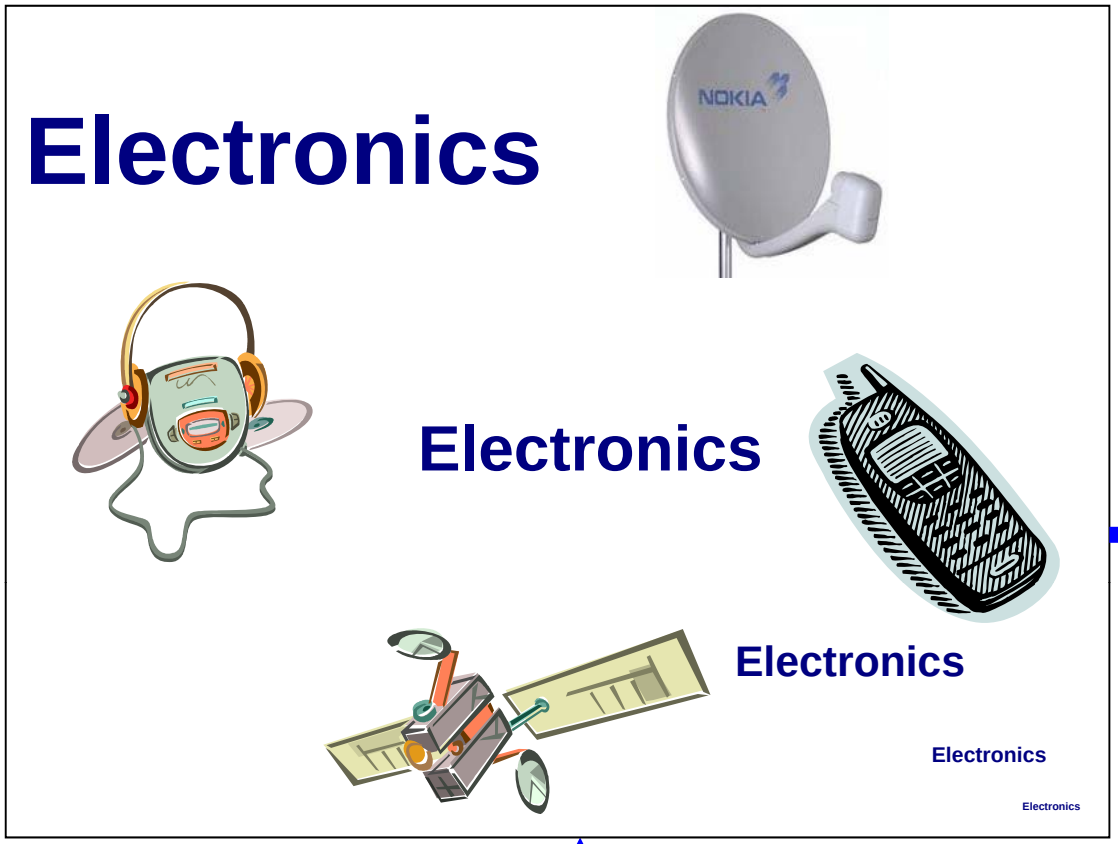


Bottom-up approach
self-assembly of nanoscale object via self-organisation.

Top-down approach
making micro- and nanometre-scale devices by growing layered materials and patterning bulk materials.

New regimes for electronic properties of material with reduced dimensions,
due to the quantum effects in the electronic system.

Nano- and micro-electronic systems / devices

Top-down manufacturing methods: growth and lithography.
Use of AFM for nanoprocessing.
Lithographically defined one-dimensional wires in semiconductors.

Electronics =

electronic transport + sensitivity of transport characteristics to external conditions:

magnetic field,

temperature,

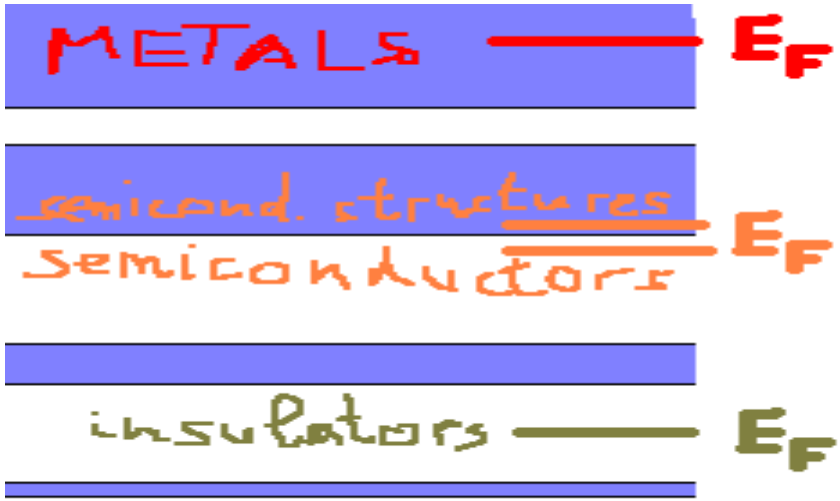
electromagnetic environment.

Electronics materials:

Semiconductors and semiconductor heterostructures

Normal and Ferromagnetic metals, Superconductor

Electron dynamics in each material is determined by

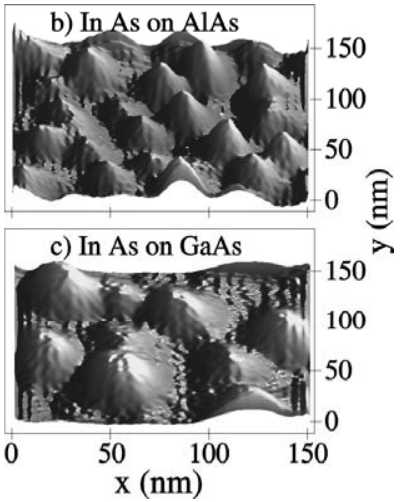


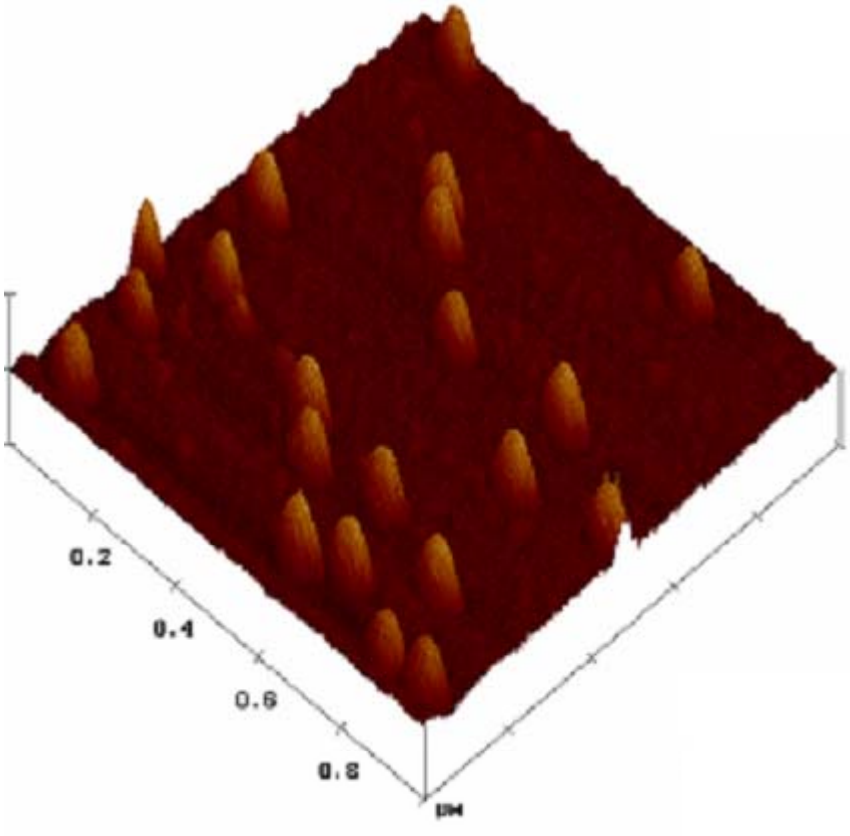
band structure ~1eV

correlations <1meV

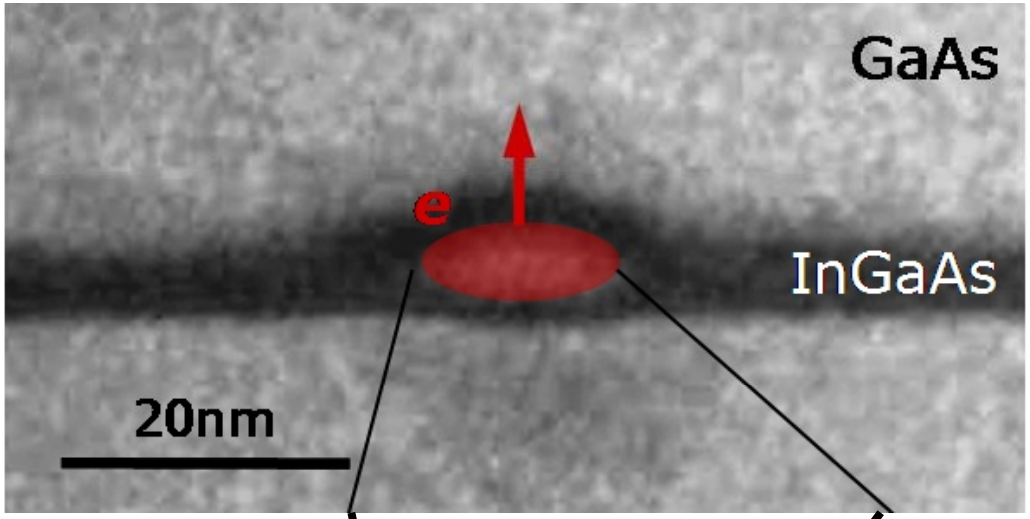
Self-assembled semiconductor dots

Due to lattice mismatch between two semiconductor materials, dots of one material tend to form, by themselves, on the surface of another: 'self-organisation'.

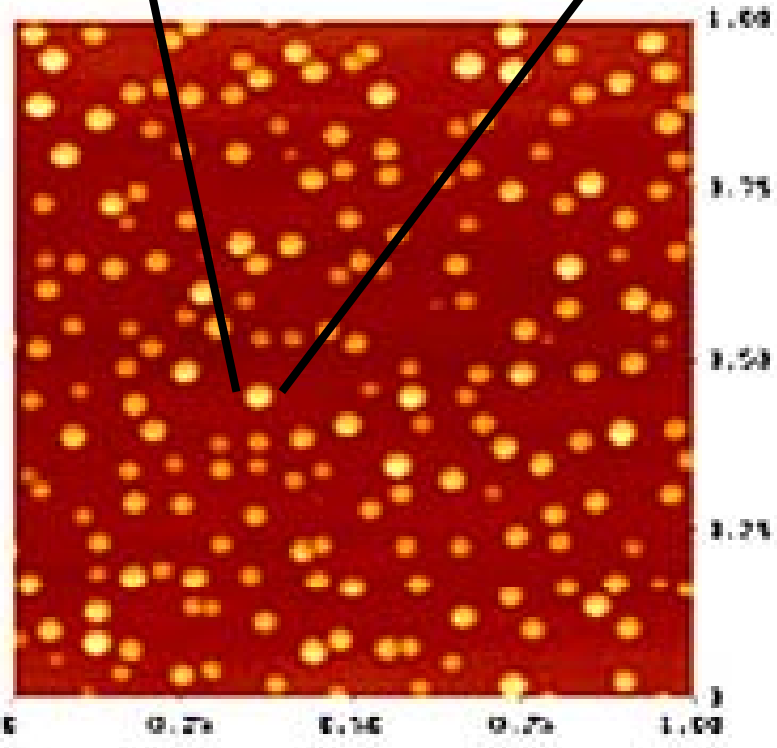


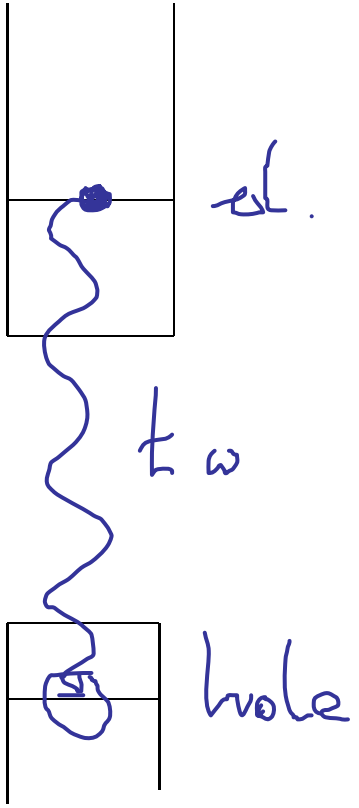


InP dots formed on the GaInP surface (AFM scan)

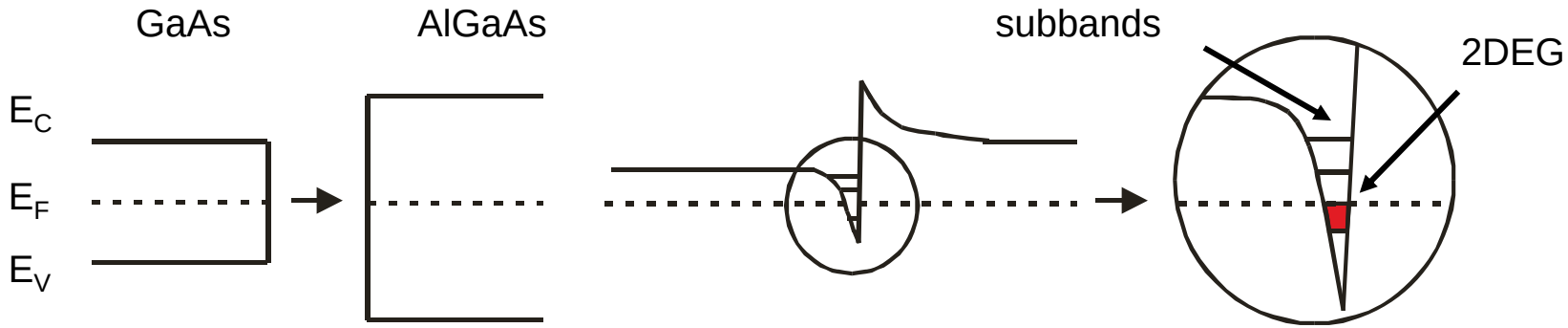


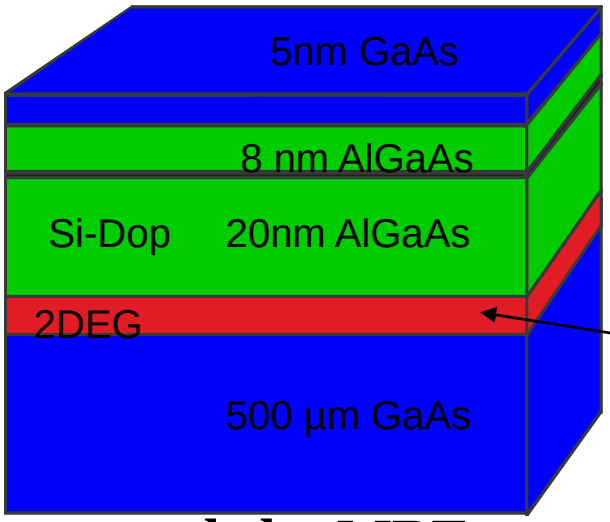
TEM image of an
InGaAs/GaAs dot





Semiconductor Heterostructures





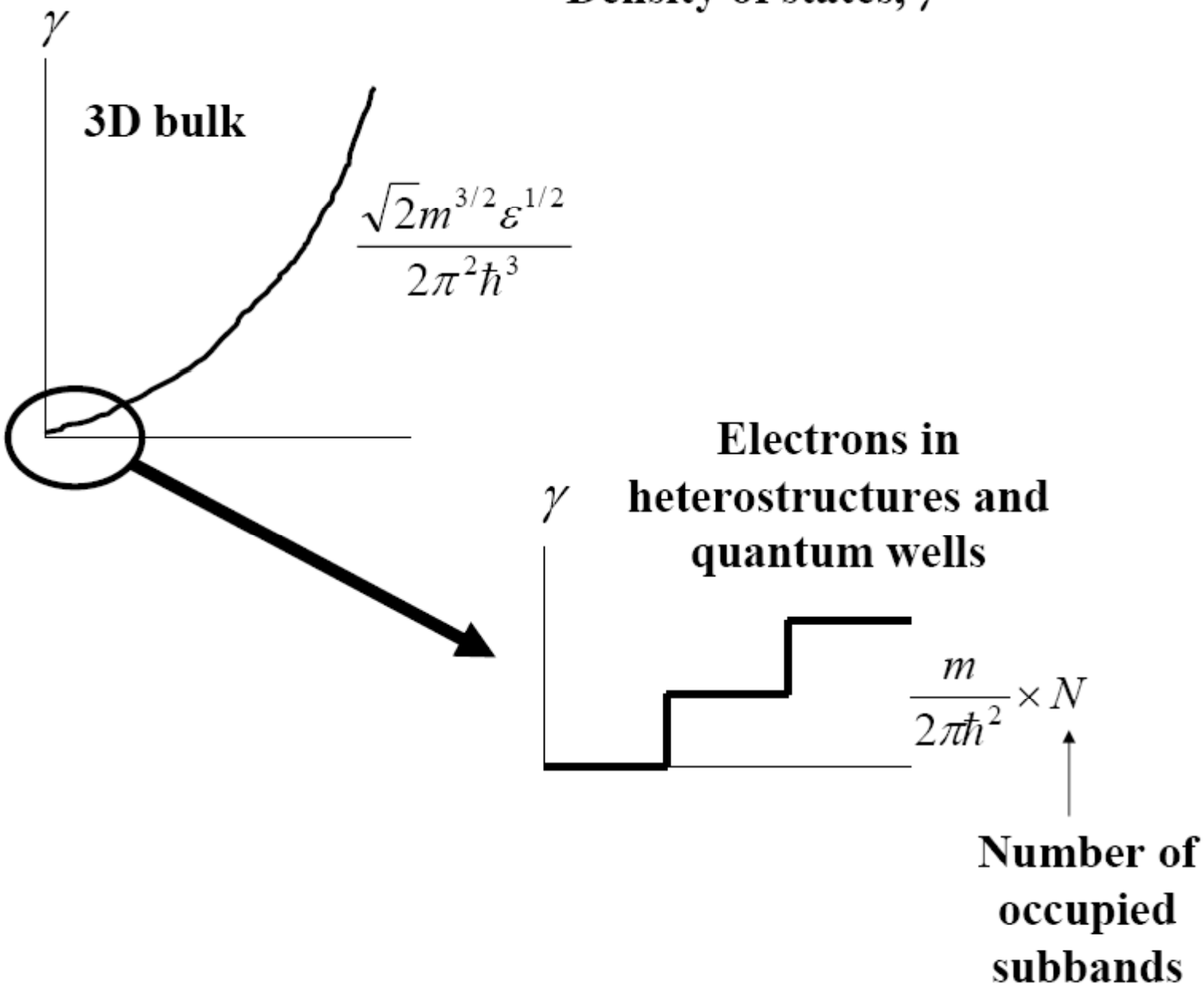
made by MBE:
molecular beam epitaxy

band-edge discontinuity produces a triangular well ➡ **2DEG**

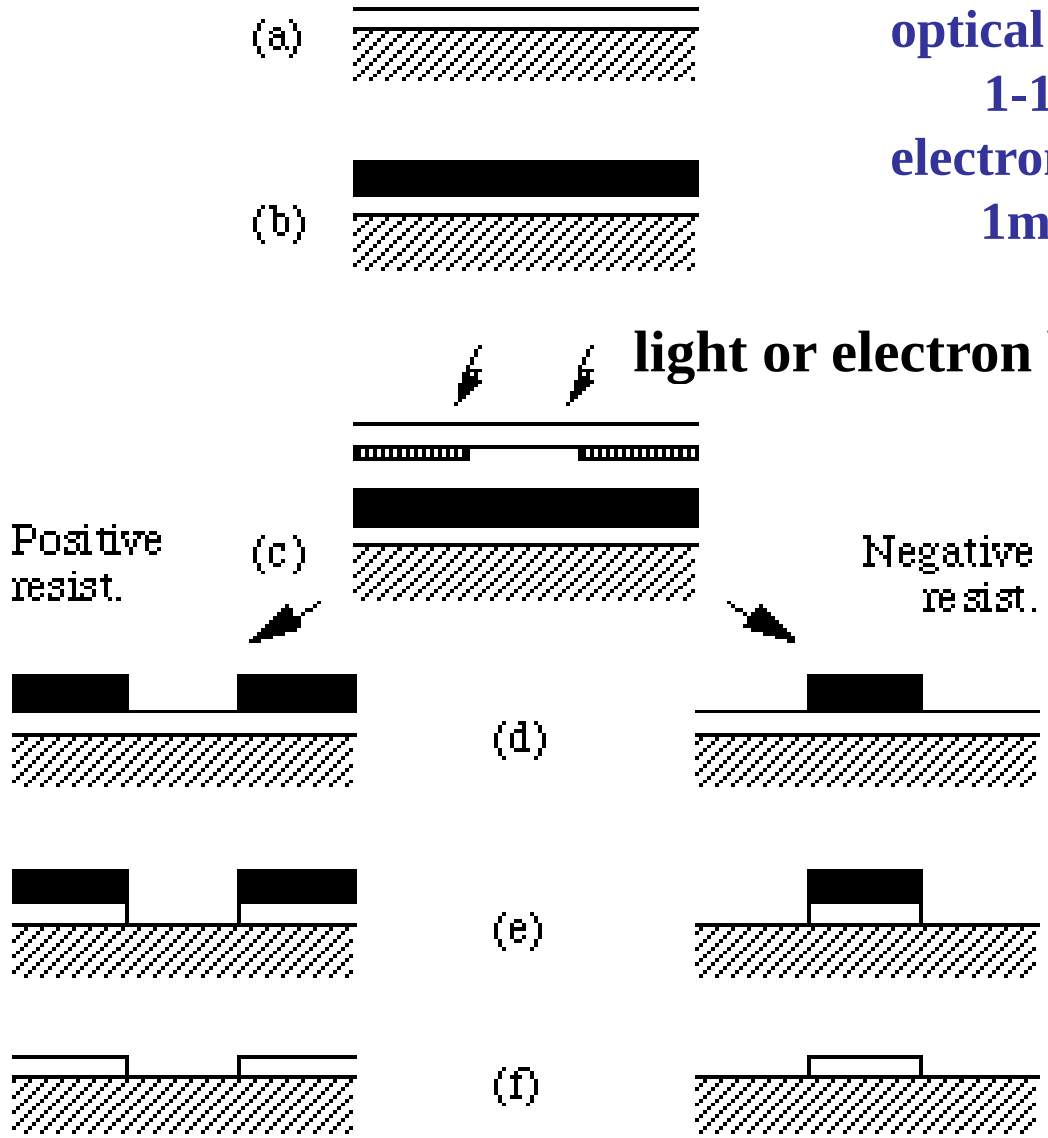
2DEG is a metal with a very low density

$$n_{2DEG} \sim 10^{10} - 10^{12}\, cm^{-2}$$

Density of states, γ



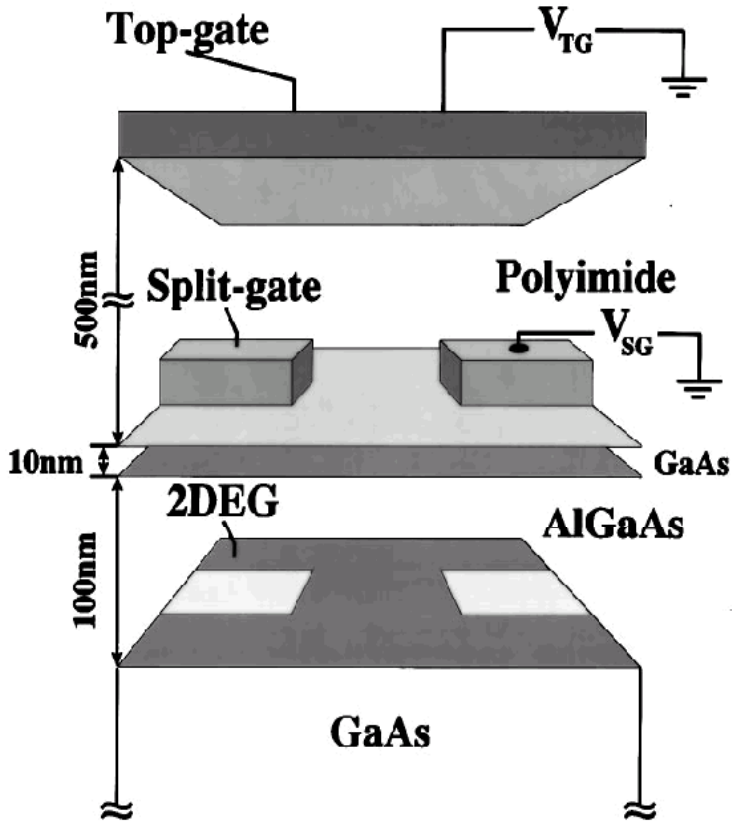
How to make micro/nanotructures: wires and dots



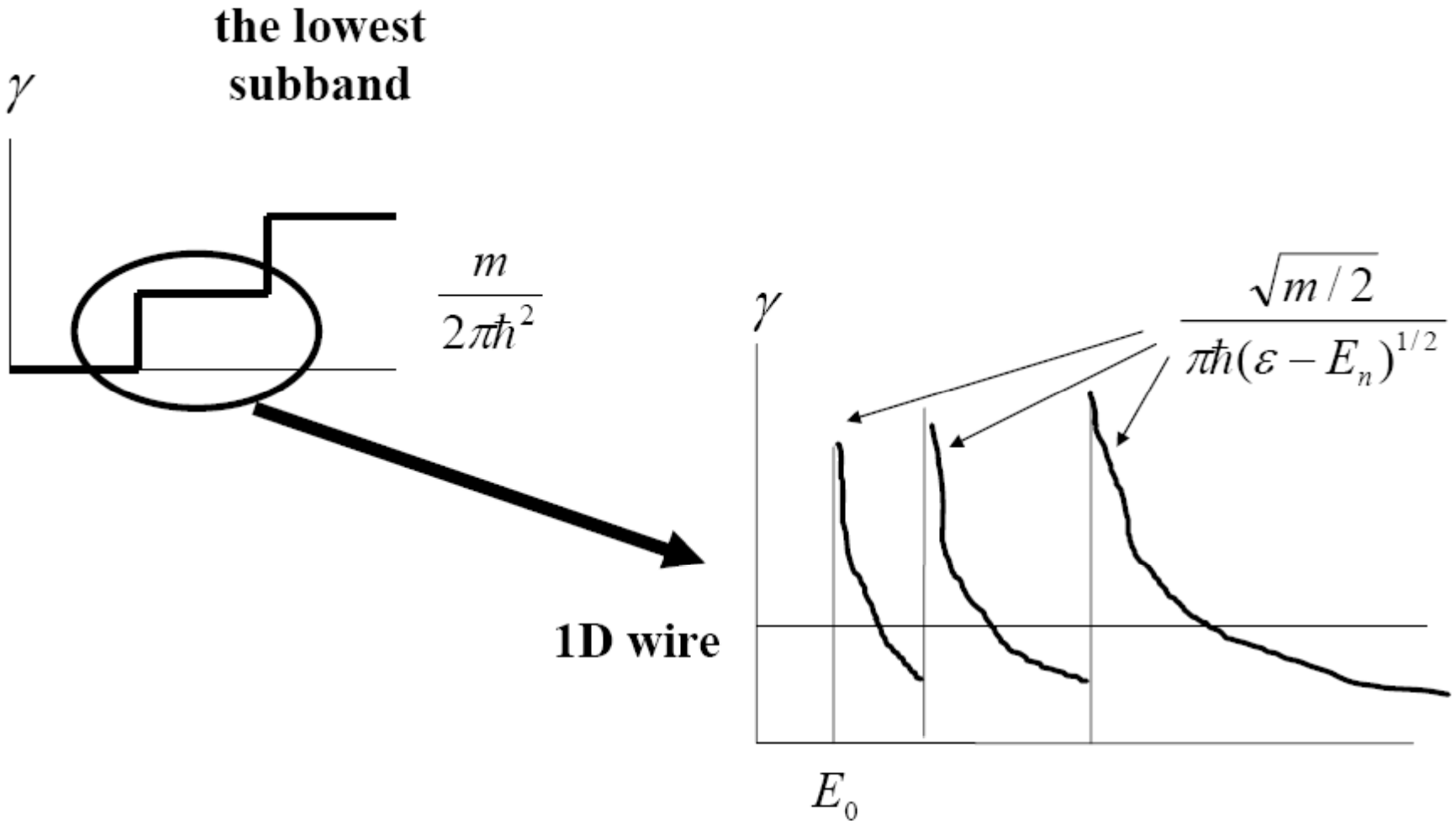
optical lithography (visible/UV light, 1-10microns)

electron beam lithography (0.1-1micron)

Making quasi-one-dimensional wires using lithographically processed metallic gates

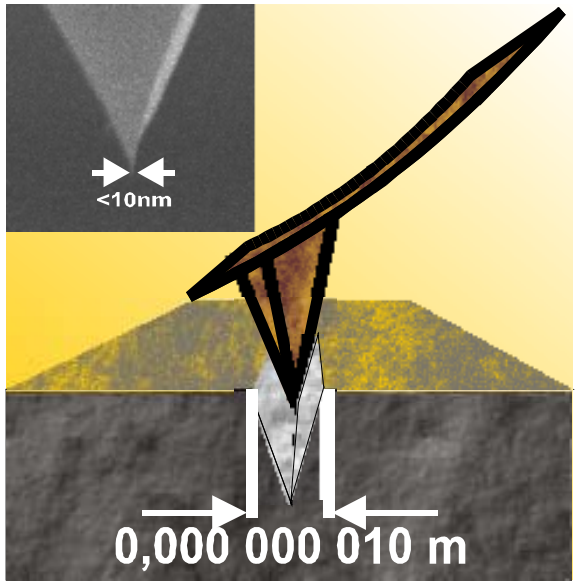


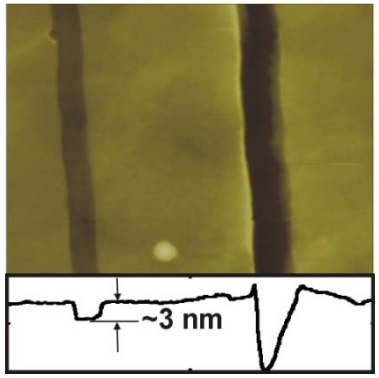
Density of states, γ



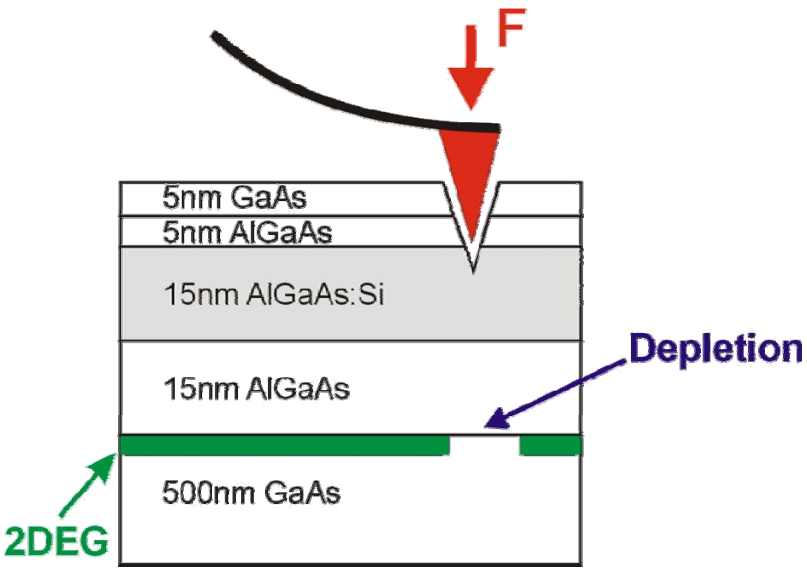
Surface Modification (direct writing) with an AFM (10-100nm)

nanomachining



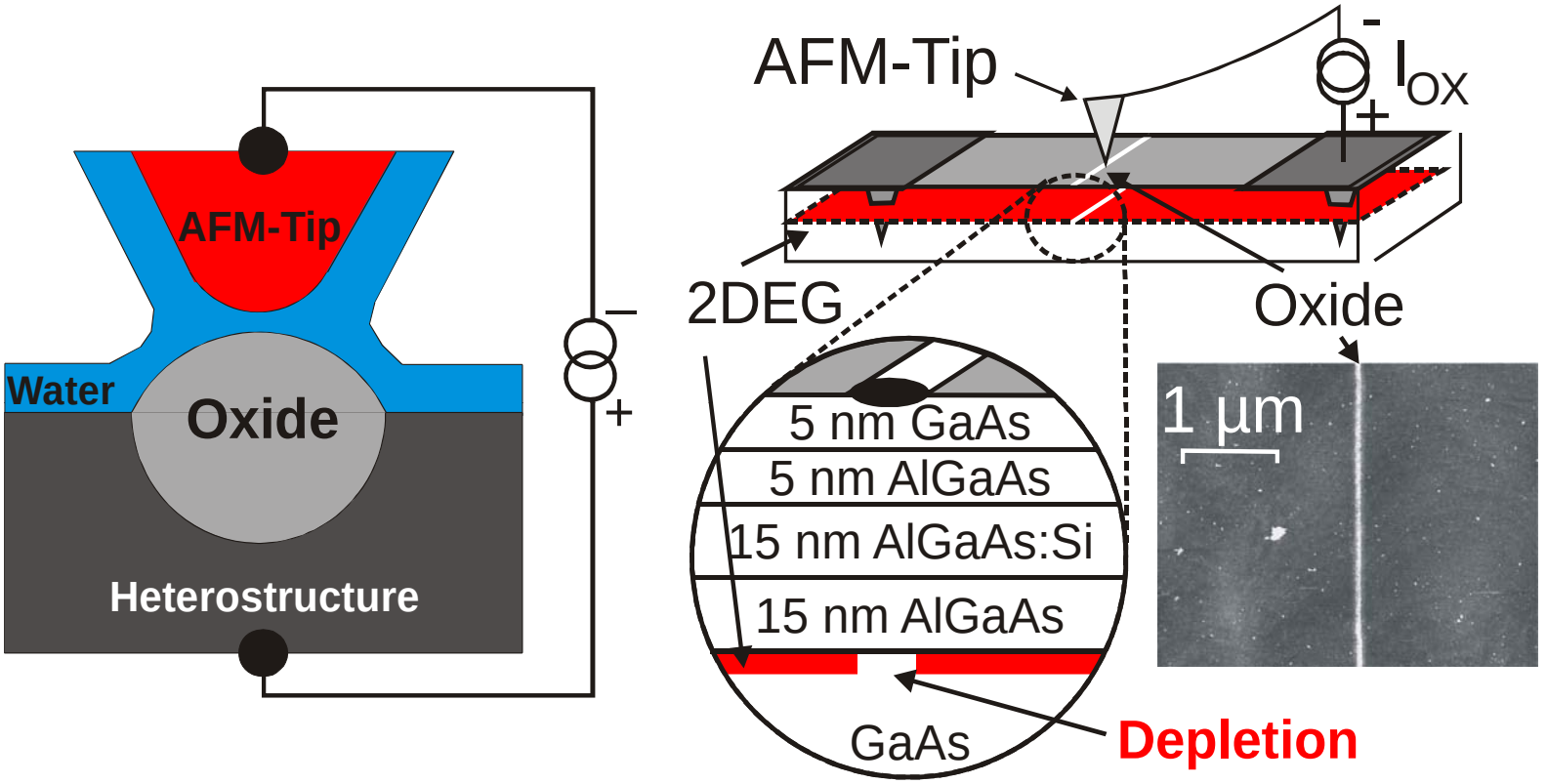


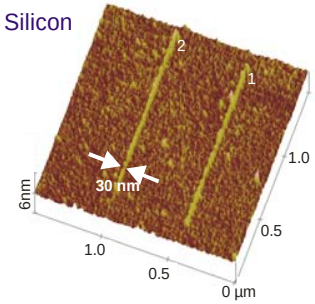
application: GaAs/AlGaAs-heterostructure



Haug et al, Appl. Phys. Lett. 75, 1107 (1999)

Local Oxidation (10-100nm)





Ishii, Matsumoto (1995), Held et al. (1998)