

Lateral inhomogeneities in Schottky barriers: a SPELEEM study at ELETTRA



S. Heun, Th. Schmidt, J. Slezak, J. Díaz,
and K. C. Prince

Sincrotrone Trieste



B. H. Müller and A. Franciosi

Laboratorio TASC-INFM

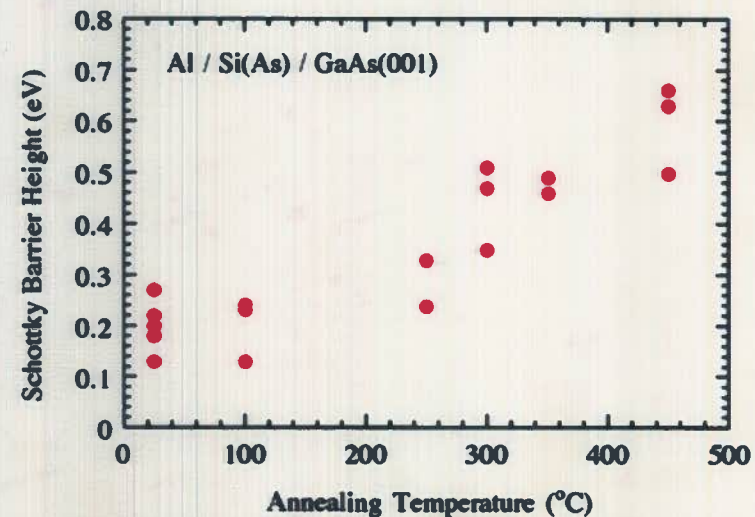


Motivation

- Metal / semiconductor junctions for solid state electronics
- Tuning Schottky barrier height
- Interface control layer
- Model system: Si between Al and GaAs

Open issues:

- Are these engineered interfaces thermally stable ?
- Are these interfaces laterally homogeneous ?



Data from L. Sorba et al.: APL 69 (1996) 1927.



Samples



In the MBE chamber at Laboratorio TASC-INFM:

1. Substrate material: n^+ -GaAs(001), $n_{\text{Si}} = 3 \times 10^{18} \text{ cm}^{-3}$.
2. Growth of a 500 nm-thick n-GaAs buffer layer at $T = 600^\circ\text{C}$, $n_{\text{Si}} = 3 \times 10^{16} \text{ cm}^{-3}$.
3. Deposition of 0.5 or 3 ML Si under As-flux ($p = 4 \times 10^{-6} \text{ torr}$) at $T = 300^\circ\text{C}$.
4. As-capping.

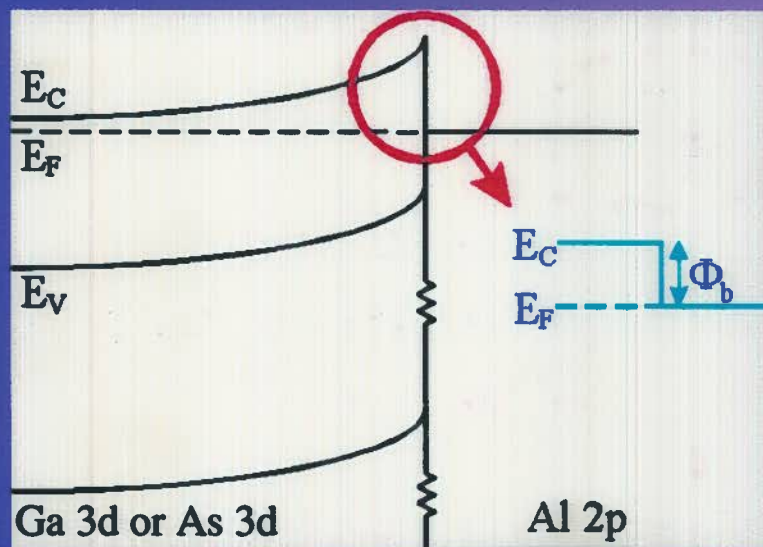


In the SPELEEM microscope at Sincrotrone Trieste:

1. As-decapping.
2. Deposition of 13\AA Al at room temperature.
3. Annealing of the sample at 500°C for 10 minutes.



Schottky Barrier Height Determination



Measured: $E(\text{Ga } 3d)$ or $E(\text{As } 3d)$ relative to E_F .

Known: Ga 3d relative to the VBM (18.86 eV).

As 3d relative to the VBM (40.80 eV).

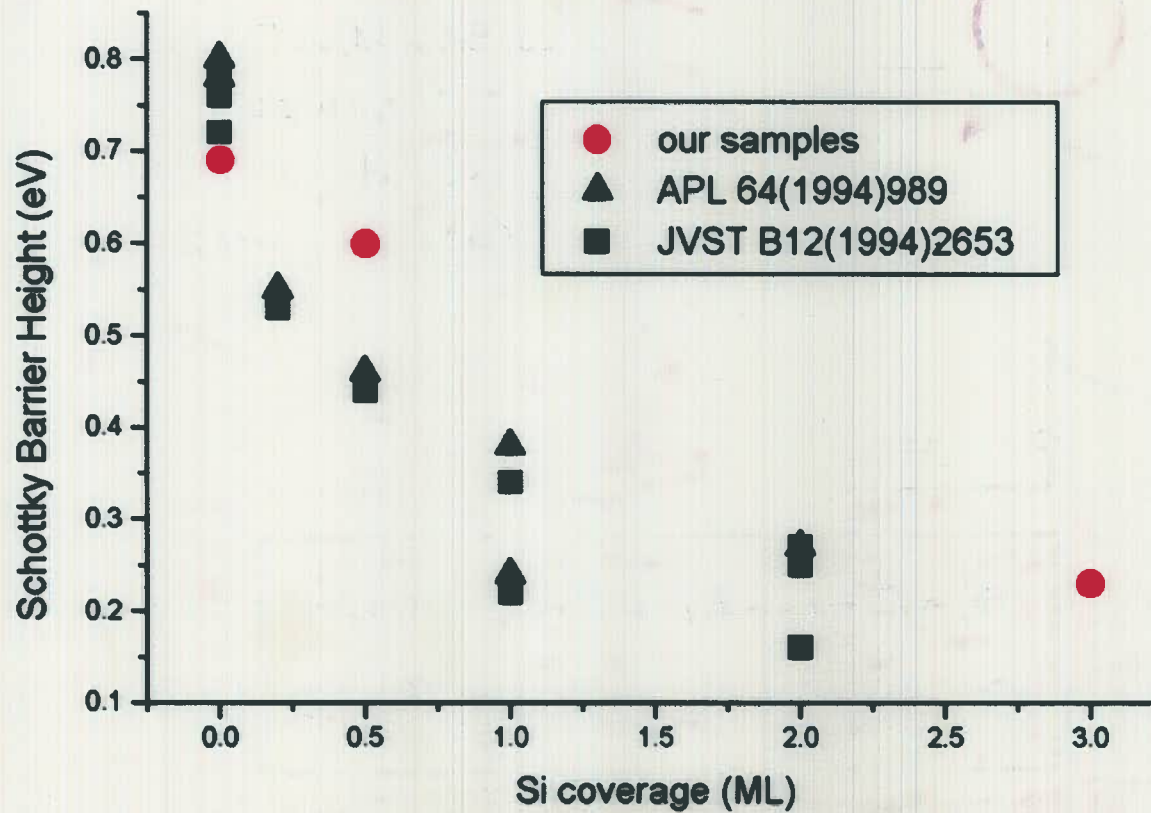
GaAs band gap at RT ($E_G = 1.42$ eV)

$$\Phi_b \approx E_C - E_F = E_G + 18.86 \text{ eV} - E(\text{Ga } 3d)$$

$$\Phi_b \approx E_C - E_F = E_G + 40.80 \text{ eV} - E(\text{As } 3d)$$



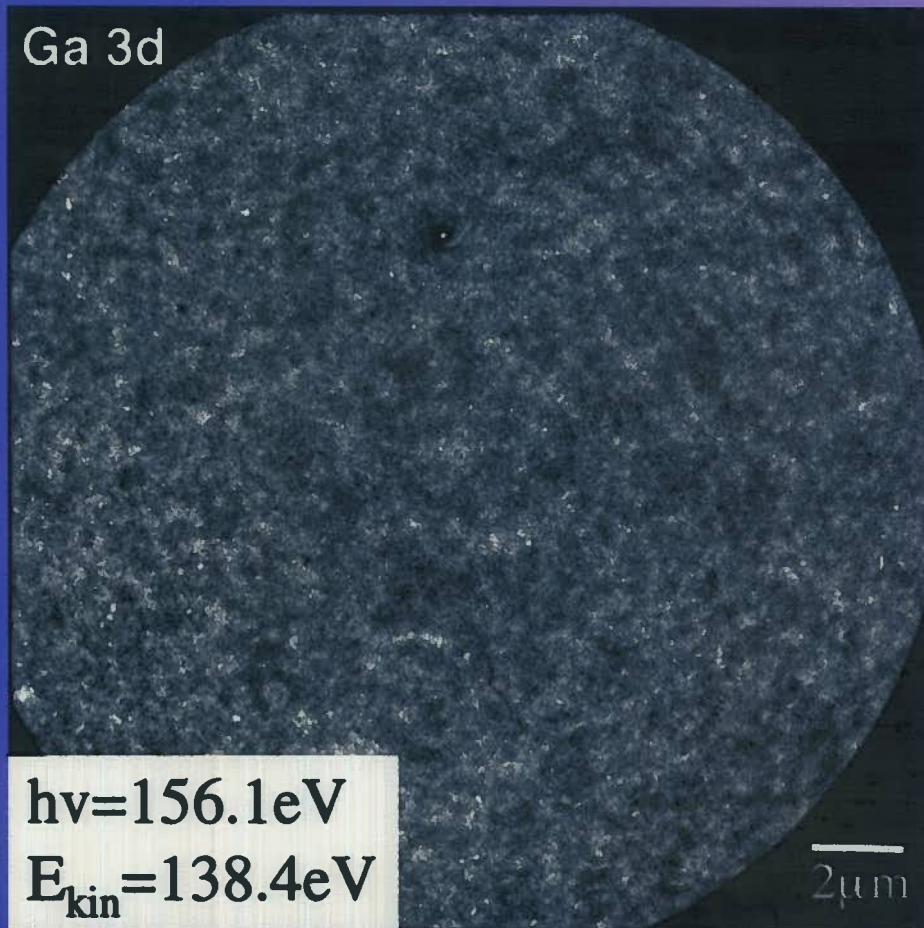
Schottky Barrier Heights





As-grown samples

Ga 3d



3 ML Si(As) / GaAs

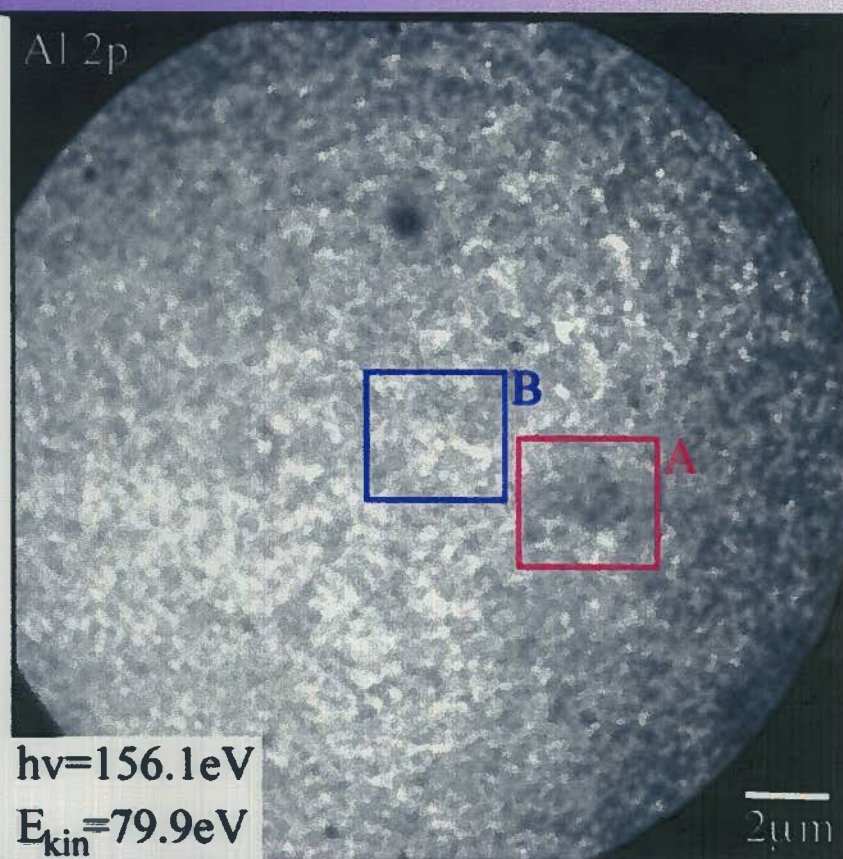
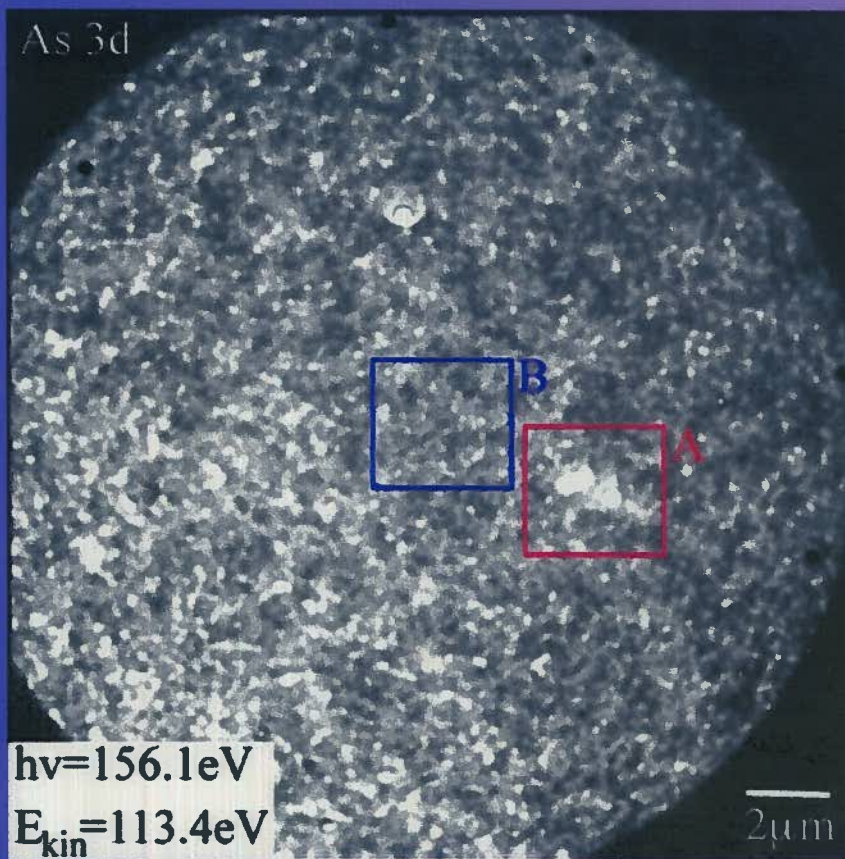
- Sample very homogeneous.
- No lateral inhomogeneities (± 0.2 ML).

13 Å Al / 3 ML Si(As) / GaAs

- Sample very homogeneous.
- No lateral inhomogeneities (± 0.1 eV).
- Image of the sample at the energy of the Ga 3d core level (field of view: 19 μ m).

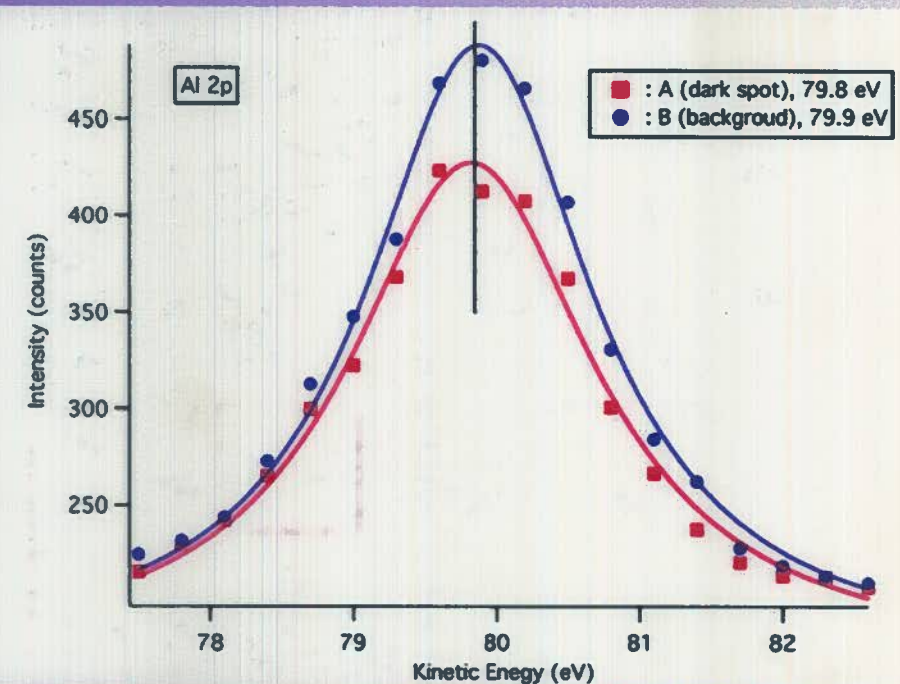
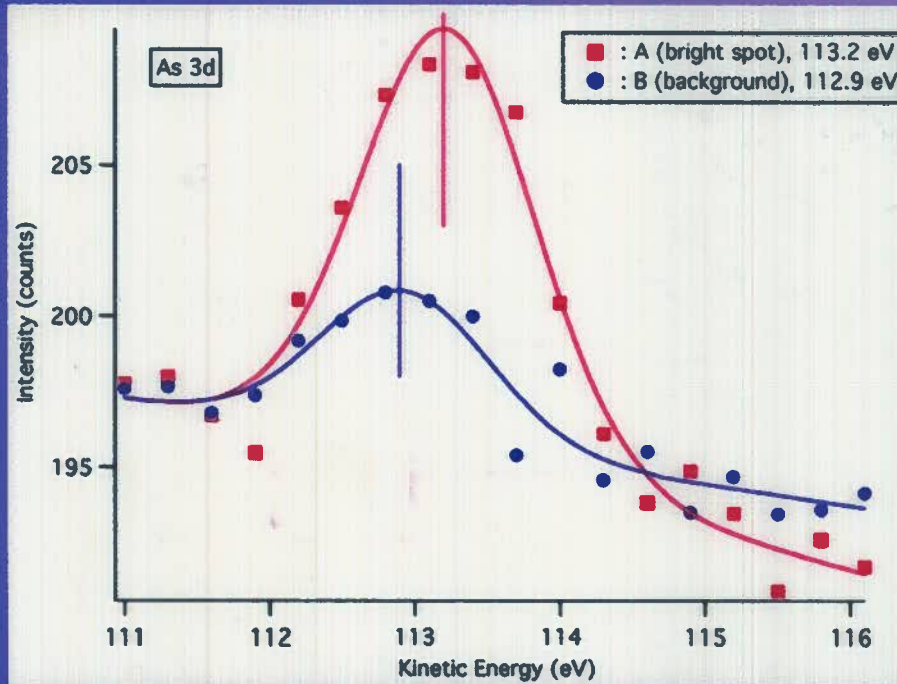


13 Å Al / 3 ML Si(As) / GaAs,
annealed at 500°C for 10 min.



no contrast at other energies like Ga 3d and Si 2p core level

Core Levels



- no evidence for inhomogeneous outdiffusion of Si into Al
- no AlAs interface phase
- As depletion of Si(As)/GaAs interface



Summary

- After growth, the Si(As)/GaAs and Al/Si(As)/GaAs heterostructures appear very homogeneous. No lateral inhomogeneities were observed.
- After annealing at 500°C for 10 minutes, inhomogeneous As outdiffusion is observed.
- This As outdiffusion is correlated with a local As 3d core level shift of 0.3 eV.
- Therefore we conclude that the observed degradation of engineered Schottky barriers might be correlated to laterally inhomogeneous As outdiffusion upon annealing of the device.