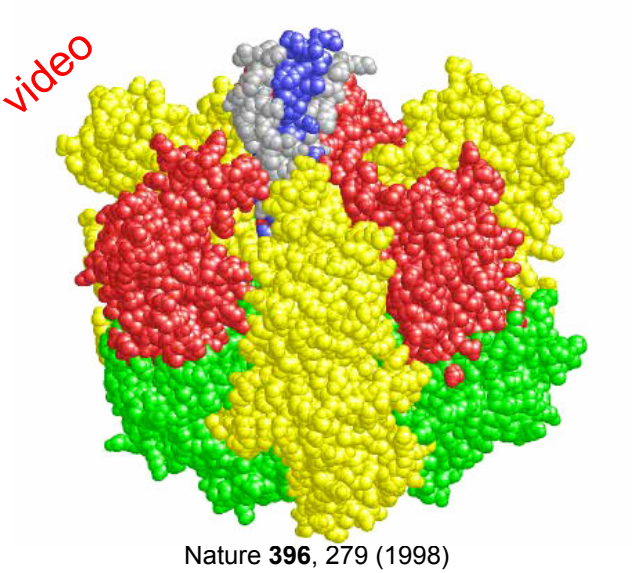
Gold Nanorods as Novel Nonbleaching Plasmon-Based Sensors for Molecular Orientations and Local Refractive Index Changes

- Jan Becker
- Carsten Sönnichsen

Motivation

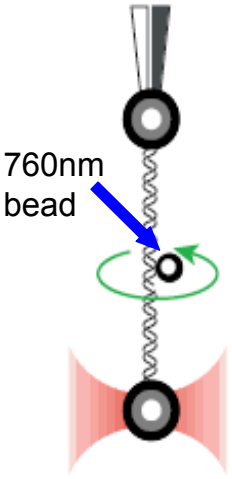
Observation of single molecule orientation



Nature **396**, 279 (1998)

Previous Observation Methods

1. Lateral movement of beads ‘localization’

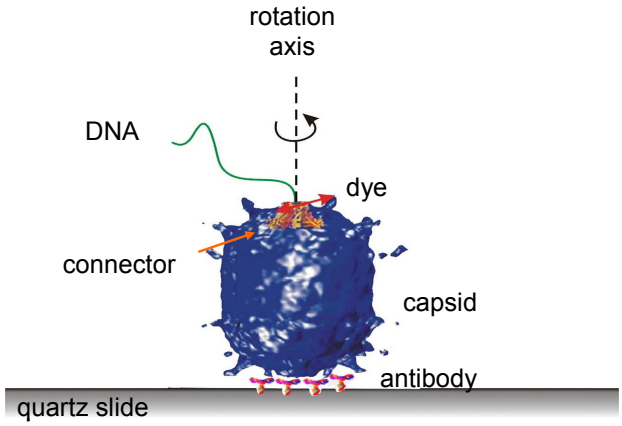


video

Nature **424**, 338-341 (y 2003)

But: large bead
=> large perturbation

2. Fluorescence polarization of single dyes



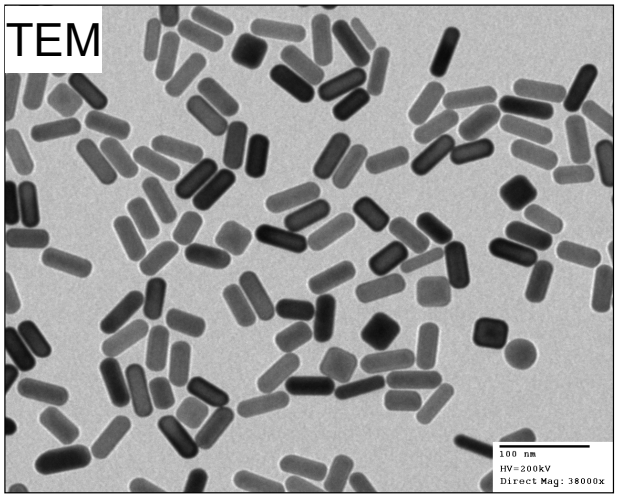
T.Hugel *et al.*, unpublished

But: bleaching & blinking
=> only short time useable

New Label: Gold Rods

- Produced by chemical synthesis

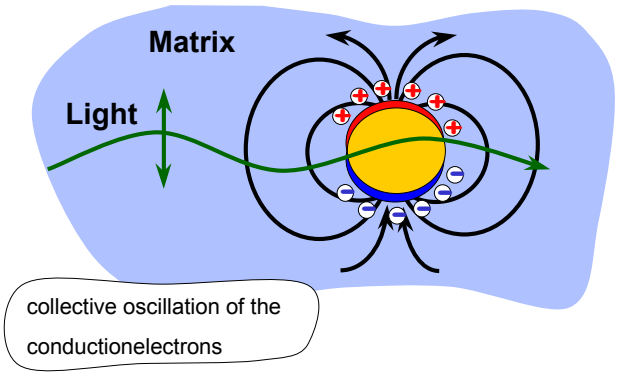
TEM picture

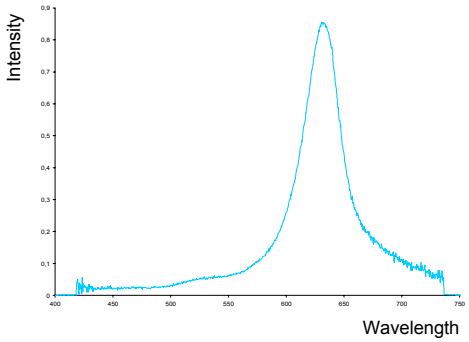


- Size: approximately 20x60 nm => less perturbation
- strong continuous signal

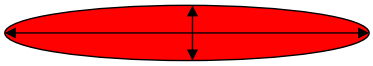
Plasmons

- At eigenfrequency of the collective e^- oscillation: strong light scattering

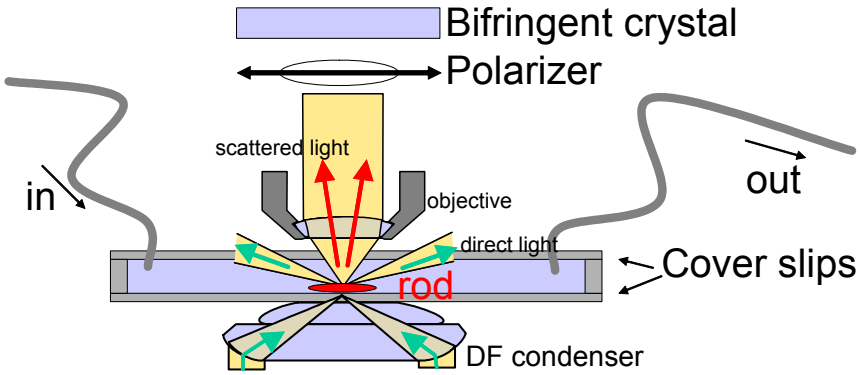


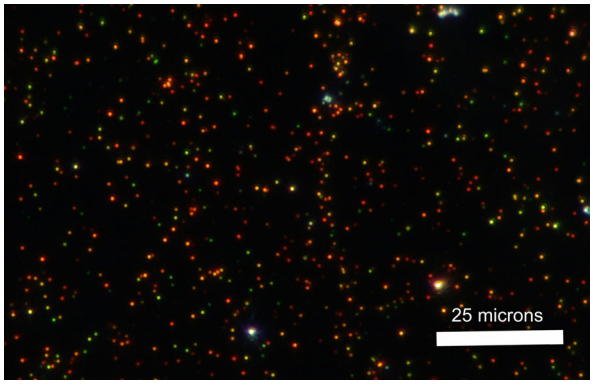


- Rods scatter light polarized along the long axis



Dark-field Microscope

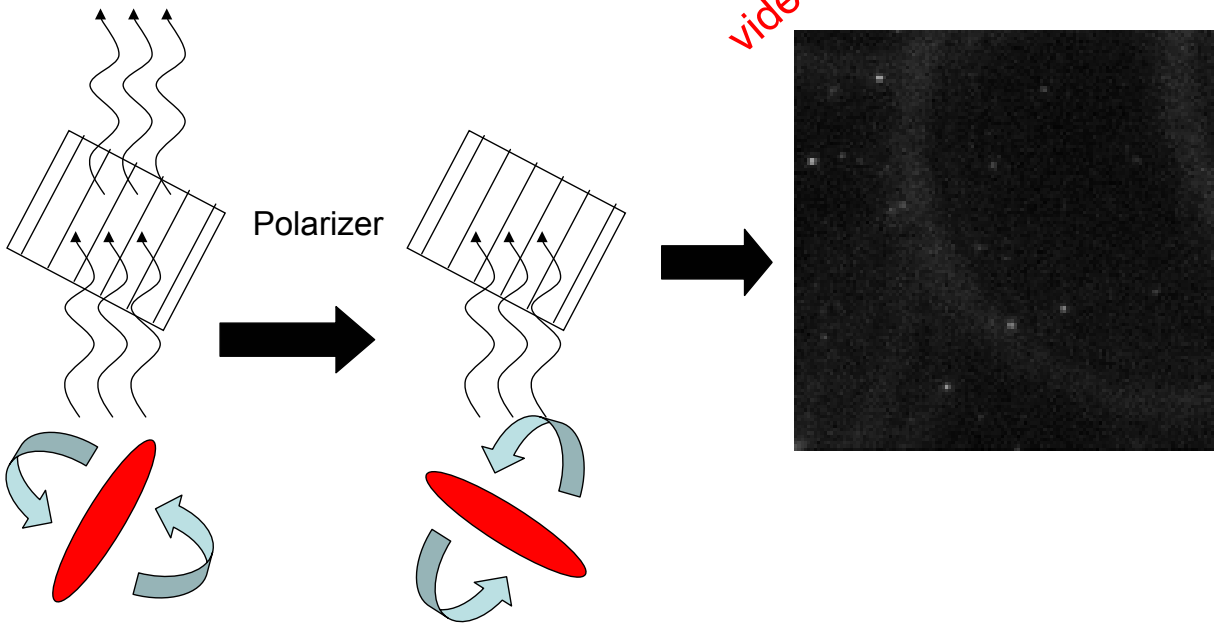




- True color picture
- Every dot is one particle
- The color (≡ resonance wavelength) depends on aspect-ratio, size and shape of the particle

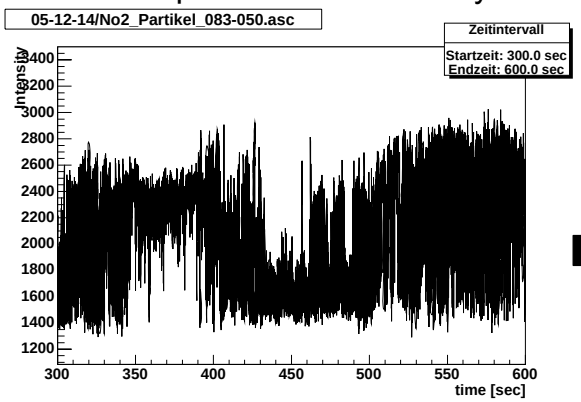
Rotation of Rods

- Polarization along the long axis => rotating particles ‘blink’ if a polarizer is used

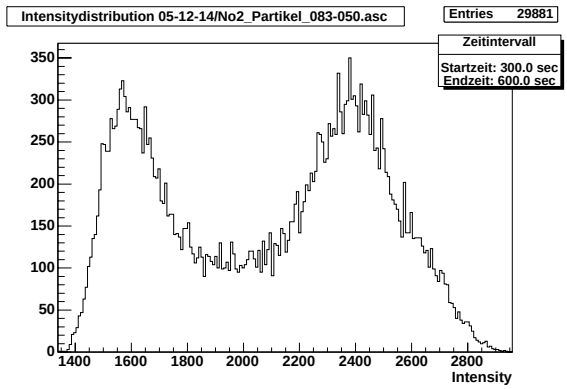


Analysis of a Rotating Particle

Time-dependence of Intensity

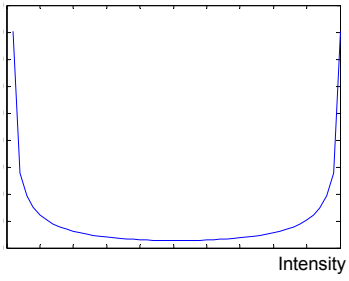


Intensity-distribution



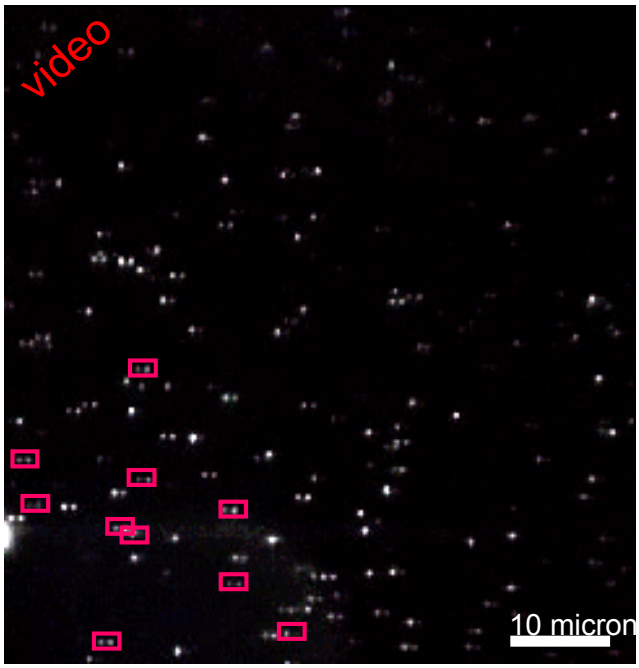
- Intensity ~ $\cos^2(\Theta)$
- If Θ is uniformly distributed

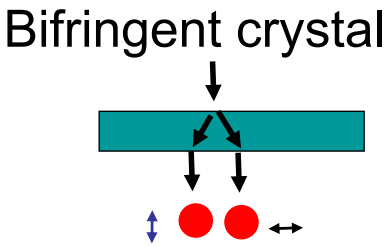
Ideal case

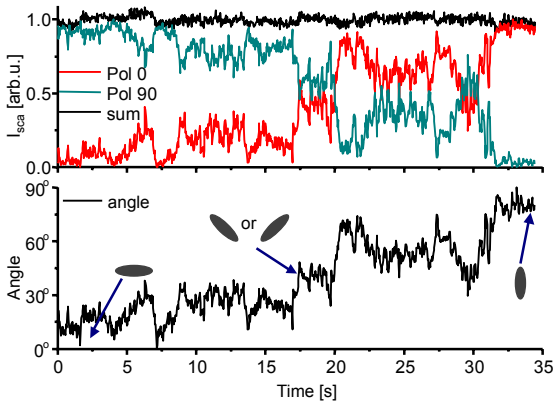


=> Measurement shows Brownian rotation

Splitting the Two Polarizations



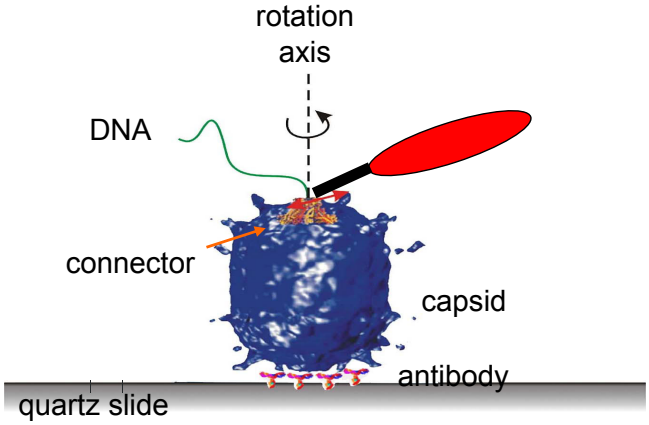


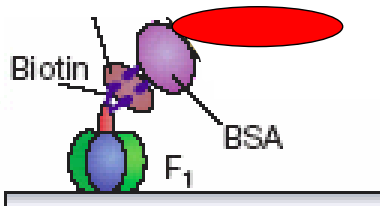


Nano Lett. 5, 301 (2005)

Future Work

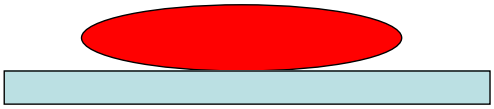
- Functionalization of rods
- Attachment of biomolecules
- Watch dynamics



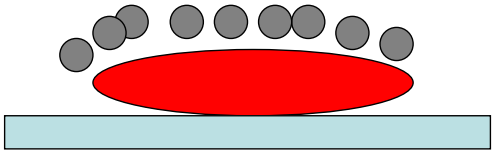


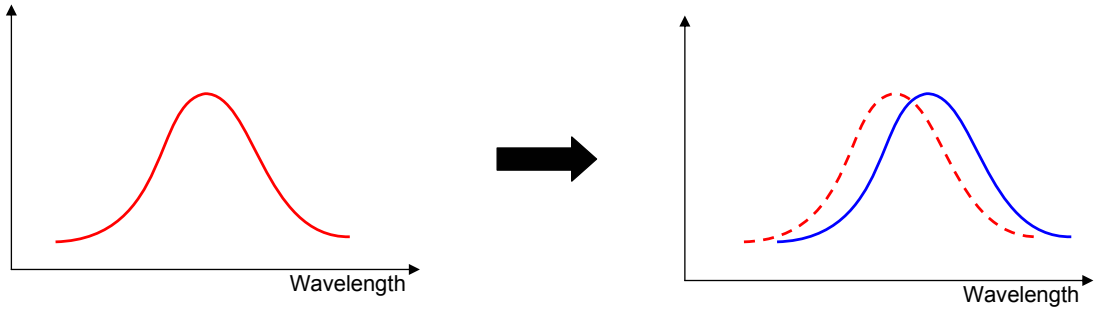
Rods as Refractive Index Sensor

Refractive Index n_1



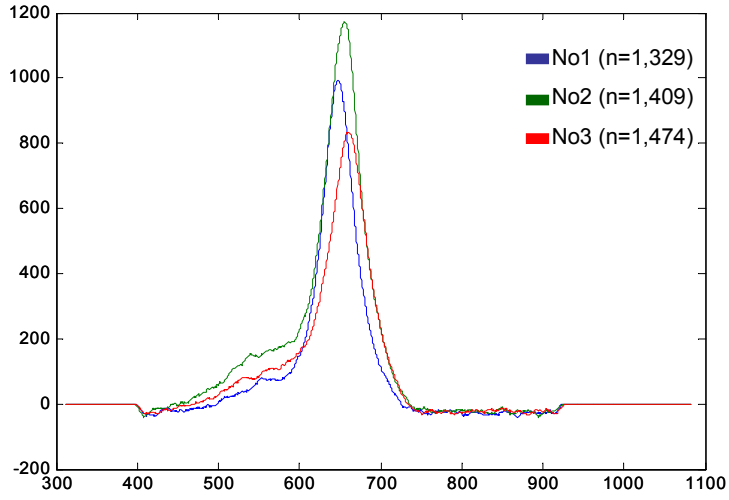
Refractive Index $n_2 > n_1$

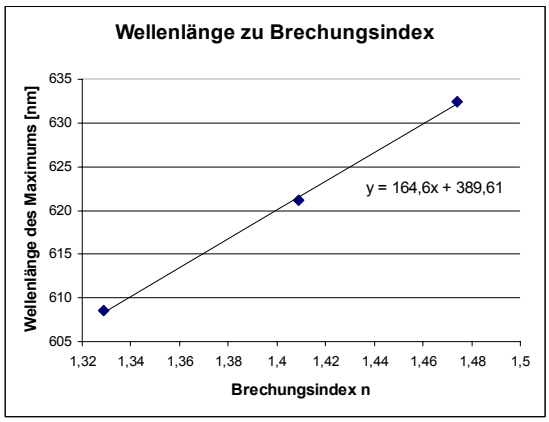




=> Plasmon resonance wavelength shift

Influence of the Refractive Index





Linear Progression

=> Gold rods can be used as refractive index sensors

Acknowledgements

- Göran Hamann
- Andreas Kurz
- Sebastien Pierrat
- Valerie Reuss
- Olaf Schubert
- Carsten Sönnichsen

Sponsored by:

Deutsche Forschungsgemeinschaft DFG

Emmy Noether Programm