Near-field optics

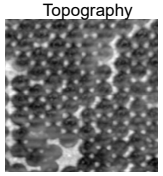
3. Near-field optics

3.4 Scanning near-field optical microscopy : Methodology

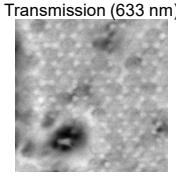
3.4.1 Probe concepts and fabrication
3.4.2 Surface distance control
3.4.3 Optical characterization
3.4.4 Artifacts

Artifacts

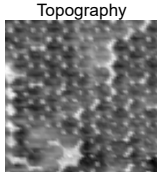
Topography



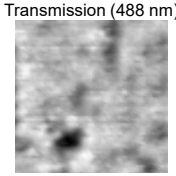
Transmission (633 nm)



Topography



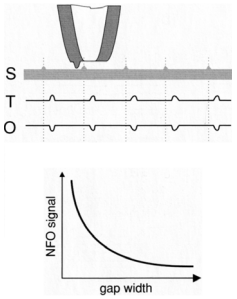
Transmission (488 nm)



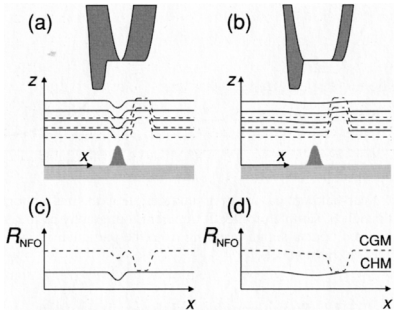
Topographic Artifacts

Modes of operation: constant gap mode (CGM) and constant height mode (CHM)

CGM: Crosstalk between topographic and optical signal



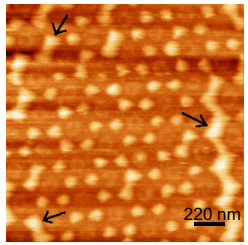
Recorded scan lines for both, CGM and CHM



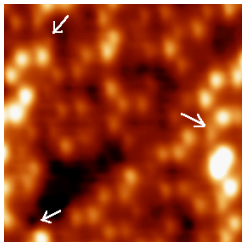
NSOM Image Contrast

Transmission image (CHM) of a regular metallic pattern

Topography



Transmission (CHM, inverted)



The images have not been taken simultaneously!

D. Molenda, Diploma thesis (2001)

Near-field optics

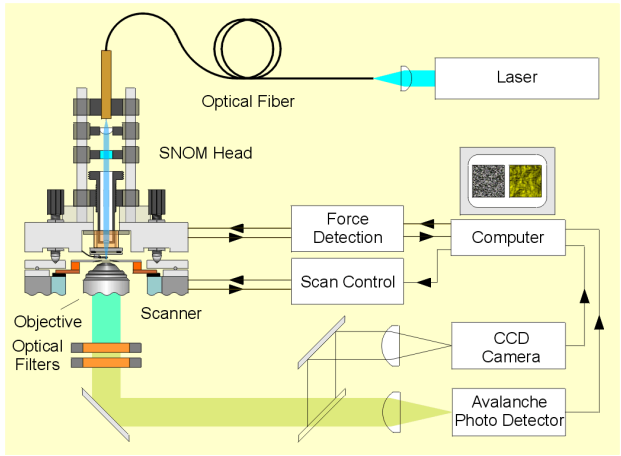
3. Near-field optics

⋮

3.5 Scanning near-field optical microscopy : Applications

- *3.5.1 Single molecule imaging*
- *3.5.2 Imaging of single proteins in biological membranes*
- *3.5.3 Autocorrelation measurements*
- *3.5.4 Fluorescence Correlation Spectroscopy*
- *3.5.5 Observation of single protein transport through a biological membrane*

Fluorescence Imaging

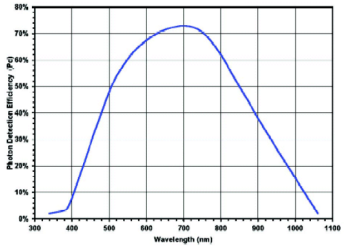


Detection of Single Molecules

Avalanche-Photodiode

SPCM

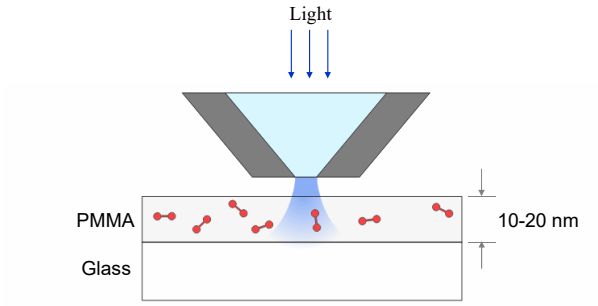
optoelectronics.perkinelmer.com



Darkcount rate : < 50 Counts/s
Temporal resolution : < 350 ps

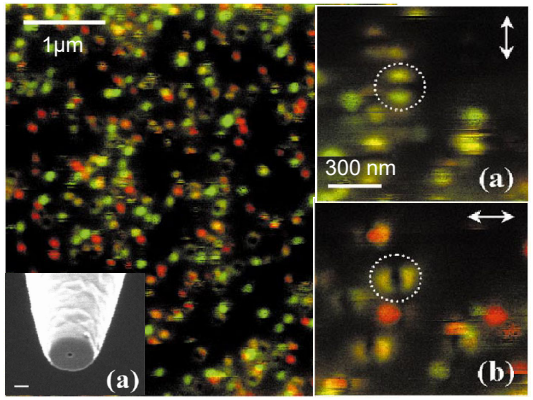
Hecht (2003)

Imaging of Single Molecules



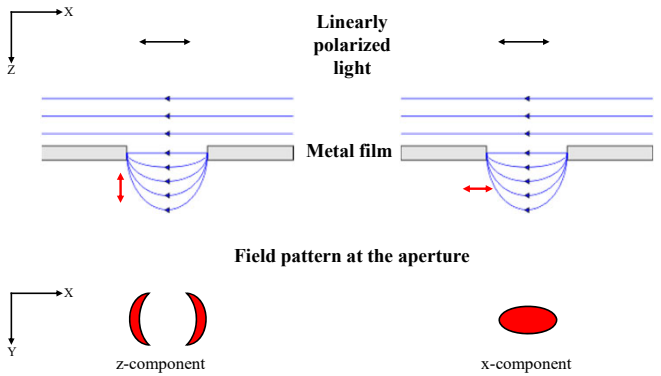
Betzig and Chichester, Science 262, 1422 (1993)

Fluorescence of Single Molecules

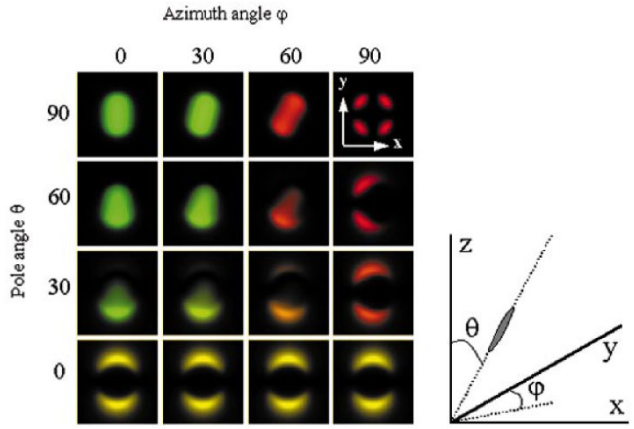


Betzig and Chichester (1993); Veerman et al. (1999)

Field Components at a Cicular Aperture

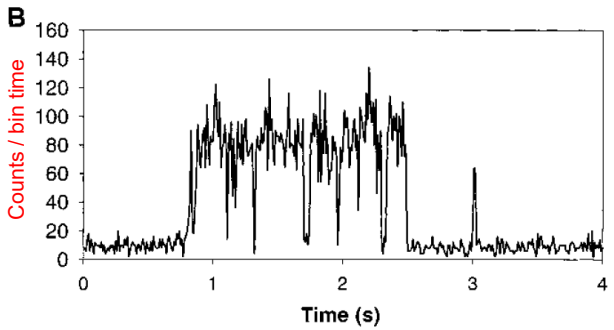


Field Pattern of an Oriented Dipole at a Circular Nano-Aperture



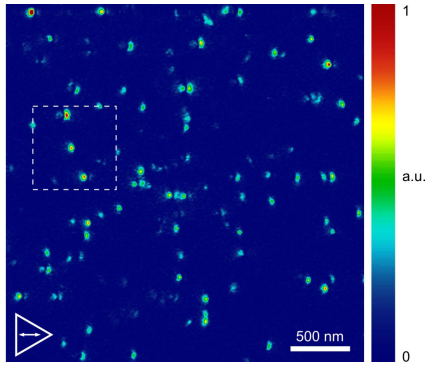
Veerman et al. (1999)

Blinking of Single Molecules



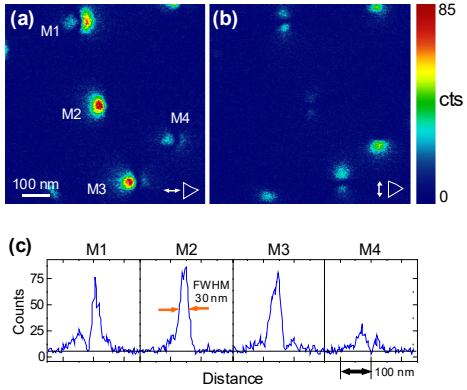
Moerner & Orrit, Science 283, 1999

TA-Probe: Imaging of Single Molecules



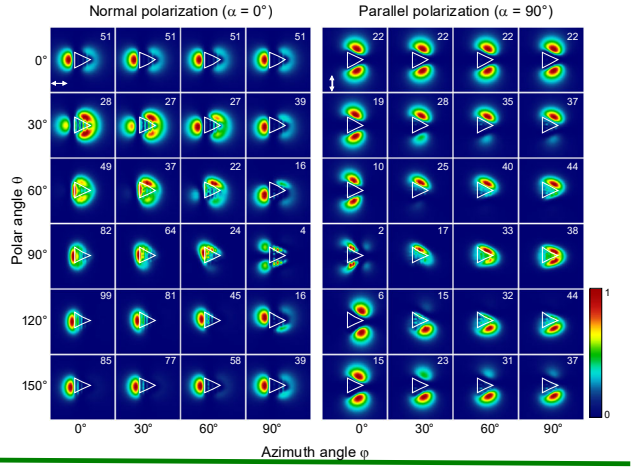
Molenda et al., Optics Express (2005)

TA-Probe: Imaging of Single Molecules

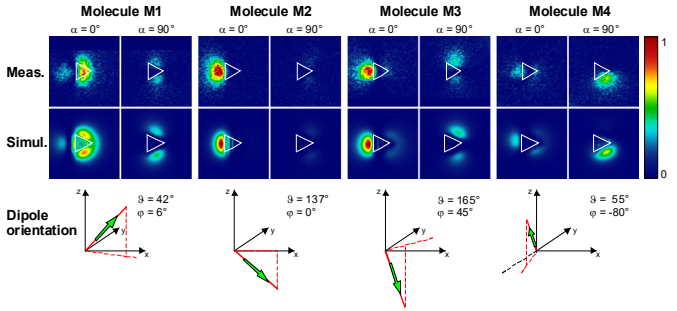


Molenda et al., Optics Express (2005)

Field Patterns for Various Molecule Orientations

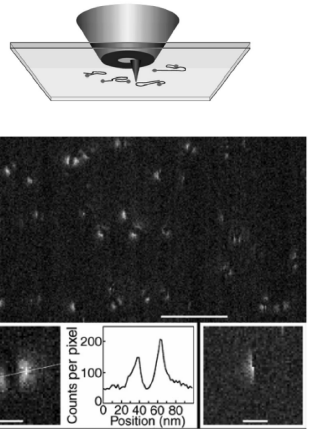


Assignment of Molecule Orientation



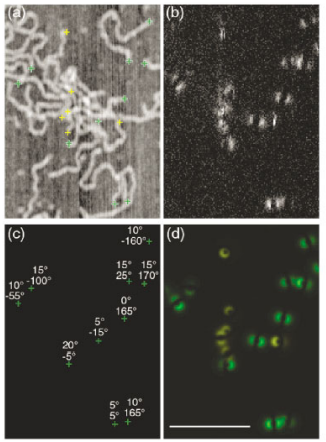
Molenda et al., Optics Express (2005)

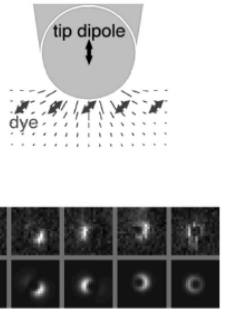
TOA-Probe: Single Molecule Microscopy



Frey et al., PRL 2004

TOA-Probe: Single Molecule Microscopy





Frey et al., PRL 2004

Optical Nanoantenna

Purcell-Effect
By increasing the density of final states ρ for the photons emitted from a molecule its spontaneous life time τ will decrease.

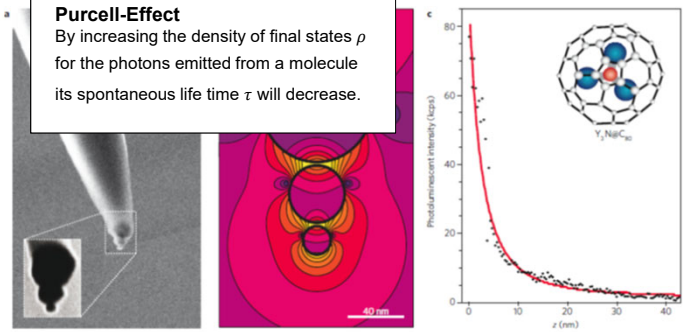


Figure 5 | Example of a bottom-up fabricated optical antenna. a, SEM image of a gold trimer antenna consisting of gold nanoparticles supported by a dielectric tip. The particle sizes are 180, 90 and 50 nm. **b**, Computed intensity near a trimer antenna irradiated at a wavelength of 650 nm. Adjacent contour lines differ by a factor of two in intensity. **c**, Fluorescence from a metallofullerene ($Y_3N@C_{80}$, pictured inset) as a function of its distance from a gold nanoparticle antenna. Because of the low intrinsic quantum yield of $Y_3N@C_{80}$, the antenna enhances the fluorescence by two orders of magnitude. Figure **c** reproduced with permission from ref. 98, © 2010 ACS.

Novotny and Hulst, Nature Photonics (2011)

Oral Exams

Available dates

- Mo, 26.02.2024
- Mo, 08.04.2024

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E-Mail: naber@kit.edu