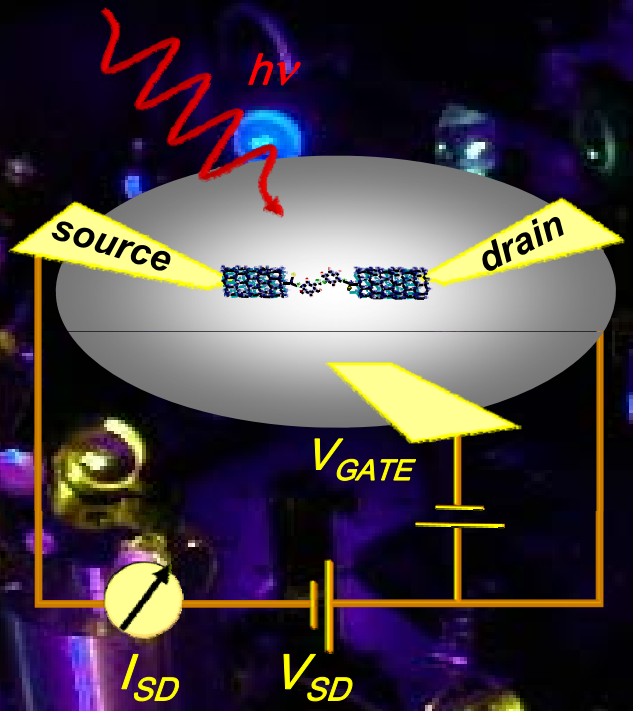
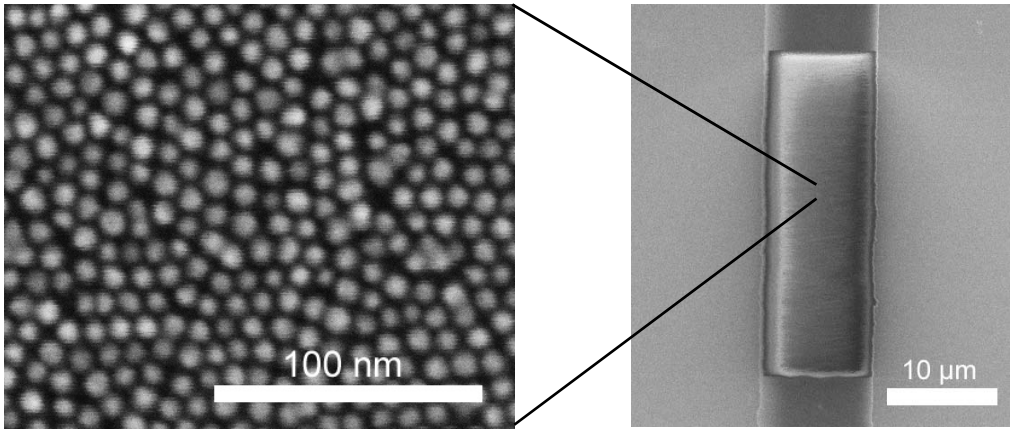
Optically induced transport phenomena in organic and inorganic nanosystems

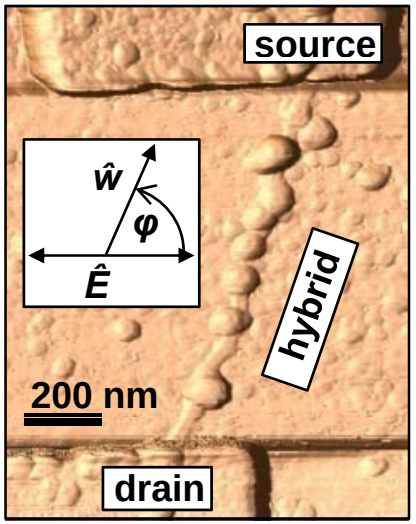


Alexander W. Holleitner
Technische Universität München
Walter Schottky Institut

Optoelectronic experiments

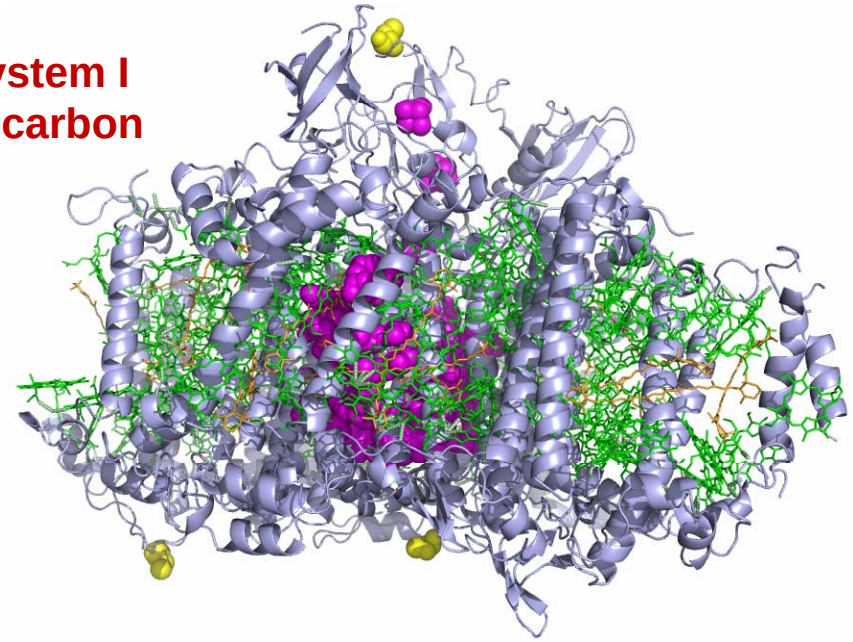


(1) Two-dimensional arrays of Au colloids and molecules

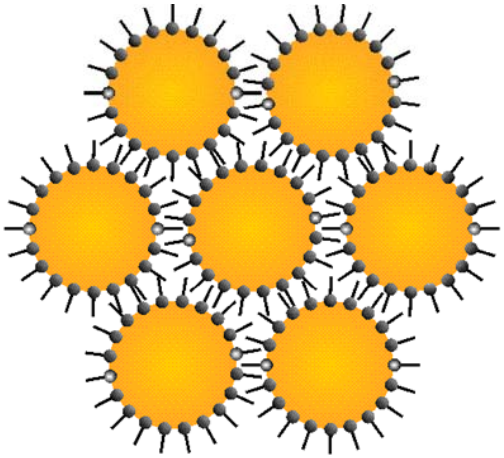


(2) CdTe nanoparticles coupled to carbon nanotubes

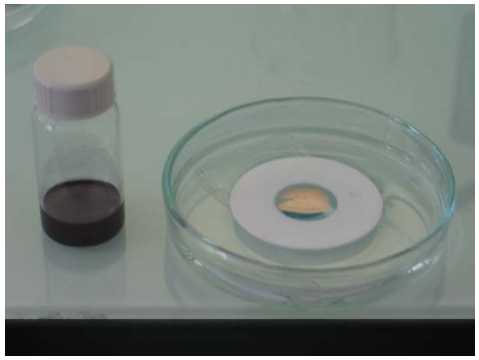
(3) Photosystem I coupled to carbon nanotubes



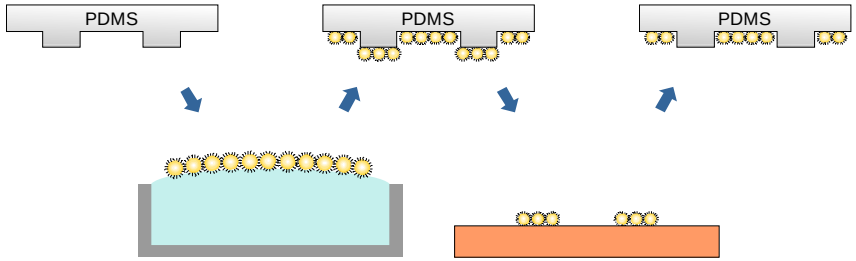
Two-dimensional gold nanoparticle arrays



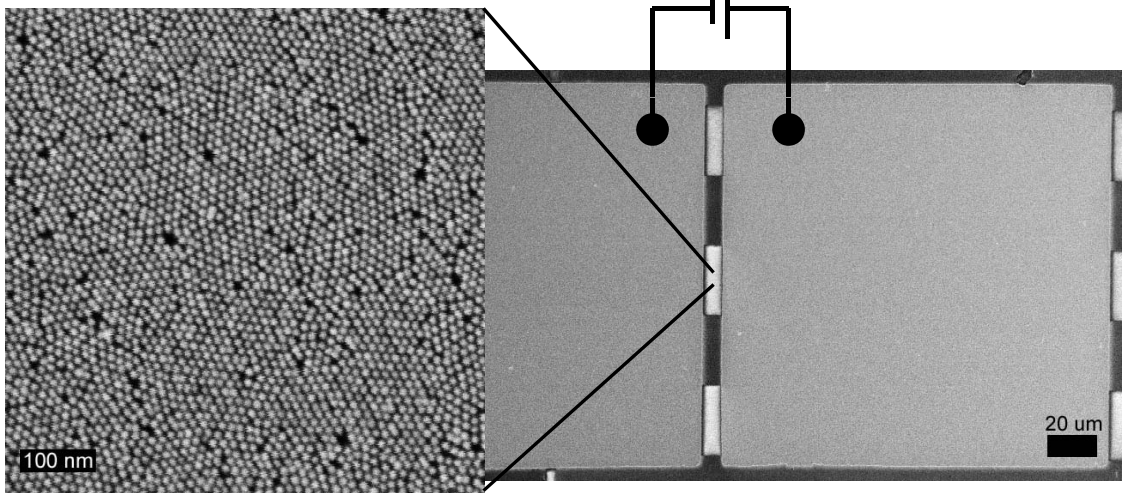
1. Self-assembly:



2. Patterning:



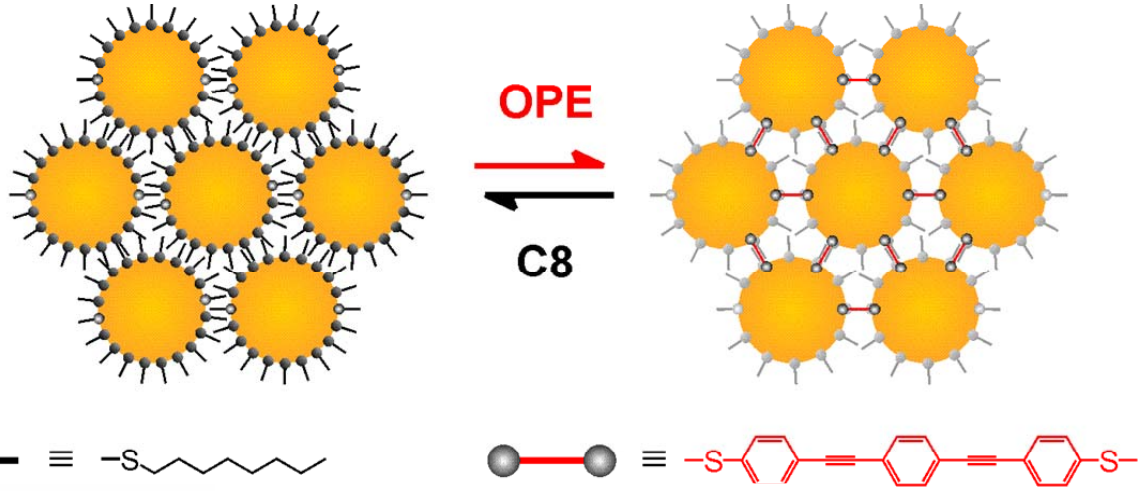
3. Contacting:

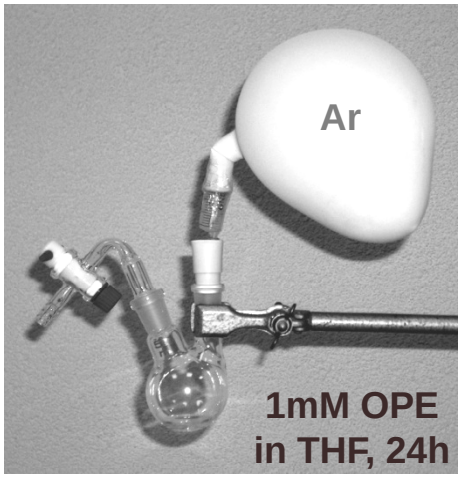


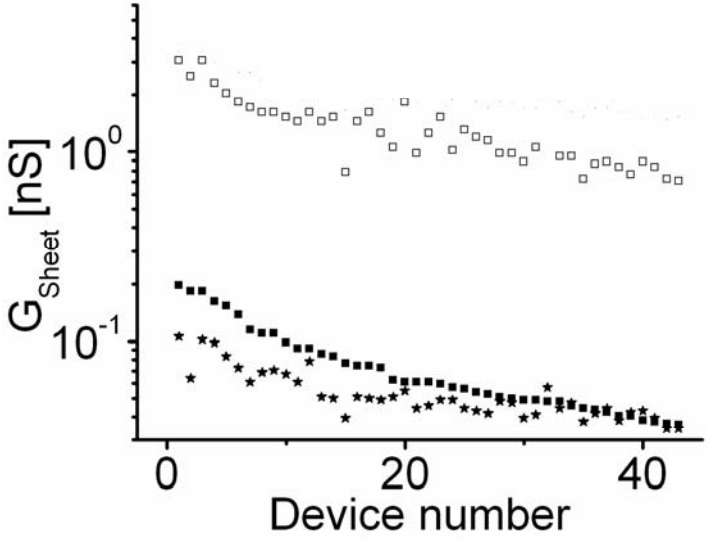
J. Liao et al., Adv. Mat. (2006).

Exchanging molecules in nanoparticle arrays

Molecular exchange:







after OPE insertion

initial G
after back-exchange

Tunneling conductance:

$$G = G_c \cdot e^{-\beta d}$$

J. Liao, M. Mangold et al., NJP (2008). J. Liao et al., Adv. Mat. (2006).

Schönenberger Group, Basel

Optoelectronic measurements

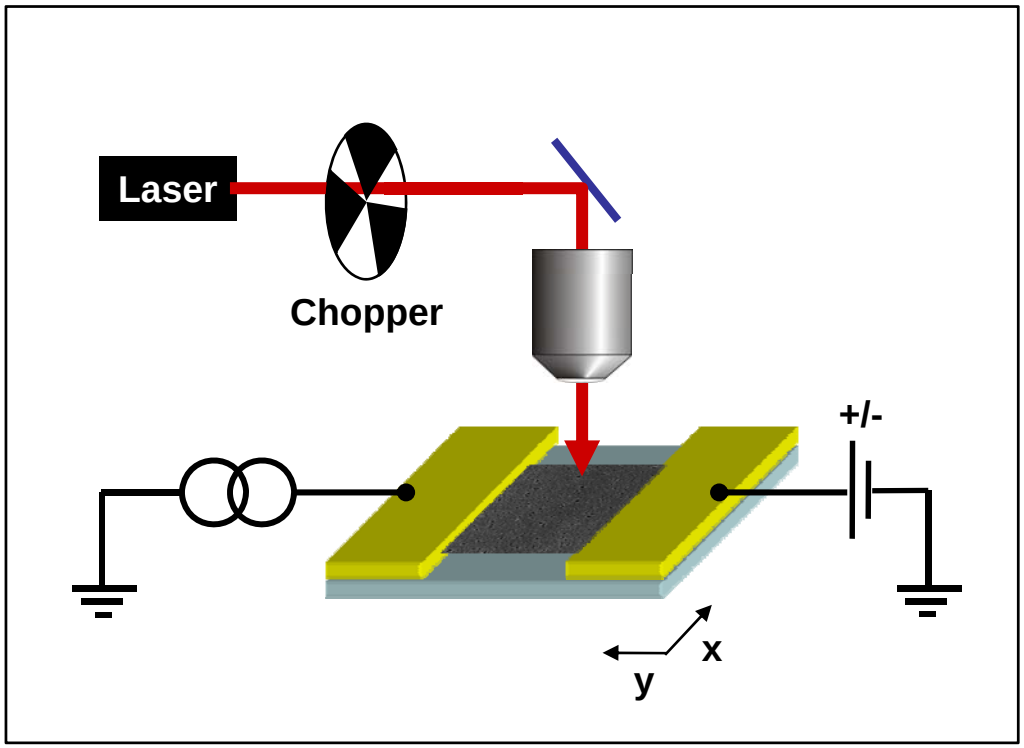
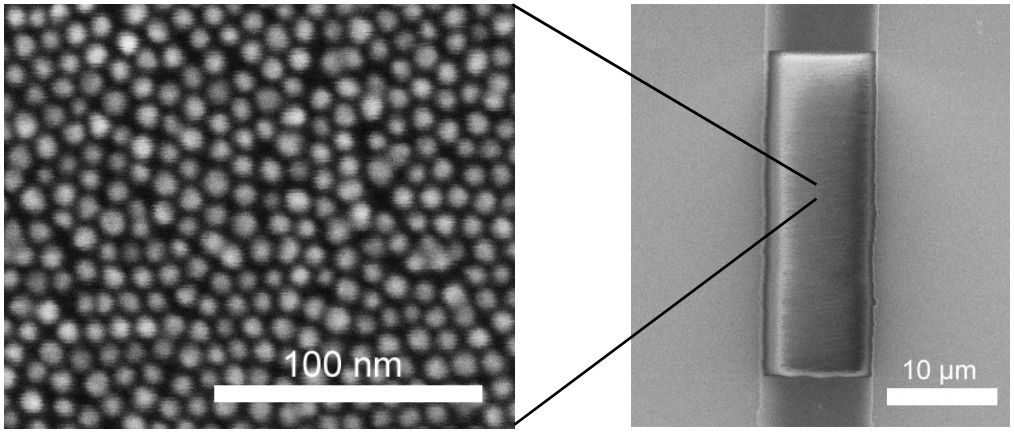


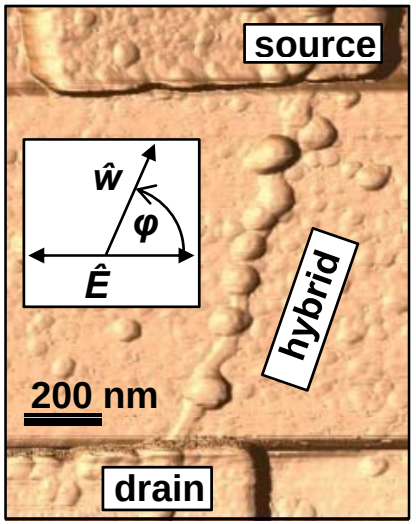
Photo-conductance $\propto$

- Photon energy
- Photon polarization
- Bias voltage
- Chopper/trigger frequency
- Spatial coordinates

Overview

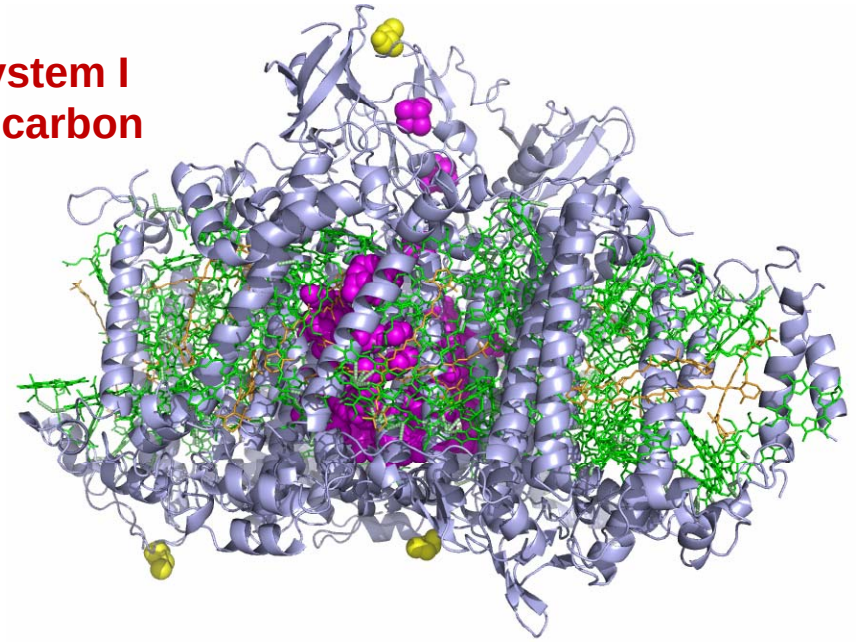


(1) Two-dimensional arrays of Au colloids and molecules



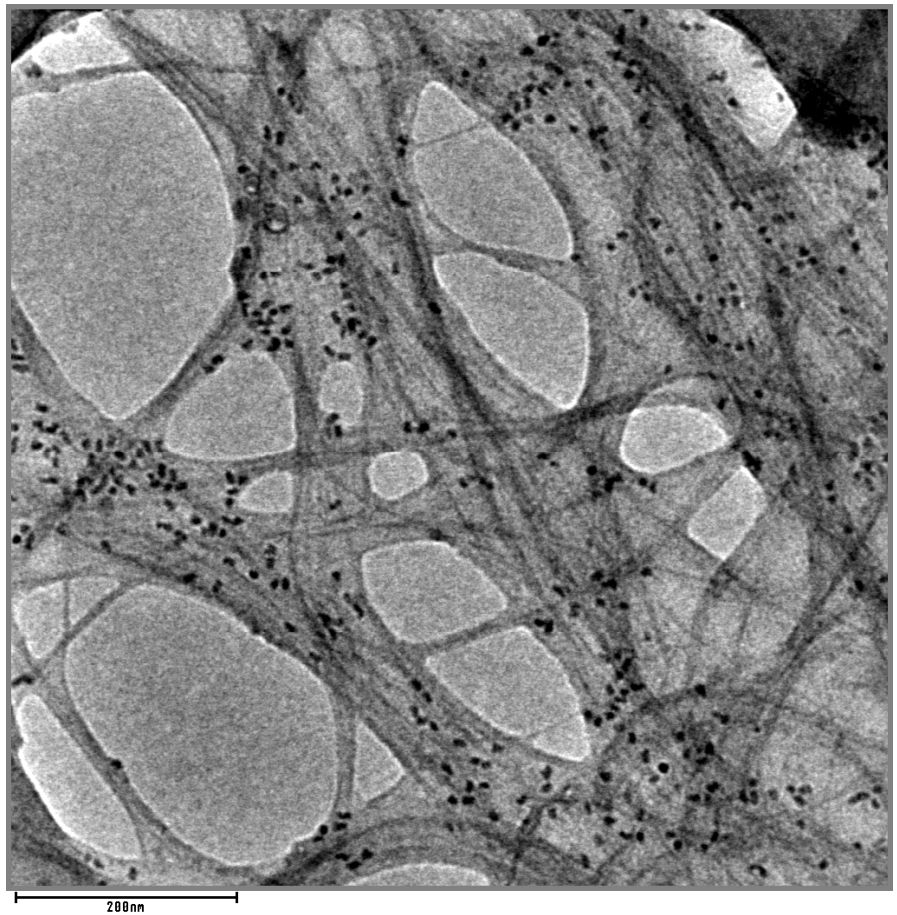
(2) CdTe nanoparticles coupled to carbon nanotubes

(3) Photosystem I coupled to carbon nanotubes

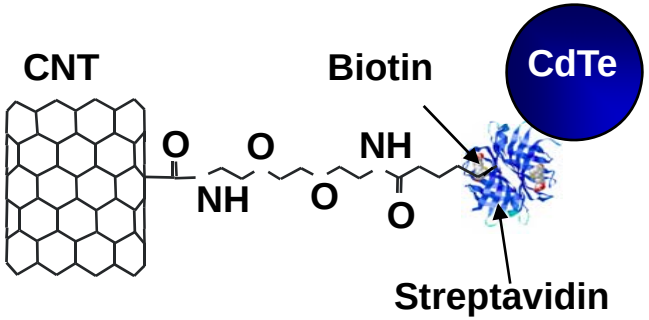


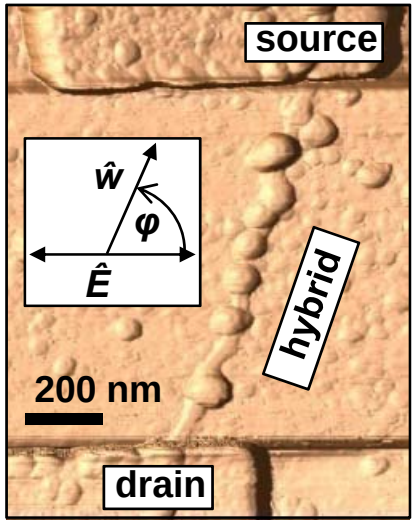
Hybrid Systems

TEM



TEM by M. Döblinger



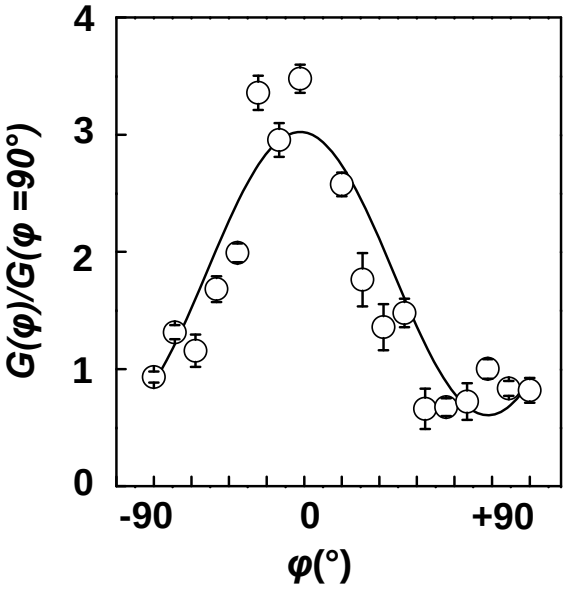


SEM

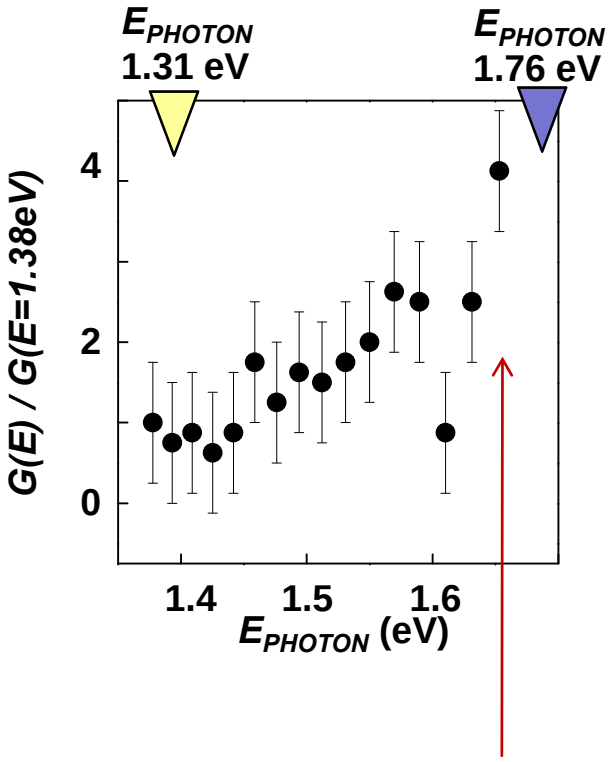
Hybrid material made of carbon nanotubes and CdTe nanocrystals

arXiv::0806.1110 (2008).

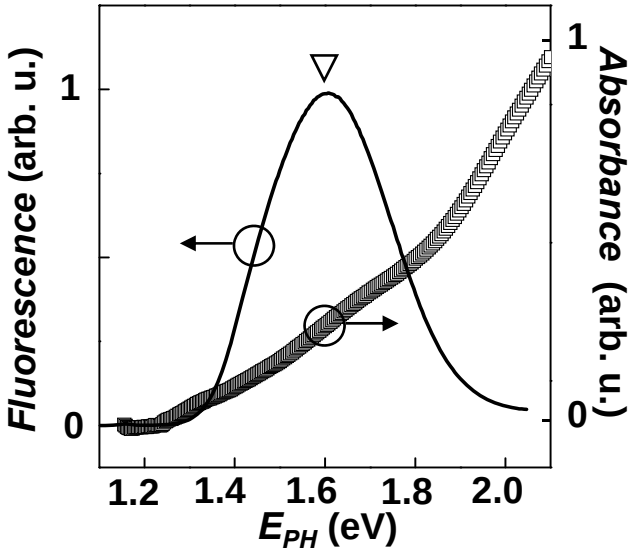
Photoconductance of single hybrids



Polarization of photons influences photoconductance

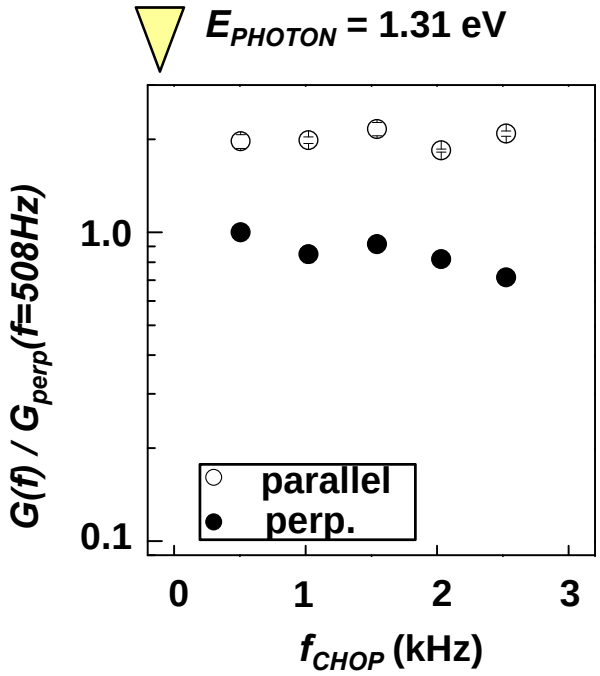


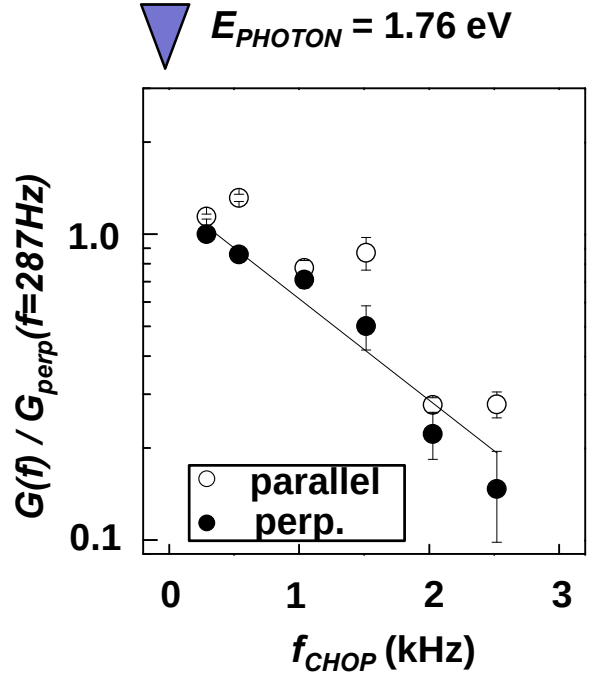
For higher E_{PHOTON}: Absorption in CdTe crystals dominates photoconductance



arXiv::0806.1110 (2008).

Photoconductance of single hybrids





Resonant excitation of carbon nanotubes:

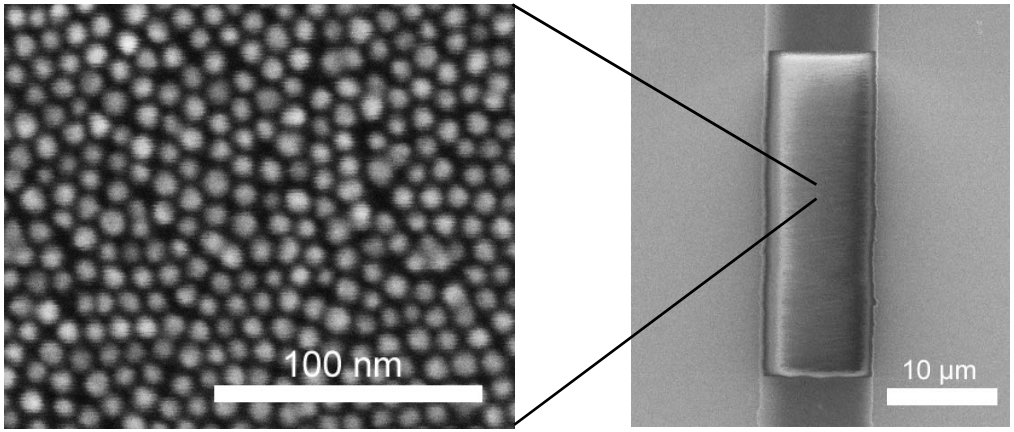
Fast photoresponse

Resonant excitation of CdTe crystals :

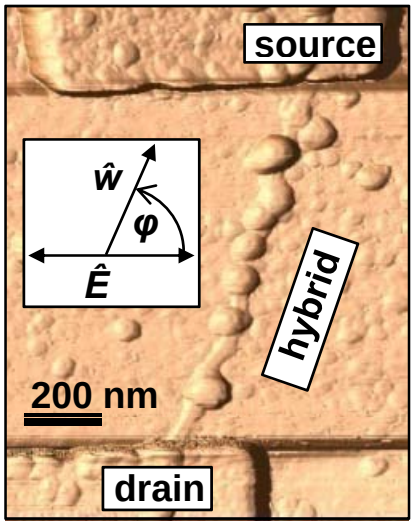
Slow (bolometric) photoresponse

arXiv::0806.1110 (2008).

Overview

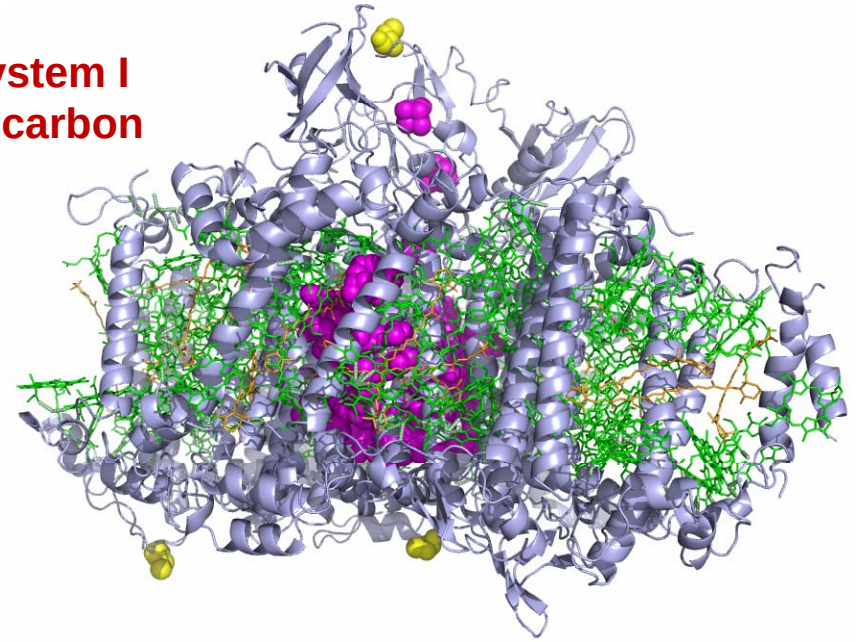


(1) Two-dimensional arrays of Au colloids and molecules



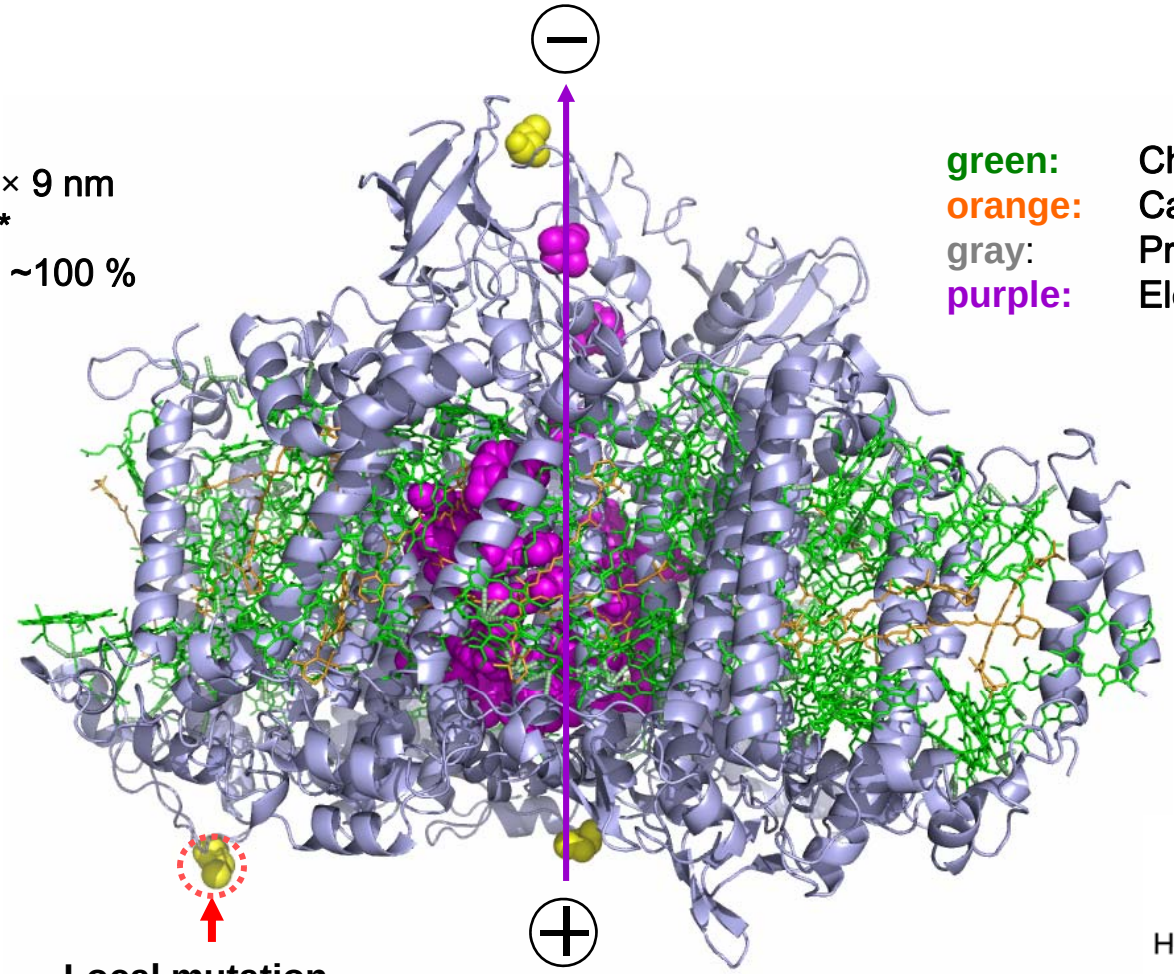
(2) CdTe nanoparticles coupled to carbon nanotubes

(3) Photosystem I coupled to carbon nanotubes



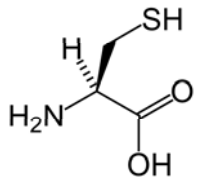
Photosystem I

Dimensions: 15 nm × 9 nm
Photo voltage: ~1 V*
Quantum efficiency: ~100 %



green: Chlorophyll
orange: Carotenoide
gray: Protein
purple: Electron transfer path

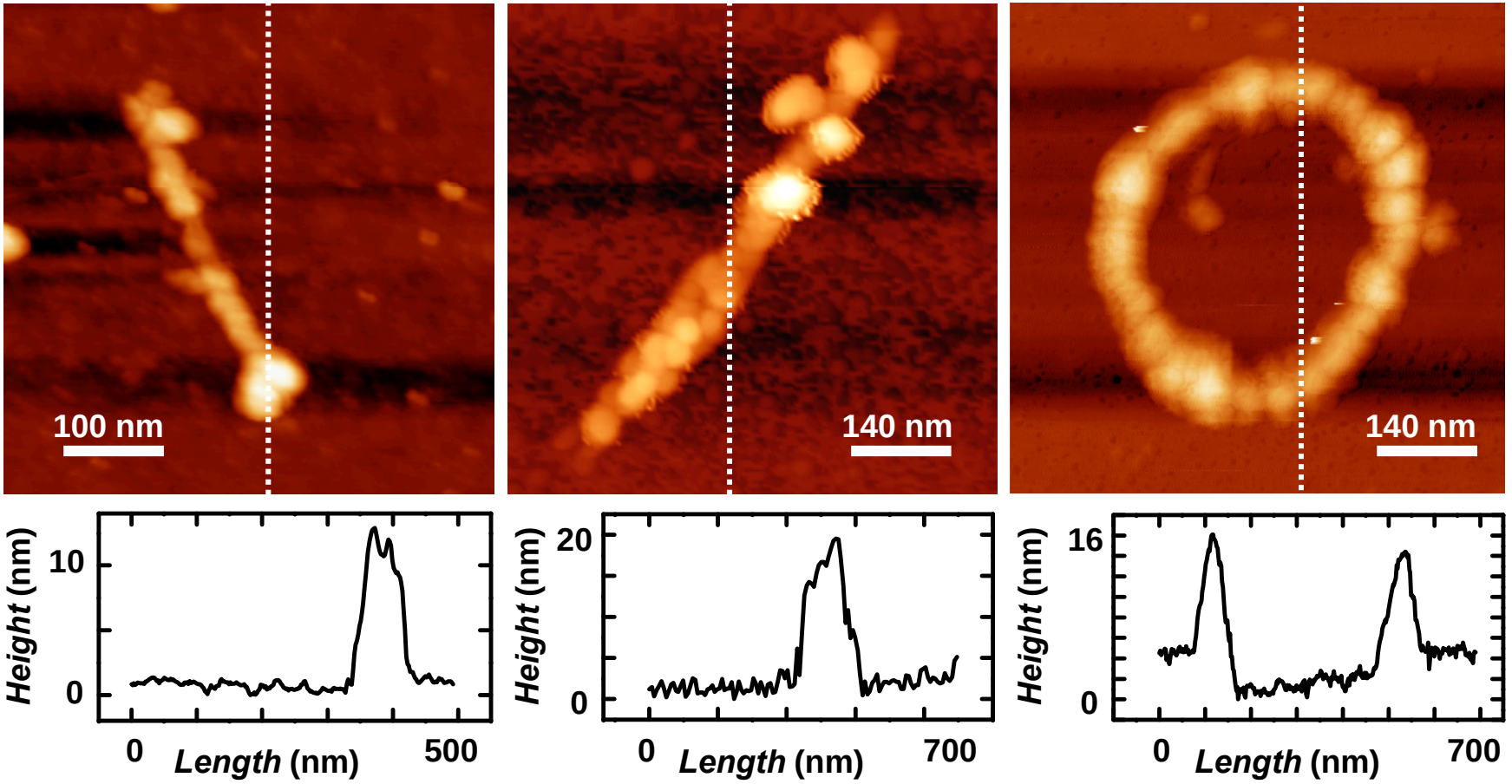
Local mutation
Cysteine for carbodiimide chemistry
Carmeli, Tel Aviv, Israel



Cysteine

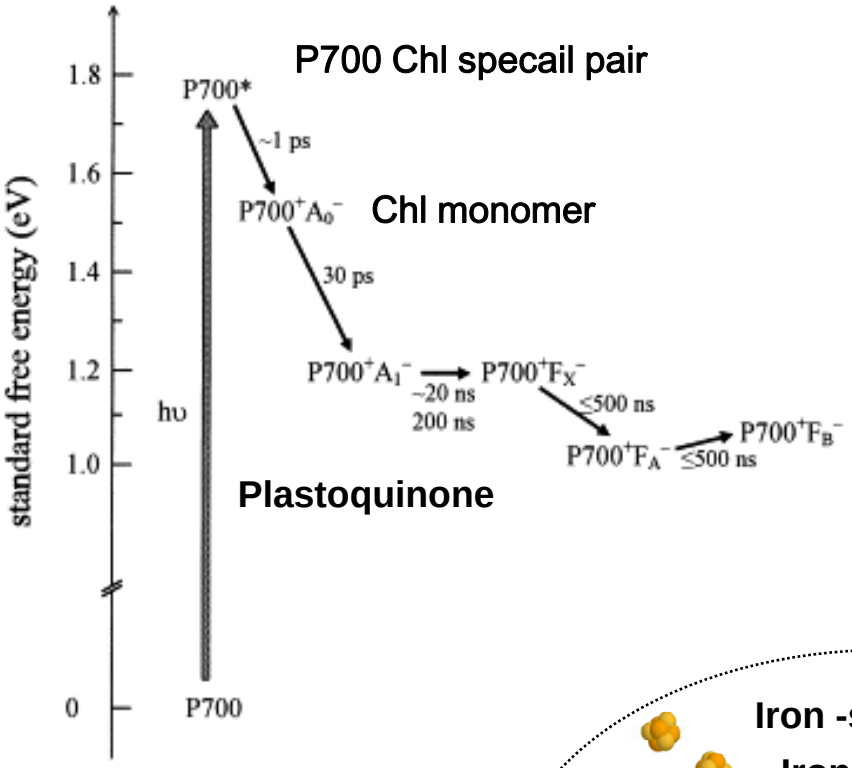
* L. Frolov et al., Adv. Mat. 17, 2434 (2005).
K. Brettel, Biochimica et Biophysica Acta 1318 , 322 (1997).

Photosystem I coupled to carbon nanotubes

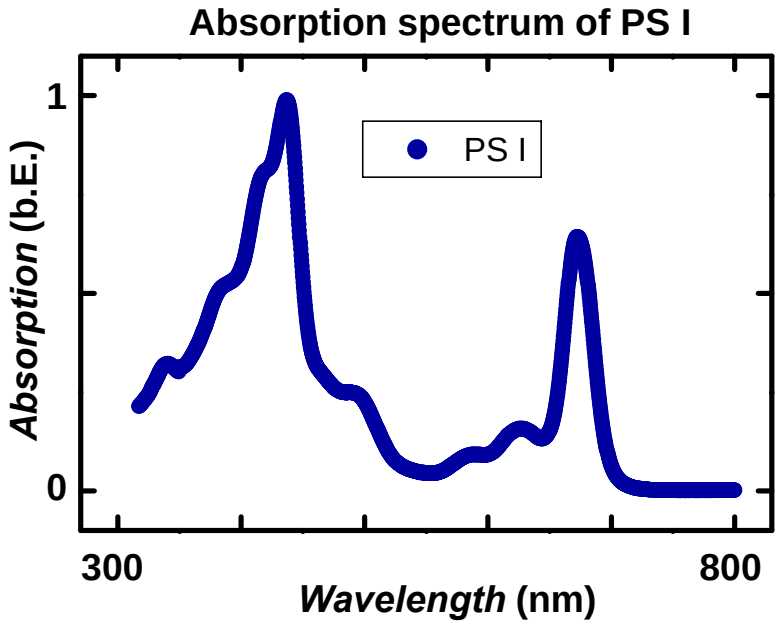


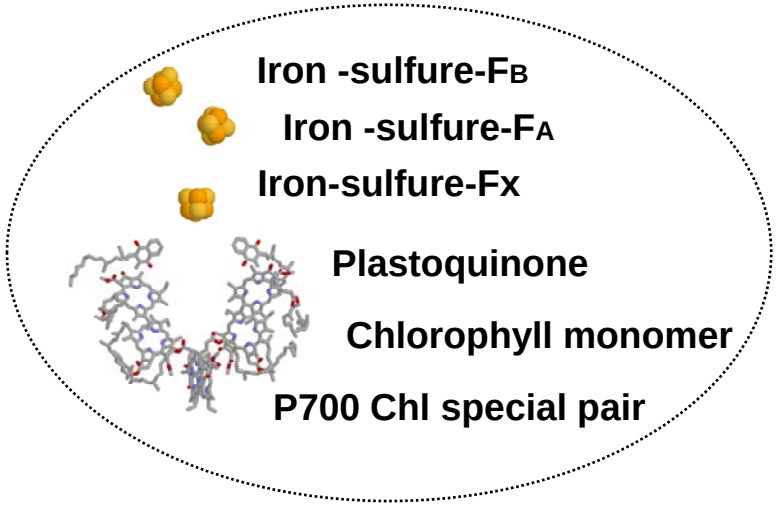
I. Carmeli, A.W. Holleitner et al. Adv. Materials 19, 3901 (2007).

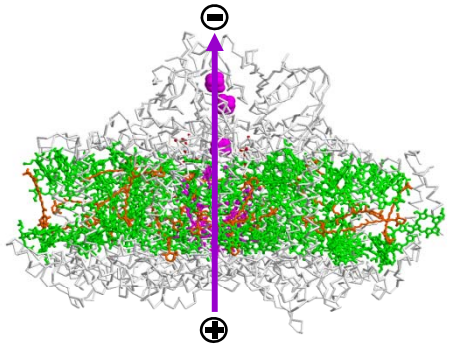
Electron transfer within the photosystem I



Energy effeciency: ~58 %







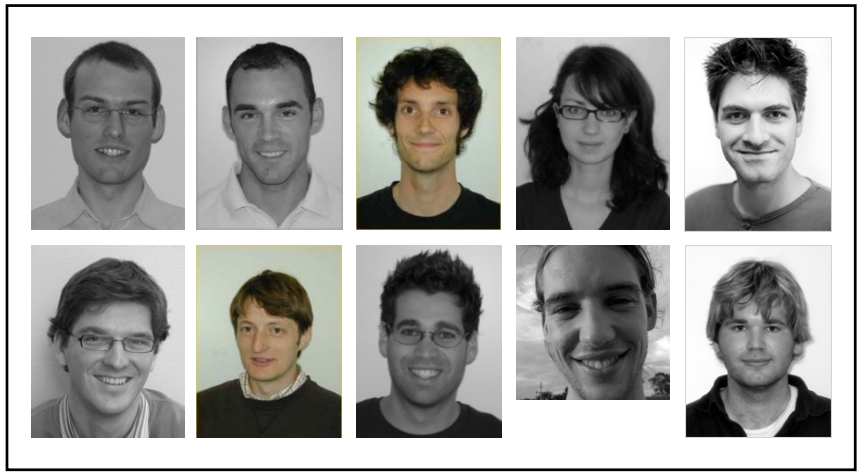
K. Brettel, Bioch. et Biophys. Act. 1318 , 322 (1997).

Recent Publications

K.-D. Hof et al. ***Phys. Rev. B* 78, 115325 (2008).**
C. Rossler et al. ***Applied Physics Letters* 93, 071107 (2008).**
K.-D. Hof et al. ***Phys. E* 40, 1820 (2008).**
M. Kroner et al. ***Physical Review Letters* 100, 156803 (2008).**
Li Song et al. ***J. Phys. Chem. B*, 112, 9644 (2008).**
M. Kroner et al. ***Appl. Phys. Lett.* 92, 031108 (2008).**
S. Seidl et al. ***Appl. Phys. Lett 92*, 153103 (2008).**
M. Kroner et al. ***Phys. E 40*, 1994 (2008).**
S. Seidl et al. ***Phys. E 40*, 2153 (2008).**
A. Gärtner et al. ***Phys. E 40*, 1828 (2008).**
A. Gärtner et al. ***Physical Review B* 76, 085304 (2007).**
A.W. Holleitner et al. ***New Journal of Physics* 9, 342 (2007).**
I. Carmeli et al. ***Advanced Materials* 19, 3901 (2007).**
A.W. Holleitner et al. ***Physical Review Letters* 97, 036805 (2006).**
H. Knotz et al. ***Applied Physics Letters* 88, 241918 (2006).**
A. Gärtner et al. ***Applied Physics Letters* 89, 052108 (2006).**

Team

Matthias Brandstetter
Klaus-Dieter Hof
Simone Kaniber
Leo Prechtel
Markus Stallhofer
Florian Seilmeier
Sebastian Thunich
Xaver Vögele
Bernd Zebli
Markus Mangold



David Awschalom
Itai Carmeli
Chanoch Carmeli
Anna Fontcuberta
Achim Hartschuh
Jörg Kotthaus
Chr. Schönenberger
Dieter Schuh
Friedrich Simmel
Werner Wegscheider

DFG HO-3324/2
DFG HO-3324/4
BMBF NanoQUIT
SFB 486 TP A1
SFB 631 TP B2
NIM (Nanosystems Initiative Munich)
Center for NanoScience (CeNS) in Munich