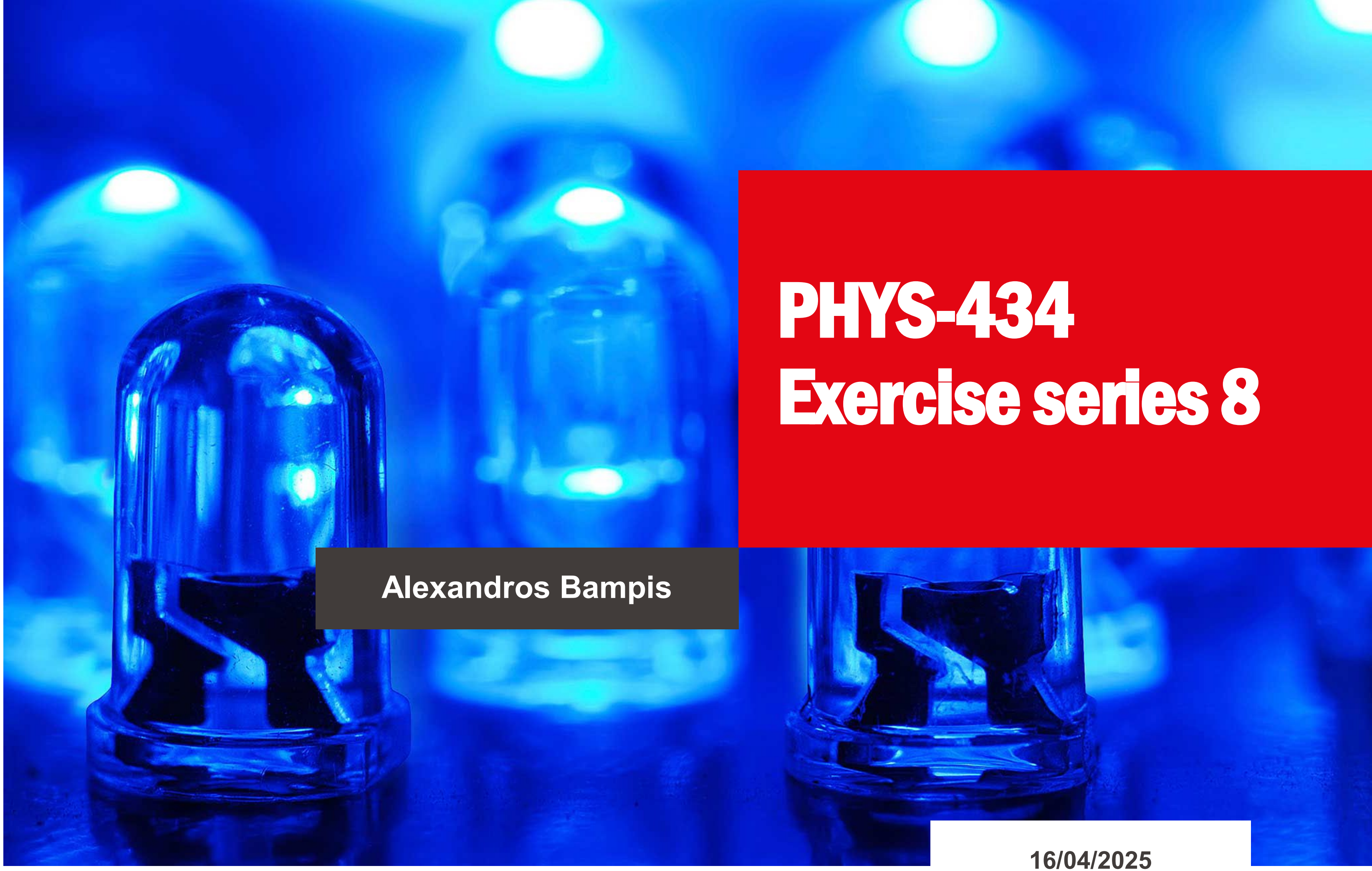


PHYS-434
Exercise series 8

Alexandros Bampis

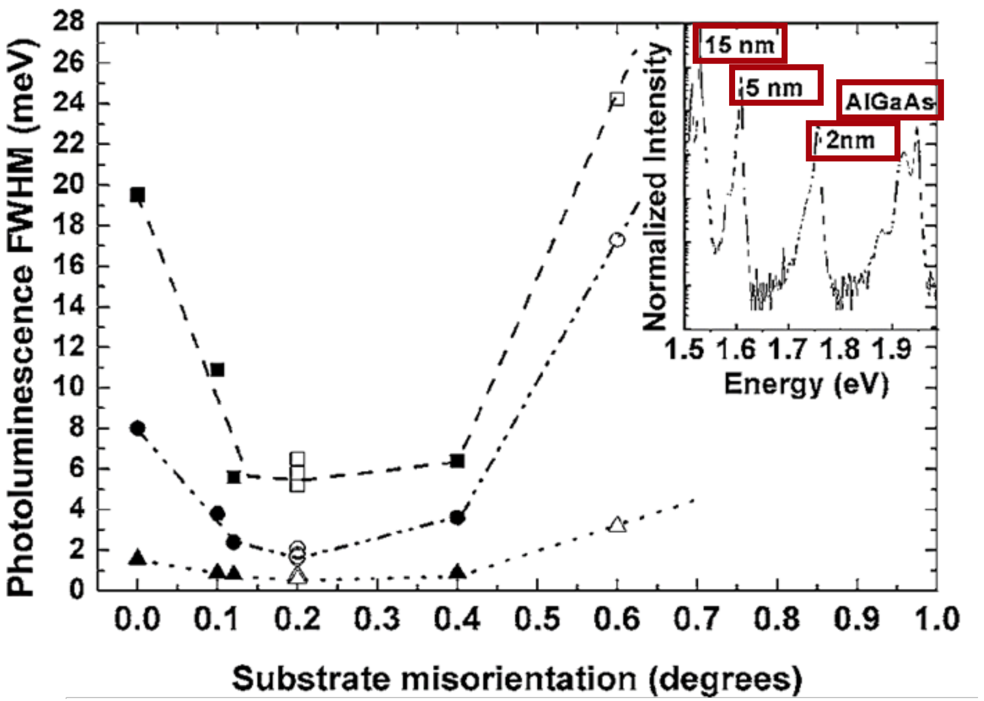
16/04/2025

École
polytechnique
fédérale
de Lausanne

QWs grown on vicinal substrates by MOVPE

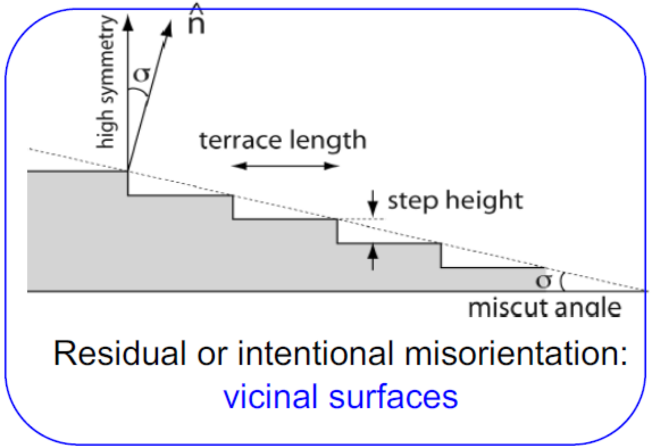
Cap	30 nm
$Al_{0.3}Ga_{0.7}As$	300 nm
GaAs	**2 nm**
$Al_{0.3}Ga_{0.7}As$	300 nm
GaAs	**5 nm**
$Al_{0.3}Ga_{0.7}As$	300 nm
GaAs	**15 nm**
$Al_{0.3}Ga_{0.7}As$	300 nm
Buffer	1 µm
GaAs substrate	

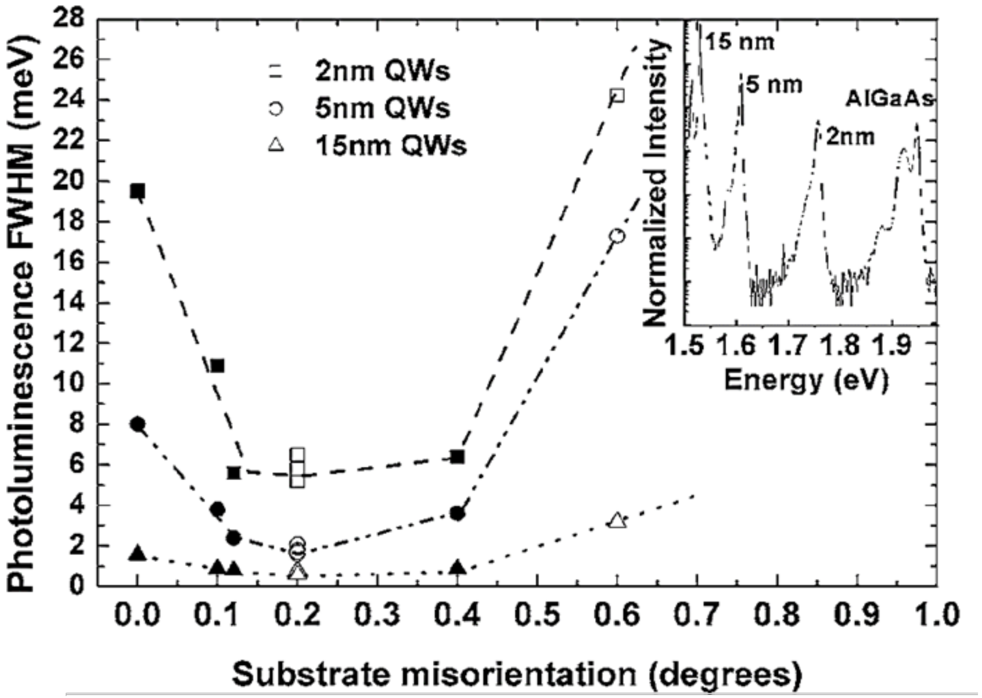
E. Pelucchi *et al.*,
J. Appl. Phys. **99**, 093515 (2006)



- The PL spectrum displays 4 peaks. The peak at highest energy is due to the $Al_{0.3}Ga_{0.7}As$ barrier that is also excited by the laser during the measurement. The remaining PL peaks can then be attributed to the QWs, keeping in mind that the confinement energies of carriers in thinner wells is higher, leading to higher emission energies.
- **NB:** the shoulders in the AlGaAs peak can tentatively be attributed to the 1st phonon replica and to bound excitons.

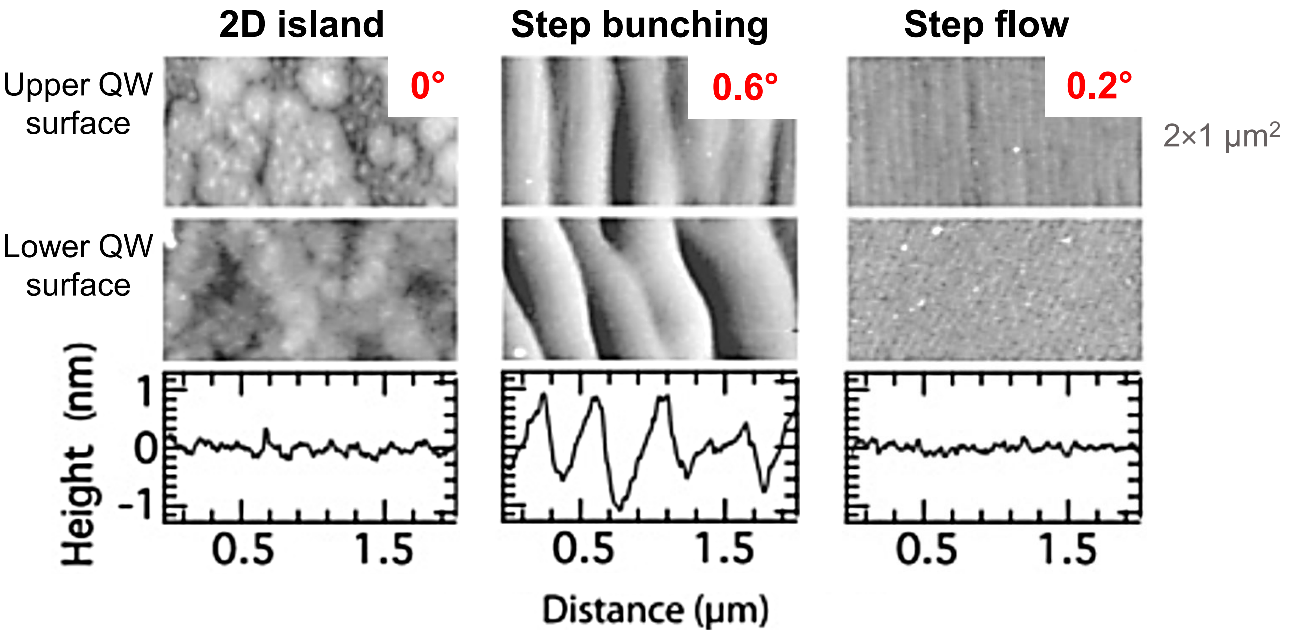
QWs grown on vicinal substrates by MOVPE





- Confined excitons in a QW are more sensitive to interface roughness the thinner the QW is. Since these measurement are probing over a large sample area, this results in a larger FWHM of the thin QW peak.
- The optimal miscut angle lies around 0.2° since this angle yields the lowest FWHM values.

QWs grown on vicinal substrates by MOVPE



N. Moret *et al.*, *Phys. Rev. B* **84**, 155311 (2011)

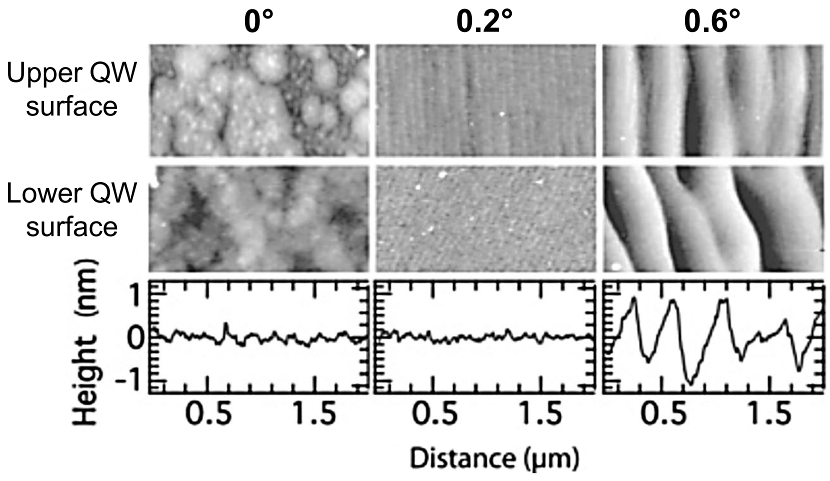
- 0 °: **2D islands** dispersed on the growth plane, diameters of x0 – x00 nms, because adatoms are first incorporated at random locations on the sample surface, and they can then act as nucleation centers for the following adatoms (they have several dangling bonds available for another adatom to bind) → 2D islands at random locations
- 0.2 °: **step flow**, neatly arranged parallel steps separated by about 75 nm, steps of ML high (2.83 A); the adatoms are incorporated at the surface steps
- 0.6 °: **periodic step bunching (PSB)**, steps merge to create multi-steps at a more or less regular interval

- Miscut angle + → terrace length - → instability induces step bunching

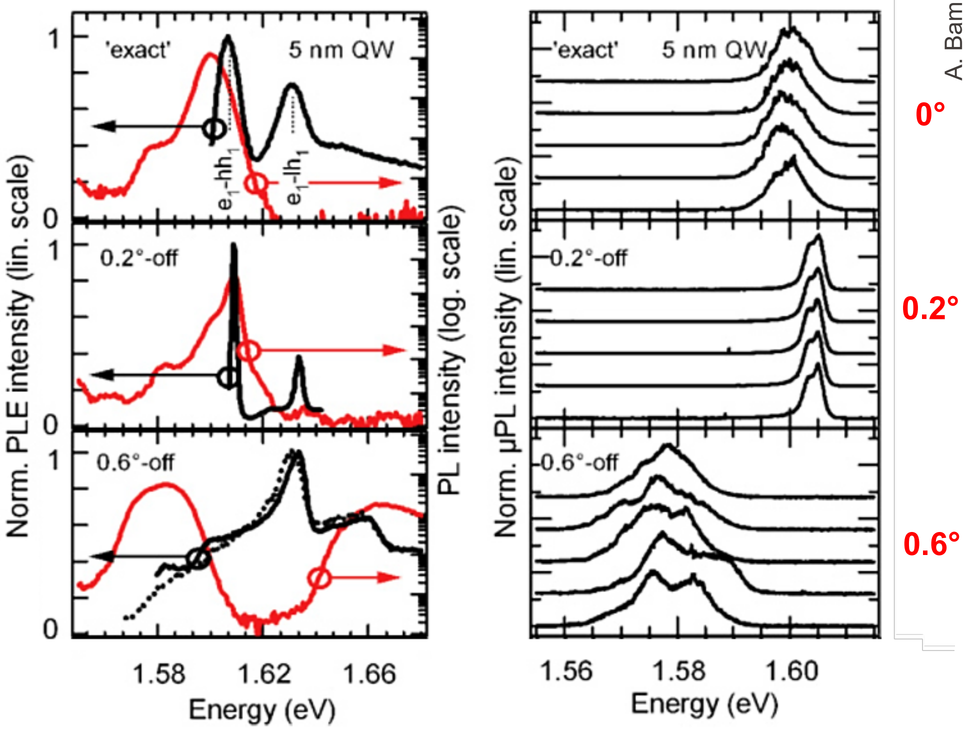
A. Bampis

QWs grown on vicinal substrates by MOVPE

A. Bampis



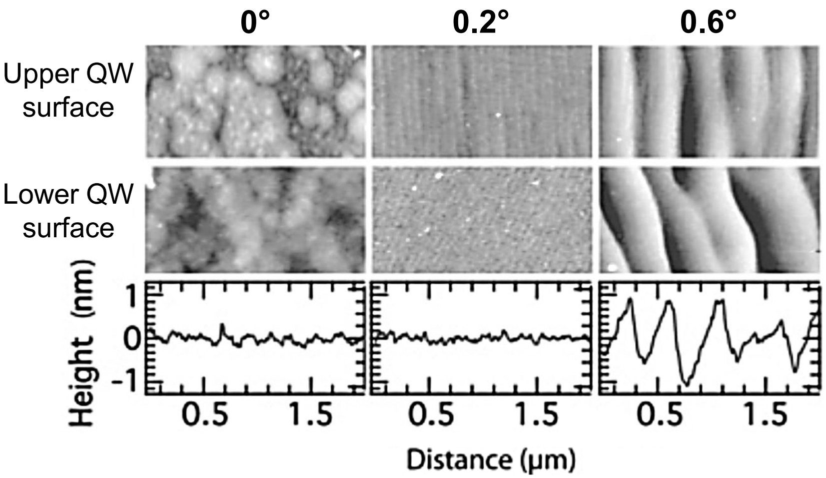
N. Moret *et al.*, *Phys. Rev. B* **84**, 155311 (2011)

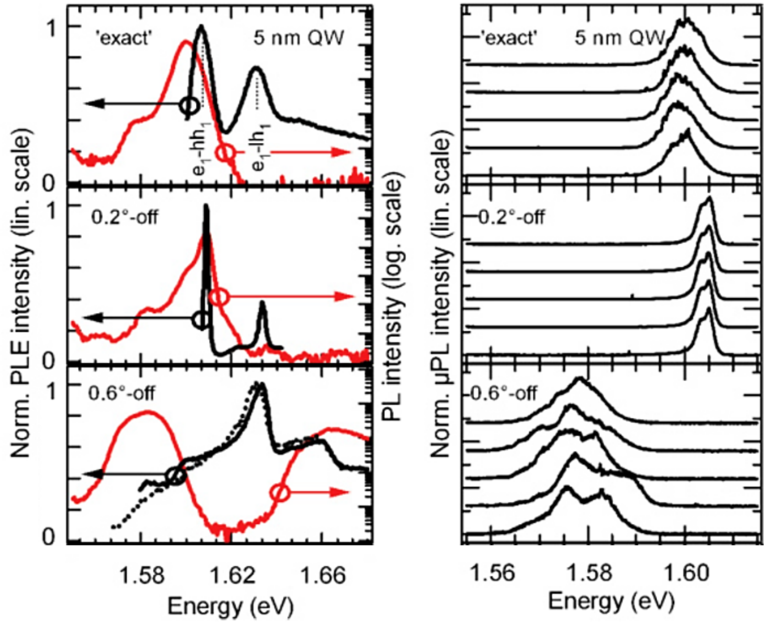


- Narrow PL linewidths → homogenous QW interfaces over a length scale > aB (exciton Bohr radius, which governs the optical properties)
- Shift in the PL peaks with respect to the absorption peaks: Stokes shift related to the degree of inhomogeneity in the samples

QWs grown on vicinal substrates by MOVPE

N. Moret *et al.*, *Phys. Rev. B* **84**, 155311 (2011)



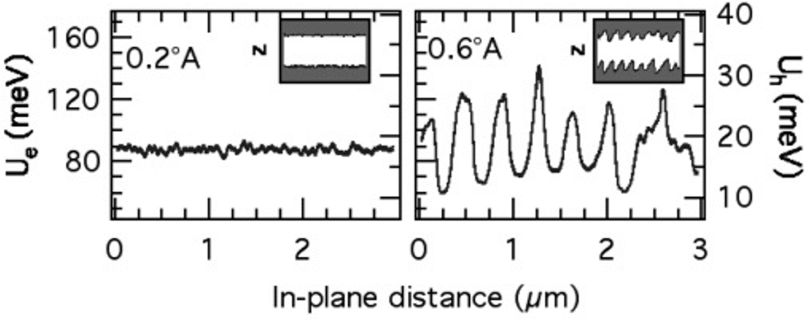


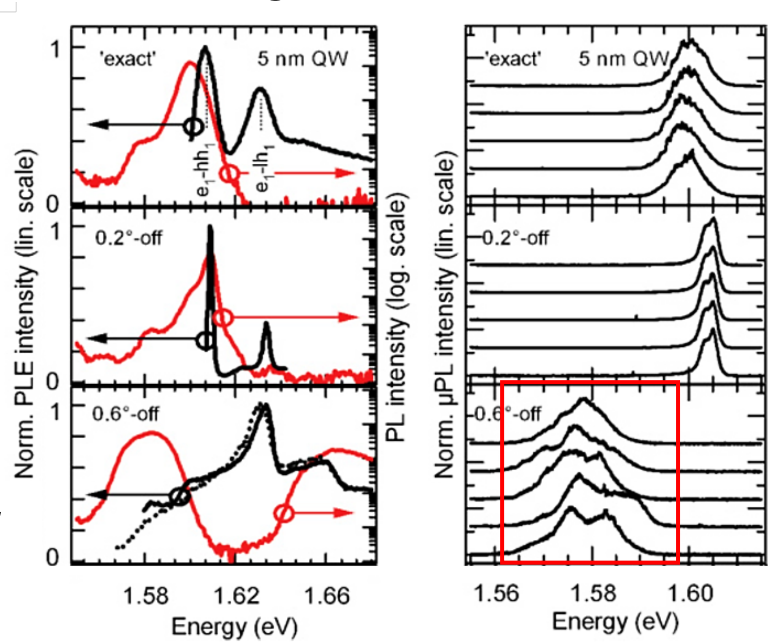
Summary

Miscut	Interface morphology	PL FWHM (d_{QW} = 5 nm)	▪ **µ-PL** (1 µm excitation spot)
0°	2D islands	1.3 meV	Multiple sharp lines
0.2°	Step flow	0.6 meV	Homogeneous line
0.6°	Step bunching	3.9 meV	Broad, distributed lines

QWs grown on vicinal substrates by MOVPE

N. Moret *et al.*, *Phys. Rev. B* **84**, 155311 (2011)





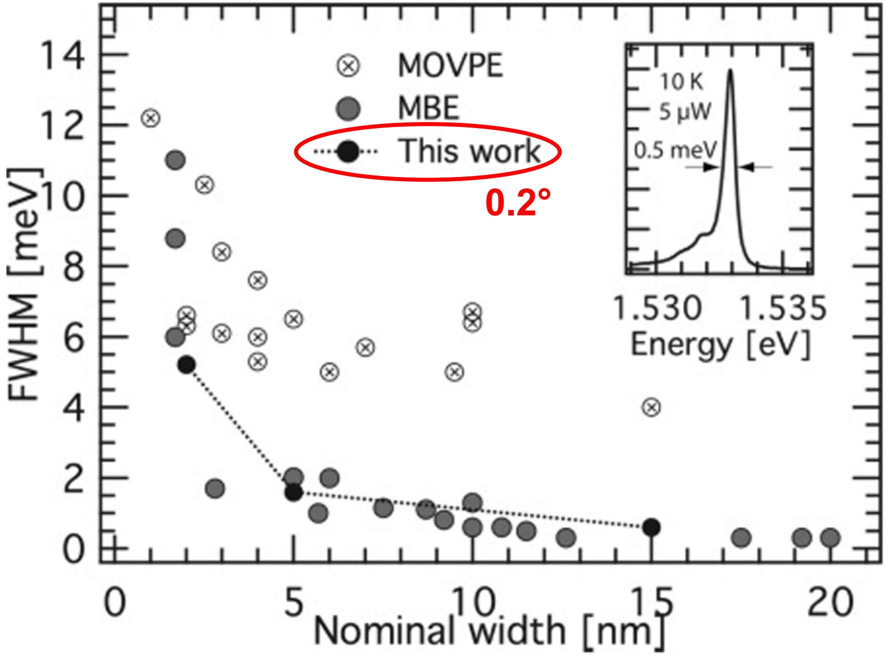
- *0.6°: large interface (well width) fluctuations*
- *PL: low temperature & low excitation*
- ➢ *Only the minima of the potential landscape are occupied*
- ➢ *Broad and redshifted lines*

Summary

Miscut	Interface morphology	PL FWHM (d_{QW} = 5 nm)	μ-PL
0°	2D islands	1.3 meV	Sharp lines
0.2°	Step flow	0.6 meV	Homogeneous line
0.6°	Step bunching	3.9 meV	Broad, distributed lines

QWs grown on vicinal substrates by MOVPE

LASPE



N. Moret *et al.*, *Phys. Rev. B* **84**, 155311 (2011)

Plot which shows how variation in the thickness of GaAs/AlGaAs QWs affects the FWHM of their PL emission.

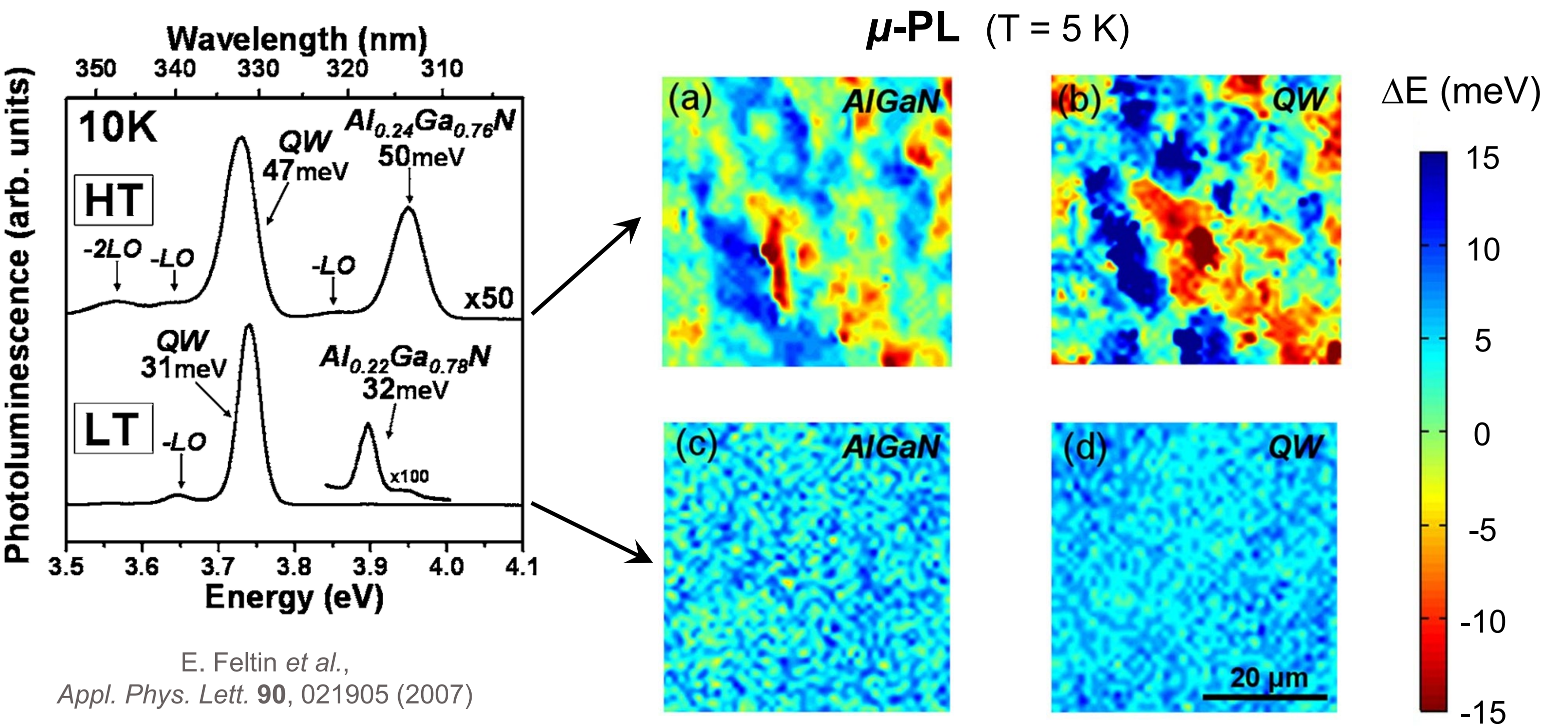
$\boldsymbol{d_{QW}} \downarrow$

→ wavefunction leakage into the barrier ↑

→ sensitivity of carriers to barrier changes (interface roughness & alloy disorder) ↑

→ **FWHM** ↑

QWs grown at various temperatures



E. Feltin *et al.*,
Appl. Phys. Lett. **90**, 021905 (2007)

- Macro-PL yields an average spectrum of the local spectra recorded with a micro-PL setup. Since the PL peak energies have larger fluctuations in the top 2 micro-PL maps, we expect a larger FWHM in a macro-PL spectrum, which corresponds to the case of the top spectrum.