Au-induced giant faceting of vicinal Si(001): a template for the growth of nanowires.

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Goal: Fabrication of 1D nanoscale structures (quantum wires) on Si

- Self-organized adsorbate induced faceting
- Step arrangement control

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One-dimensional mesoscopic system

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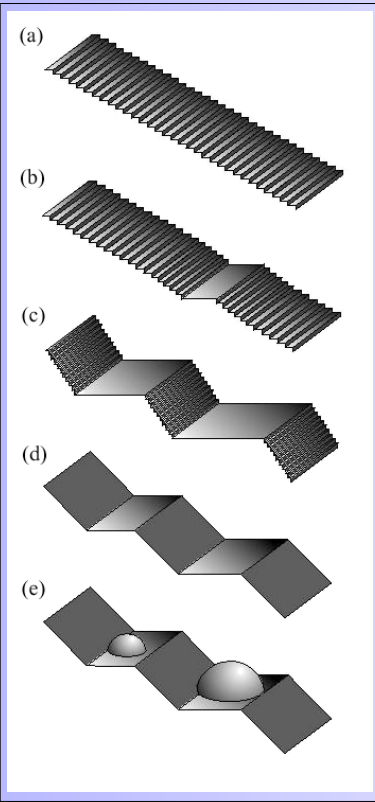
Growth of nanowires

References:

- F.-J. Meyer zu Heringdorf, D. Kähler, Th. Schmidt, E. Bauer, M. Copel, M. Horn-von Hoegen, Surf. Rev. Lett. **5** (1998) 1167.
- H. Minoda, K. Yagi, F.-J. Meyer zu Heringdorf, A. Meier, D. Kähler, M. Horn-von Hoegen, Phys. Rev. B **59** (1999) 2363.
- M. Horn-von Hoegen, F.-J. Meyer zu Heringdorf, R. Hild, P. Zahl, Th. Schmidt, E. Bauer, Surf. Sci. **433-435** (1999) 475.
- R. Hild, F.-J. Meyer zu Heringdorf, P. Zahl, M. Horn-von Hoegen, Surf. Sci., in press.



Au-induced faceting of vicinal Si(001):

(a) Starting surface:
ordered double steps, terrace width 4 nm.
Gold deposition at 850ºC:
gold adsorbs as lattice gas.

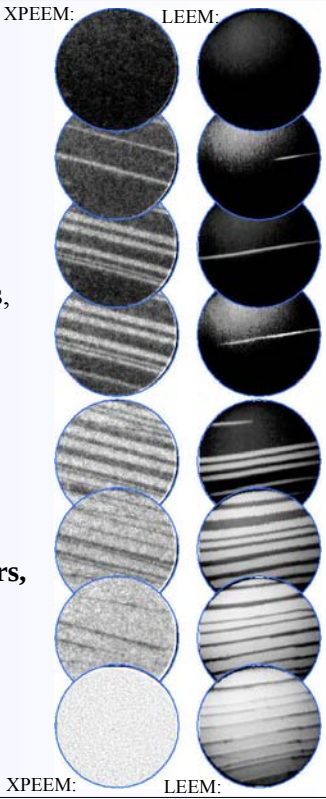
(b) At critical coverage of ≈ 0.3 ML:
Formation of flat and elongated (001) terraces, stabilized by (5x3.2) reconstruction.

(c) Upon further gold deposition:
Terraces grow, step bunches become steeper.

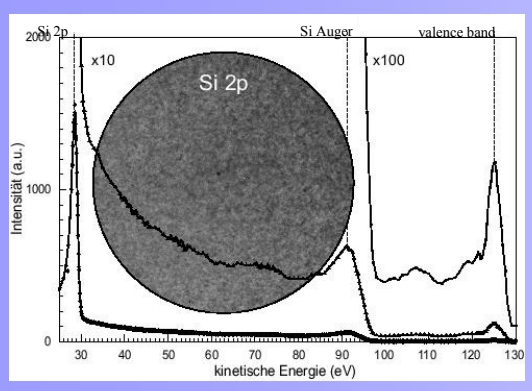
(d) When inclination angle reaches 16°:
Step bands transform into (119) facets.
Faceting process is completed.

Typical structure length: several millimeters,
(001) terrace width: 300nm - 1µm,
(119) facet width: 50 nm - 300 nm.

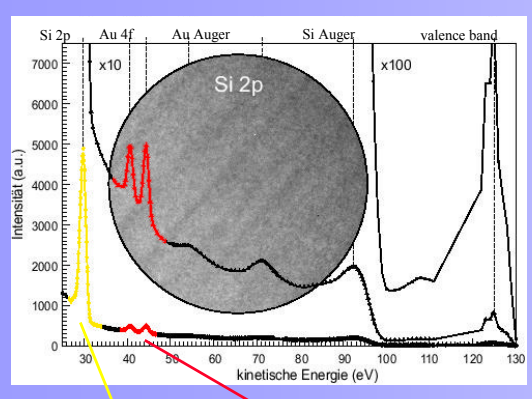
(e) Further gold deposition:
Formation of 3d clusters on the surface.



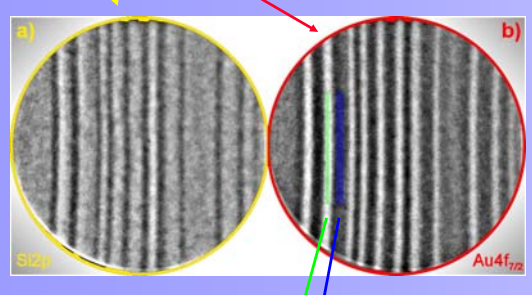
Nanospectroscopy with the SPELEEM at ELETTRA:



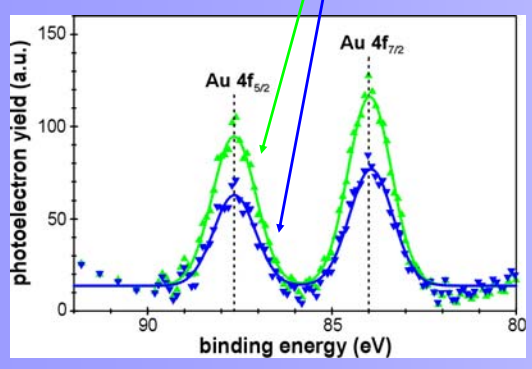
Integral photoelectron spectrum of clean Si.
Inset: XPEEM at the Si 2p core level (E_{kin} = 28 eV).
Field of view: 12 µm.
hv = 128 eV.



Integral photoelectron spectrum of completely faceted sample. Si 2p core level line shape and position unchanged.
Inset: XPEEM at the Si 2p core level (E_{kin} = 28 eV).
Field of view: 12 µm. No (topographic) contrast.
hv = 128 eV.



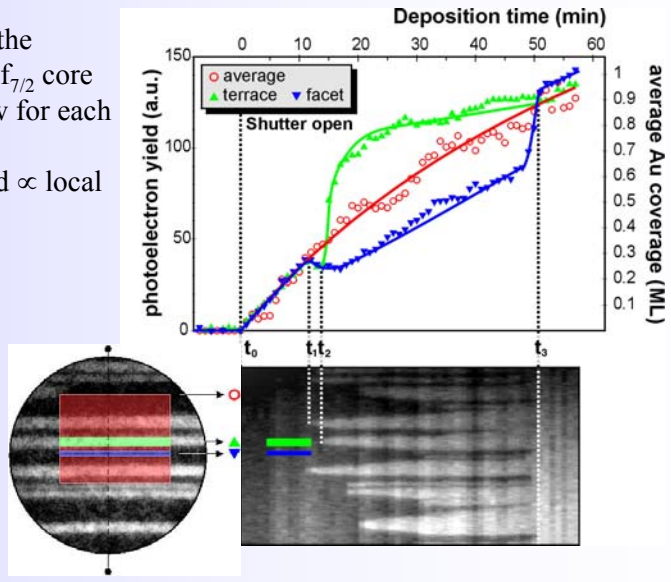
XPEEM on a partly faceted sample. Field of view: 12 µm.
Left: Image at the Si 2p core level.
Right: Image at the Au $4f_{7/2}$ core level.
Contrast inversion.
hv = 128 eV.



Laterally resolved photoelectron spectra from a stack of XPEEM images across the Au 4f core level.
Green: (001) terrace.
Blue: Step band.
No chemical shift observed.
Therefore: peak intensity ∝ local gold coverage.
hv = 128 eV.

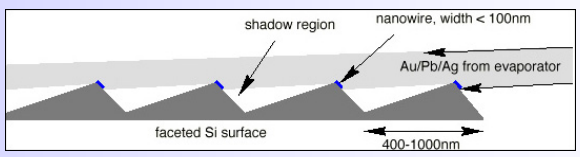
Mesurement of the local Au coverage in situ during deposition:

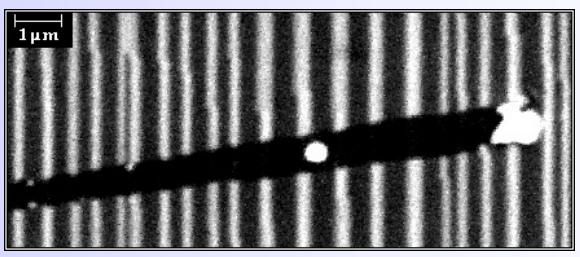
XPEEM movie at the energy of the Au $4f_{7/2}$ core level. Field of view for each image: 12 µm.
Photoelectron yield ∝ local gold coverage.



Slice from each image displayed versus time:
- Average gold coverage increases with time.
- Terrace: When a terrace nucleates, the gold coverage increases instantaneously.
- At the same time, the gold coverage on the neighboring step bands decreases.

Fabrication of long metallic nanowires





SEM image of first Au-nanowires, ex-situ grown on a Au-faceted Si(001) surface.
Nanowires are bright.

How to grow in-situ metallic nanowires?

- Metal deposition under grazing incidence (already done, see SEM image).
- Step decoration with a suitable metal?
- Use of surfactant?

This work is in progress.