Tutorial 03/04/2012 (Surface Science – Bert Müller, bert.mueller@unibas.ch; www.bmc.unibas.ch)

Electron diffraction on surfaces

1. Please explain, why only surfaces with low index (Miller indices) occur and why Miller indices are used to describe lattice planes.
2. Why one finds spots in diffraction for all electron energies but only for selected X-ray photon energies?
3. What are the important characteristics of a diffraction system such as LEED and RHEED? (see e.g. B. Müller, M. Henzler: *SPA-RHEED - a novel method in reflection high-energy electron diffraction with extremely high angular and energy resolution*, Review Scientific Instruments 66 (1995) 5232-5235)
4. How one can discriminate between surface and bulk contributions to RHEED pattern? (see appendix of B. Müller, M. Henzler: *Comparison of reflection high-energy electron diffraction and low-energy electron diffraction using high-resolution instrumentation*, Surface Science 389 (1997) 338-348)
5. What information we can extract from electron diffraction pattern of surfaces?

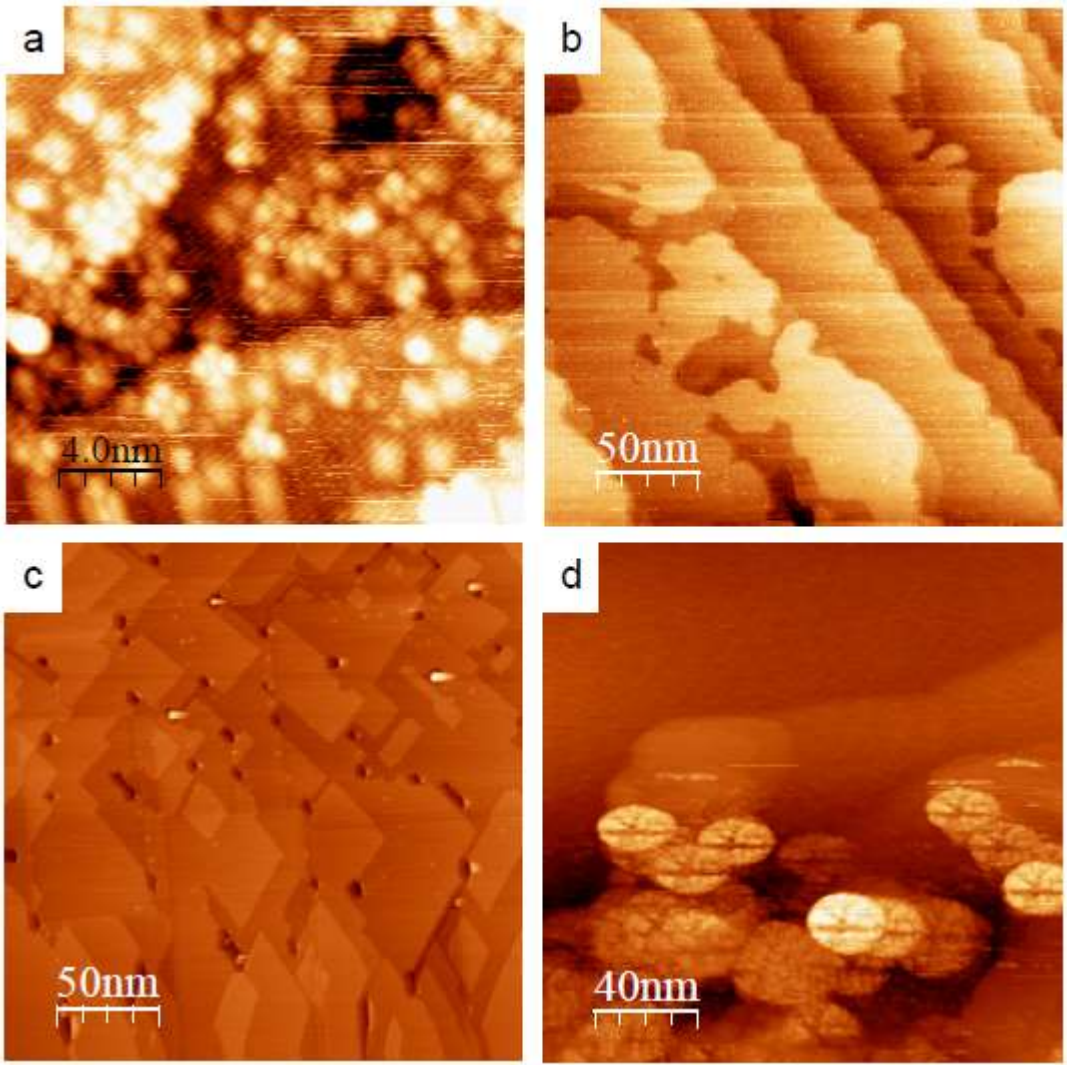
Further reading in German: B. Müller: *Profilanalyse bei der Reflexionselektronenbeugung (RHEED): elastische und inelastische Streuung*, VDI Verlag Düsseldorf 1994

STM / AFM

1) **STM**

a) Name the two different STM operation modes that are commonly used. For each mode, indicate which quantity corresponds to the recorded signal and briefly discuss the advantages and disadvantages.

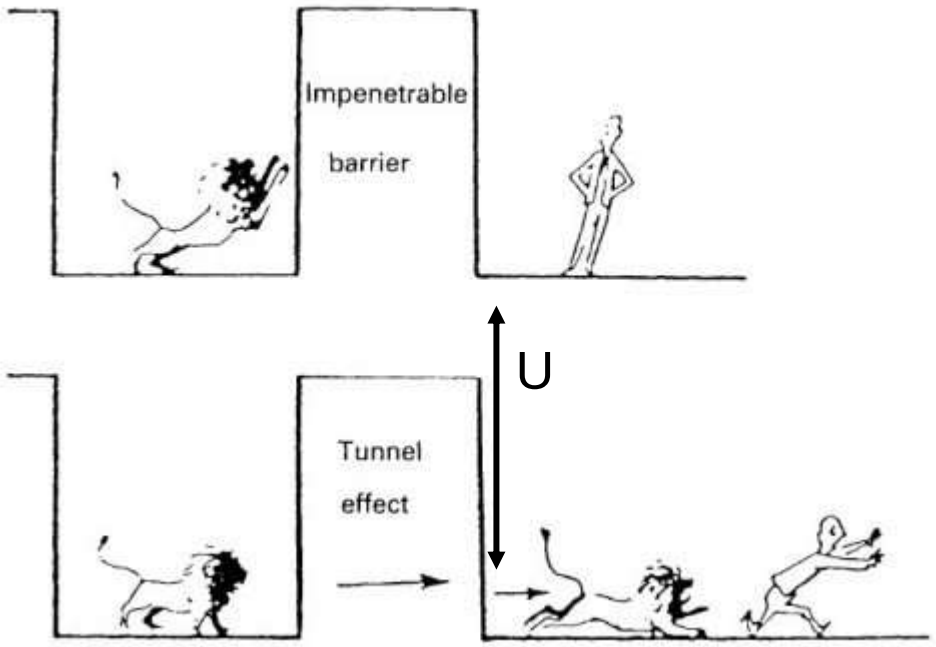
b) The following STM images all have an artefact. For each image, briefly discuss the nature of the artefact and how to avoid it.



c) The crystalline structure of the surface of highly oriented pyrolytic graphite (HOPG) is such that one would expect to image the hexagons of a graphite layer. However, STM images show a triangular structure. Explain this phenomenon.

2) **Tunneling**

a) Derive the wave function ψ(x) if we have a tunnel barrier of the constant potential U in the case of the energy E being E<U and E>U.
b) Calculate the transmission coefficient and calculate by how much the tunnel current changes when decreasing the tip-sample distance by 0.2 nm. The typical work function being about 5 eV.



3) **STS**

Describe qualitatively the I-V spectra for the following situations:

a) Tip and sample are metallic.
b) Tip is metallic and the sample is a semiconductor with a gap of ΔE1.
c) The sample is a semiconductor with a gap of ΔE1 and the tip is also a semiconductor having a gap of ΔE2.
d) How does the temperature influence the I-V spectra?
e) Why are I-V spectra normally given in dI/dV/(I/V)?