Plans for In-situ Breakdown Studies in a Scanning Electron Microscope

V. Ziemann, R. Ruber, T. Muranaka, A. Palaia
Department of Physics and Astronomy, Uppsala University

K. Leifer, T. Blom
Department of Engineering Sciences, Uppsala University

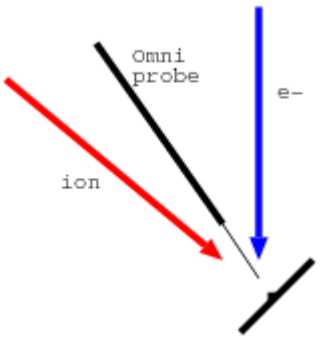
Within the FP7 EuCARD NCLinac Workpackage

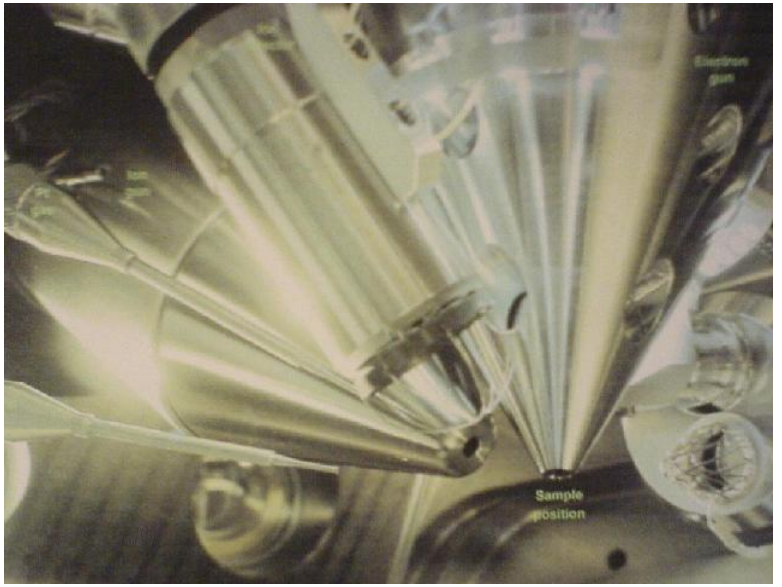
Background

- Basic idea: 1 kV/μm = 1GV/m
- Difficult to aim, … , but in a SEM we can
- We have several electron microscopes in the Microstructure Laboratory in Uppsala
  - 4 SEM, 2 TEM, 1 AFM, 1 FIB!
- Need personnel and funding
  - As part of FP7 EuCARD WP9.2 we received funding for a PostDoc, who started last saturday (Tomoko Muranaka)

The Instrument

- Combined Focussed Ion Beam and SEM
- FEI Strata DB235
  - Scanning electron microscope column
  - Focussed in beam column (Ga, 30 kV)
  - Omniprobe (isolated)
  - EDX for element analysis
  - Positioning knobs
  - Translation+tilt+rotation



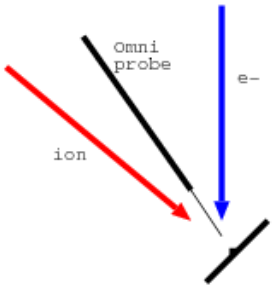


FEI Strata DB 235

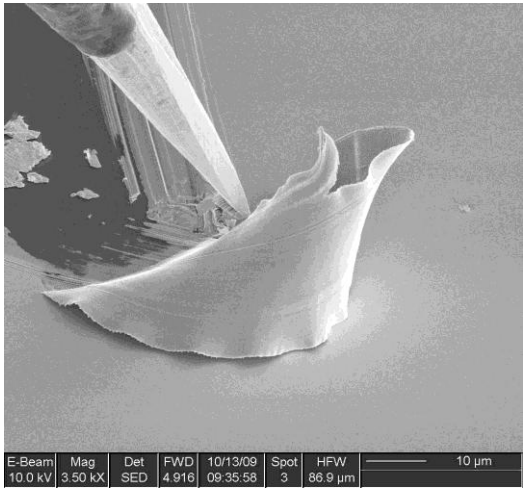
- Vertical SEM
- Omniprobe manipulator
- Ion beam in the back
- EDX (big cylinder)
- about cube-foot space
- available flanges
- positioning knobs

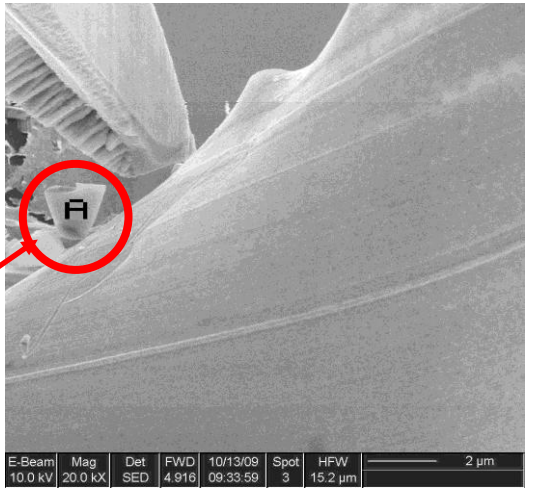
UPPSALA UNIVERSITET

Aiming Studies

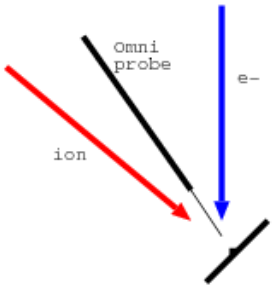


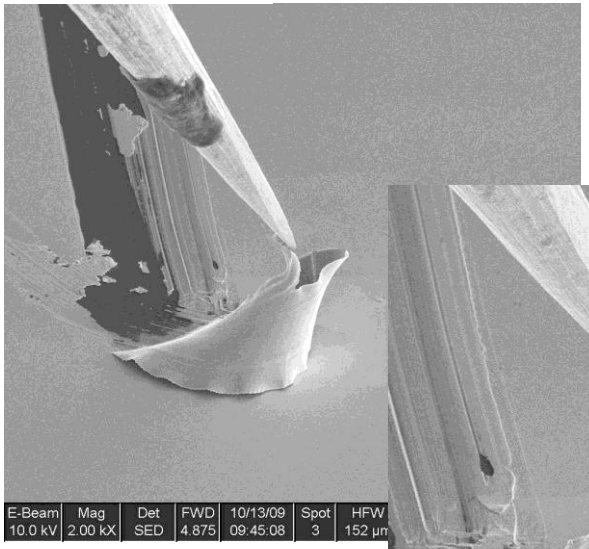
- TB+VZ, October 2009
- Target: scratch on a gold-plated silicon wafer
- Optimize SEM: focus, centering, astigmatism
- Then rotate table to center on ion column, then zooming worked
- Move table, put probe at the a few µm from focus. We broke the tip.
- Sharpened needle with FIB

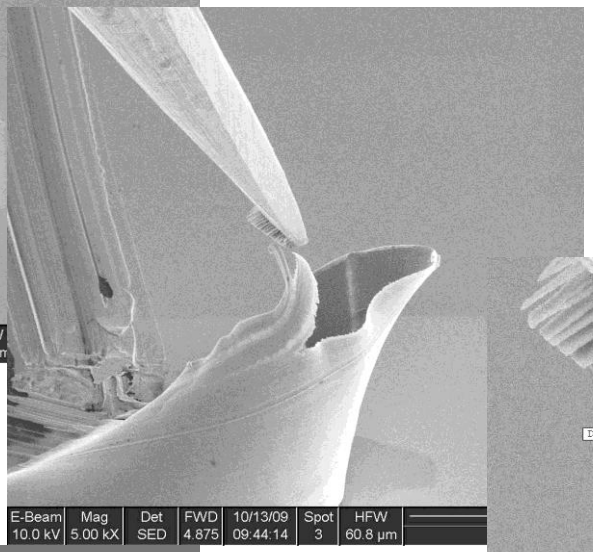


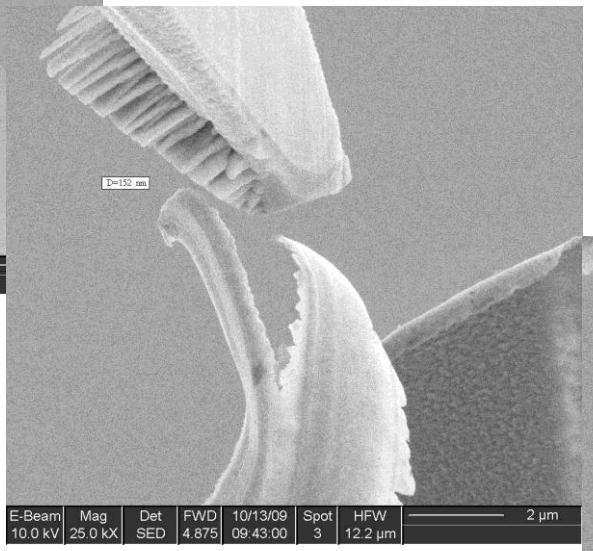


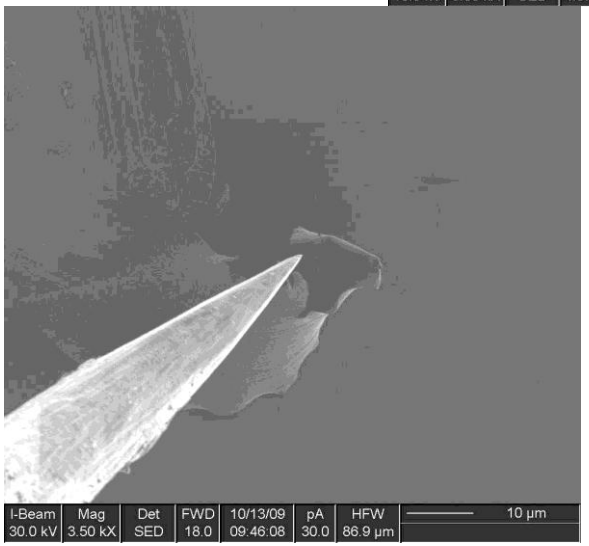
Zooming in

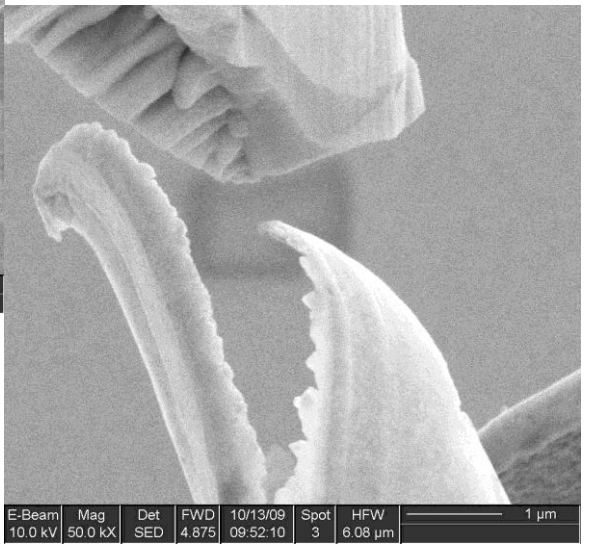












- Can sharpen tip to 40 nm or so (Only partially done on pics!)
- Position to better than 200 nm

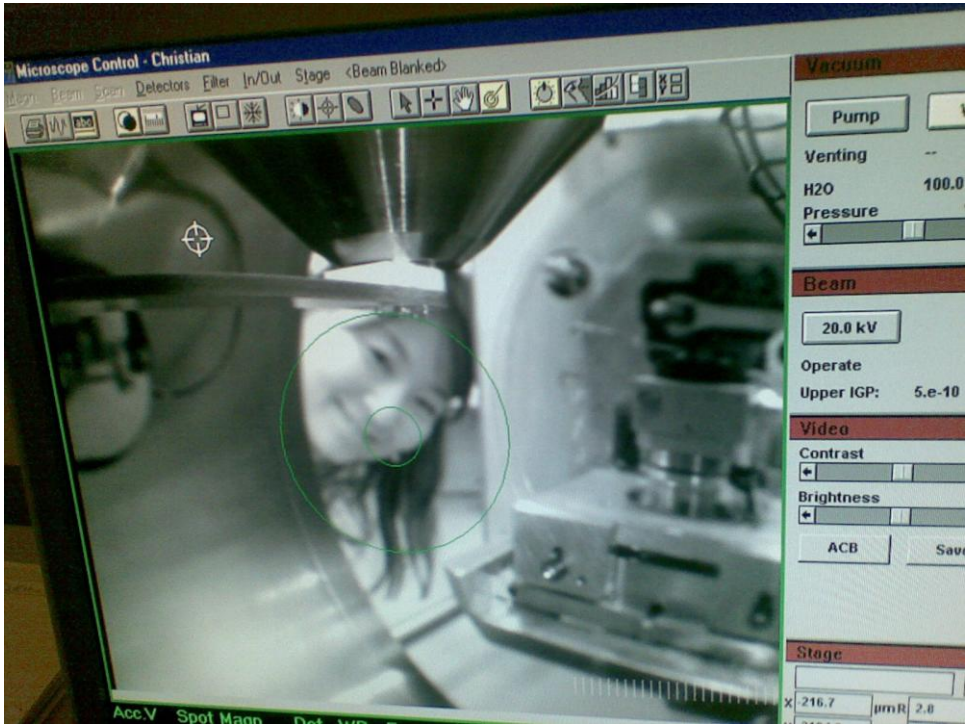
Ion image

UPPSALA UNIVERSITET

EuCARD

Near Future

- New PostDoc Tomoko Muranaka needs to take a driver's license on the microscope(s).
- Install high-voltage supply on the Omniprobe micro-manipulator.
- PicoAmp meter
- Focus on Copper.



First Experiments

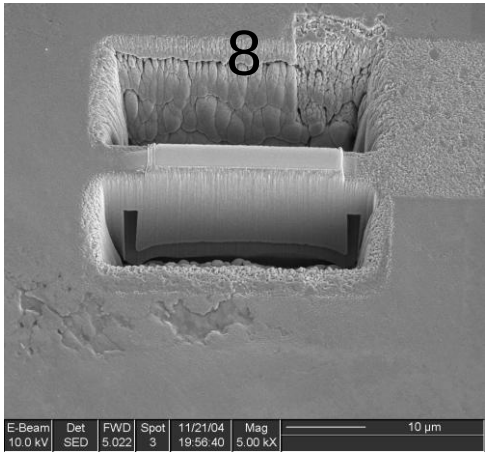
- Correlate SEM observation with Fowler-Nordheim data
  - Sharpen micromanipulator tip.
  - Locate interesting (high beta) surface feature
  - Determine/estimate beta from SEM data
  - Try to verify with Fowler-Nordheim determination of beta
- Repeat with different locations

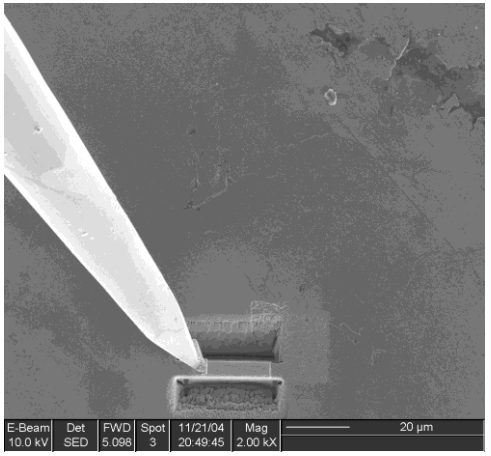
Second Experiments

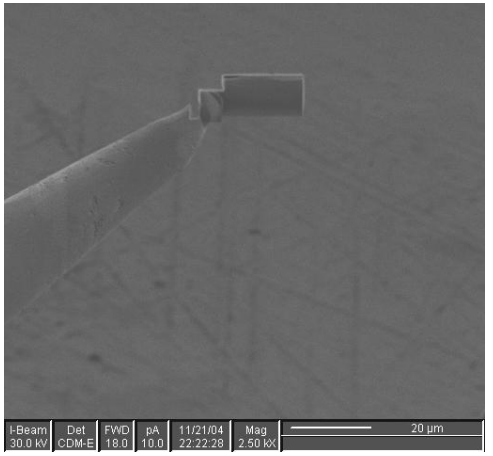
- Can we make high-beta surface structures (HBS) grow? (Finnish connection)
  - Find structure in SEM (and turn off SEM)
  - Increase Voltage (HV) until HBS starts melting (how do we detect this? Measure field emission current and calculate heating of tip?)
  - Turn off HV and look with SEM again.
- Can we stay at the verge of melting such that the HBS grows slowly and 'freezes' again when turning off the HV?

Outlook

- Force a breakdown and see how the surface morphology changes
- Use FIB to cut slice with surface cross-section and put on a sample holder to investigate in a transmission electron microscope (TEM)







Pictures are shown courtesy of E. Coronel Uppsala University

UPPSALA UNIVERSITET

EuCARD

More?

- We have a bunch of ideas and great hardware at home that we want to use to understand what leads to breakdown microscopically.
- We are grateful for guiding ideas from our theoretically minded colleagues.
- And are of course open to suggestions for more things to investigate...
- ....anybody?