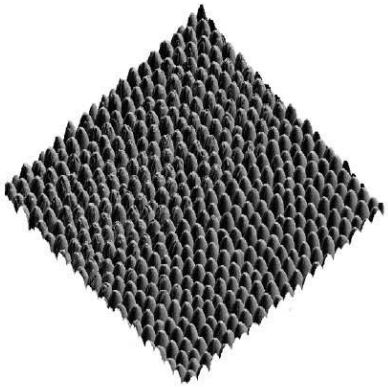
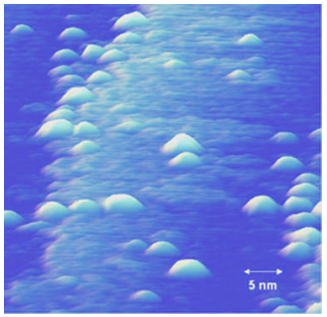
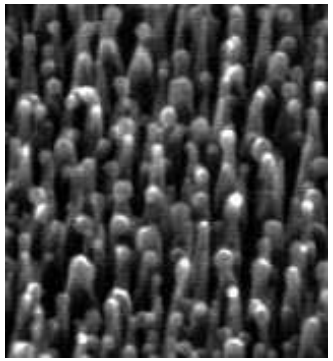
# *Semiconductor Nanostructures*





Dr. Gavin Bell

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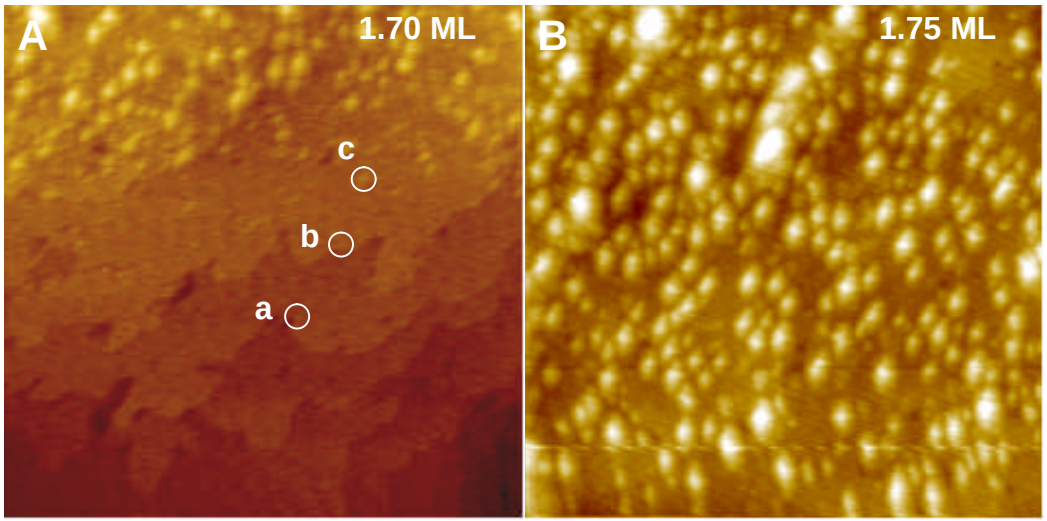
# Semiconductor nanostructures *without fabrication*

- 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)



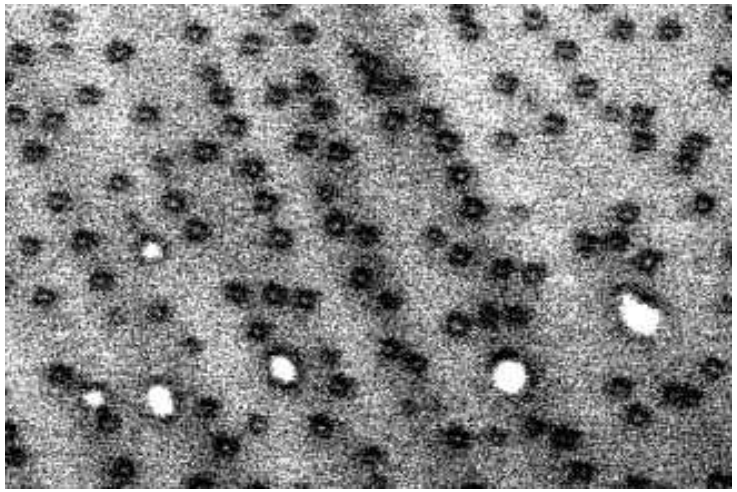

'STMBE' – Prof. Shiro Tsukamoto, University of Tokyo

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

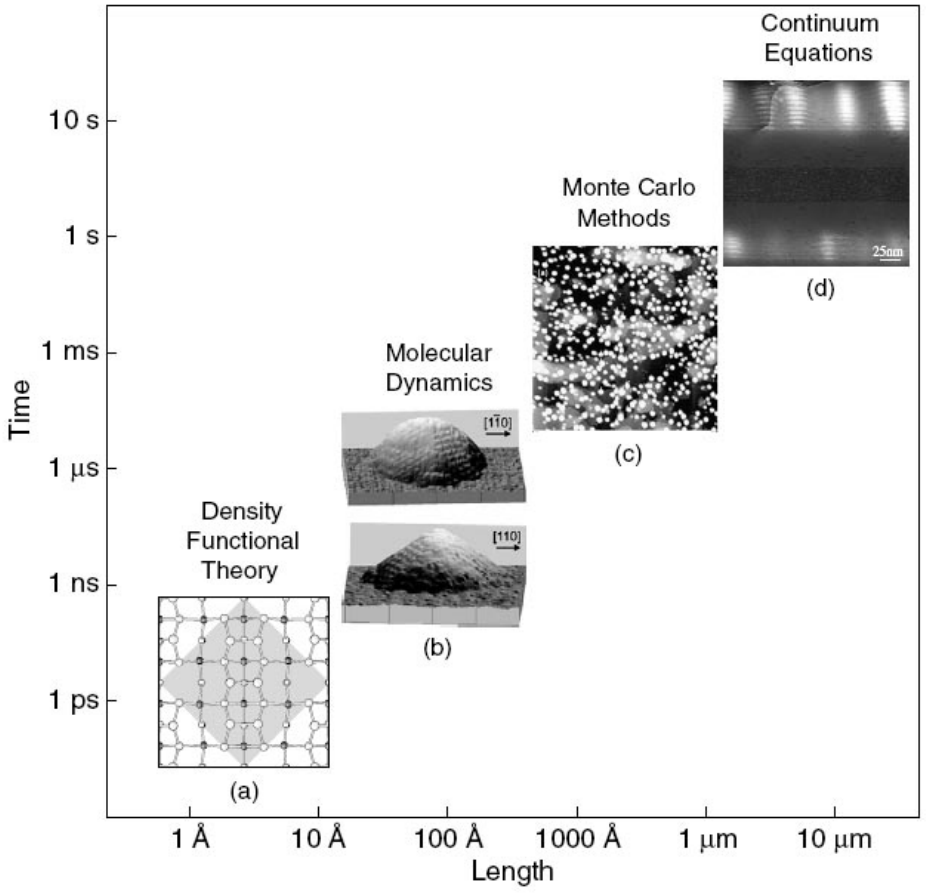
SEM - Warwick

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

General problem – compositional analysis for nanostructures



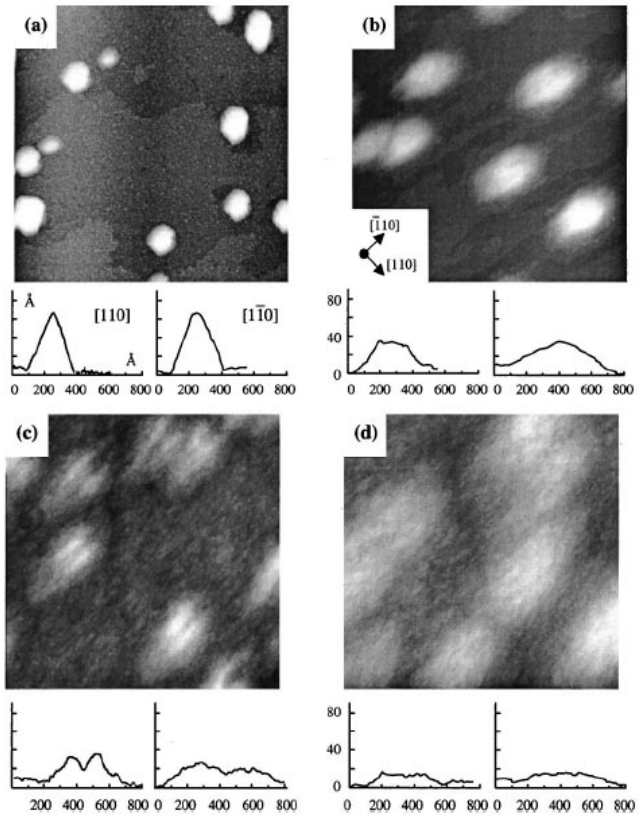
# Modelling QD growth kinetics




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.

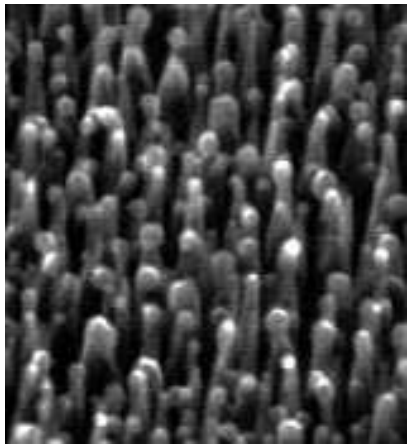
# Related structures (InAs-GaAs)

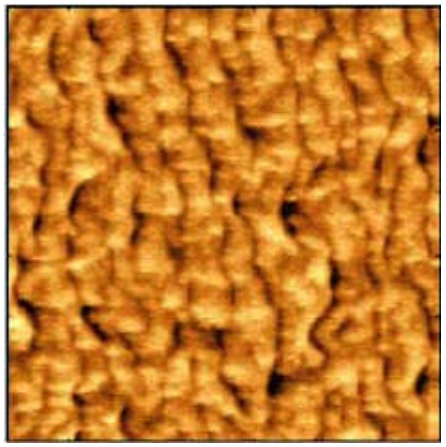


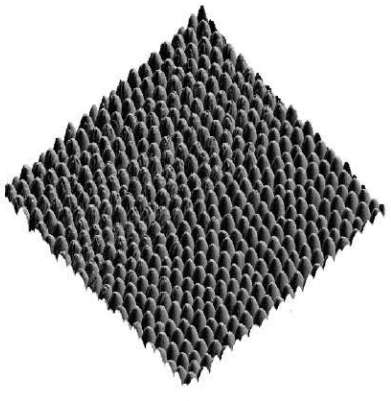

- Quantum wires / dashes
- QD ‘vertical stacks’
- Quantum rings

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