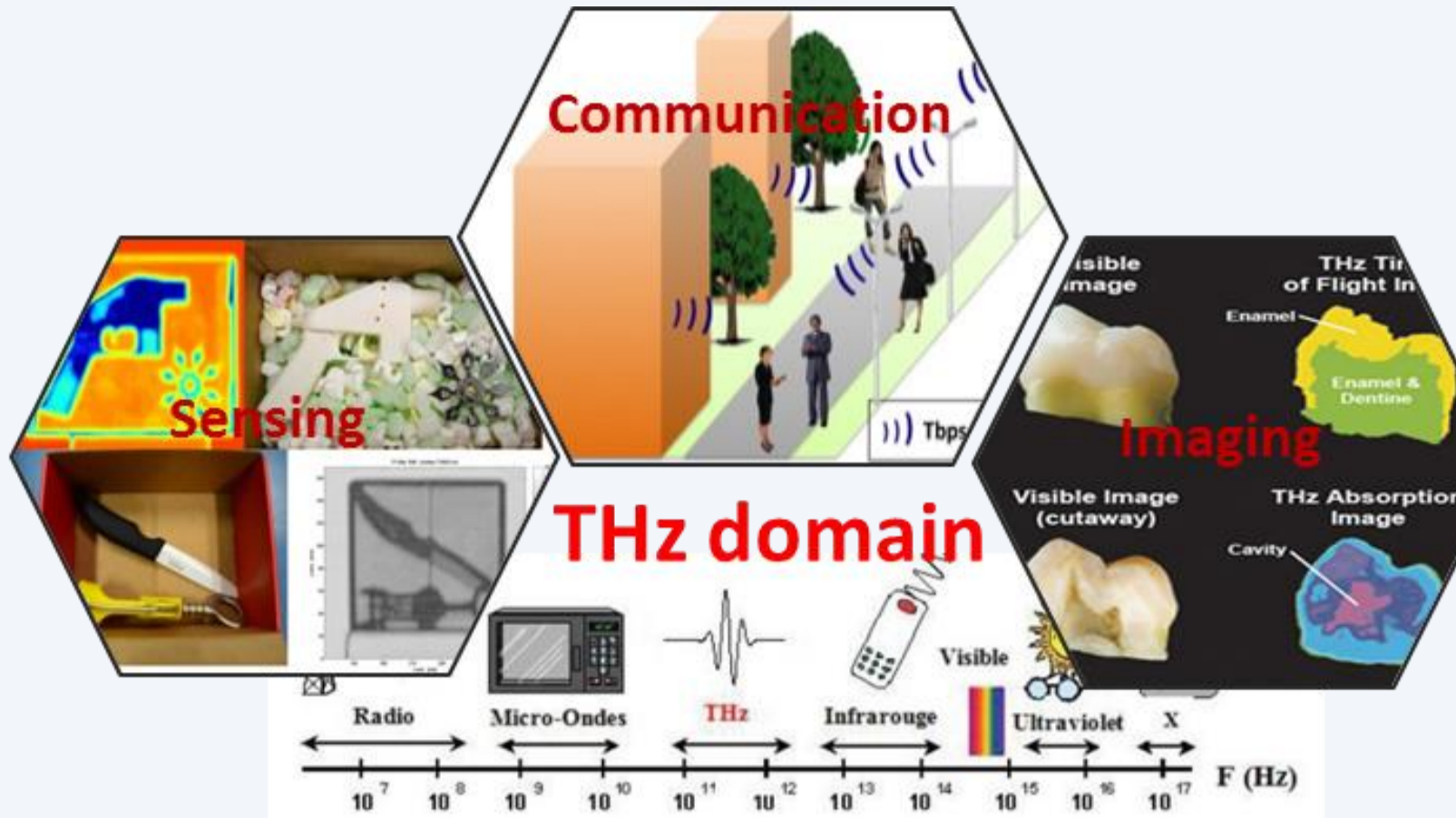
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# Structural & Spectroscopic Study of InAs/InP Quantum Dots for Dual-Frequency Laser Engineering

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**THz domain**

Why VECSEL ?

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

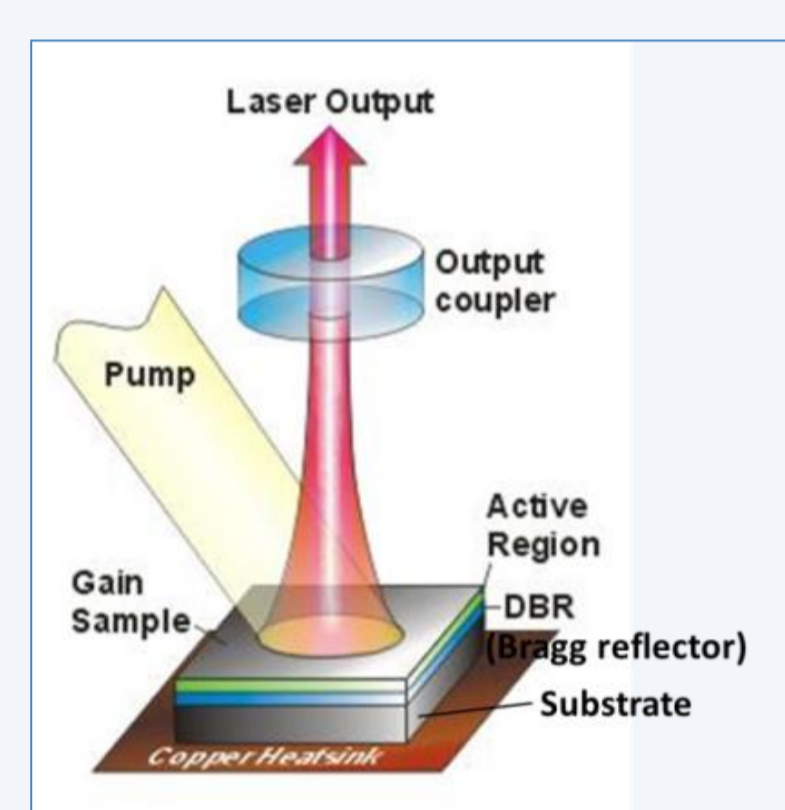
Why QDs ?

- Weak coupling (inhomogeneous medium)
- Possible electrical injection

### Introduction

**Problem**  
Few efficient compact tunable room temperature THz sources available

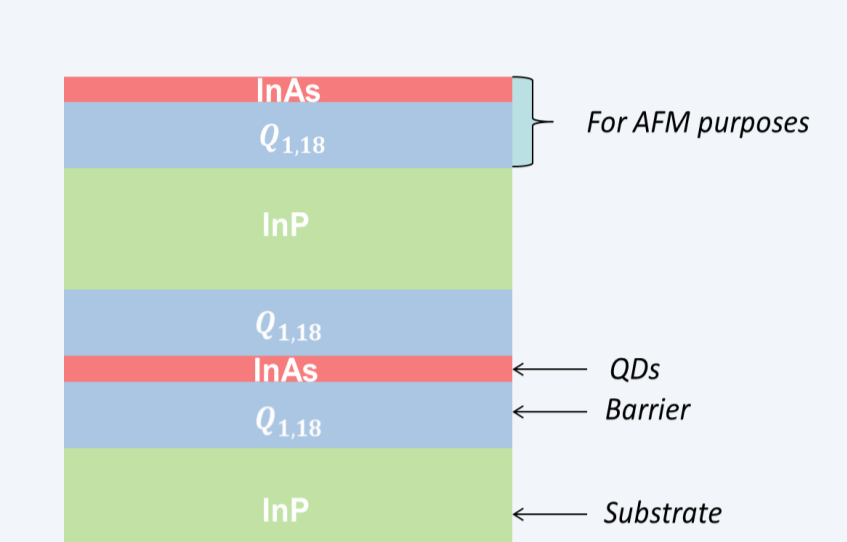
Wavelength beating from a Coherent dual wavelength Quantum Dots (QDs) based Vertical External Cavity Surface Emitting Laser (VECSEL)



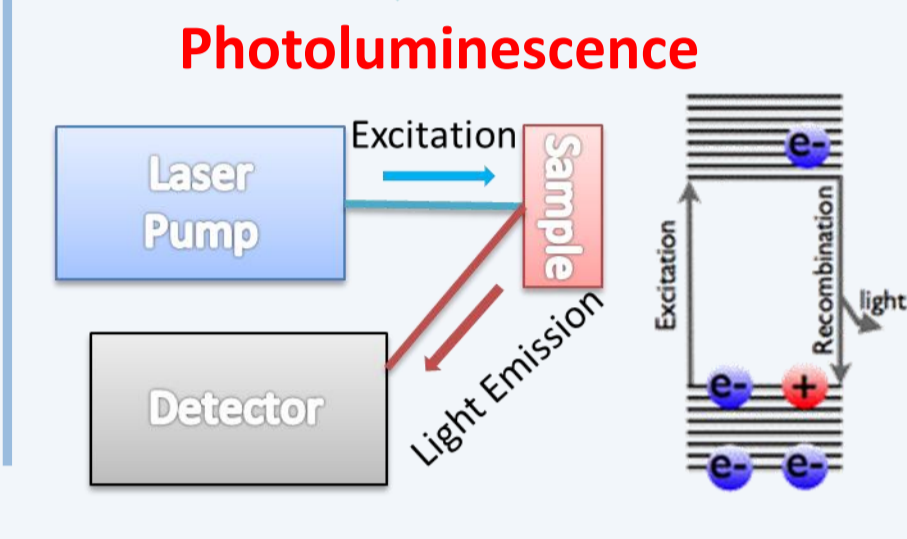
### Requirements for the QDs

InAs/InP QDs  
Molecular Beam Epitaxy Growth parameters:

- AsH<sub>3</sub> Flow
- Quantity of deposited InAs

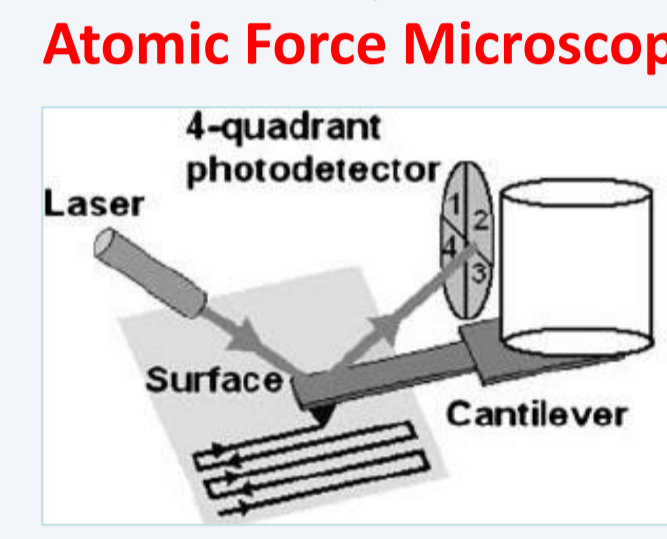


**Telecom wavelength**



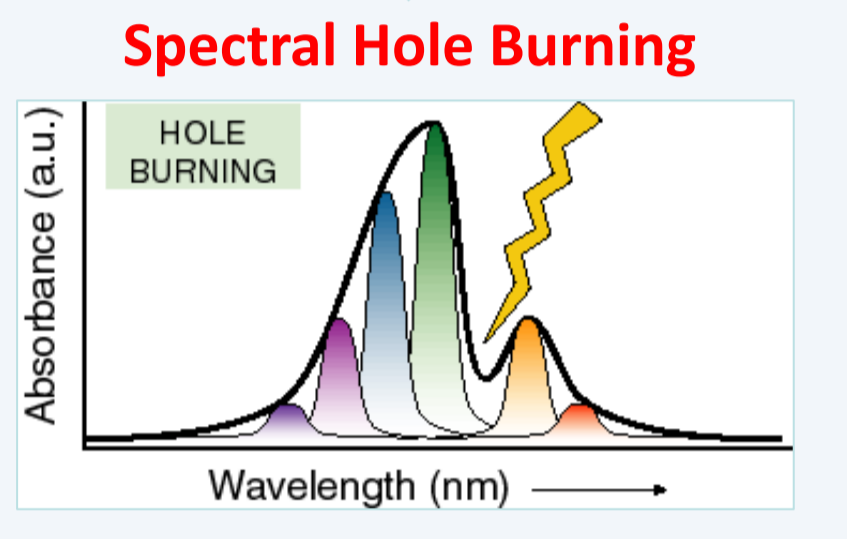
Photoluminescence

**Weak Coupling**



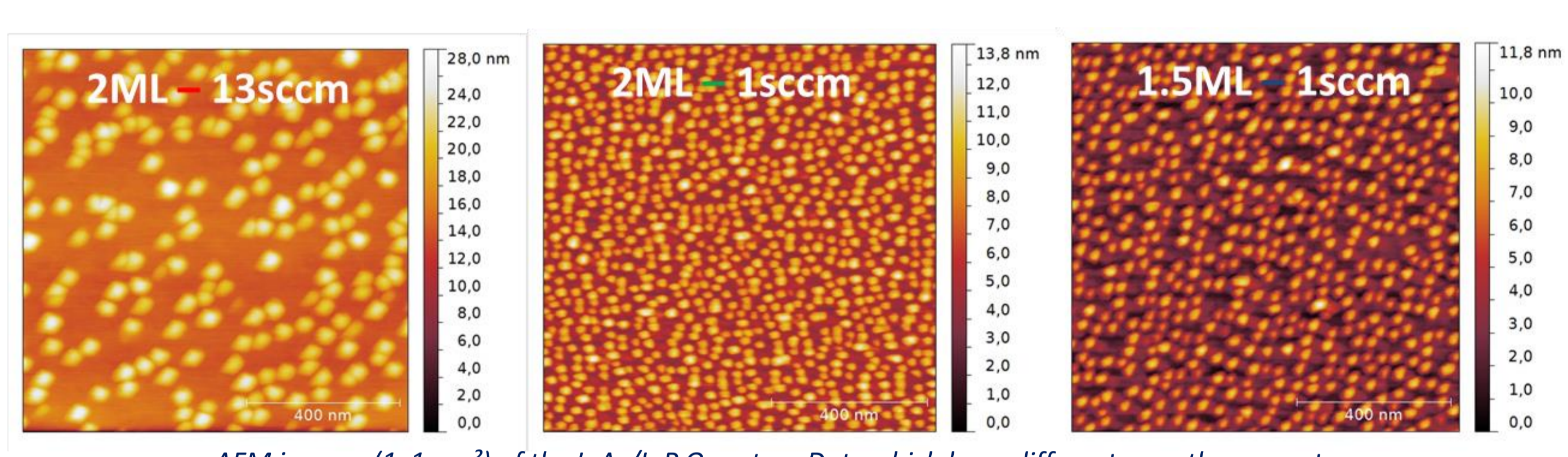
Atomic Force Microscopy

**Homogeneous linewidth**

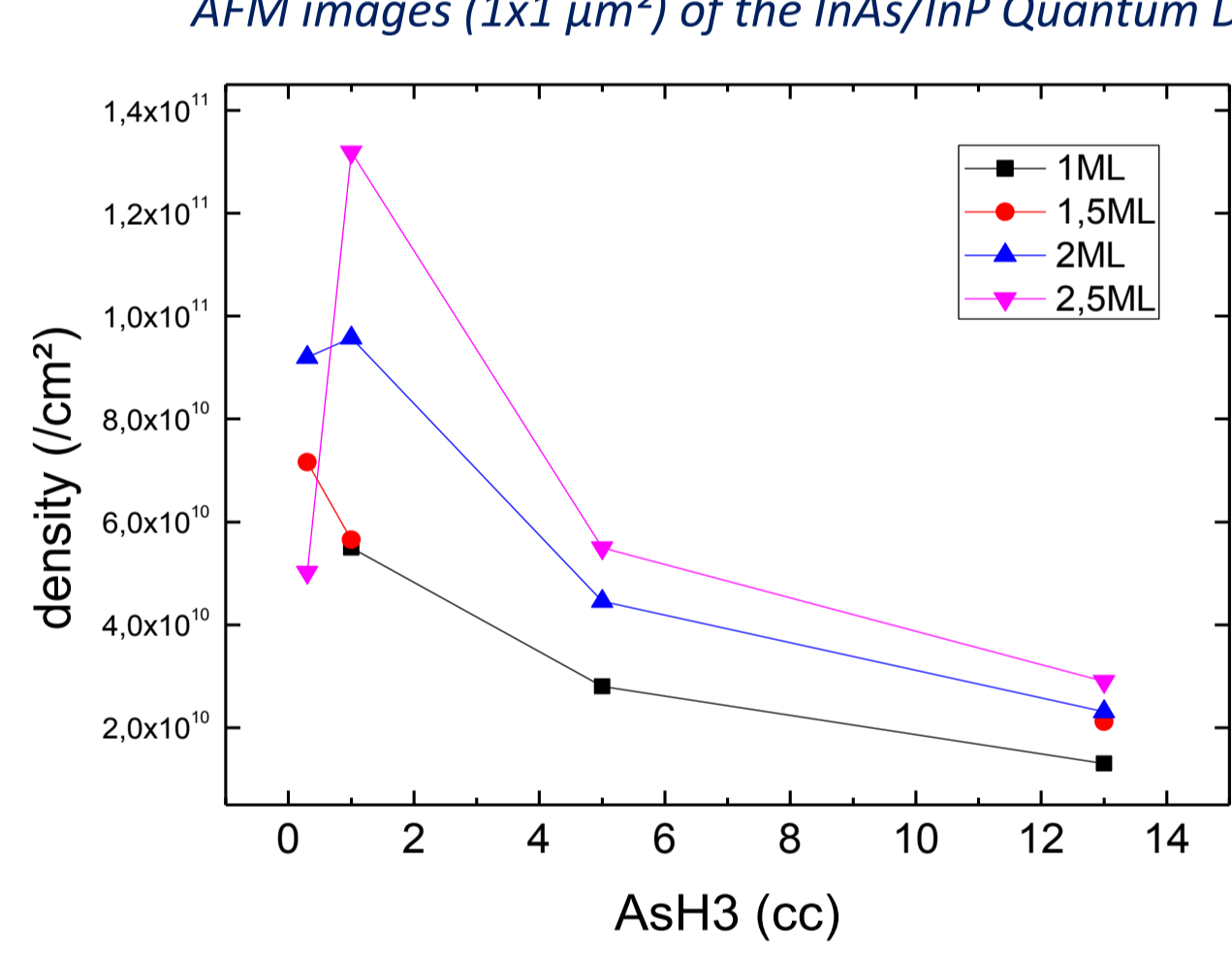


Spectral Hole Burning

### Tuning of the QDs density - AFM



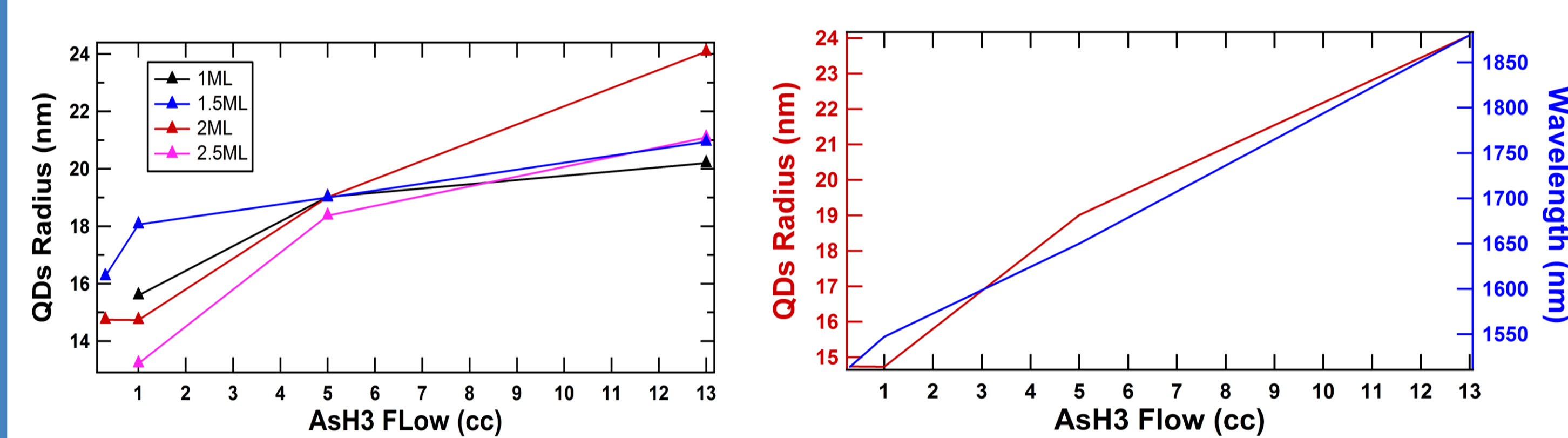
AFM images (1x1 μm<sup>2</sup>) of the InAs/InP Quantum Dots which have different growth parameters



QDs density as a function of AsH<sub>3</sub> Flow

When the AsH<sub>3</sub> Flow increases, the QDs get bigger and the density greatly decreases (x10)

### QDs size and emission wavelength

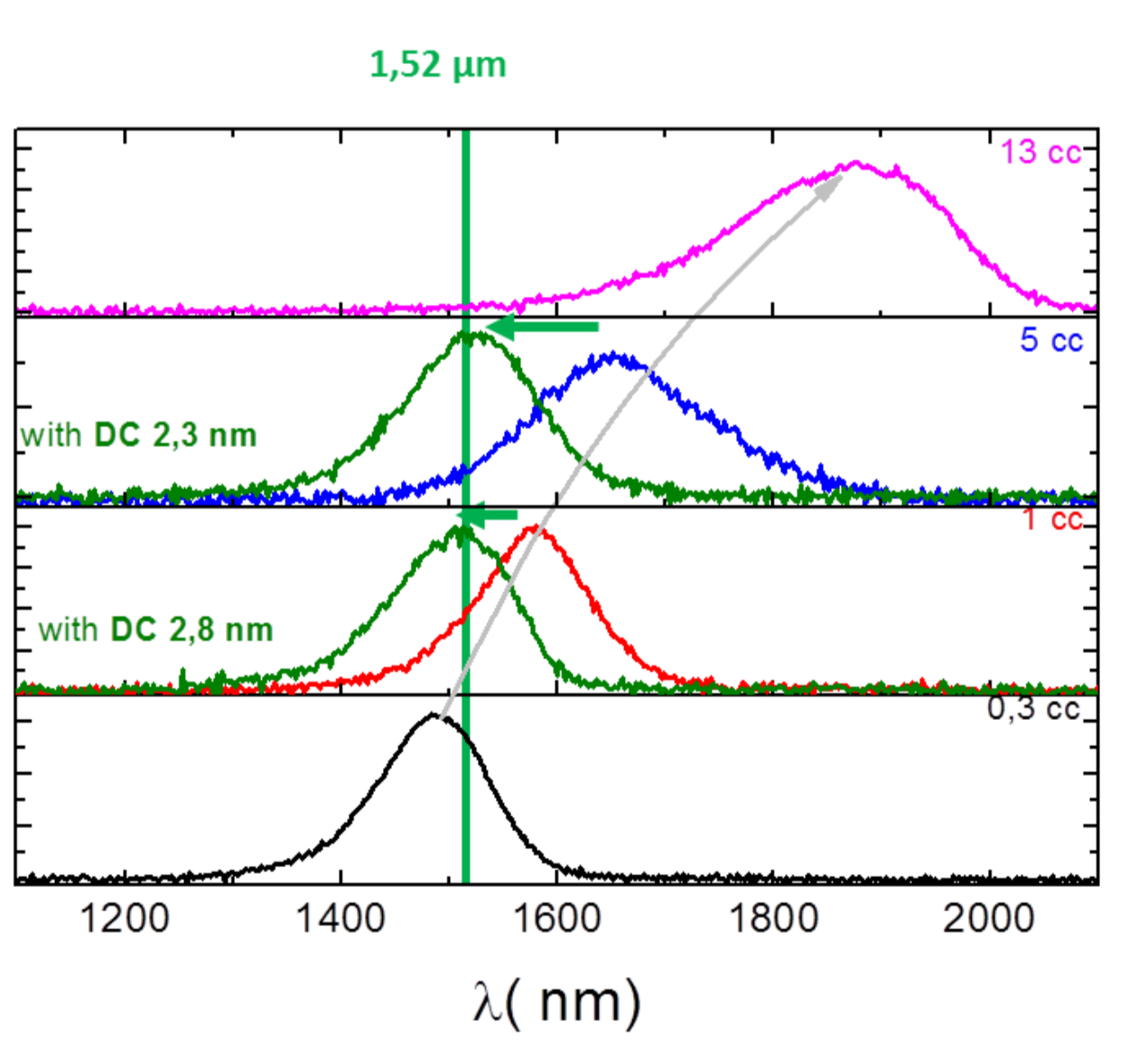


The radius of the QDs is bigger for higher flow

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

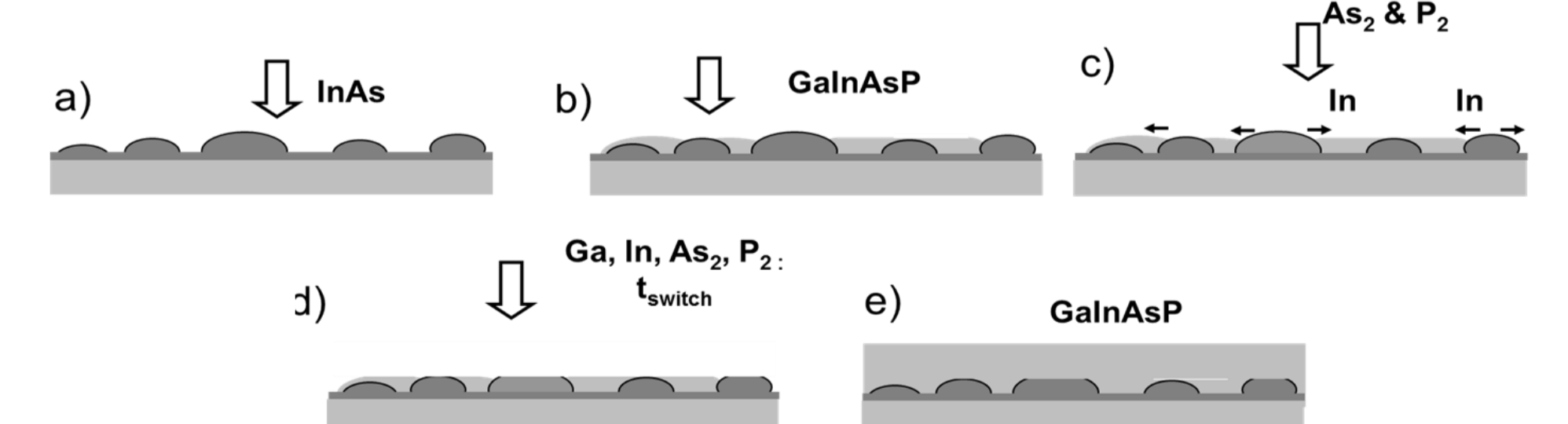
### Control of the wavelength – Double Cap



Emission Wavelength for different AsH<sub>3</sub> flow

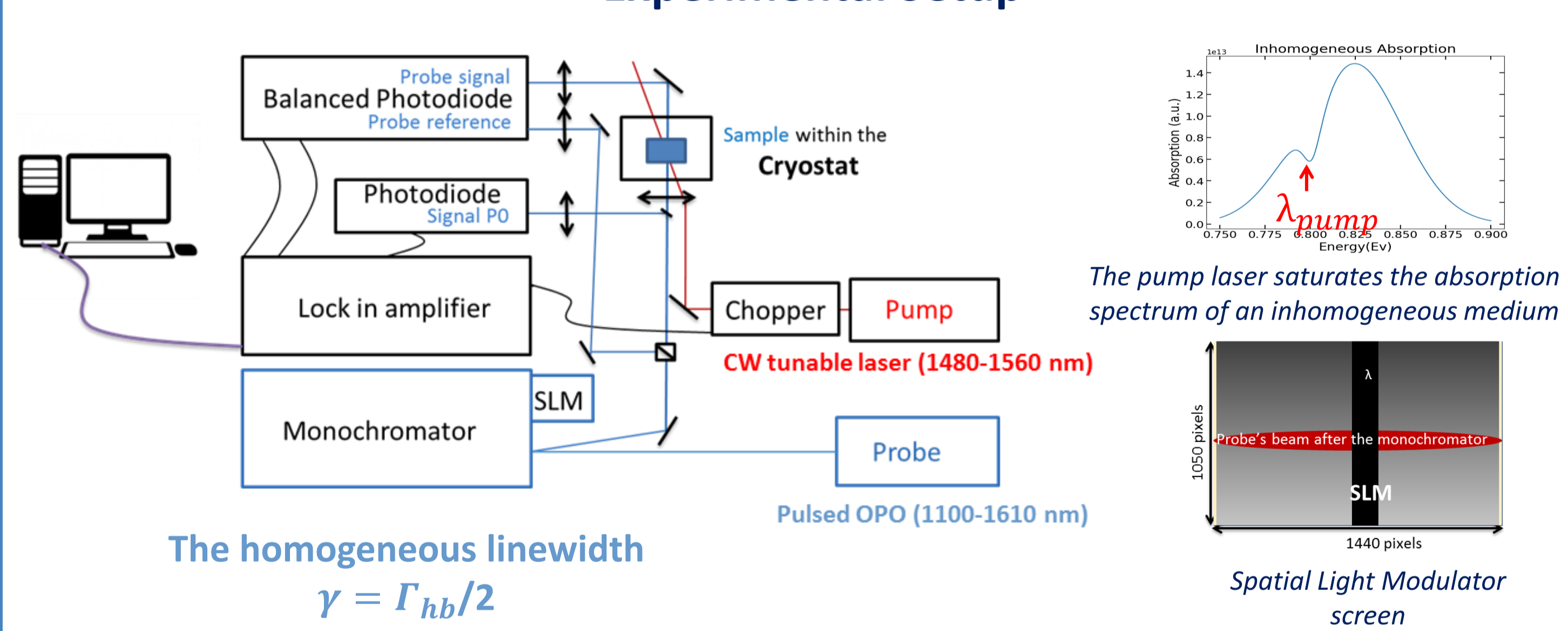
QDs Wavelength: Tendency with growth parameters but impossibility to control it by only the growth

**Double cap process**



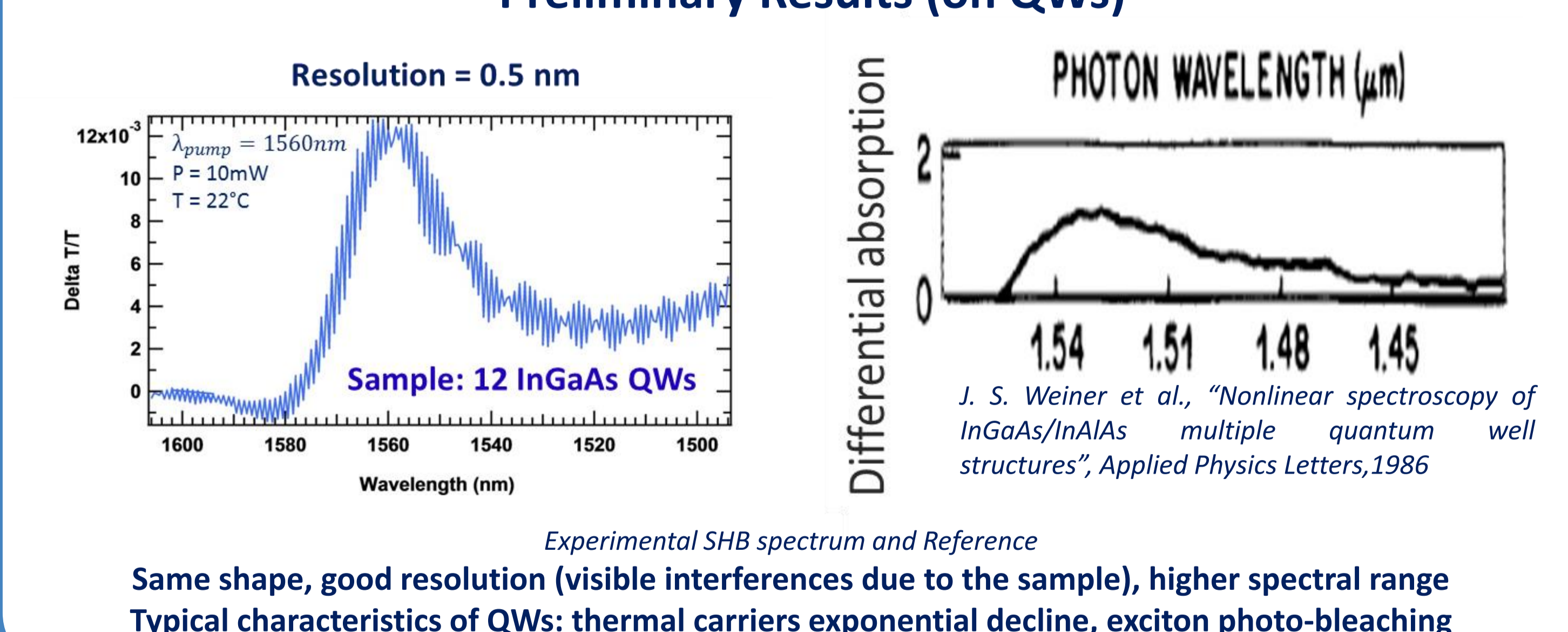
Schematic of the Double cap process

### Spectral Hole Burning Experimental Setup



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

### Preliminary Results (on QWs)



Resolution = 0.5 nm

Sample: 12 InGaAs 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 10<sup>11</sup> down to 10<sup>10</sup> cm<sup>-2</sup>, 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