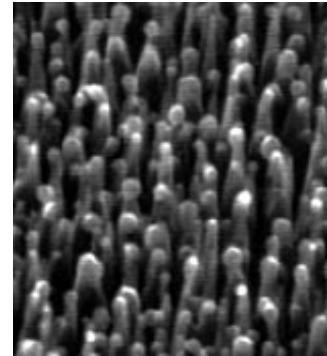
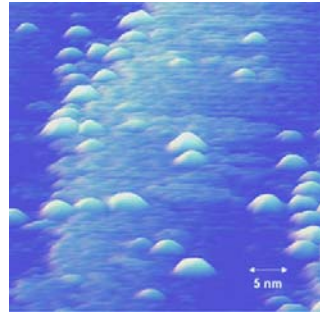
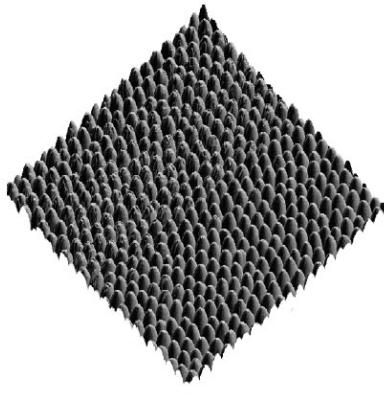


# *Semiconductor Nanostructures*



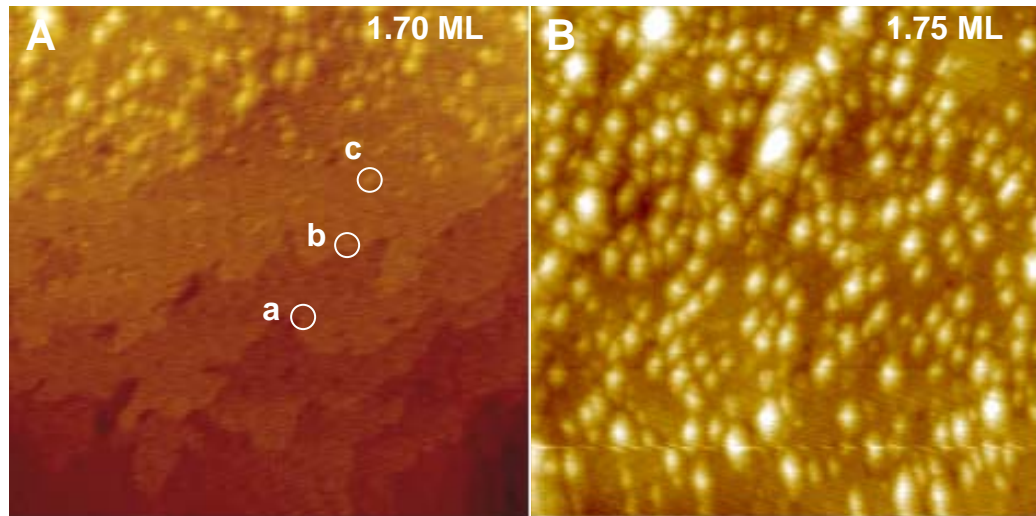
Gavin Bell

Surface Science Group (Physics)

# Semiconductor nanostructures *without fabrication*

- Self-assembled semiconductor quantum dots and wires
  - typically *heteroepitaxy*: InAs-GaAs and Ge-Si
  - need to understand growth processes
    - big challenge for multi-scale modelling
    - challenge for observational techniques
- Semiconductor surfaces nanostructured by ion beam erosion
  - Growth templates for other materials, e.g. magnetic pnictides?
  - Magnetic nanostructures, control of magnetic anisotropy?
  - Templates for molecular adsorption?

# Microscopy (InAs-GaAs QDs)



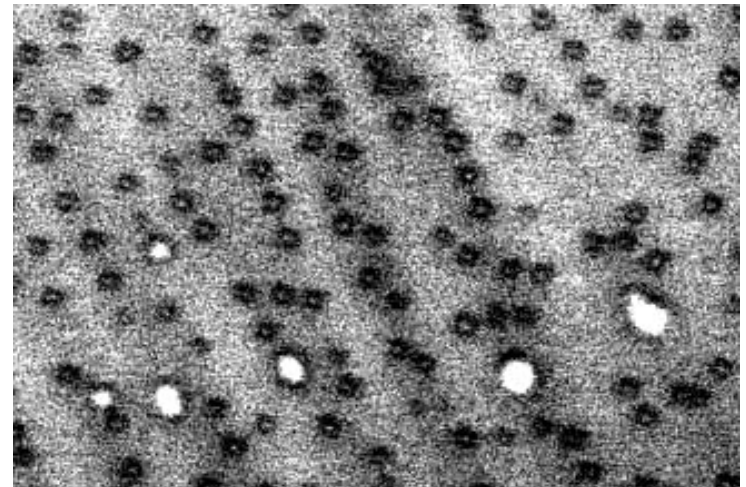
‘STMBE’ – Shiro Tsukamoto,  
University of Tokyo

Scan *during* growth  
– try to watch  
kinetics in action

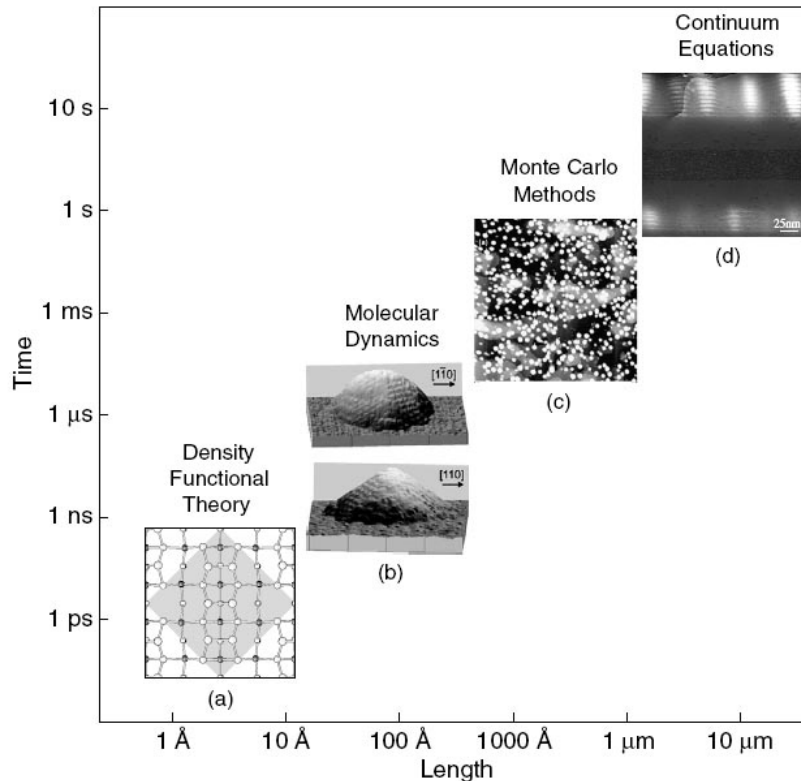
SEM - Warwick

Z-contrast mode: In-rich QD tops /  
centres and irregular In-rich islands

General problem – compositional  
analysis for nanostructures



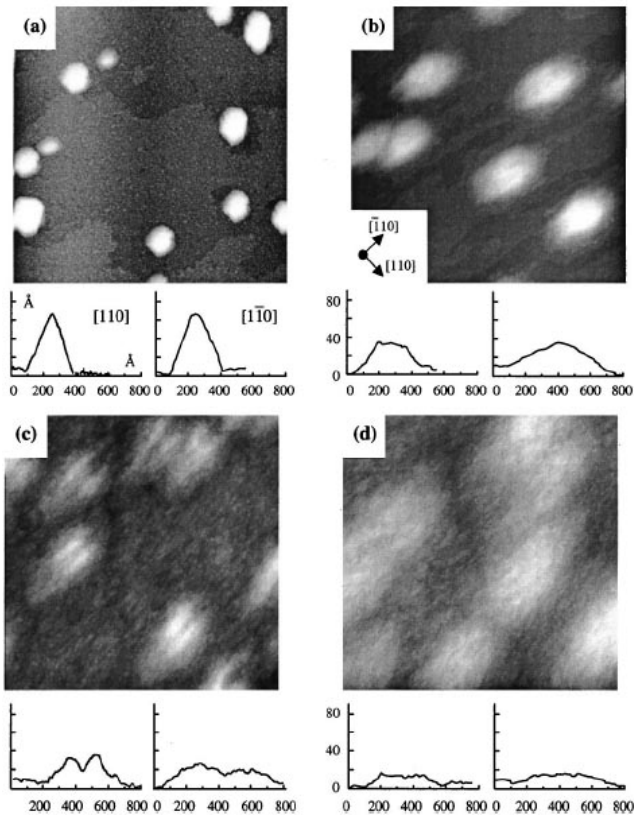
# Modelling QD growth kinetics



Dimitri Vvedensky, JOURNAL OF PHYSICS  
CONDENSED MATTER **16** R1537 (2004)

- Need to understand growth kinetics to optimise properties.
- InAs-GaAs QDs – very rapid assembly at critical thickness.
- Depends on surface reconstruction (atomic scale) but end up with  $10^4 - 10^5$  atoms per QD.

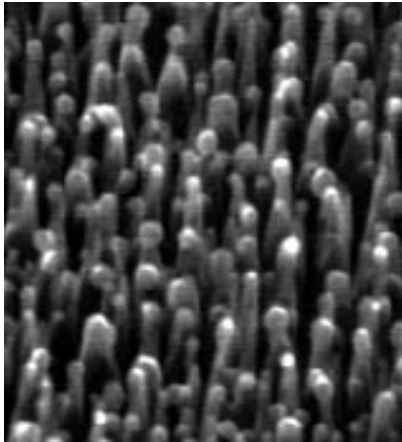
# Related structures (InAs-GaAs)



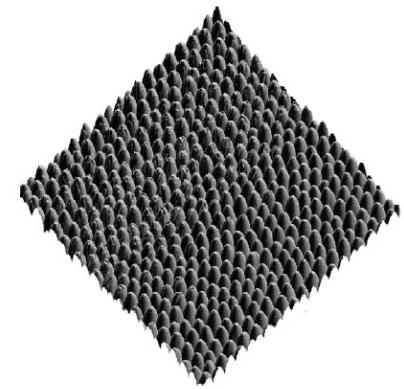
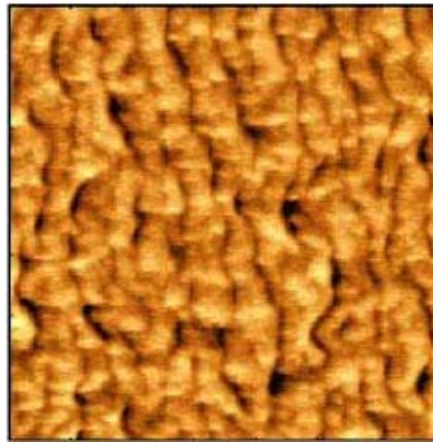
- Quantum wires / dashes
- QD 'vertical stacks'
- Quantum rings

Overgrowth of InAs island with GaAs – formation of more complex structures e.g. 'quantum ring'

# Ion beam nanostructuring



*Surf. Interface Anal.* **29**, 782–790 (2000)



NIM B 178 (2001) 101

‘Anti-growth’ – sputtering material away from initially flat wafer surface

Various structures possible – e.g. InP filaments with In tips, ripple structures or well-ordered 3D island arrays