

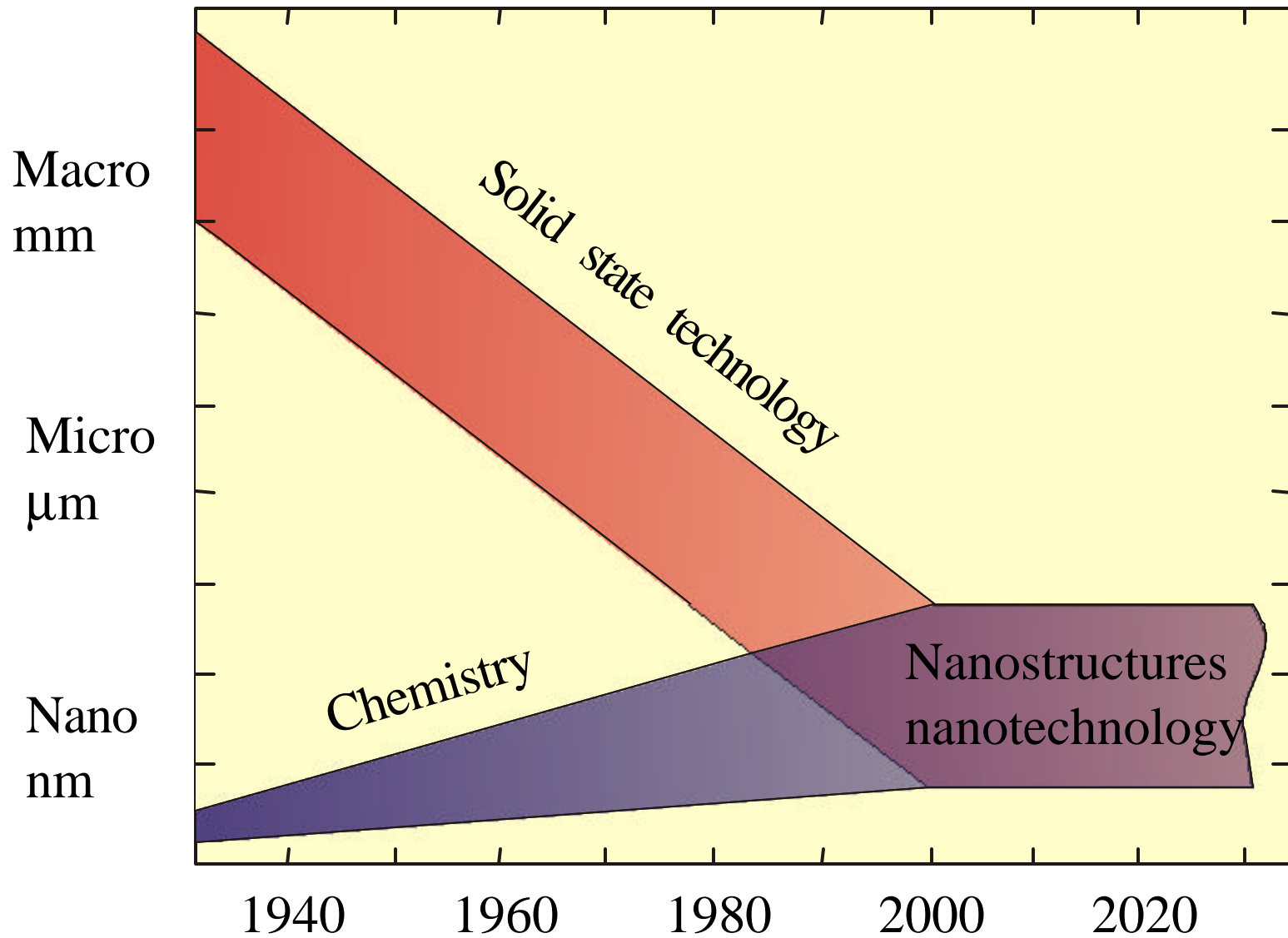
Rastersondenverfahren

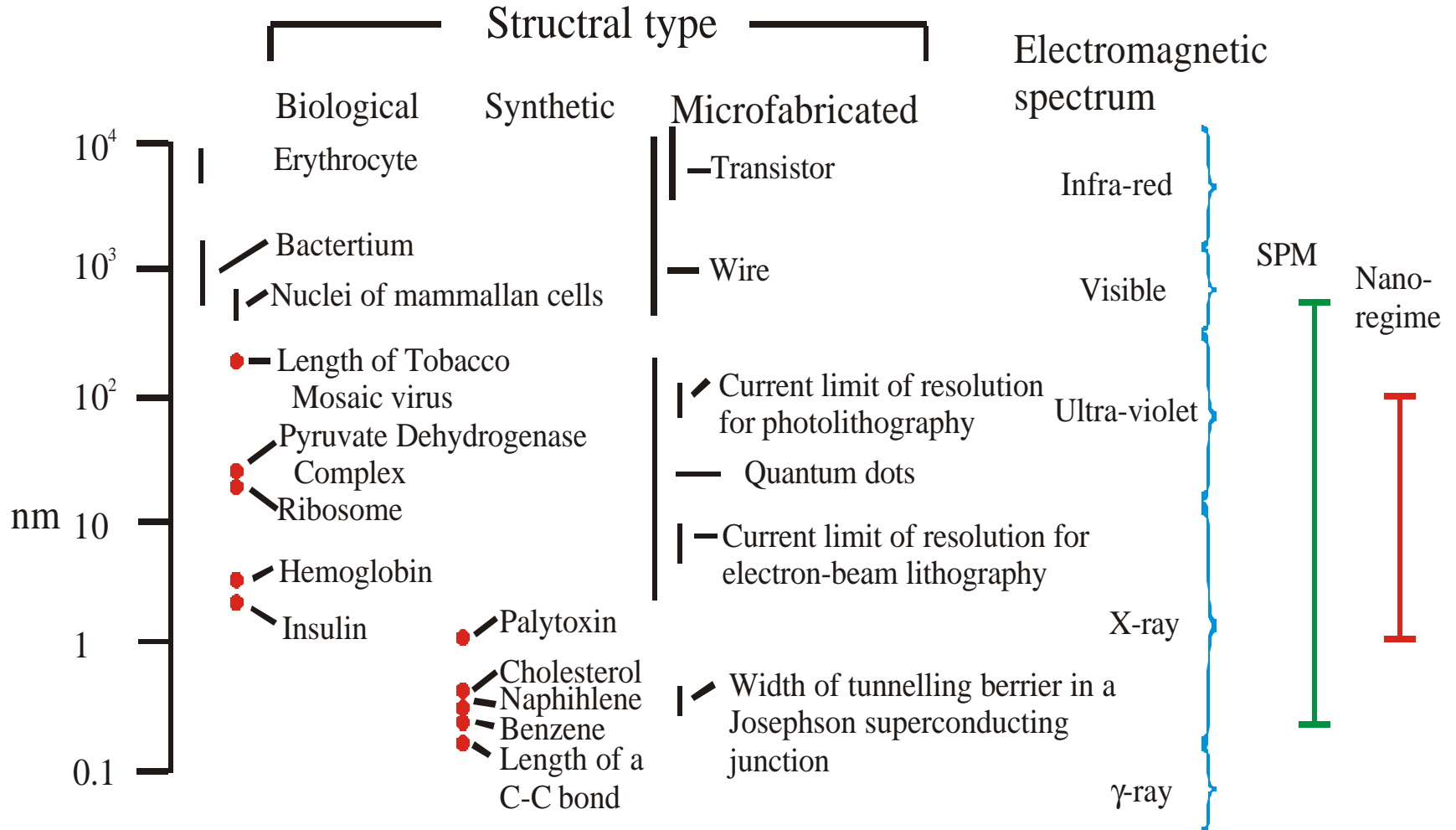
U. Hartmann

FR Experimentalphysik, Universität des Saarlandes

Themenbereiche

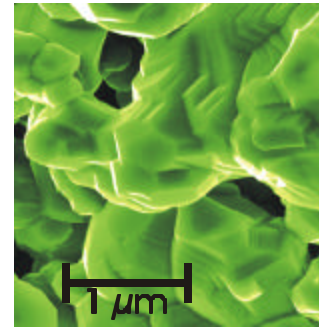
- Nanotechnologie und analytischer Bedarf
- Sonde – Probe – Wechselwirkungen
Nanoskalige Experimente
Mikroskopie
- Rastersondenmikroskopie
- Manipulation auf Nanometerskala
- Zusammenfassung



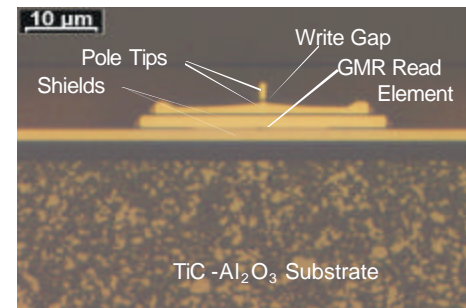


Nanostructure Research / Nanotechnology: Requirements

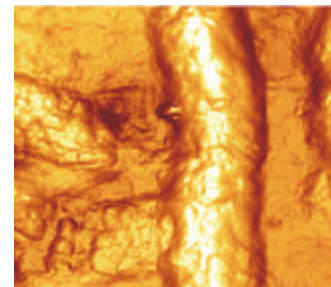
→ Nanostructured Materials



→ Nanoscale Devices



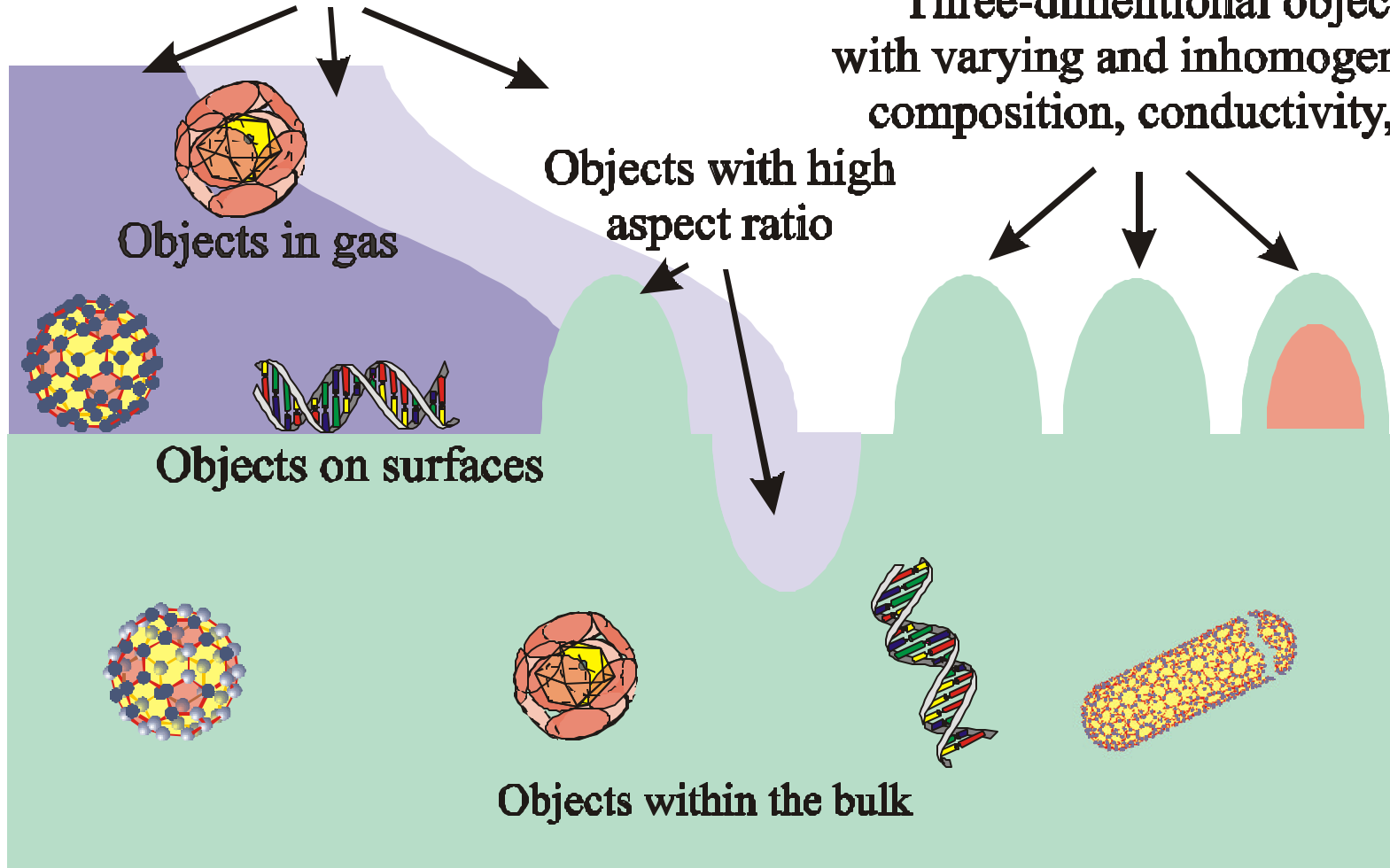
→ Nanobiotechnology



Requirements in nanoscale analytics

Environmental conditions

Three-dimensional objects
with varying and inhomogeneous
composition, conductivity,



Sonde – Probe – Wechselwirkungen

Nanoskalige Experimente

Mikroskopie

Nanoanalysis → Probing physical, chemical or biological properties at the nanometer scale

Microscopy → Repeating analytical experiment at any image point one after the other or in parallel

Nanoscale information → Averaged data from diffraction, individual data from microscopy

Reversible destruction

No destruction

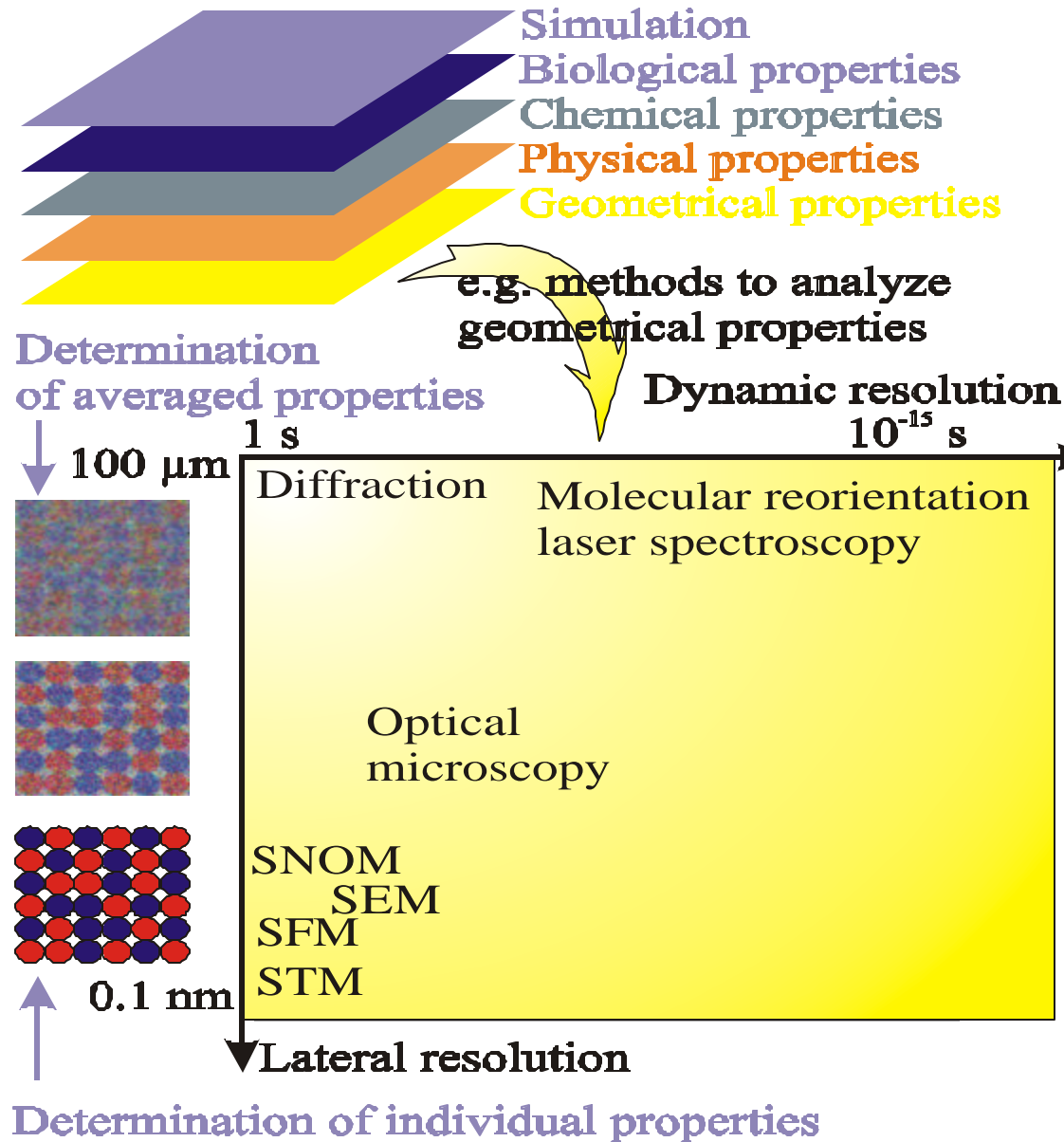
Irreversible destruction

wanted ?



unwanted ?

Sensitivity/resolution

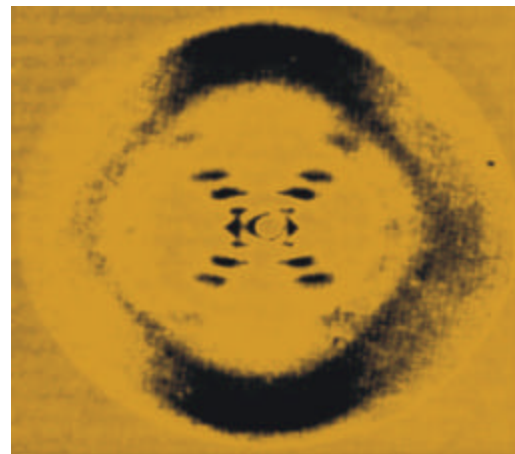
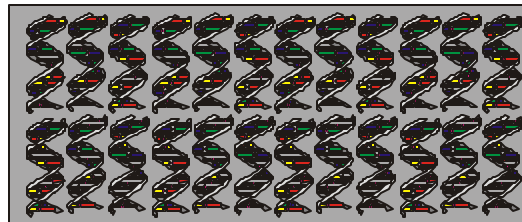


Diffraction versus imaging

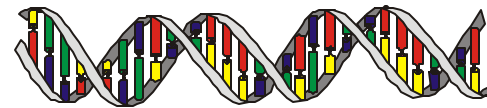
Example: DNA exploration



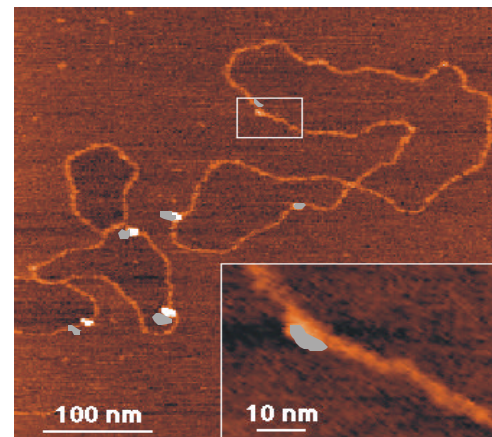
Crystallisation of an ensemble,
x-ray analysis



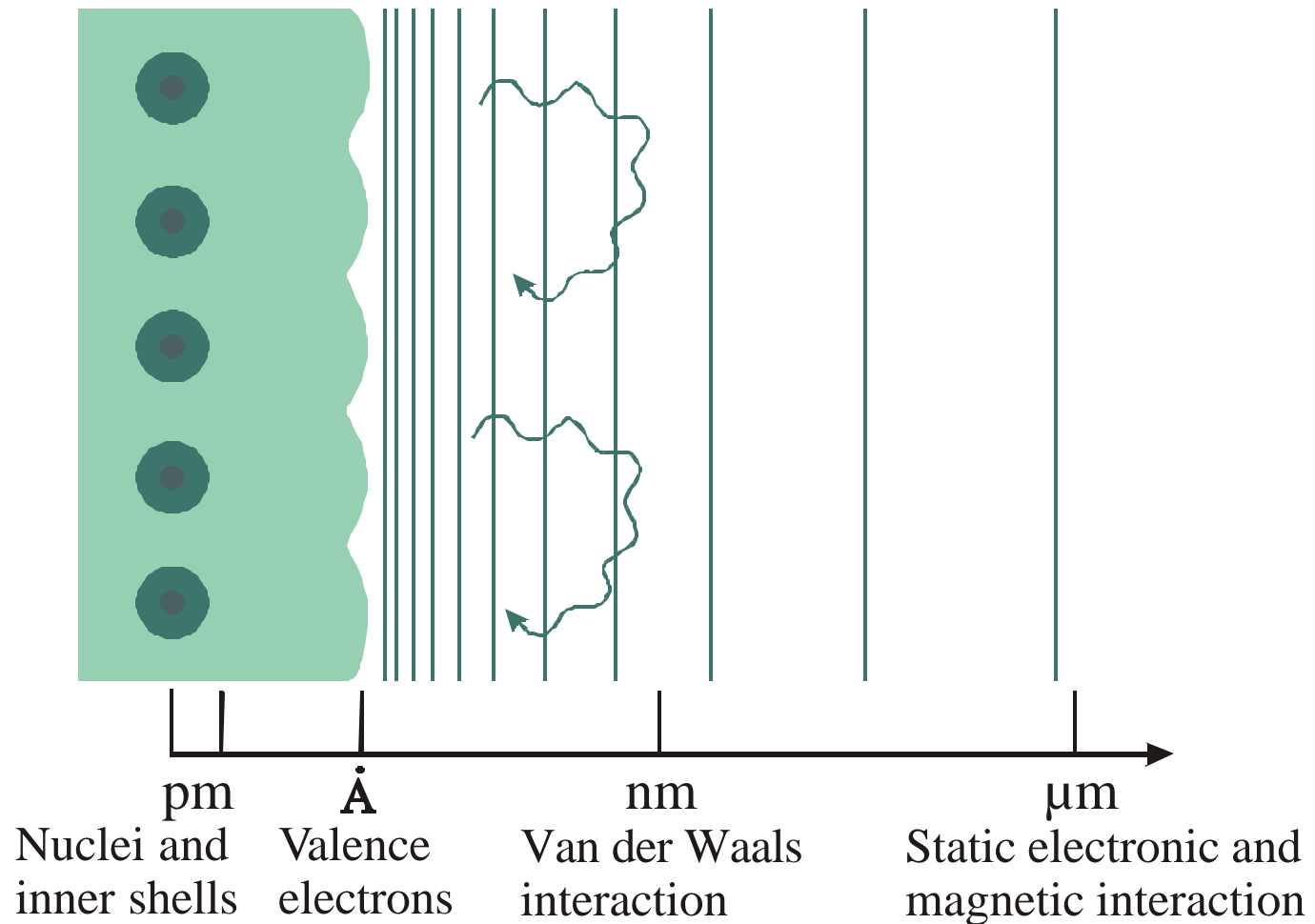
Imaging of an individual molecule
e.g by STM



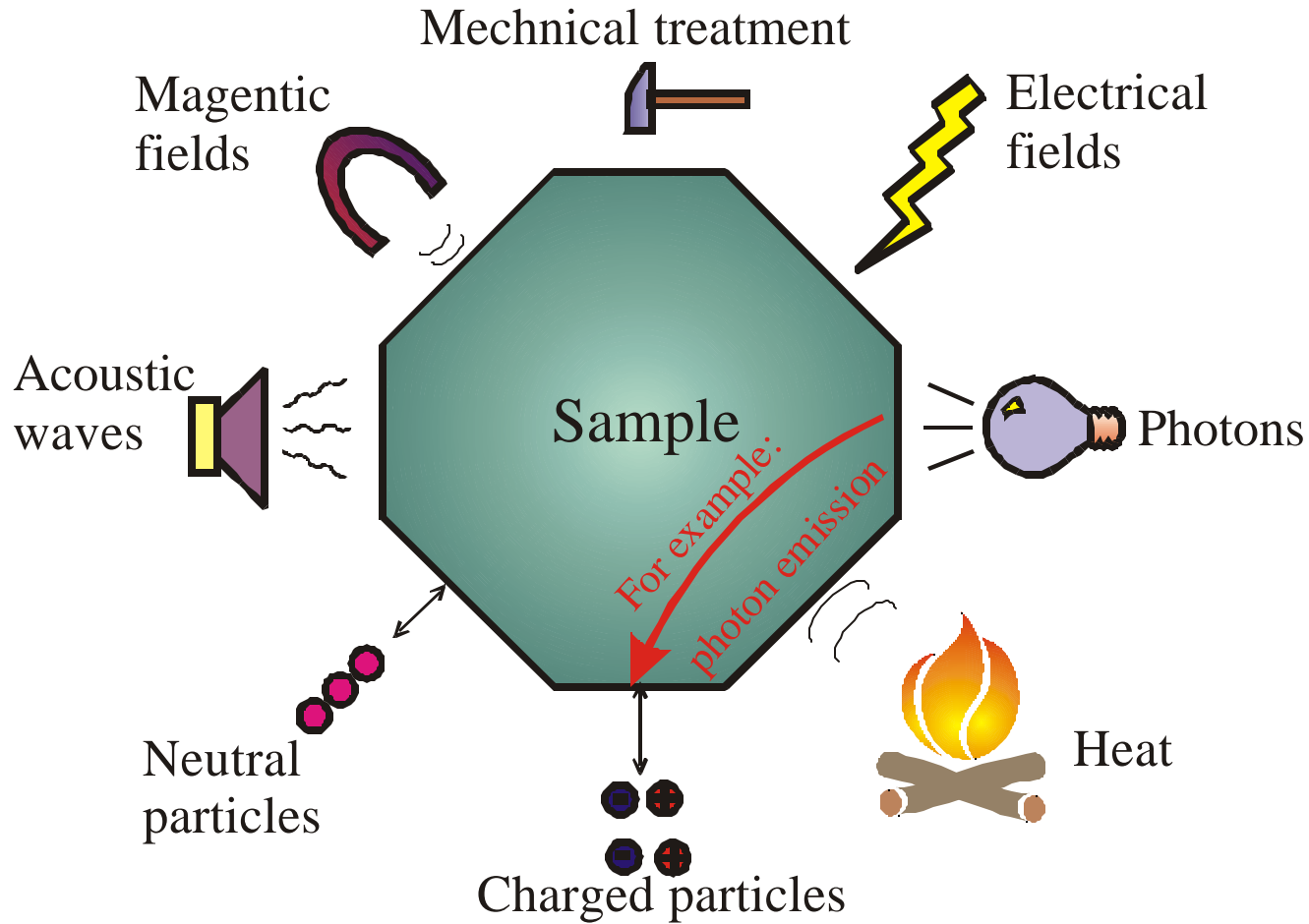
Substrate



Surface structure and interactions



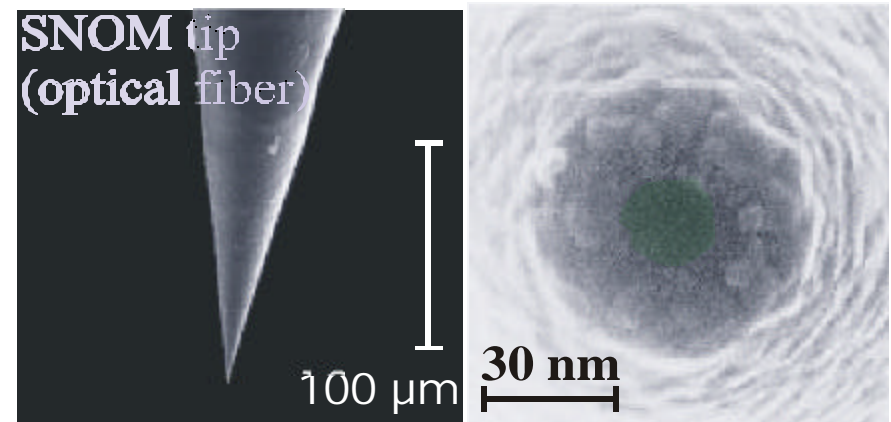
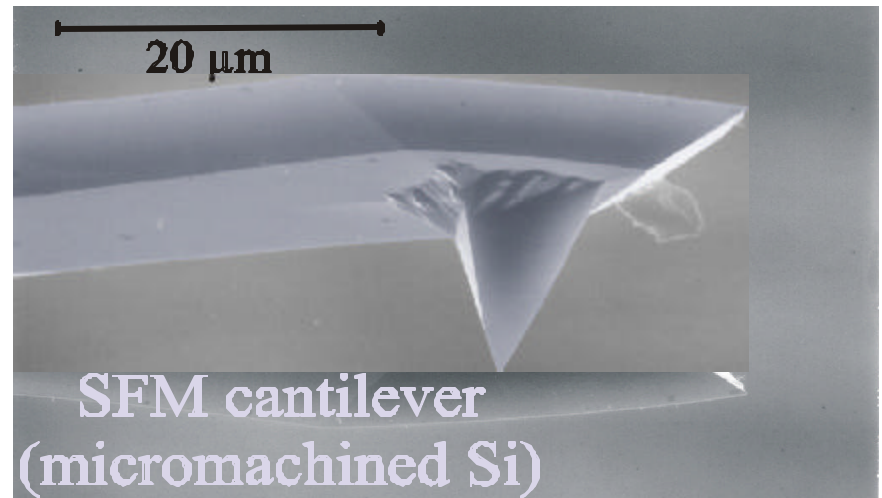
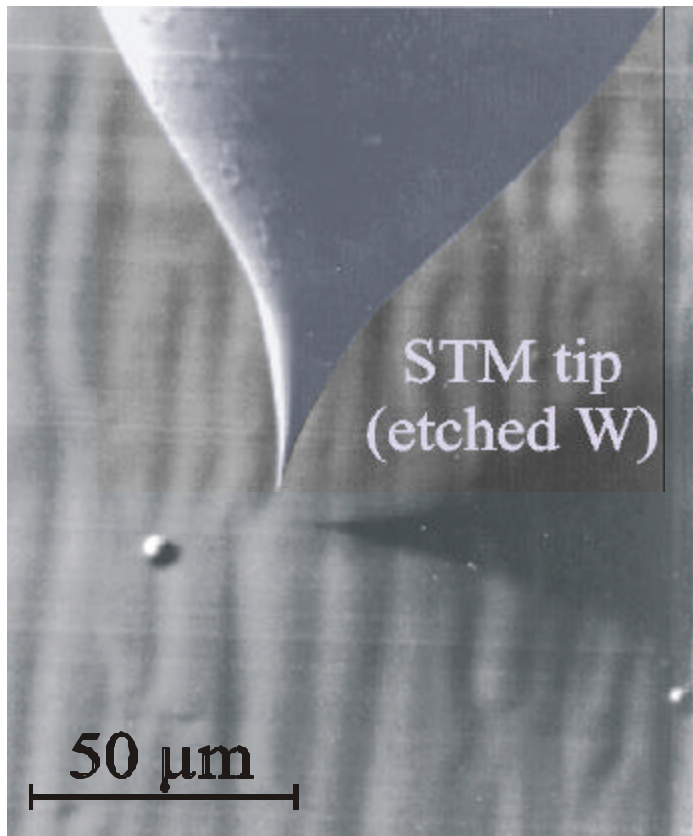
Typical probes



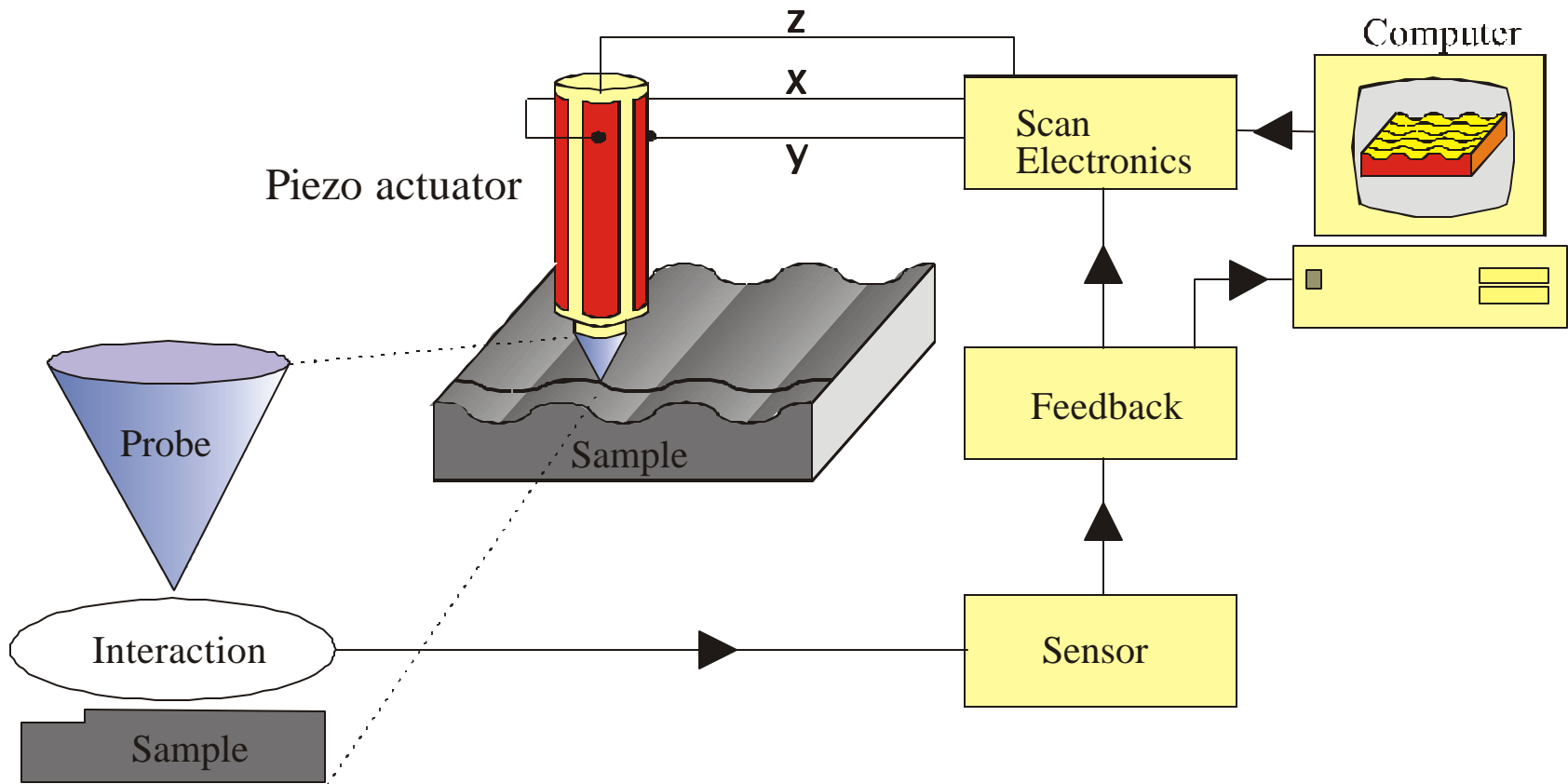
Rastersondenverfahren

- Experimente auf Nanometerskala

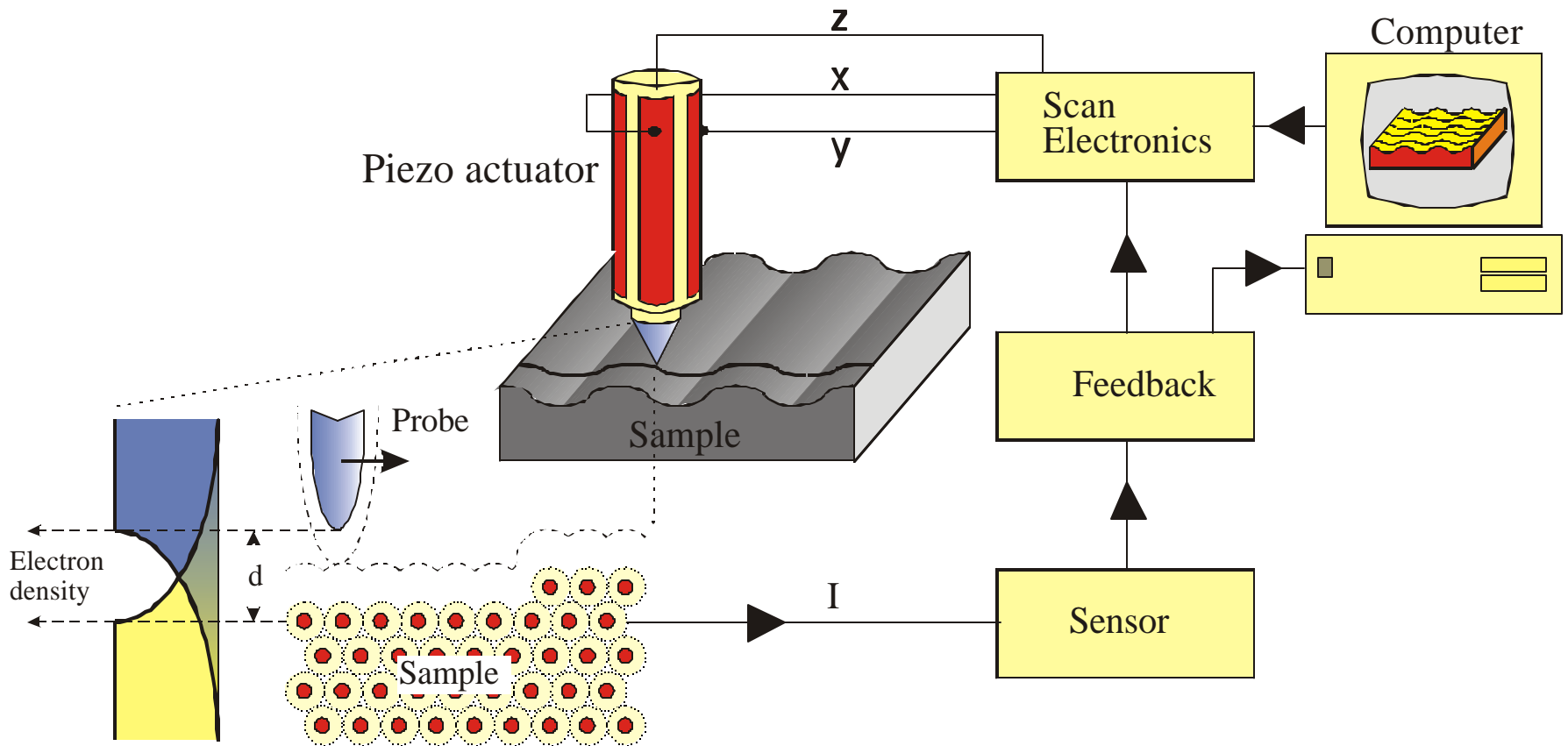
Typical probes

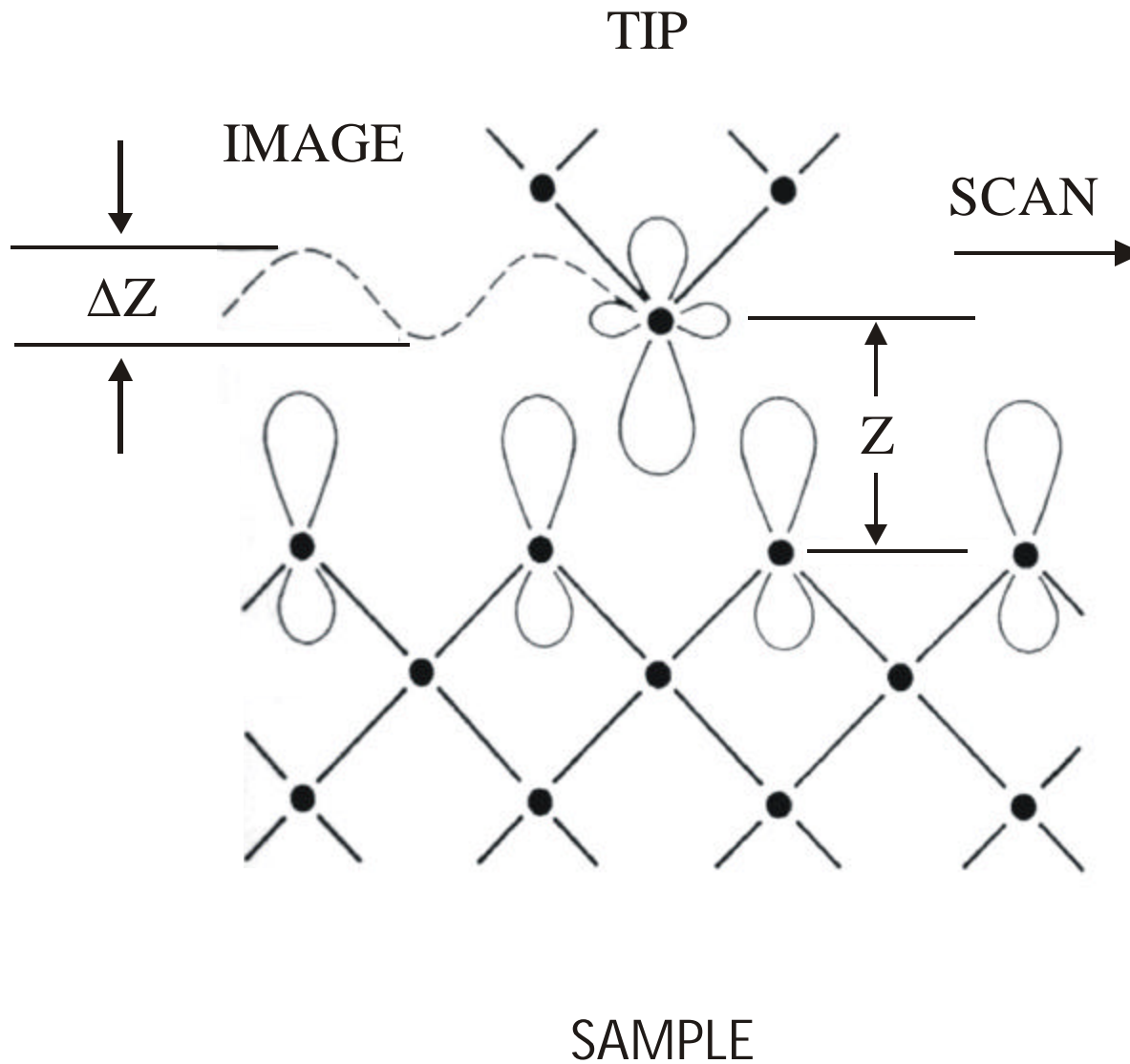


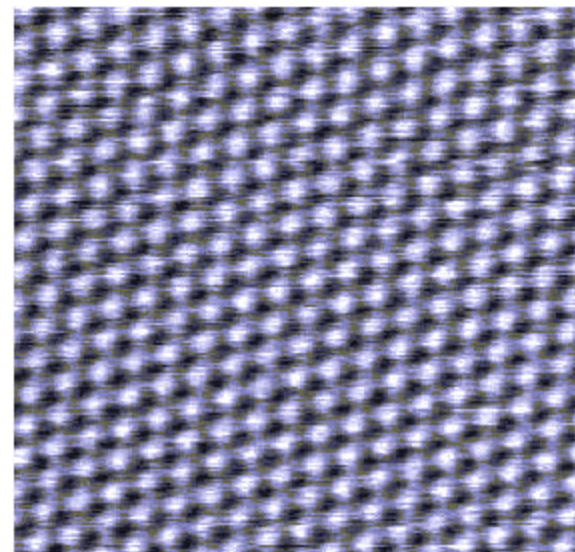
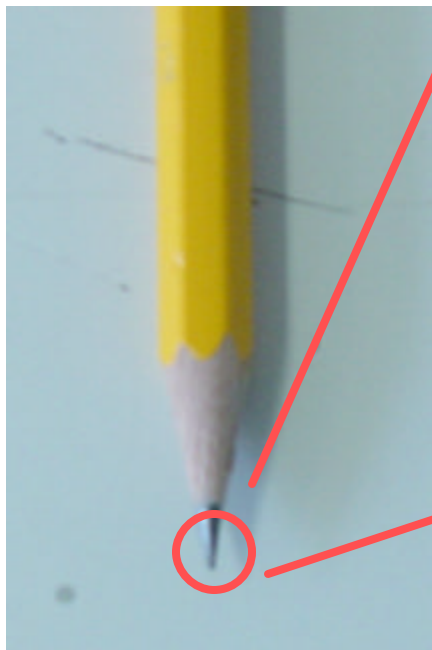
Scanning probe microscopy (SXM, SPM)



Scanning tunneling microscopy (STM)



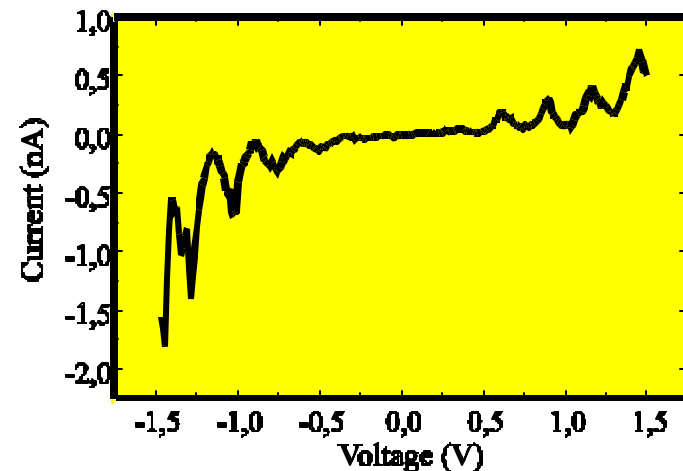
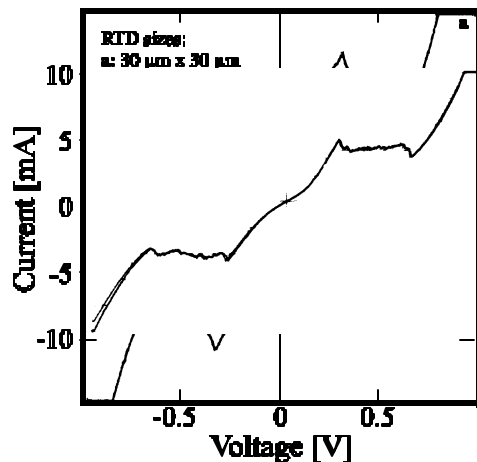
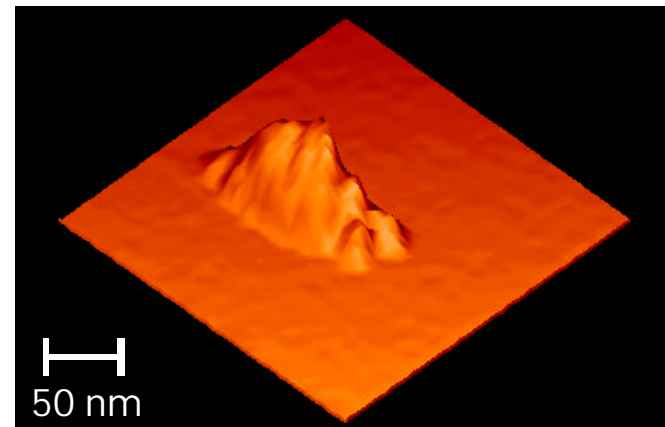
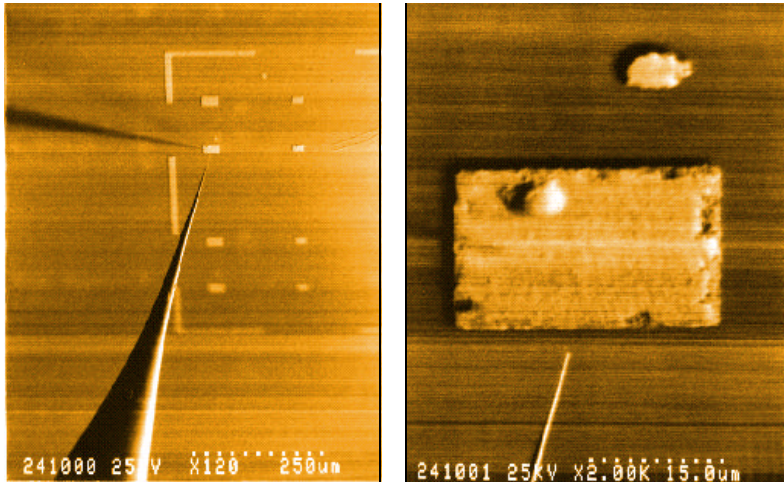




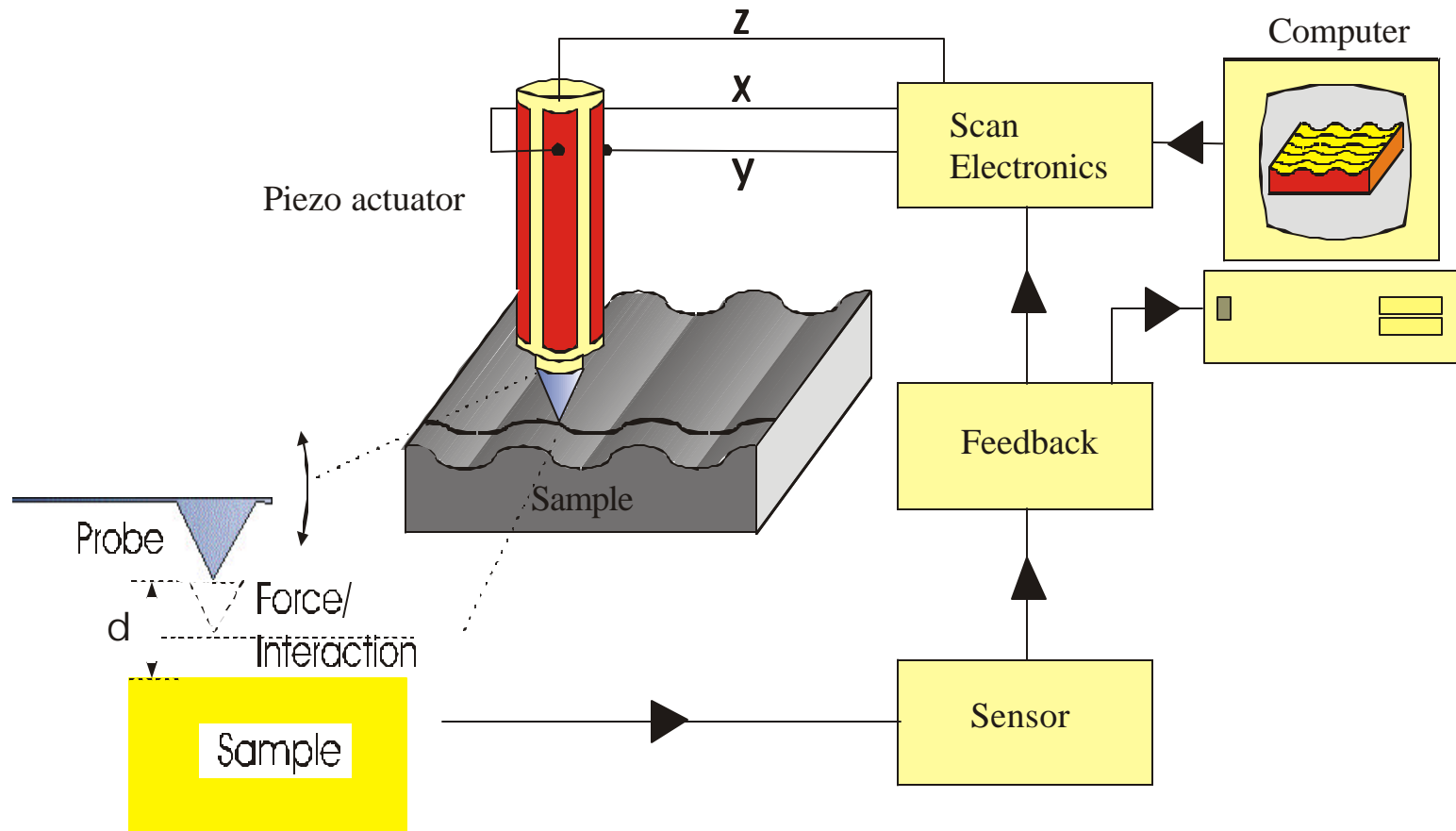
Verwendung von STM-Sonden zur lokalen Charakterisierung einzelner Bauelemente

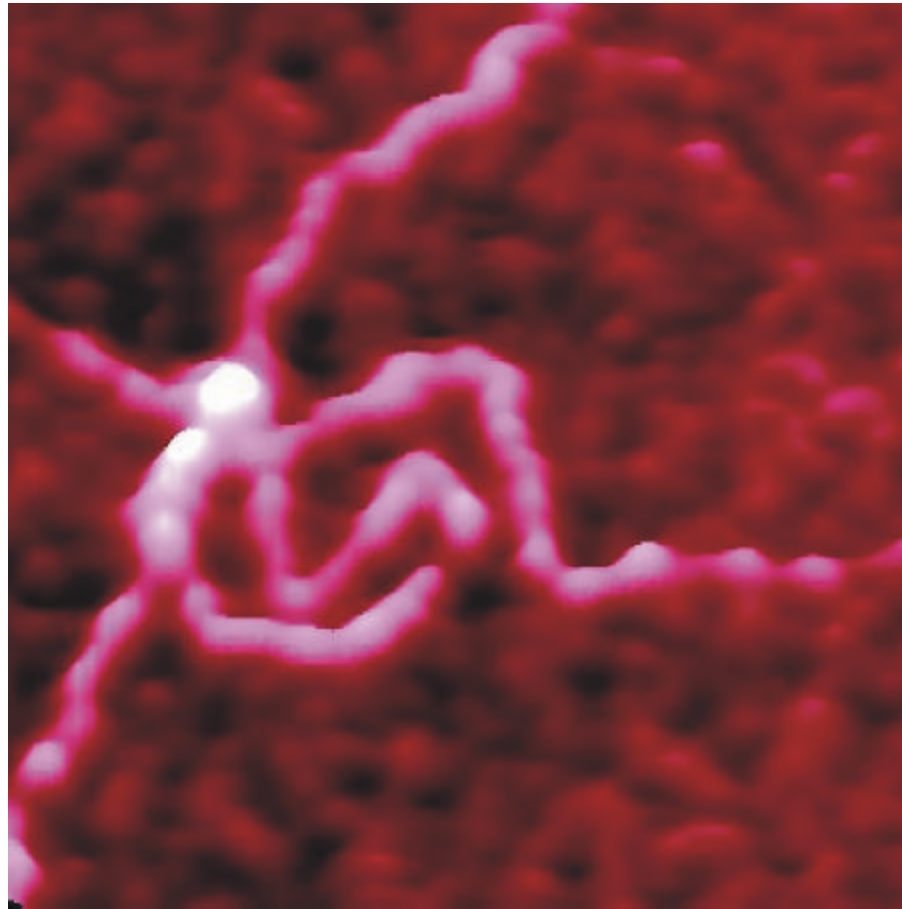
Kontaktierung resonanter Tunneldioden
mit einer STM/SEM-Kombination

Bildung und Untersuchung
von metallischen Nanostrukturen
mit dem STM

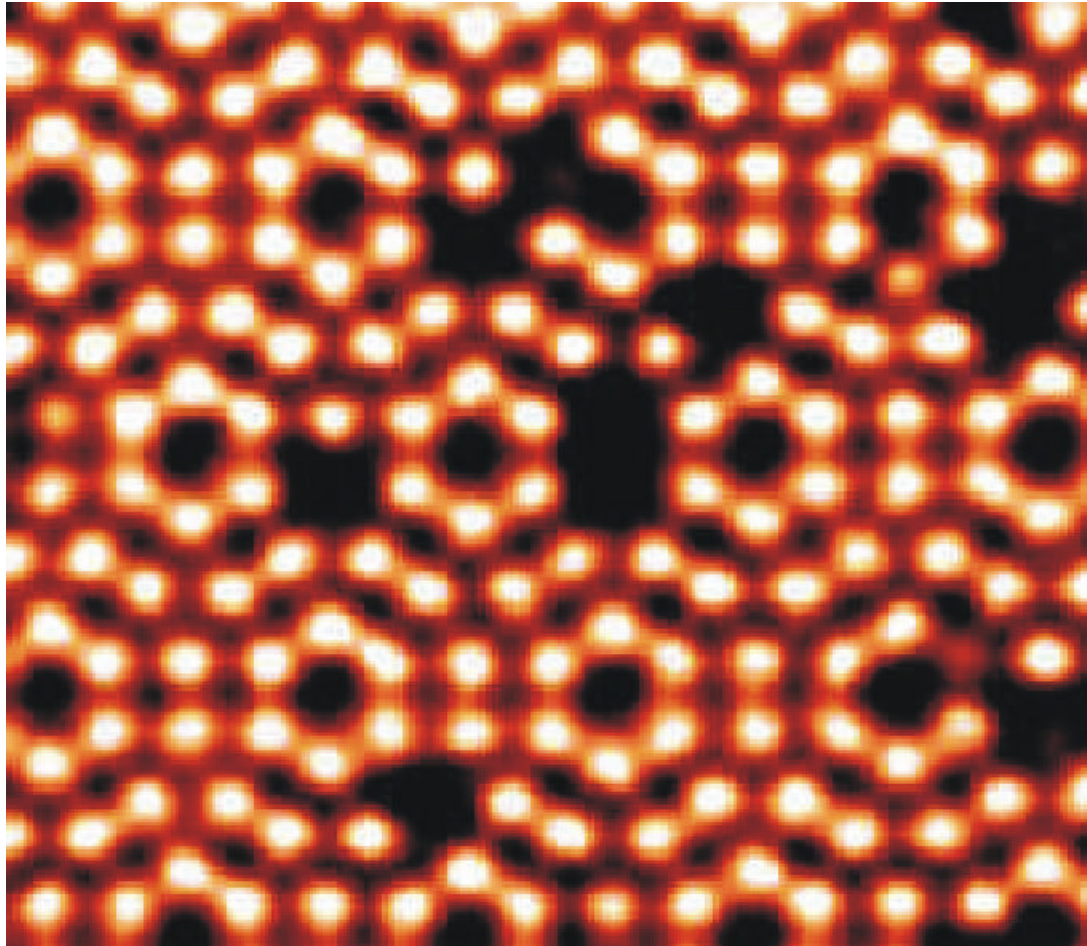


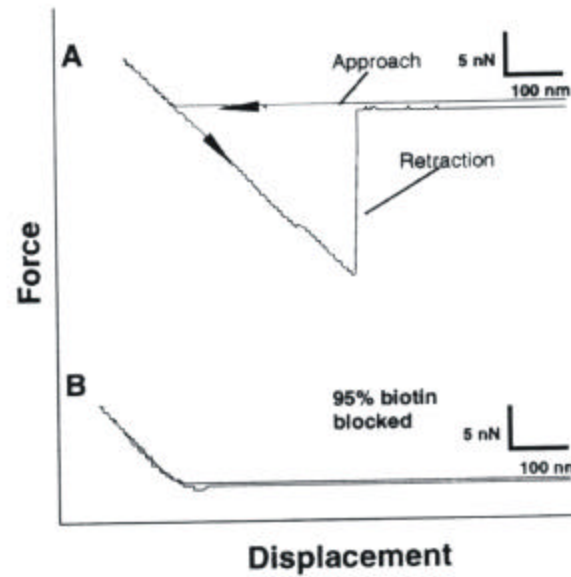
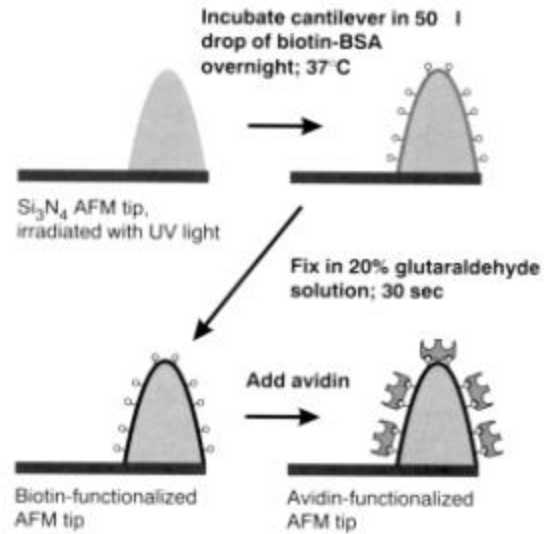
Scanning force microscopy (SFM/AFM)



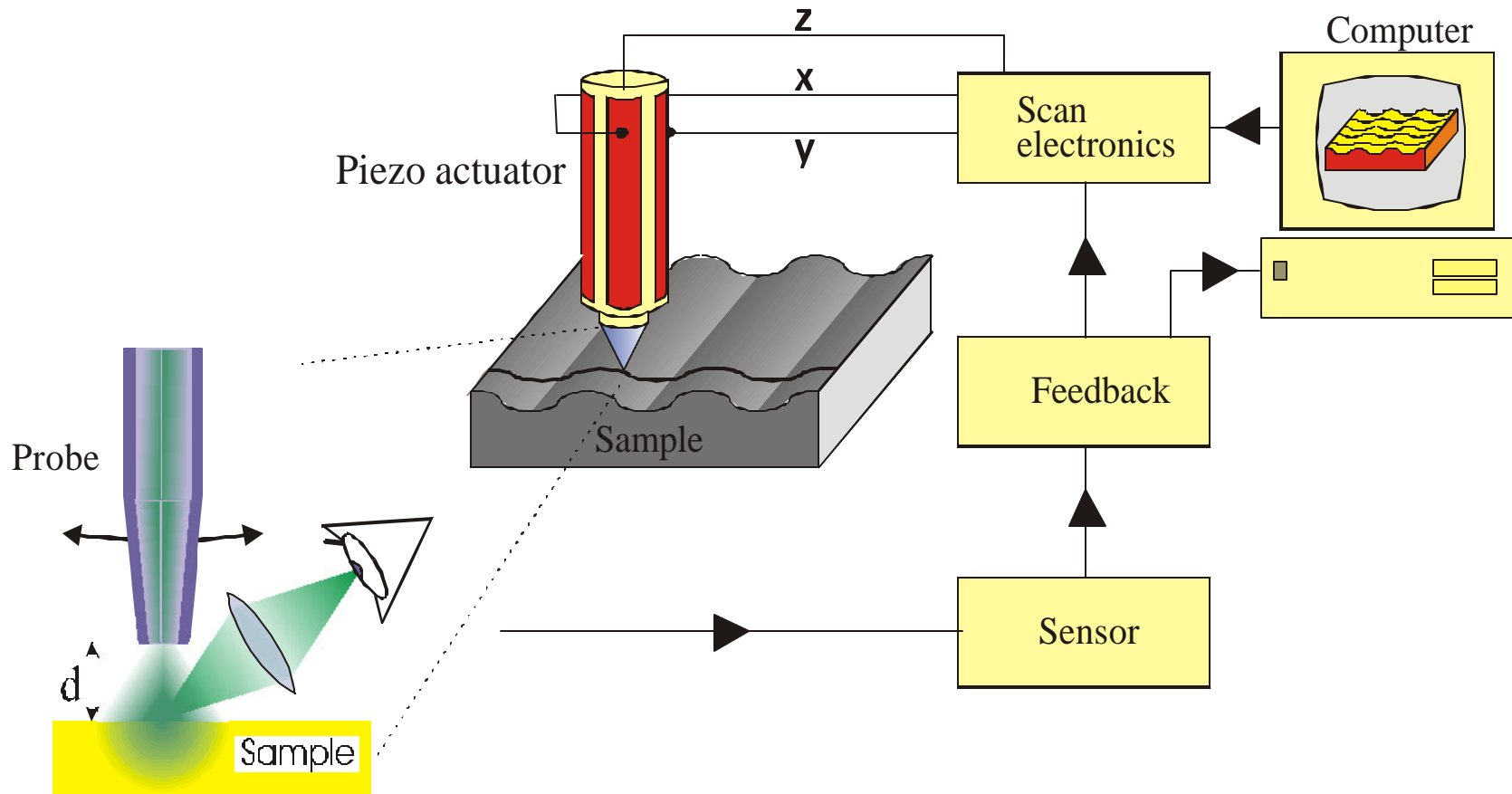


(180 nm x 180 nm)

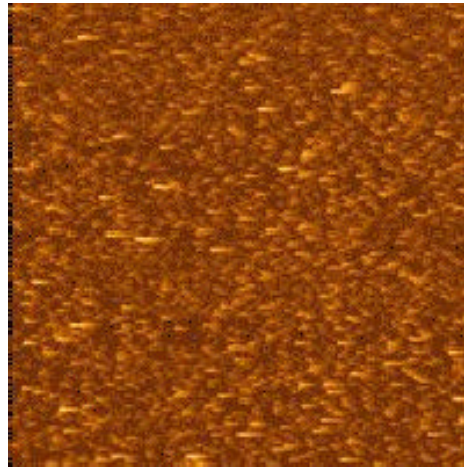
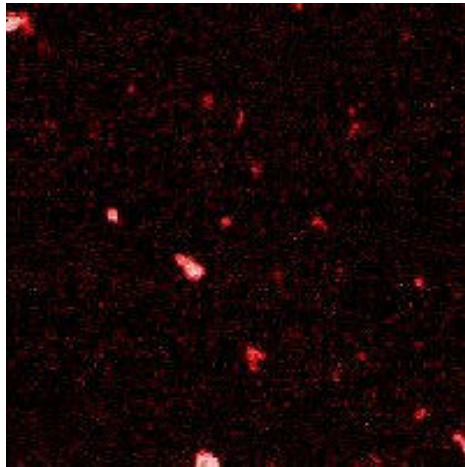




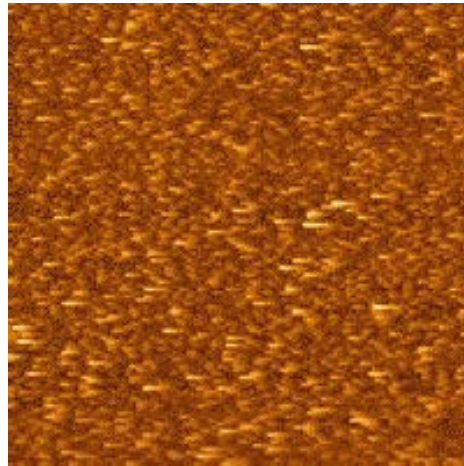
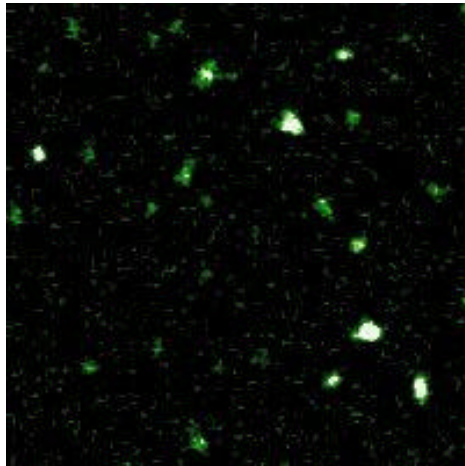
Scanning near-field microscopy (SNOM)



SNOM fluorescence images of proteins



Streptavidin-AlphaRed in PMMA



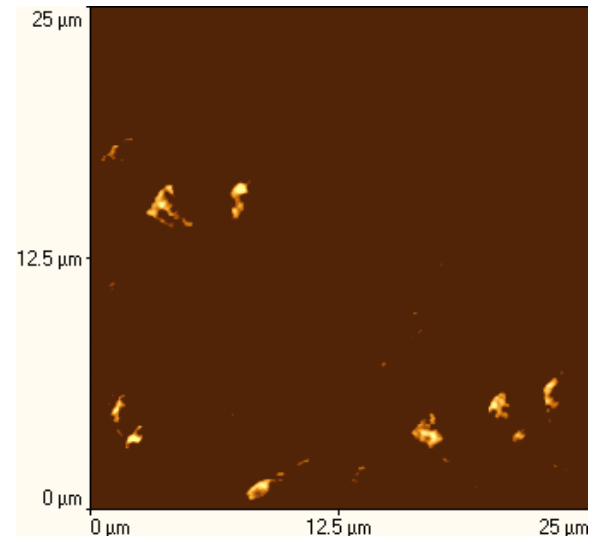
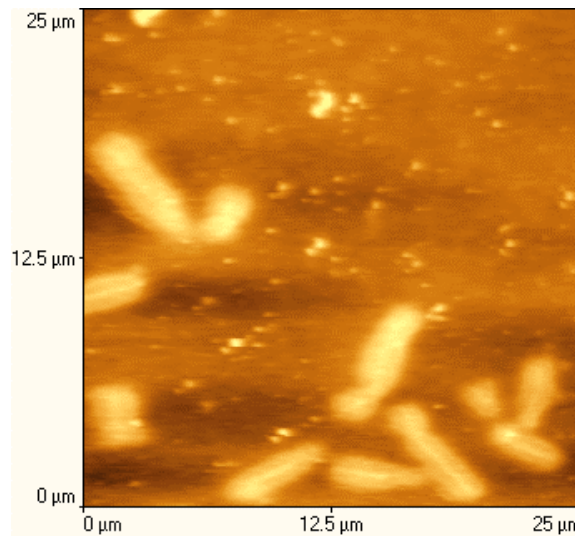
Streptavidin-FITC in PMMA

2 μ m x 2 μ m

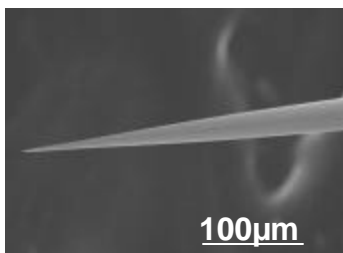
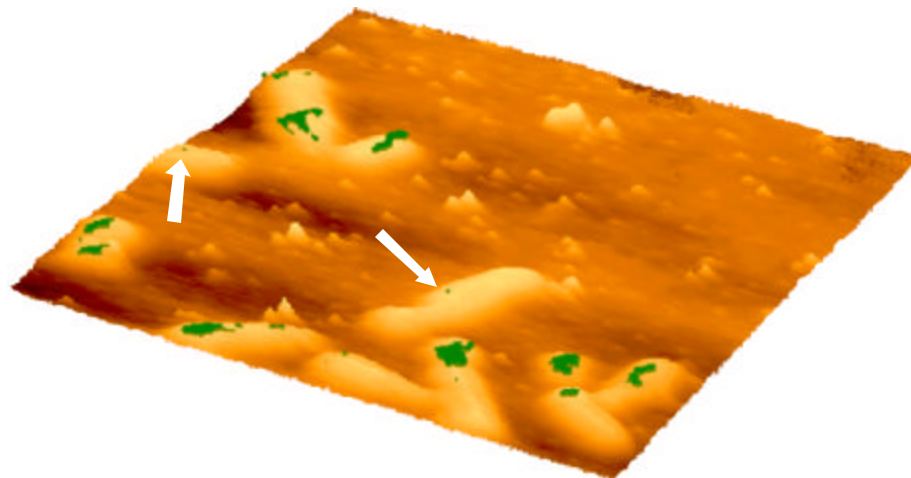
Fluorescence Images

Topography

Molekulare Zytogenetik: Fluoreszenz in situ-Hybridisierung

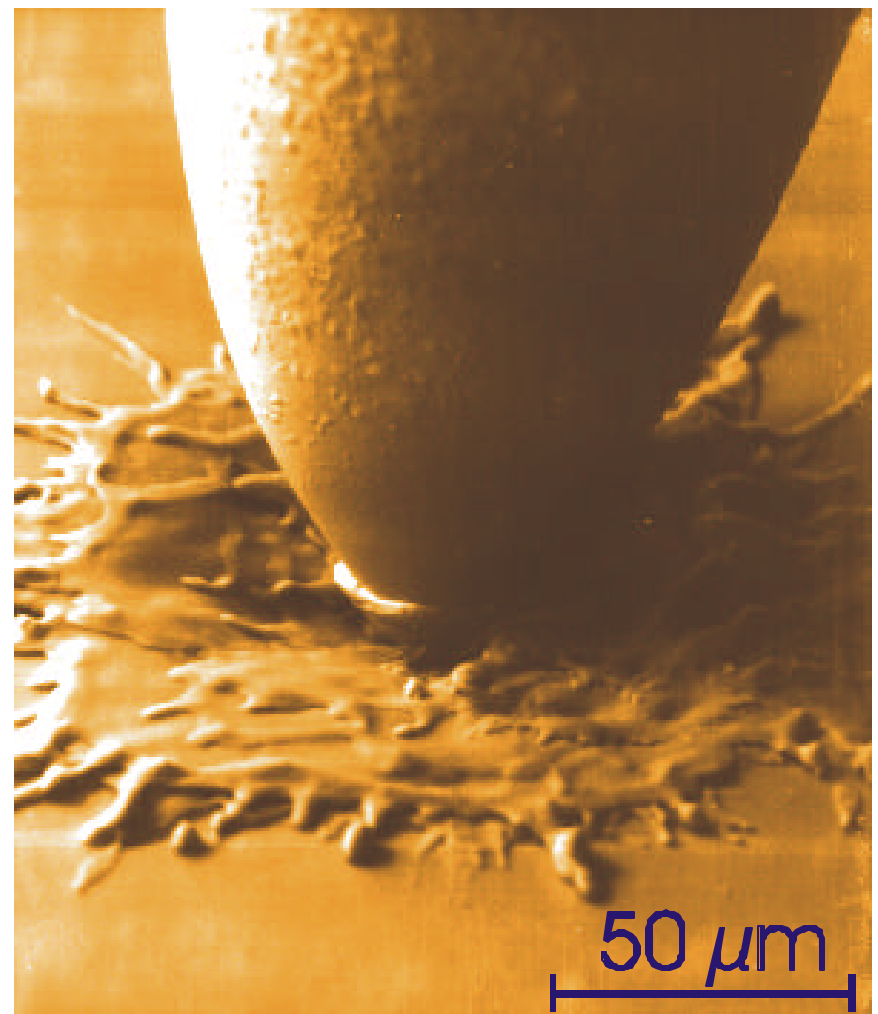
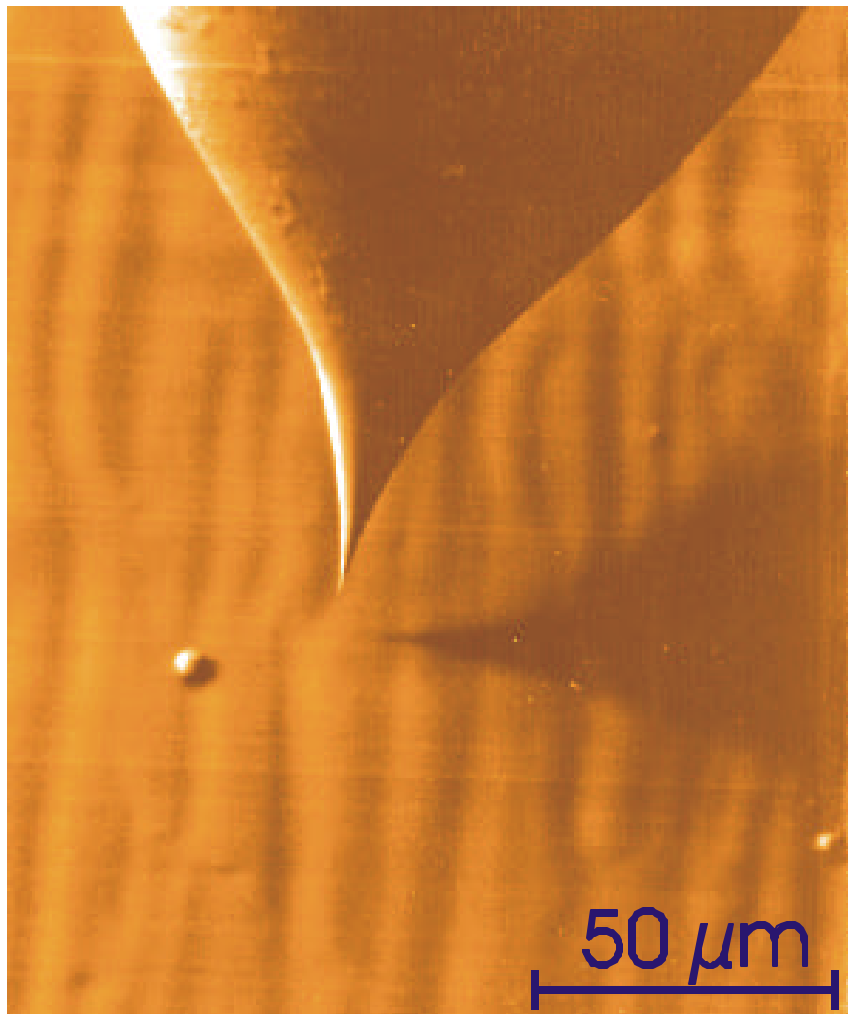


Zentromersonden

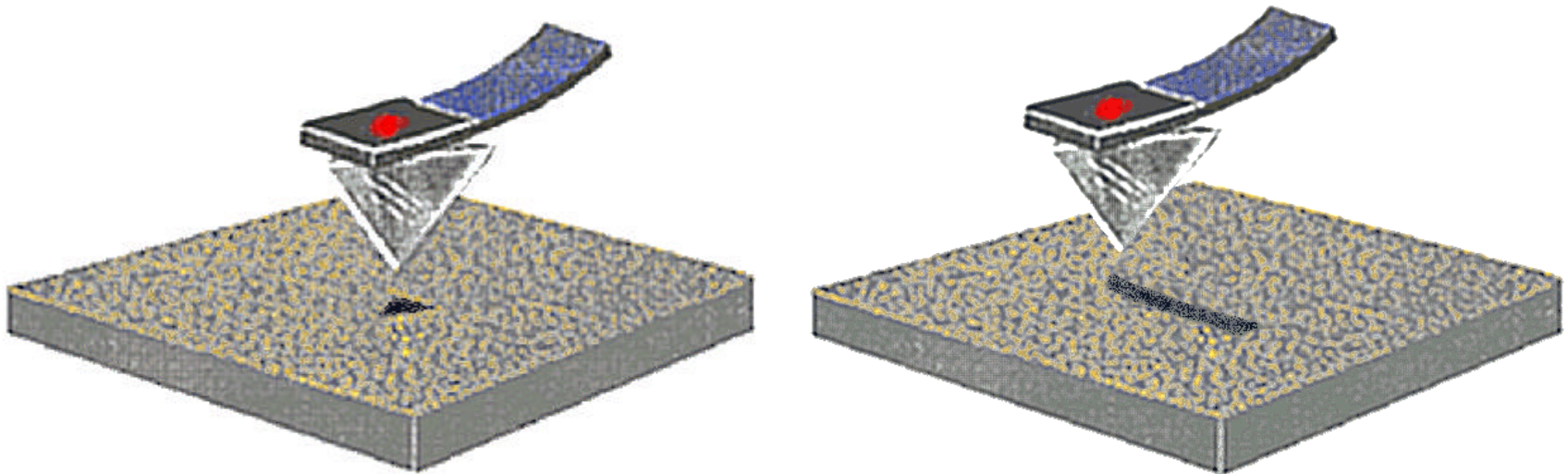


Manipulation auf Nanometerskala

STM tip before and after a spark at 600 V



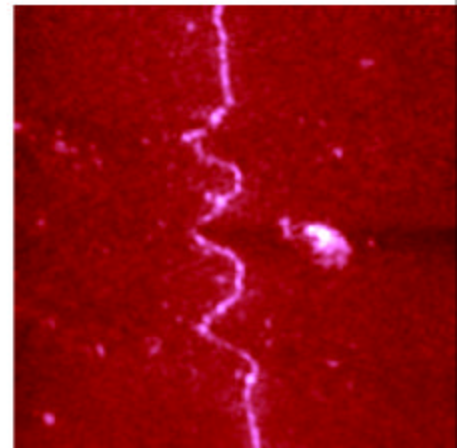
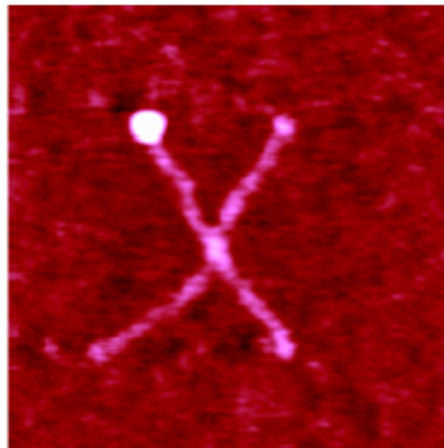
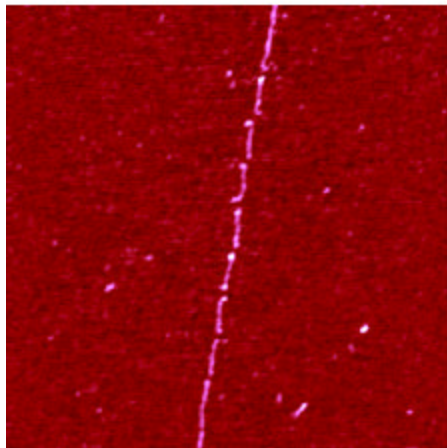
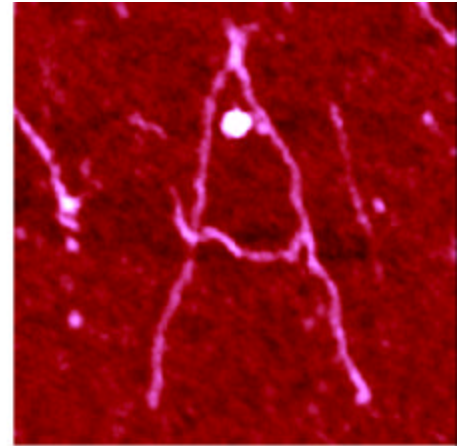
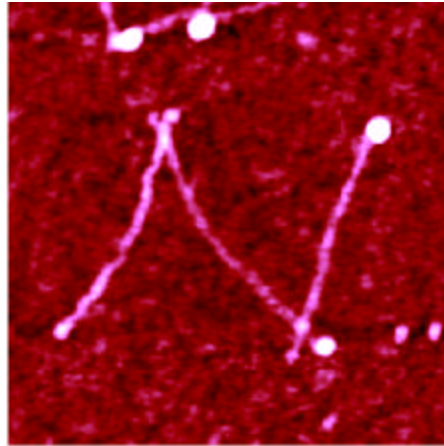
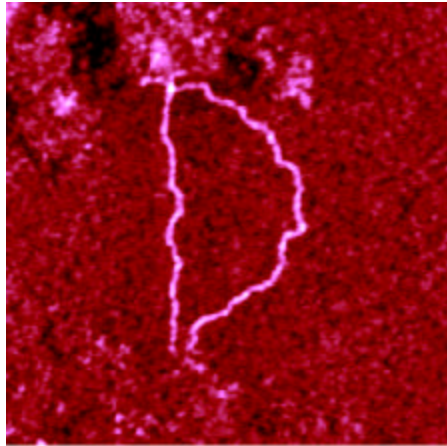
Nanomechanical Testing using SPM

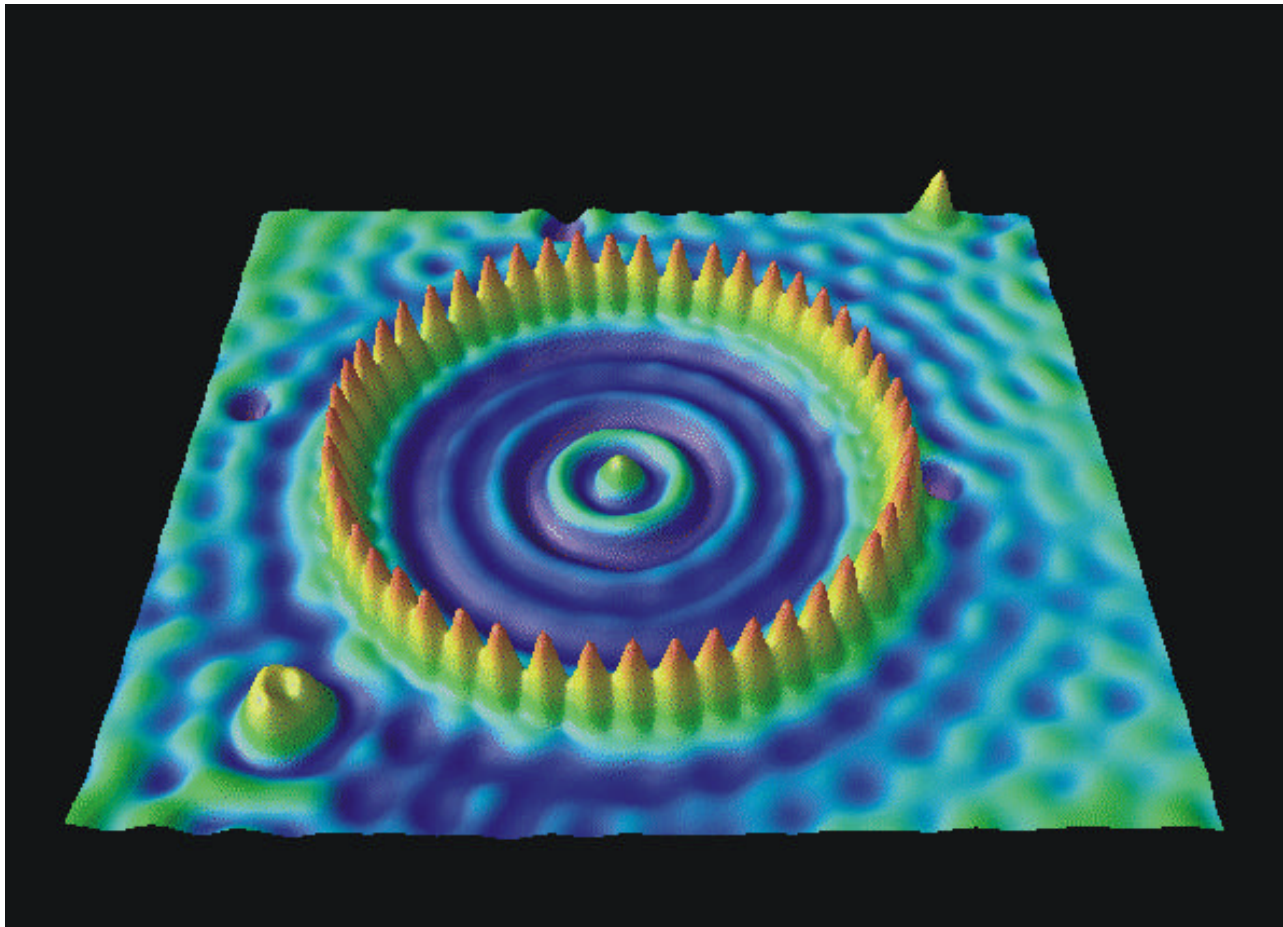


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48 iron atoms on copper (111)

Crommie, Lutz and Eigler, IBM, 1993

Zusammenfassung

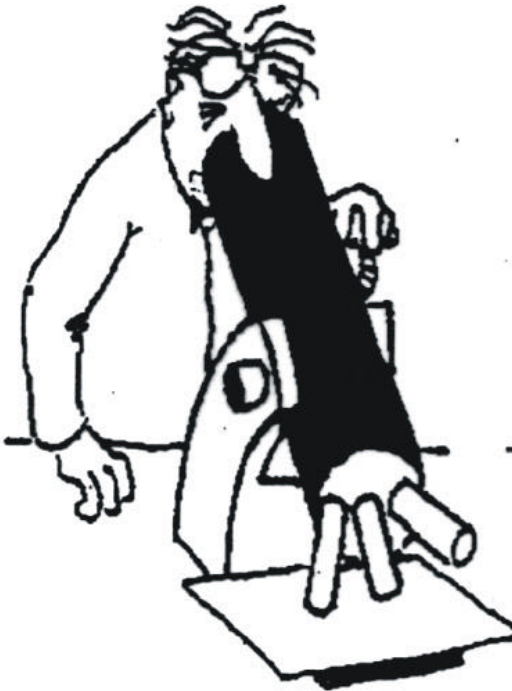
Zusammenfassung

- Rastersondenverfahren sind Auslöser, Wegbereiter und wichtigstes analytisches Werkzeug der Nanostrukturforschung/Nanotechnologie
- Weiterhin nicht erschlossene Verfahren kombinieren eine hohe räumliche und zeitliche Auflösung oder bieten tomographische Abbildungsmöglichkeiten



DITTMANN

MINI



MIKRO



NANO