



Research Campus RUB

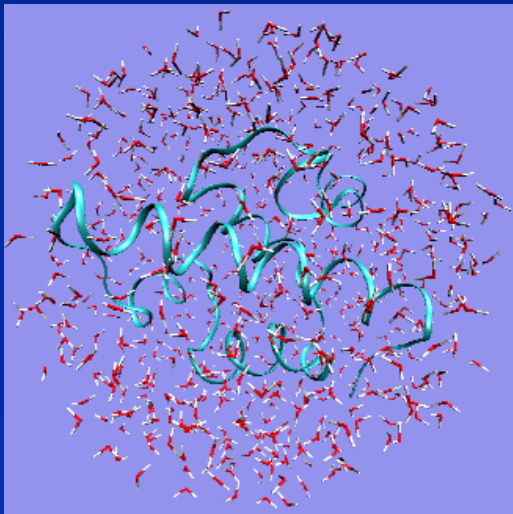
www.rub.de/pc2/eb.html

Dept. of Physical Chemistry II (Prof. M. Havenith)



Erik Bründermann

Exploring the nanoworld with THz + IR radiation / lasers using chemical nanoscopes



THz - FIR



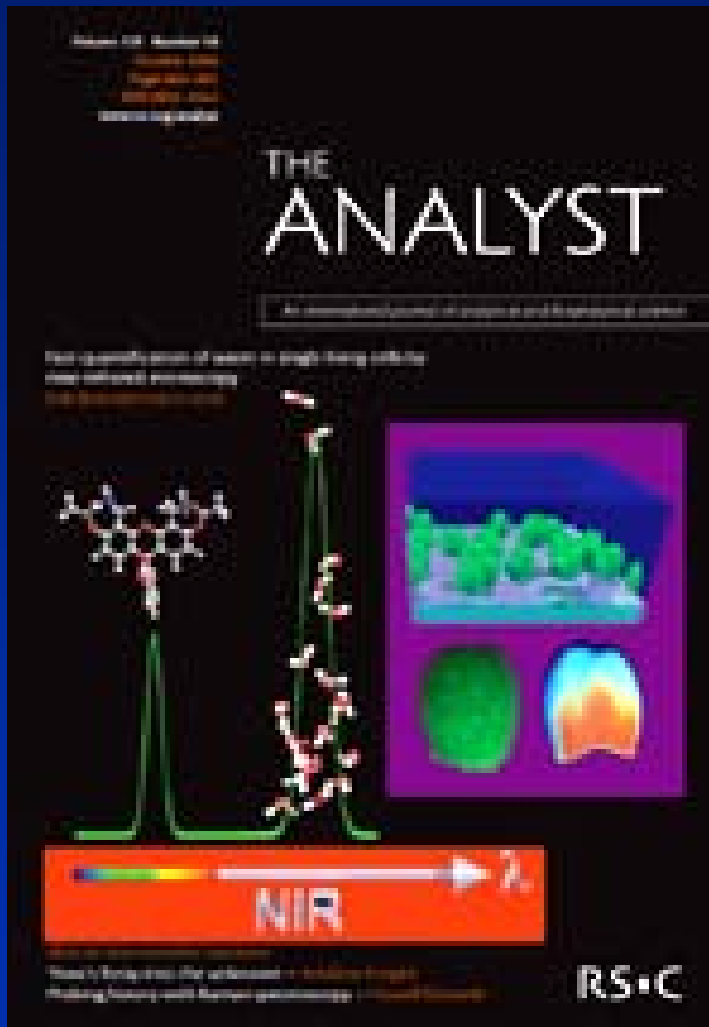
MIR - NIR



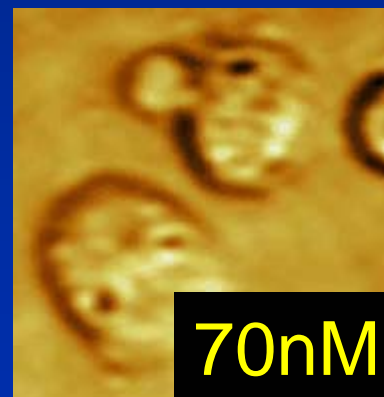
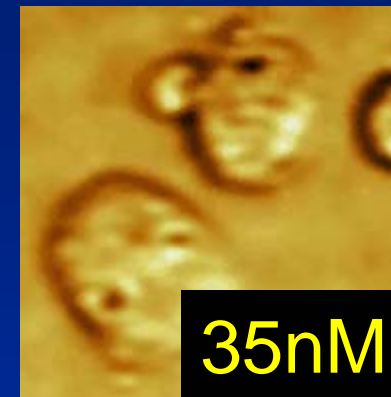
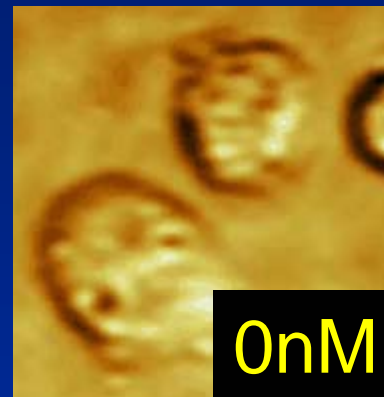
MIR - NIR



fast quantification of H₂O in single living cells



NIR microscopy



1530 nm
insulin
response

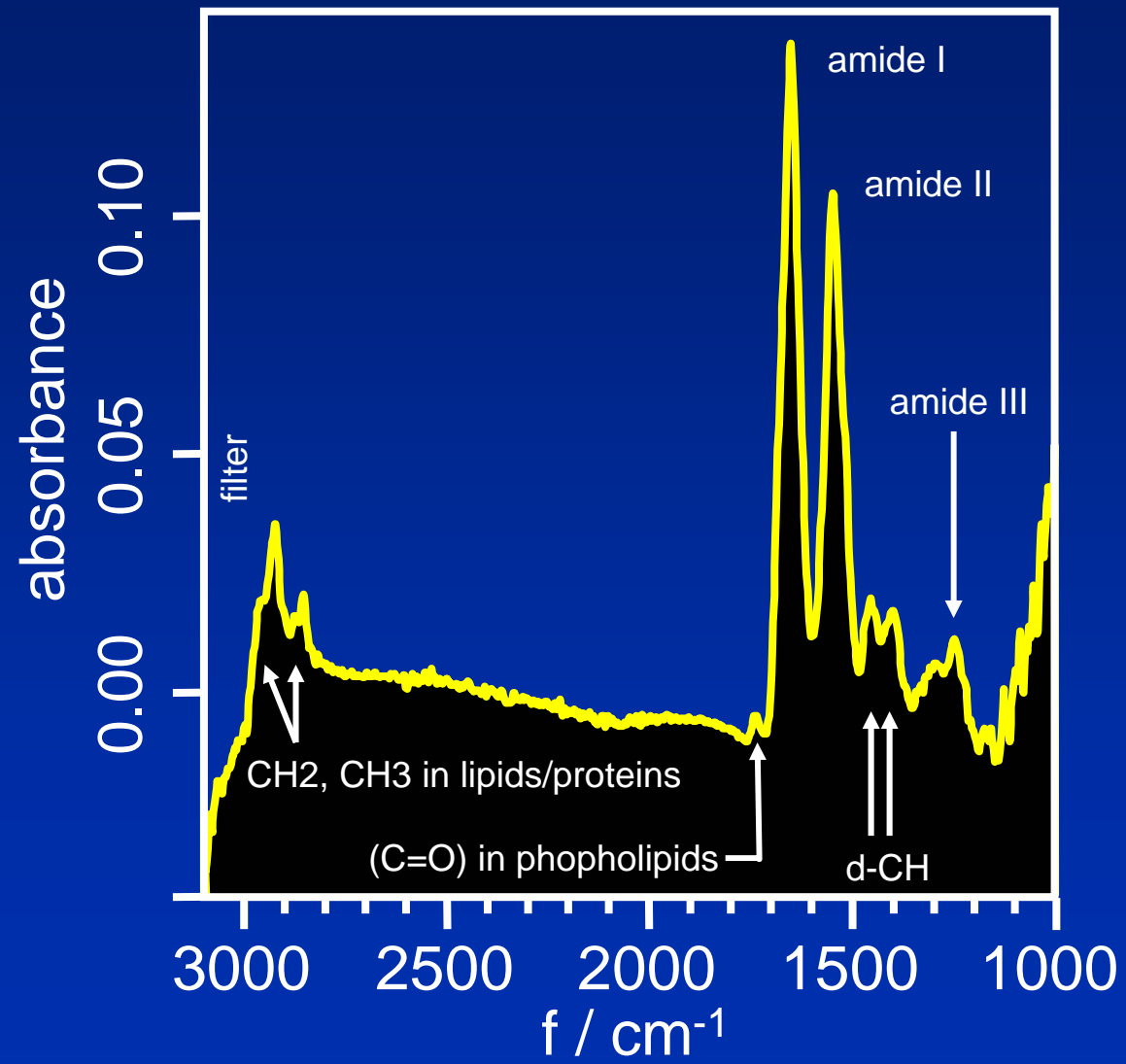
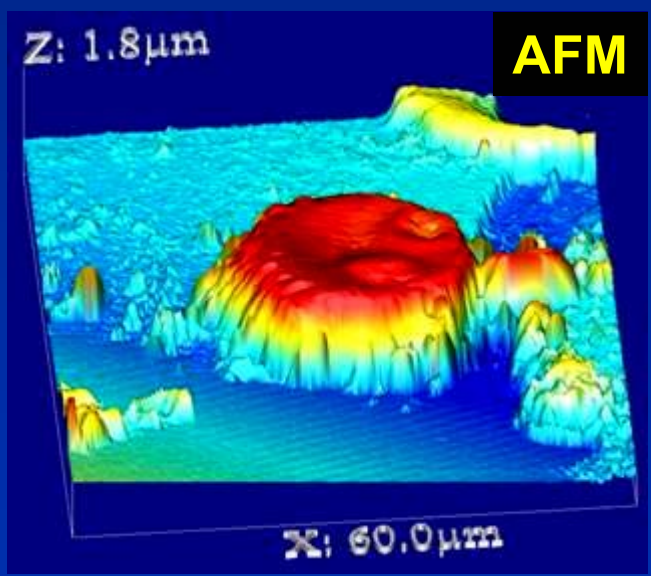
E. Bründermann, et al., *Analyst* 129, 893 (2004)



synchrotron ANKA: living cell study

combine high AFM resolution and infrared spectroscopy

BMBF: IR and THz near-field microscope for ANKA



ANKA collaboration: David Moss, Yves-Laurent Mathis, Biliana Gasharova

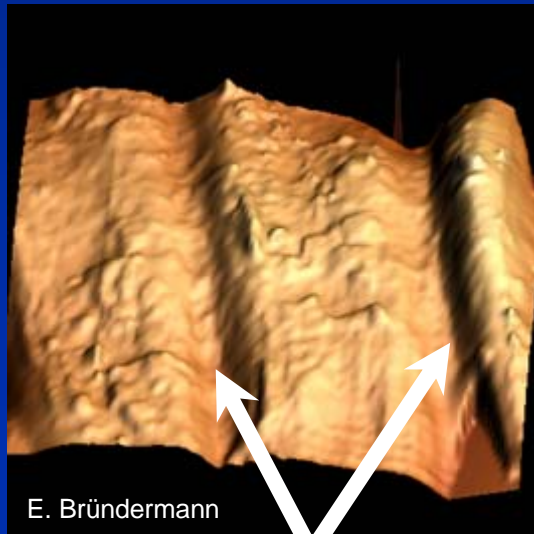
5 days after cultivation, aperture 0,75 = 50 µm, 256 Scans
ANKA (71.4 mA; 2,401 GeV), 27.06.2007



concept: AFM – tactile nanoscope

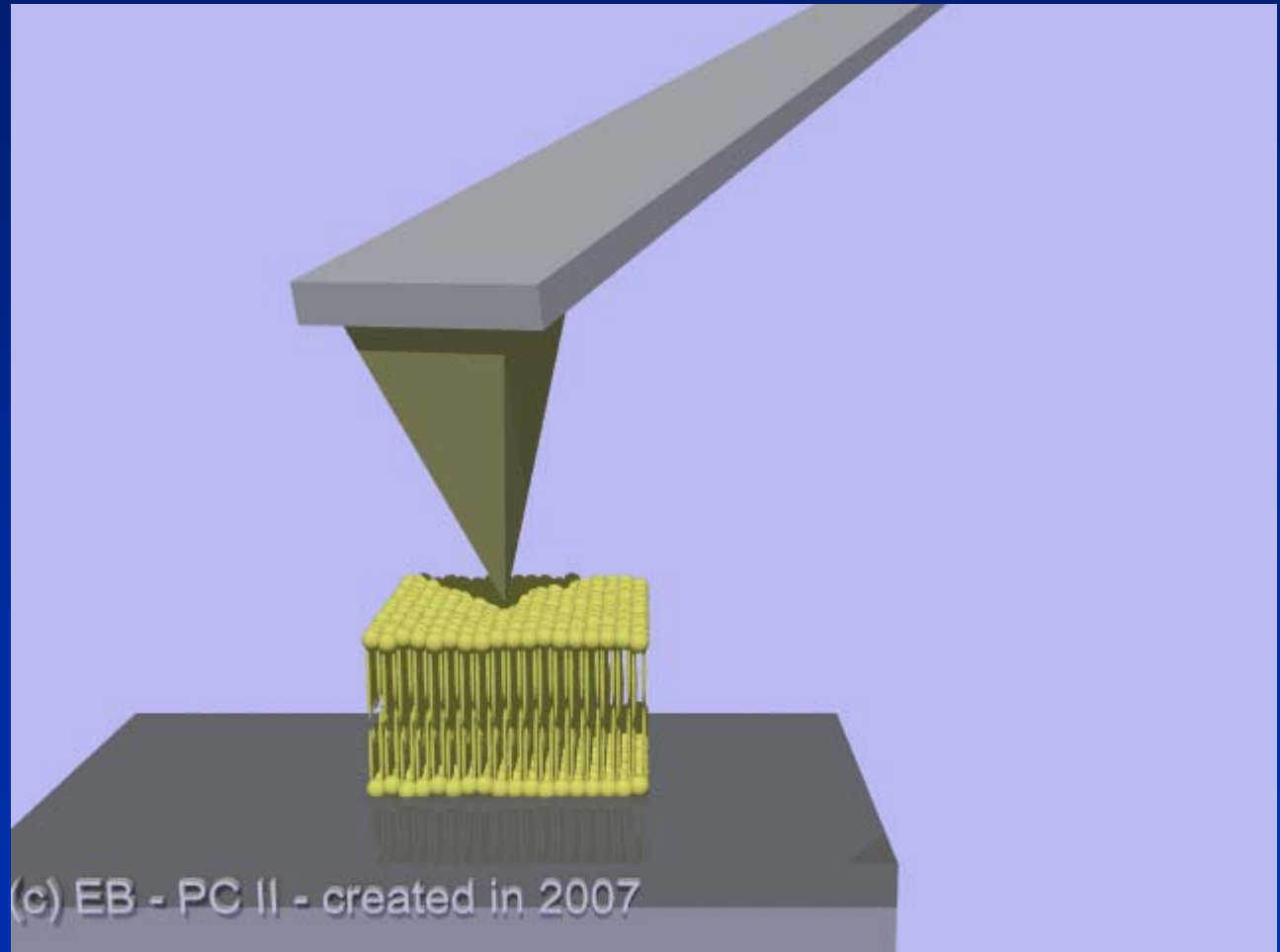
feel
molecules

3 onion cells
80 x 80 μm^2



E. Bründermann

cell walls



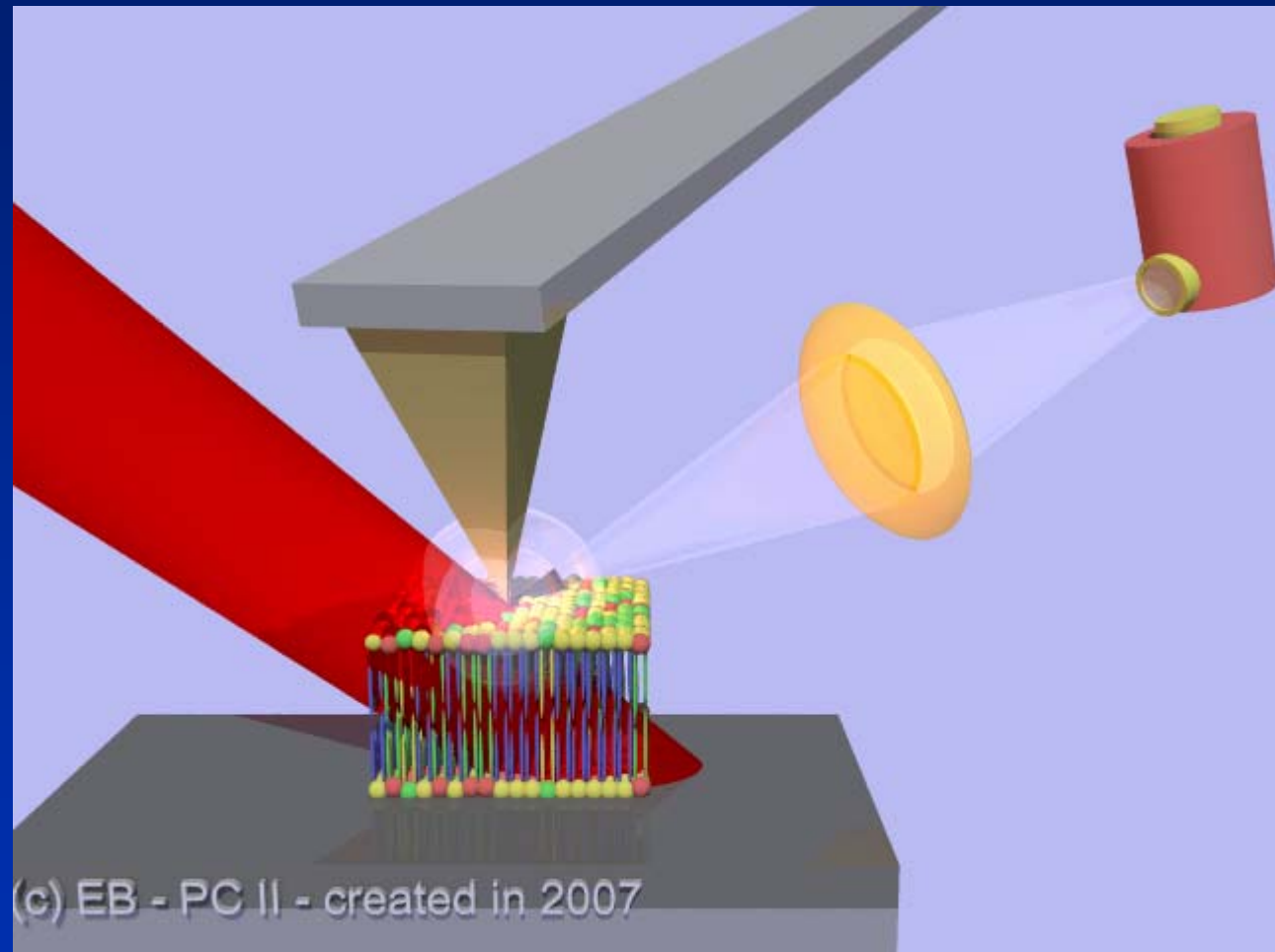
(c) EB - PC II - created in 2007



concept: SNIM – chemical nanoscope

see
molecules

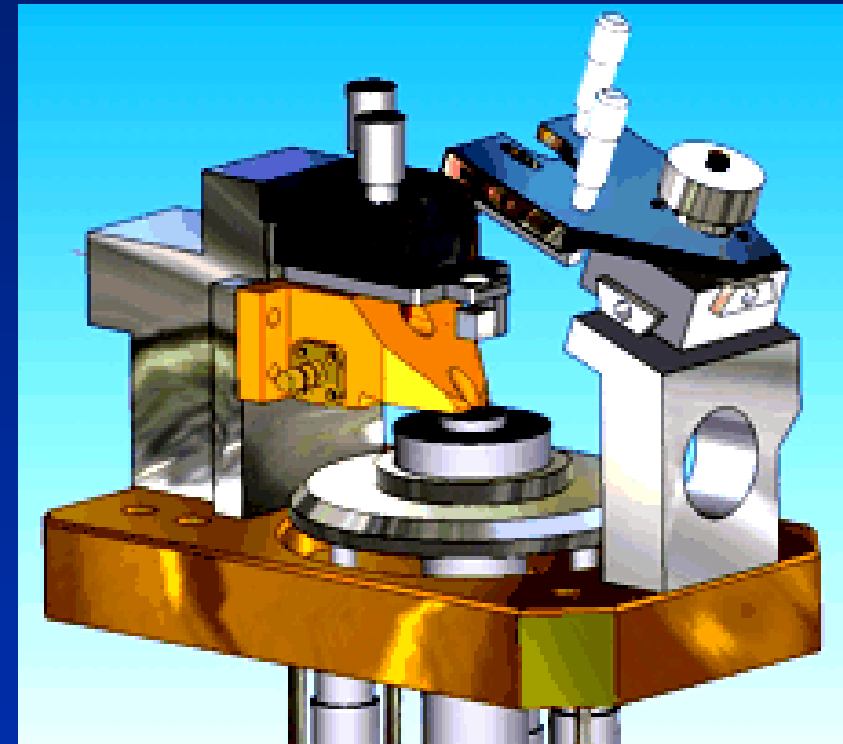
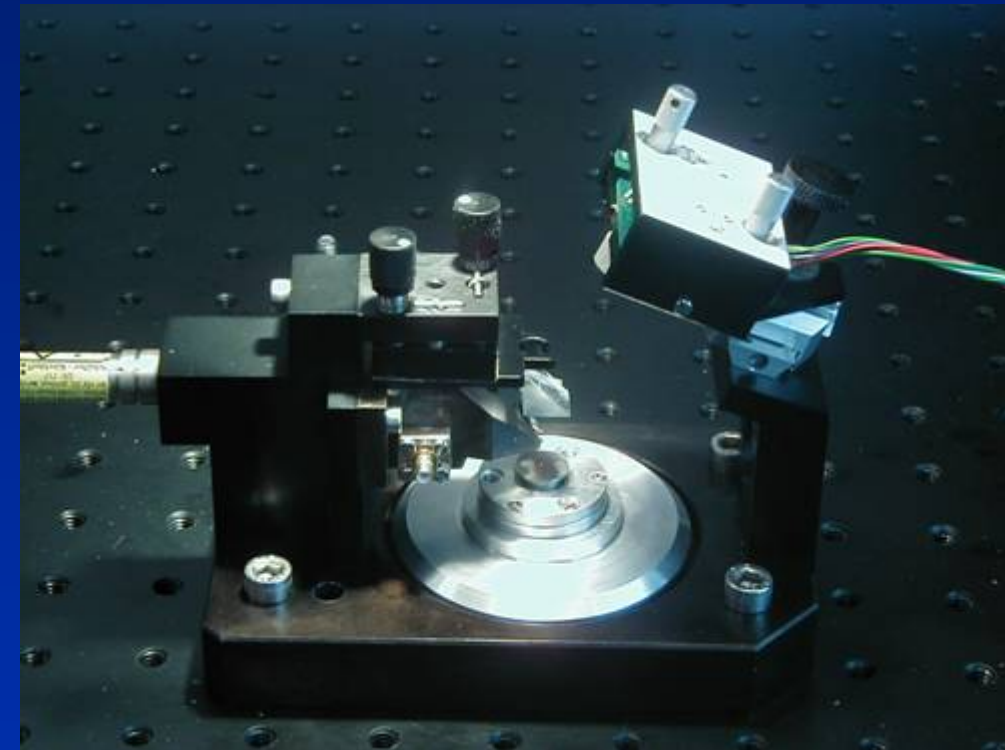
in the light
look for colors
to identify
molecules



Scanning **N**ear-field **I**nfrared **M**icroscopy



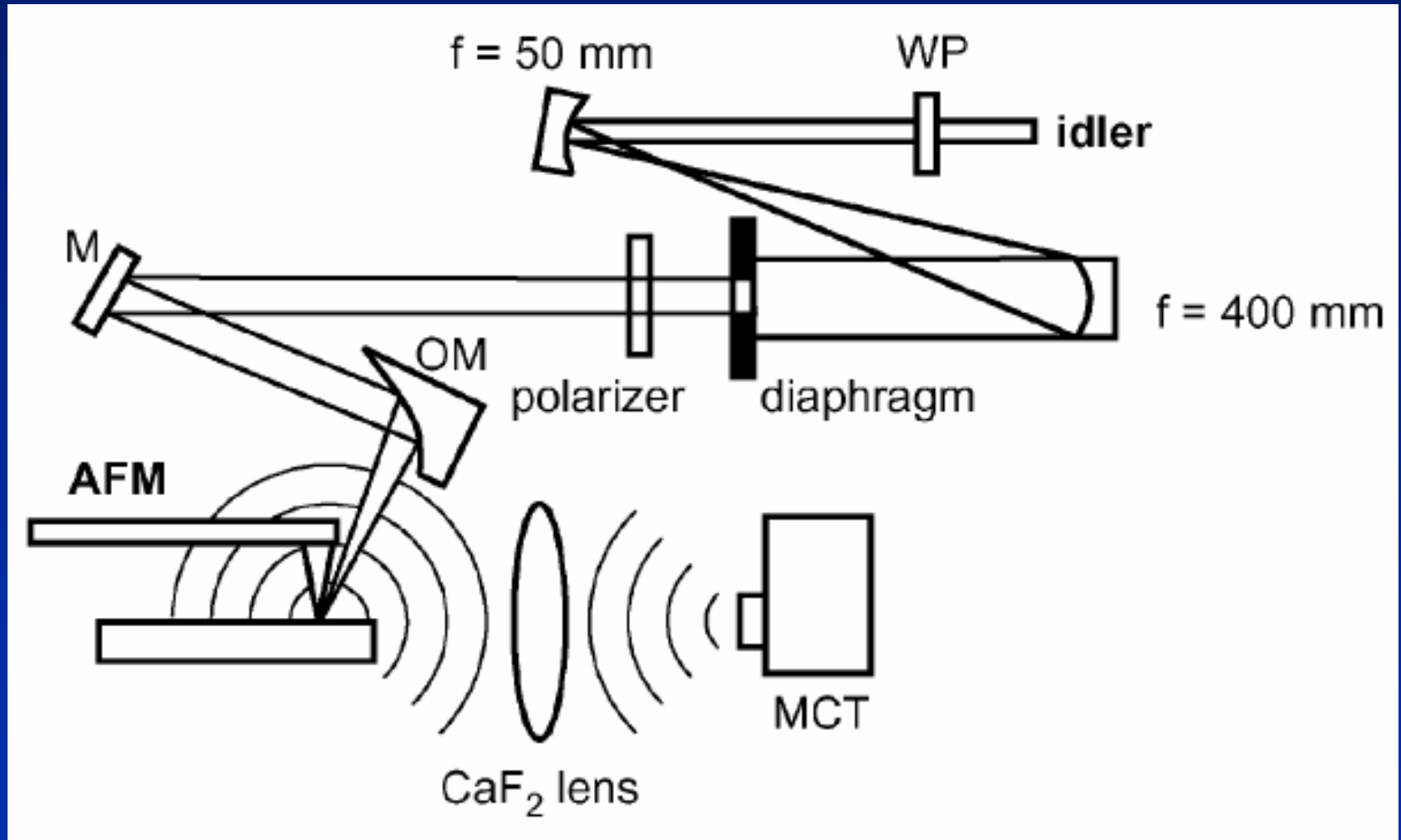
our atomic force microscope – AFM designed for collection in large solid angle



fixed laser focus \Rightarrow move sample – not tip



set-up of near-field microscope

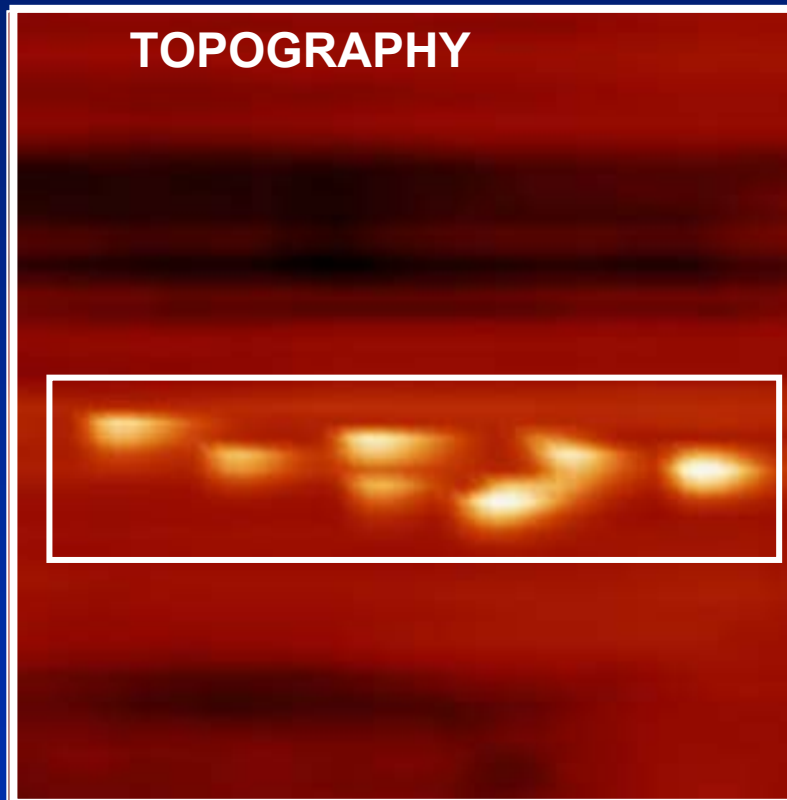




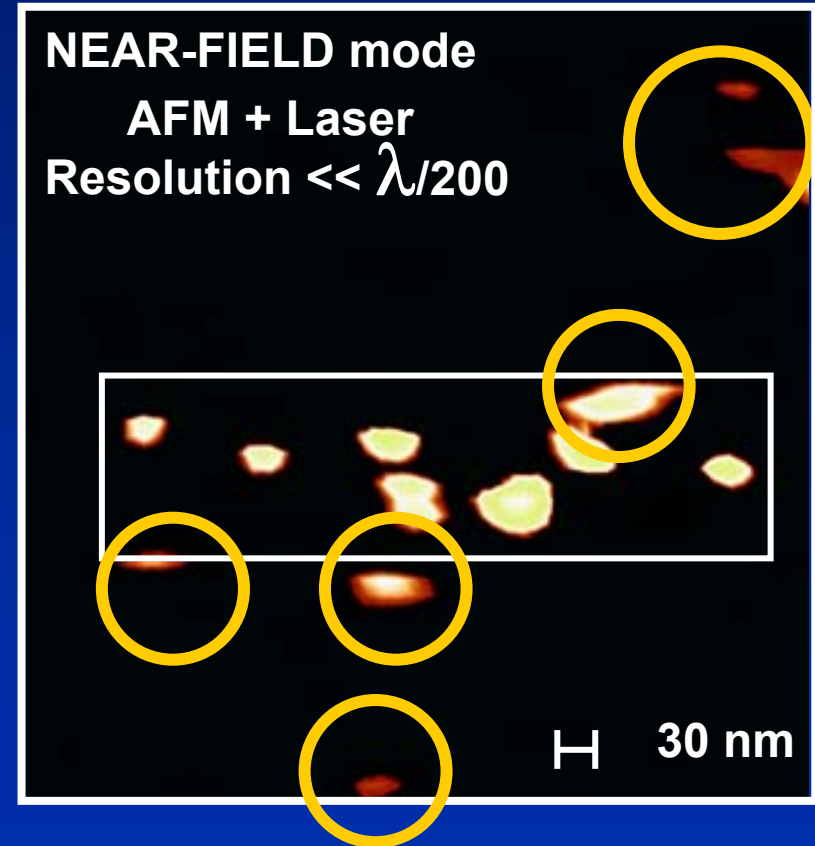
near-field microscopy ($\lambda = 3222 \text{ nm}$)

93 THz

resolution 30 nm = tip curvature



30 nm gold nanoballs



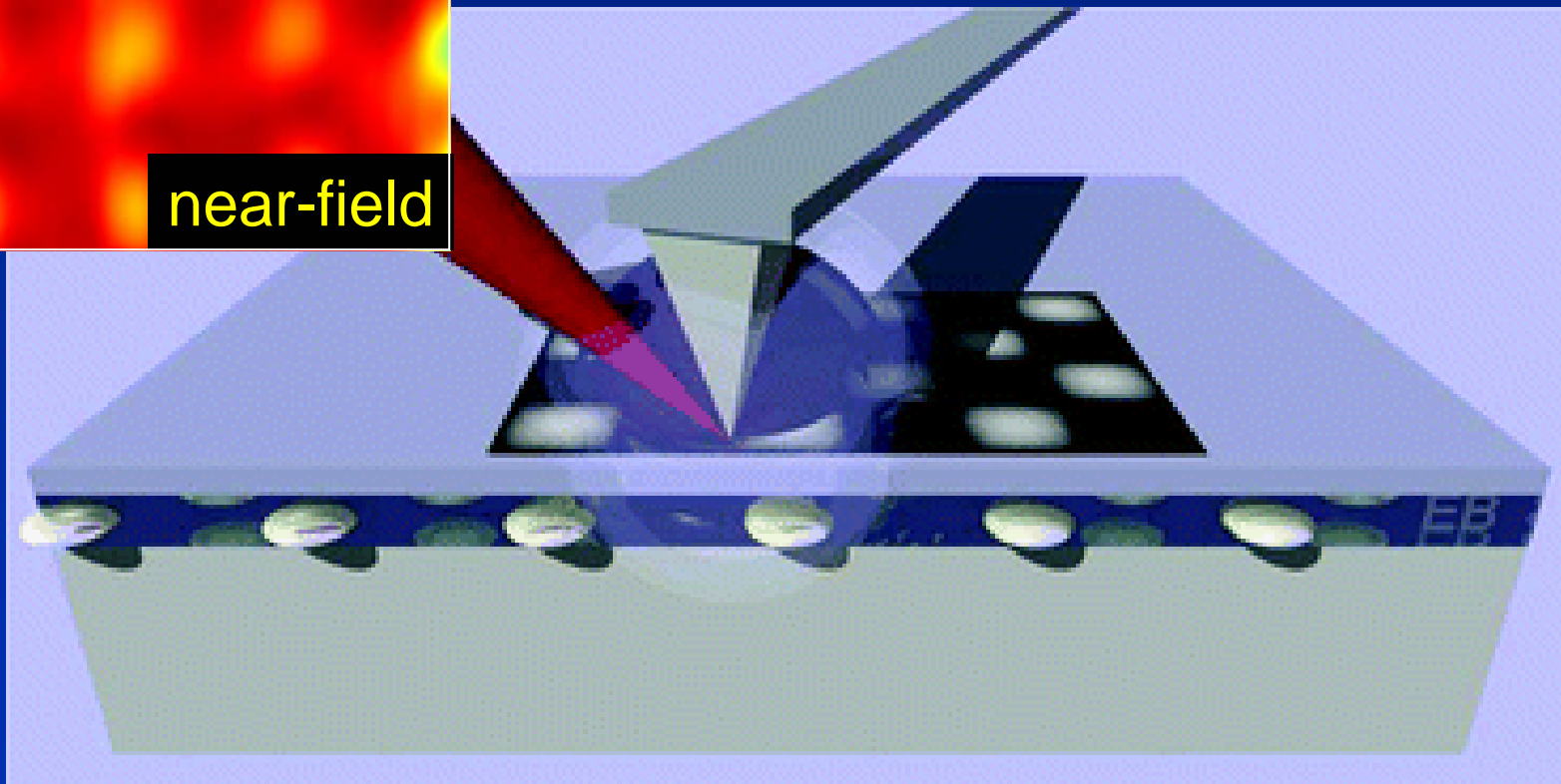
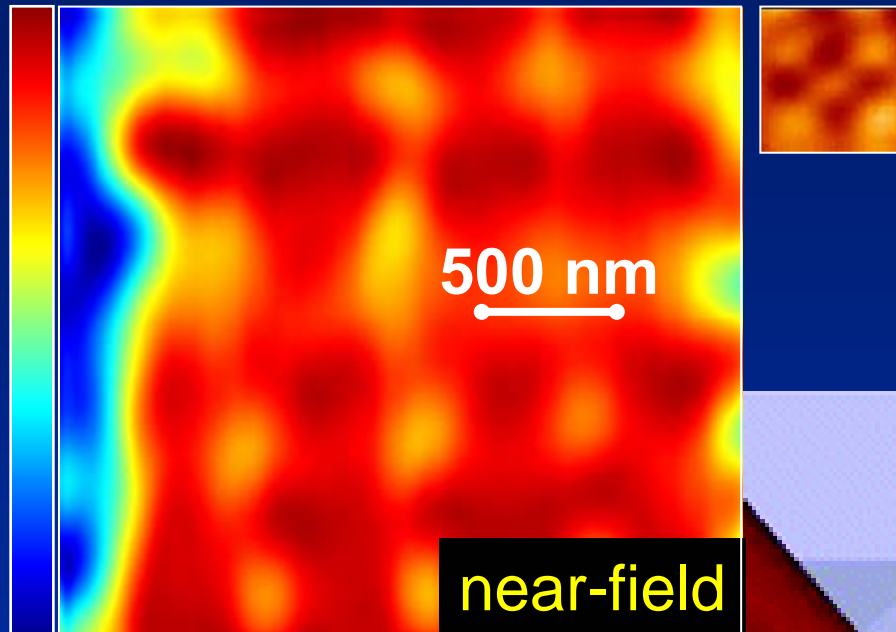
poly-L-lysine



sub-surface Ga-implant in Si ($\lambda = 3222$ nm)

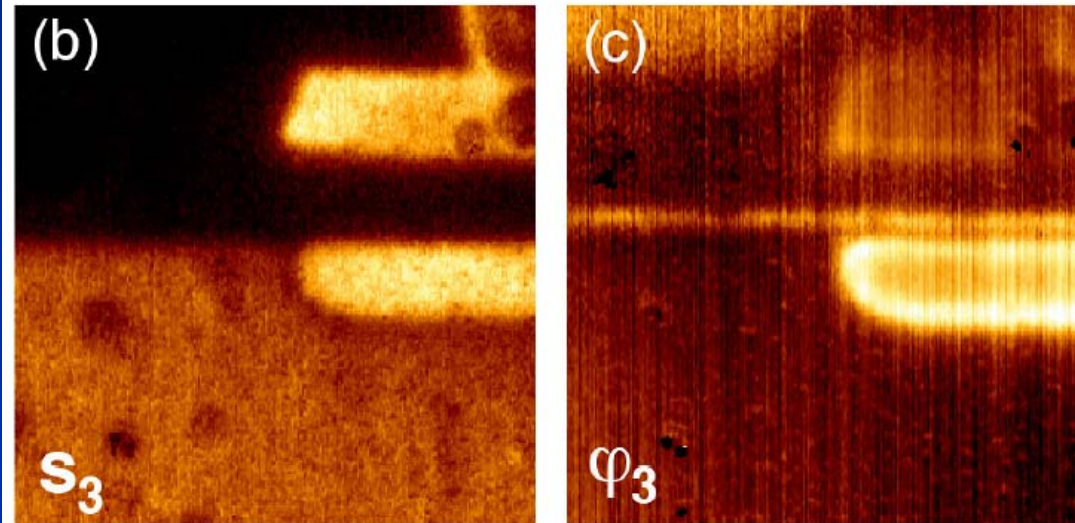
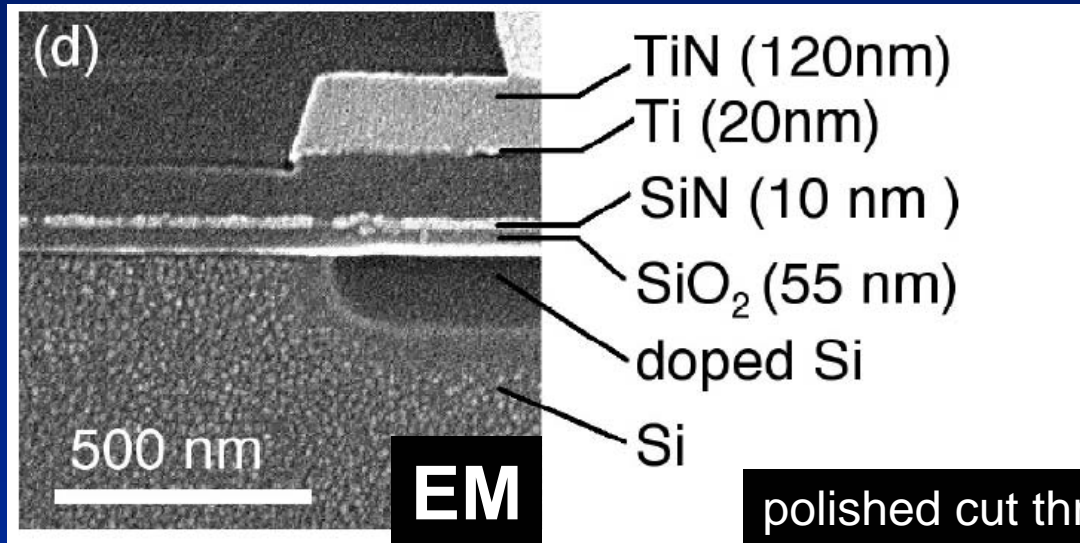
93 THz

flat (no) topography



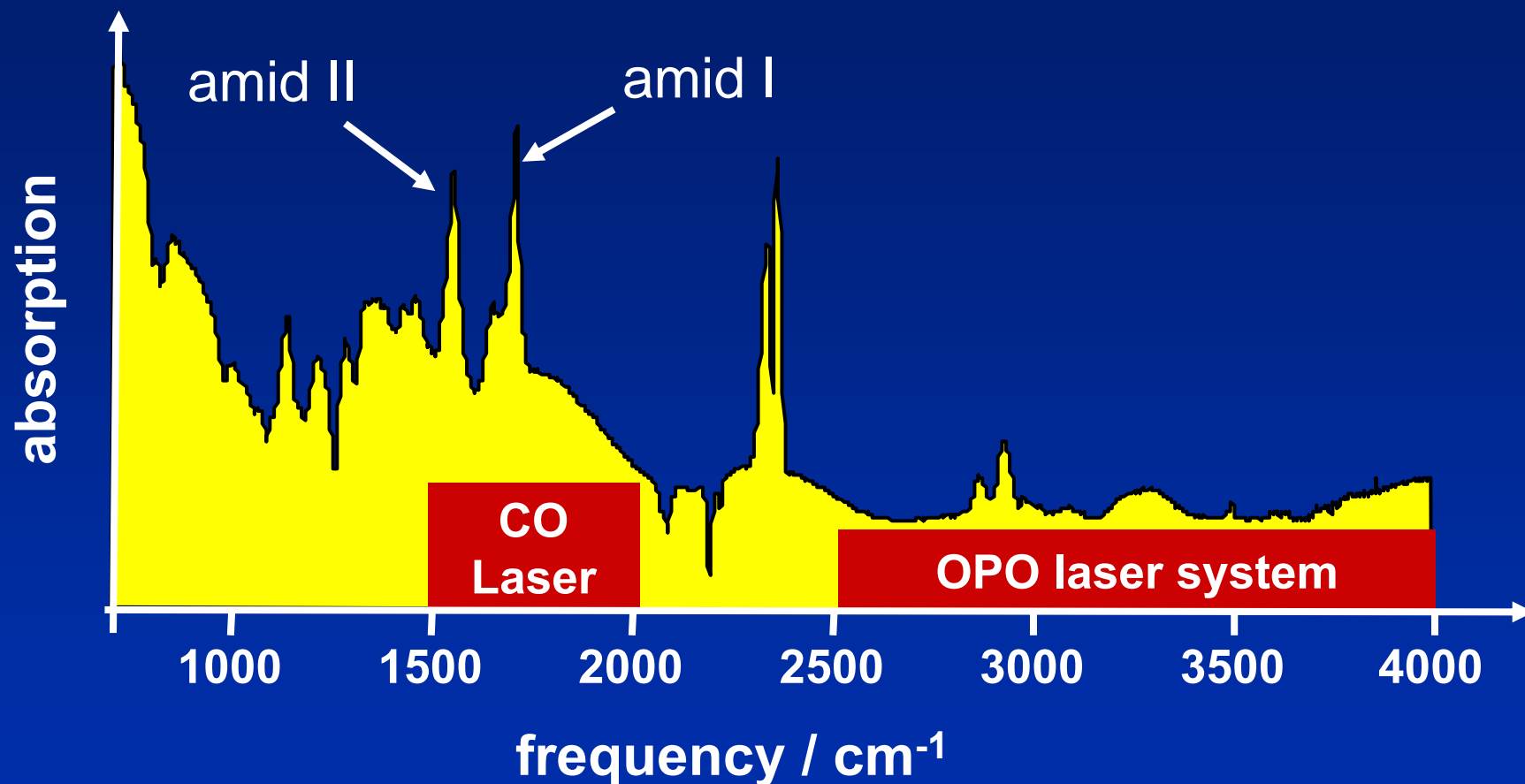


IR ($\lambda = 10.7 \mu\text{m}$) s-SNOM amplitude (s_3), phase (φ_3)





biotin

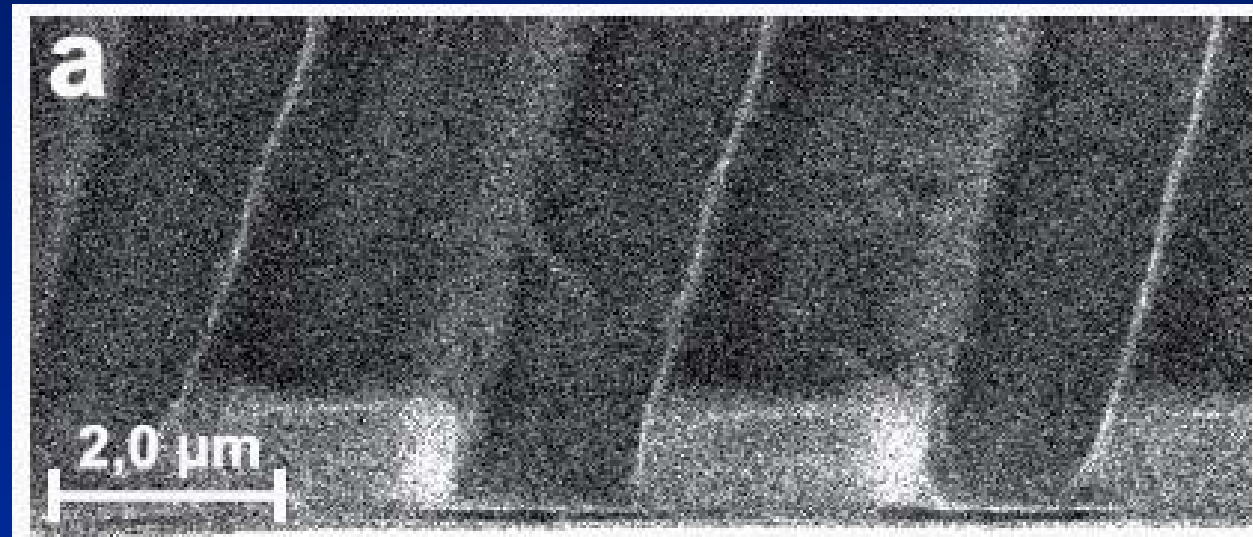


reference (no absorption in amide band): octadecanethiolate ($\text{SH}-(\text{CH}_2)_{17}-\text{CH}_3$)

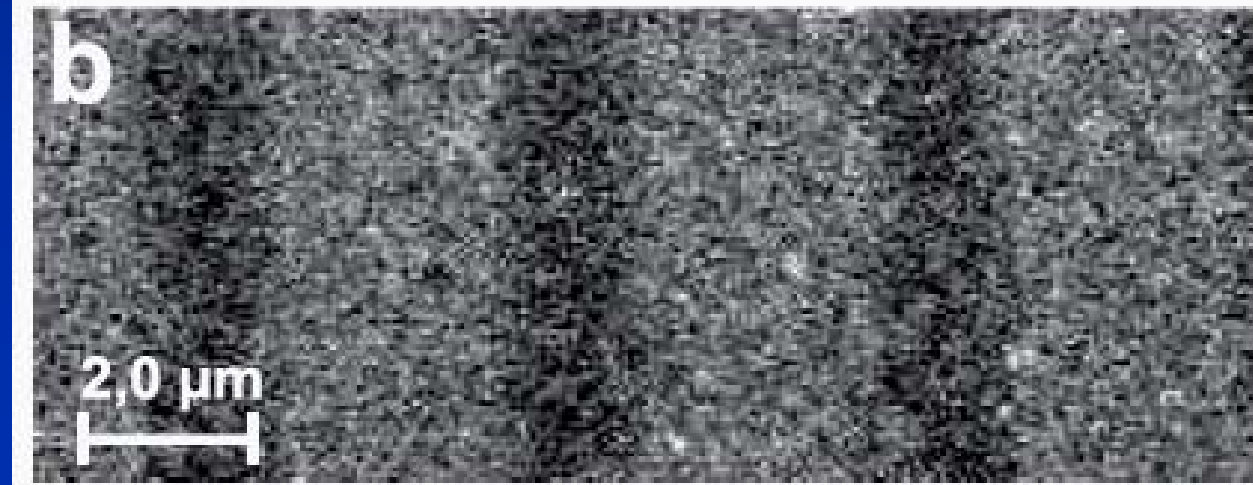


electron microscope images

PDMS stamp
polydimethylsiloxan



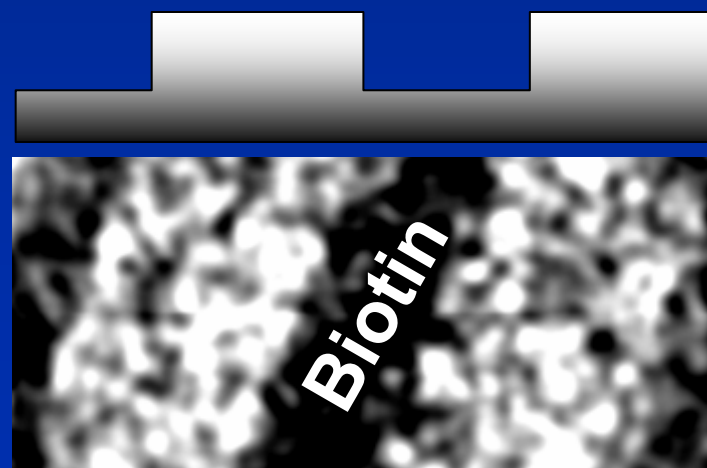
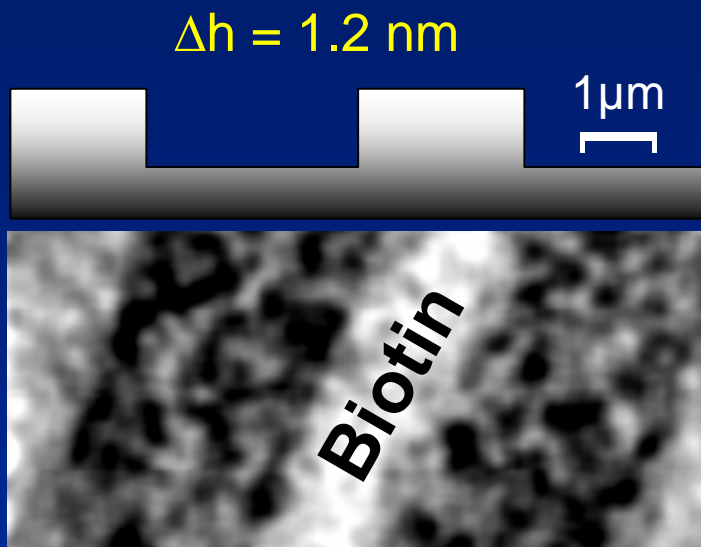
stamped structure



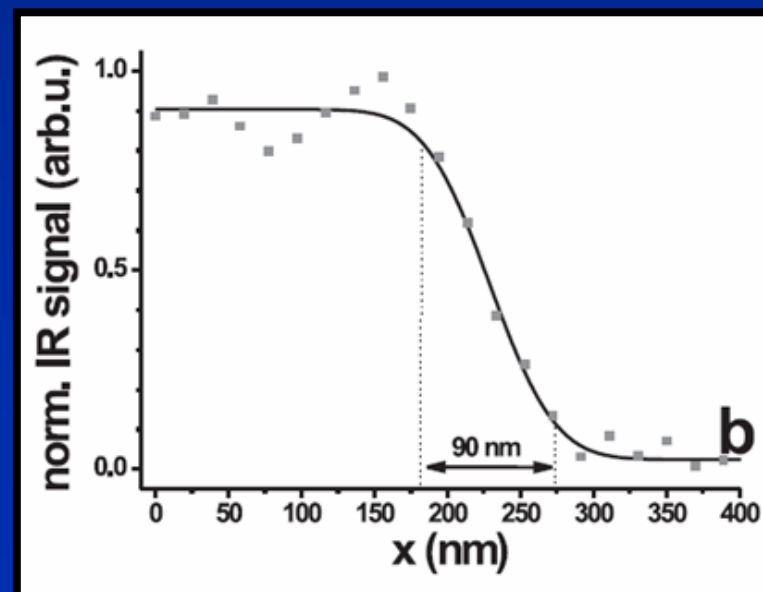
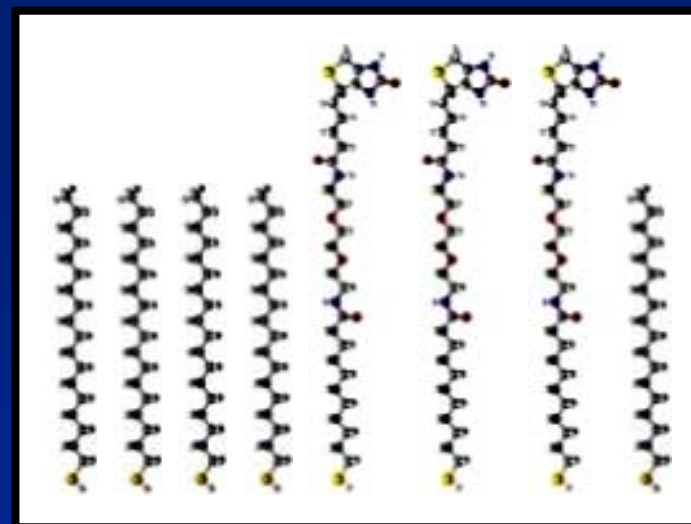


Self-Assembled Monolayers – bioactive surfaces / sensors

micro „potato“ stamp



near-field $f = 1711 \text{ cm}^{-1}$





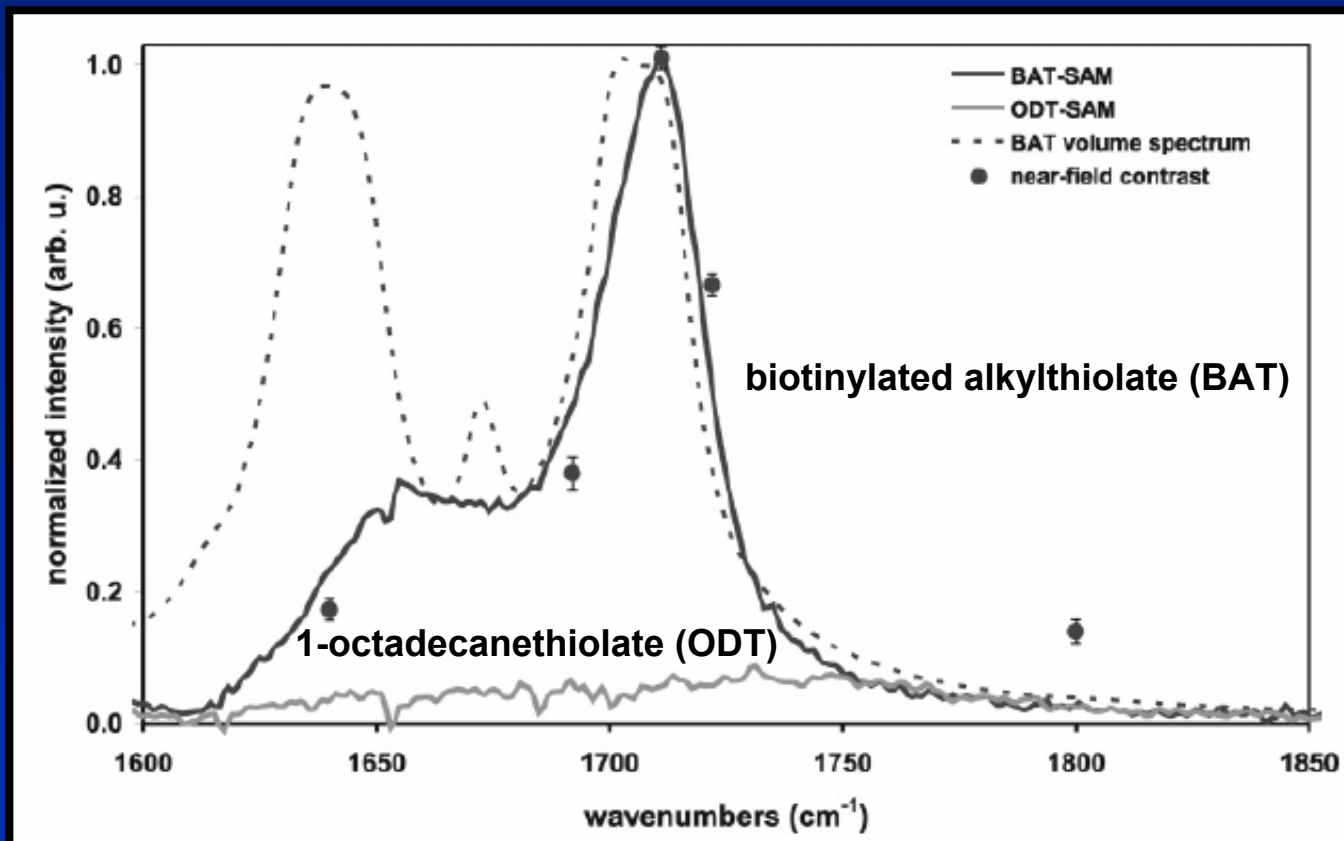
near-field spectrum and image

resolution: 90 nm $\sim 2 \times$ tip radius

near-field: $\nu = 1711 \text{ cm}^{-1}$
(5.8 μm , 51 THz, CO laser)



1 μm



< 30000 molecules
10⁻²⁰ liter
0.01 attoliter



thanks

to Prof. Martina Havenith
& the team of Physical Chemistry II, Bochum
& the ANKA team

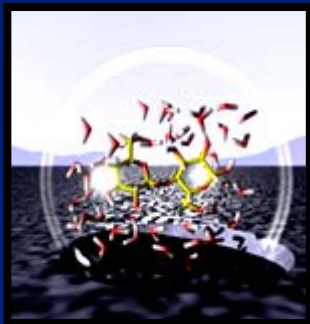


BMBF: IR and THz near-field microscope for ANKA

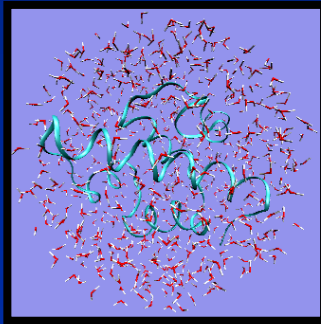


summary

sensitive, fast

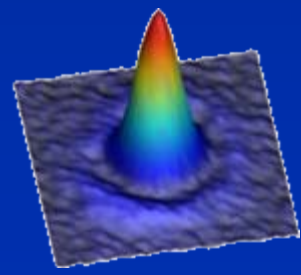


Ge laser
THz-TDS
sweet water

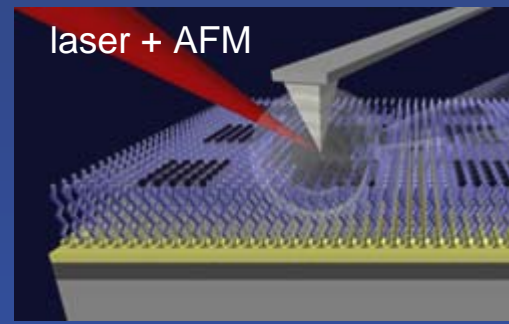


complex

H₂O + protein
+ ...
protein folding



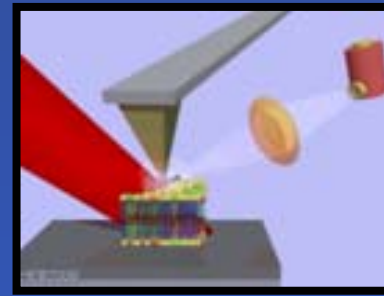
THz video



laser + AFM

SAMs

chemical nanoscope



ultra
resolution



living cells