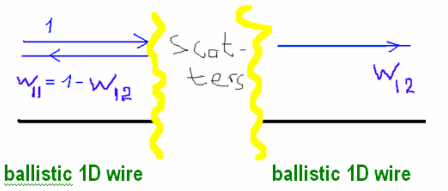
Lectures 19: Scanning Tunneling Microscopy

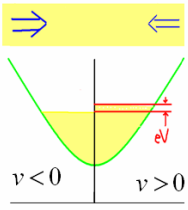
$$I = 2e\int_{E_F-eV/2}^{E_F+eV/2} w_{12}(\varepsilon)\cdot V_F \nu_F d\varepsilon = \frac{2e^2V}{h} w_{12}(\varepsilon_F)$$



ballistic 1D wire ballistic 1D wire

$$G = \frac{2e^2}{h} w_{12}(\varepsilon_F)$$

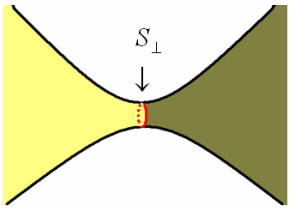
Landauer, Buttiker 1984



$$w_{12} = 1$$

Ballistic and adiabatic constriction:
reflection-less passage from one entry to the other

'Point contact' between two bulk 3D metals



$$G = \frac{2e^2}{h} N_{ballistic}$$

$$N\left(\frac{S_\perp^{\min}}{\lambda_F^2}\right) \sim \frac{S_\perp^{\min}}{\lambda_F^2}$$

$$G = a_{geom}\frac{2e^2}{h}\frac{S_\perp^{\min}}{\lambda_F^2}$$

Sharvin 1982

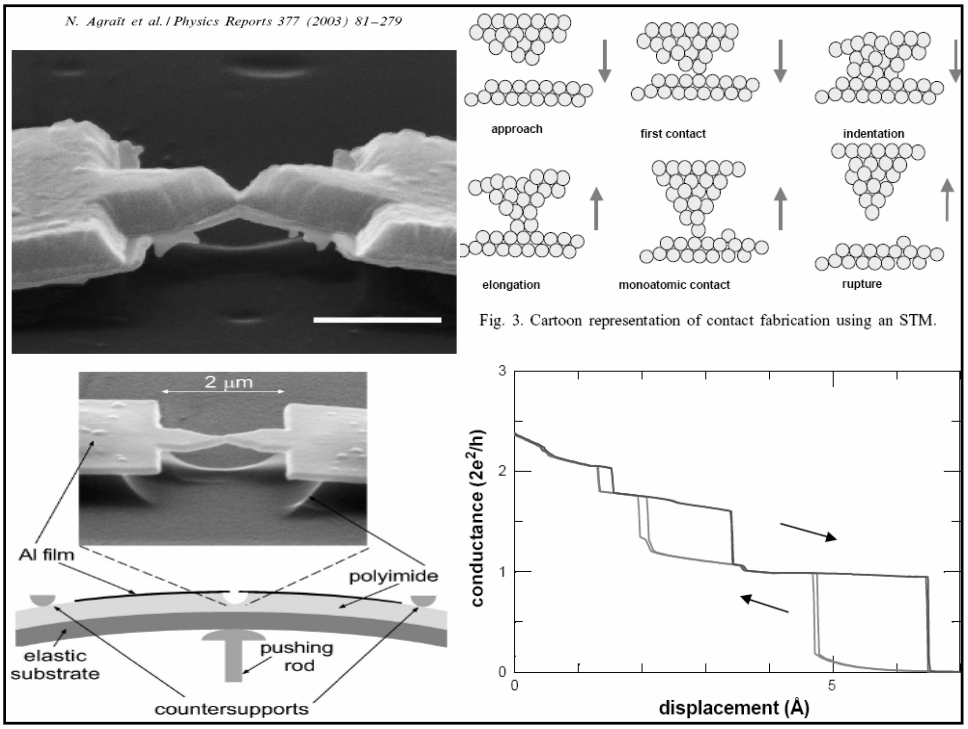
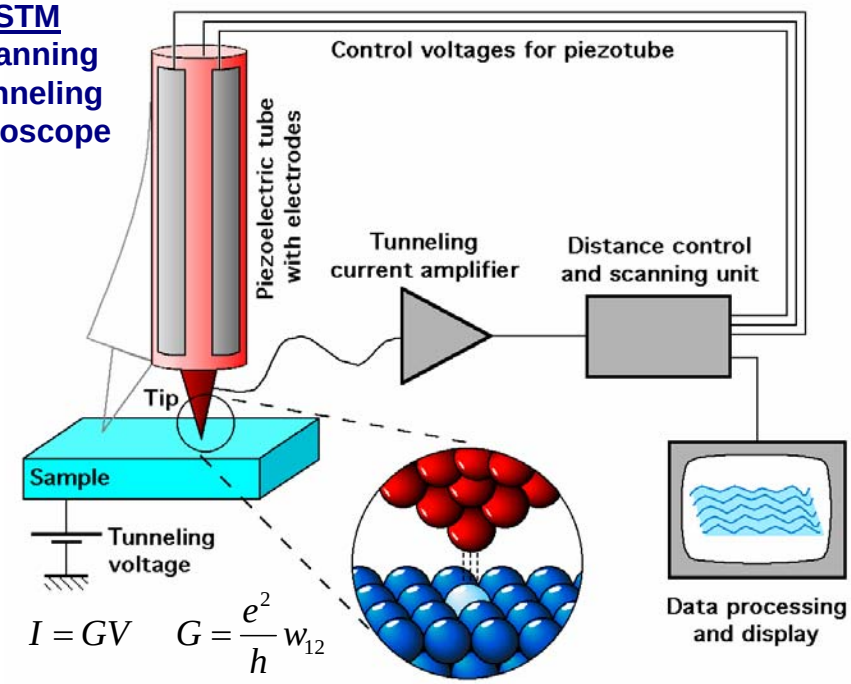


Fig. 3. Cartoon representation of contact fabrication using an STM.

STM
Scanning Tunneling Microscope

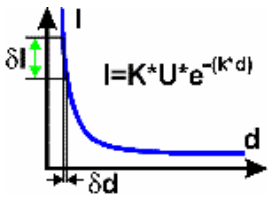


$$I = GV \qquad G = \frac{e^2}{h} w_{12}$$

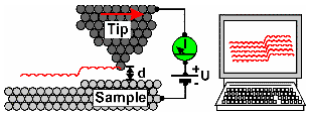
Scanning Tunneling Microscope

Heinrich Rohrer
Gerd Binnig
Nobel Prize 1986

Tunneling current starts to flow when a sharp tip approaches a conducting surface at a distance of approximately 1nm (10Angstrom).

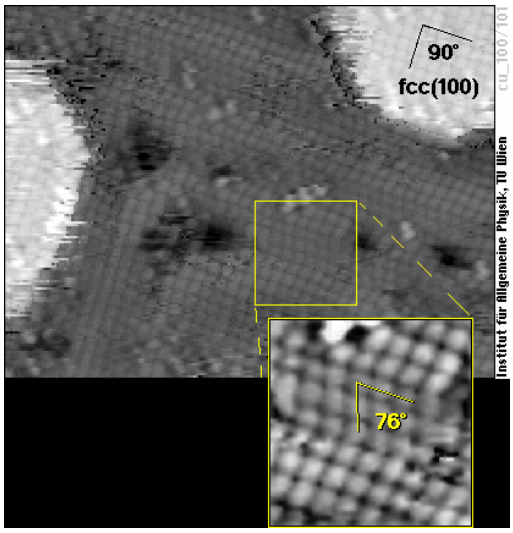


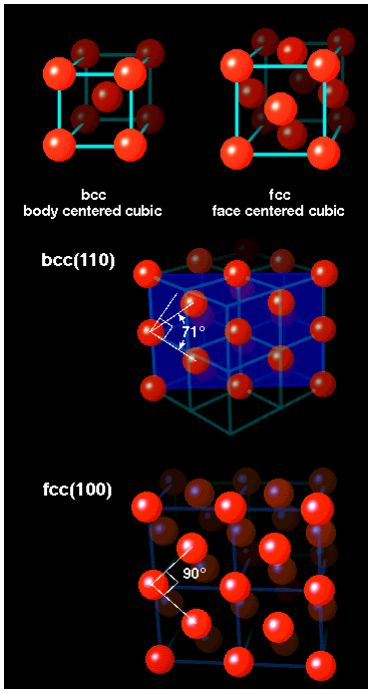
The tip is mounted on a piezoelectric tube, which allows tiny movements by applying a voltage at its electrodes. The electronics control the tip position to keep tunneling current and, hence, the tip-surface distance constant, while at the same time scanning a small area of the sample surface.

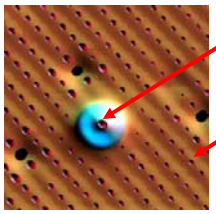


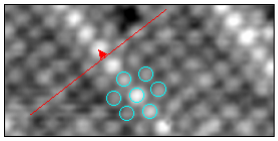
This movement is recorded and can be displayed as an image of the surface topography. Under ideal circumstances, the individual atoms of a surface can be resolved and displayed.

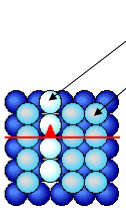
Example:
fcc and bcc Iron in Films

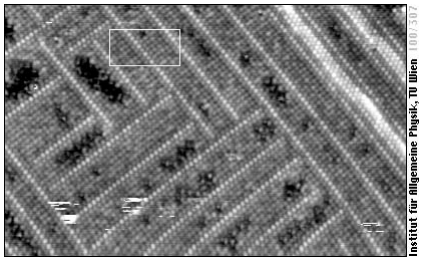












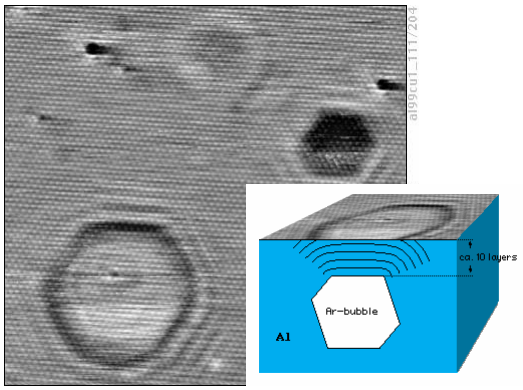
Surface Reconstruction

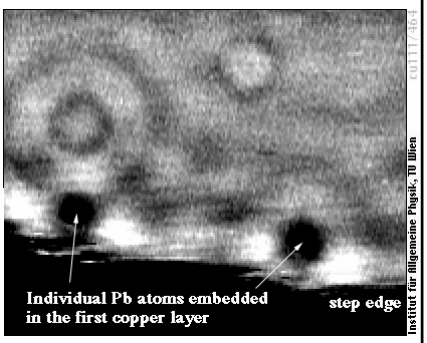
Rearrangement of Atoms at a Surface

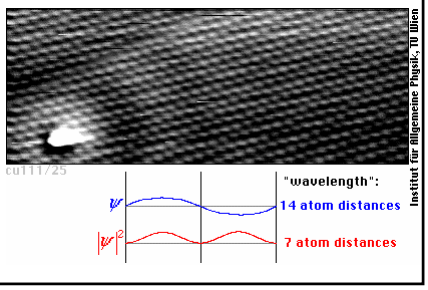
The (100)-oriented surface of Ni is a simple square lattice of atoms, Pt atoms form layer on top of the square lattice of the unreconstructed second layer. And this is what the (100) surface of a PtNi alloy looks like at approx. 68% Pt concentration in the first monolayer.

What you see in the image is a single bright row of atoms shifted by half an interatomic distance in the direction of the rows (red arrow). These atoms have a hexagonal environment (6 nearest neighbours) in the first monolayer, which is already the same local structure as in the 'hex' reconstruction of pure Pt.

Electron Waves and Interference Phenomena of de Broglie waves of electrons

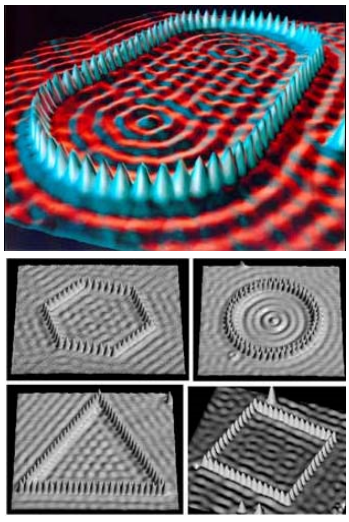


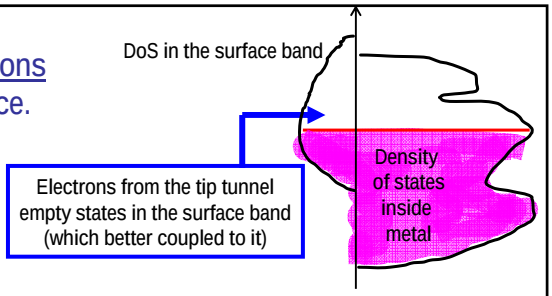




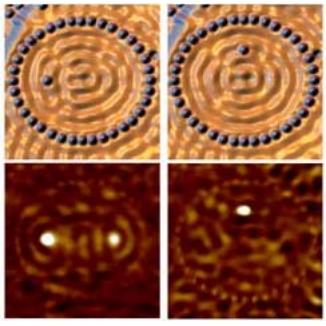
Corrals for surface state electrons

iron atoms on a copper surface.





Quantum 'Mirage'



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