

dr hab. Sebastian Maćkowski, UMK, "Technologie kwantowe a problem energii (nanostruktury fotowoltaiczne)"



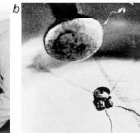
Technologie kwantowe a problem energii (nanostruktury fotowoltaiczne)

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Instytut Fizyki
Uniwersytet Mikołaja Kopernika w Toruniu
adres poczty: mackowski@fizyka.umk.pl
strona: welcome.fizyka.umk.pl



Początki nanotechnologii

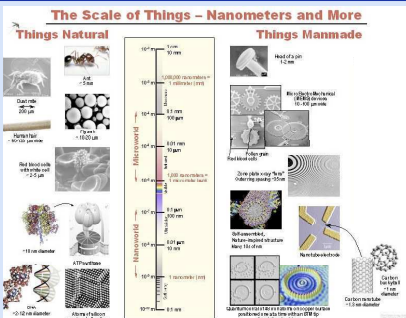
Richard P. Feynman
"There's Plenty of Room at the Bottom"
• APS address – December 28, 1959



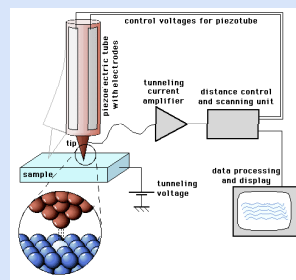
In the late 1950s visionary physicist Richard Feynman issued a public challenge by offering \$5000 to the first person to create an electrical motor smaller than 1/64th of an inch. Much to Feynman's consternation the young man who met the challenge, William McElean, did so by investing many tedious and painstaking hours building the device by hand using tweezers and a microscope.



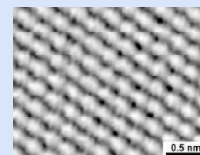
Skale



Narzędzia nanotechnologii



skaningowy mikroskop
tunelowy (STM)

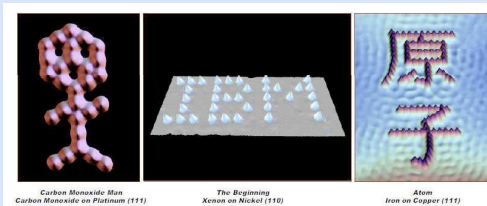


powierzchnia grafitu



Narzędzia nanotechnologii

STM – manipulacja atomami na powierzchniach



Carbon Monoxide Molecule
Carbon Monoxide on Platinum (111)

The Beginning
Xenon on Nickel (110)

Atom
Iron on Copper (111)



Narzędzia nanotechnologii

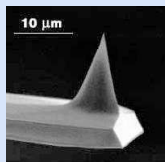
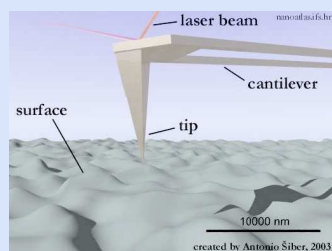
STM – chwila niewagi





Narzędzia nanotechnologii

AFM – mikroskop sił atomowych



Narzędzia nanotechnologii

AFM – AD 1986



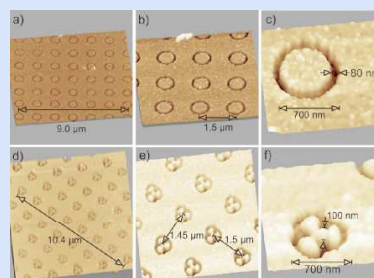
Narzędzia nanotechnologii

AFM – XXI w.



Narzędzia nanotechnologii

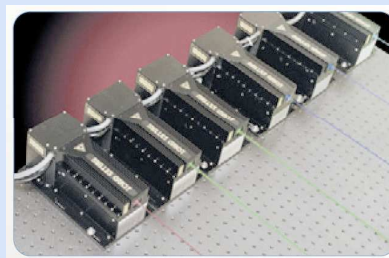
AFM – obrazowanie powierzchni



Mikroskop konfokalny



Lasery





Lasery

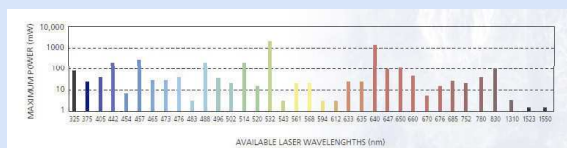
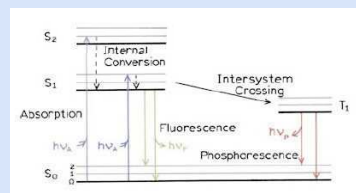
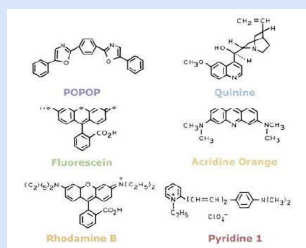


Diagram Jabłońskiego

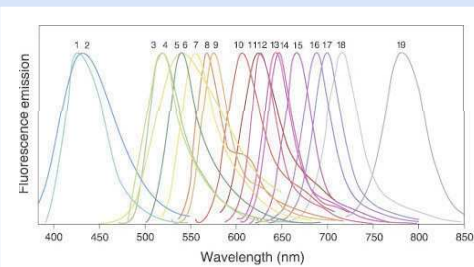


Molekuły



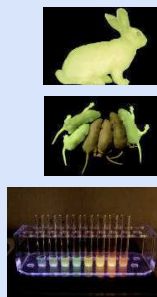
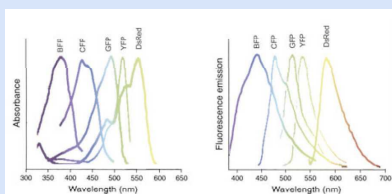
Molekuły organiczne

barwniki Alexa



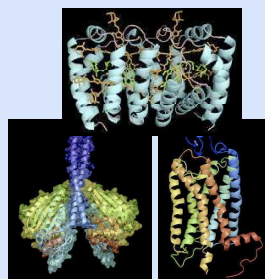
Białka fluorescencyjne

GFP (Green Fluorescent Protein) i pochodne

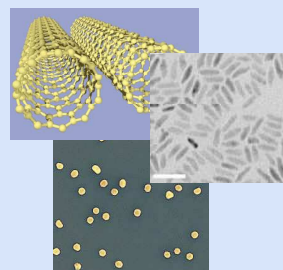


Nanostruktury

organiczne (naturalne)

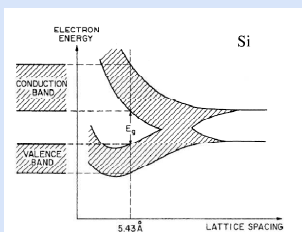


nieorganiczne (sztuczne)





Co to jest półprzewodnik

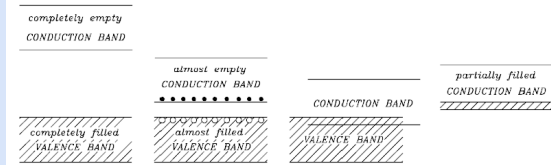


minimum całkowitej energii elektronów

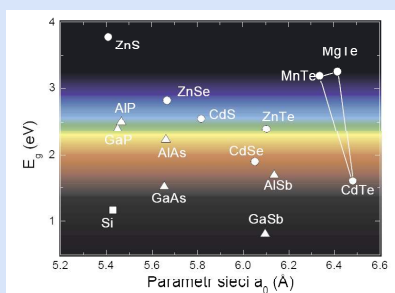


Pasma energetyczne

izolator półprzewodnik przewodnik/metal



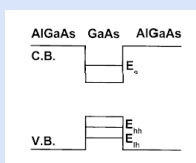
Półprzewodniki



Studnia kwantowa



Ekscyton w 2D

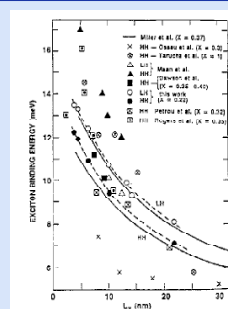
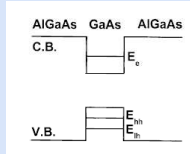


dla nieskończonych barier

$$E_n = \frac{\hbar^2 \pi^2 n^2}{mL^2}$$

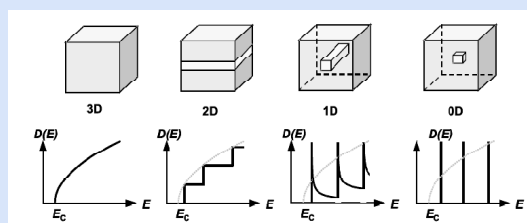


Ekscyton w 2D

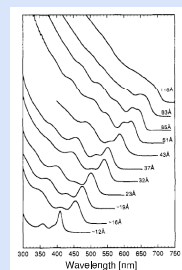




Kropka kwantowa



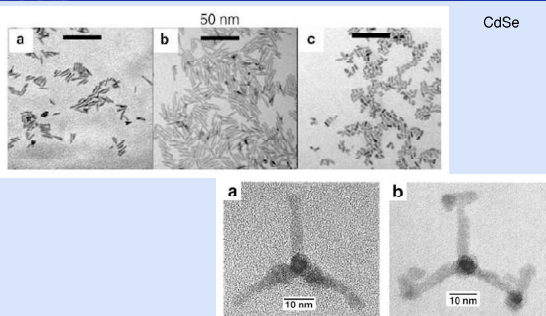
Nanokryształ z półprzewodnika



kontrola absorpcji

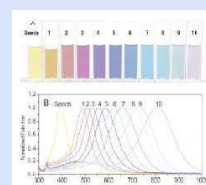
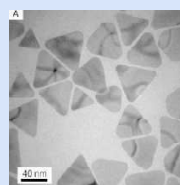
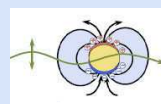


Nanokryształ z półprzewodnika

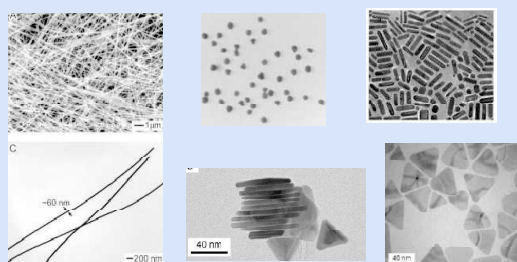


Nanokryształ z metalu

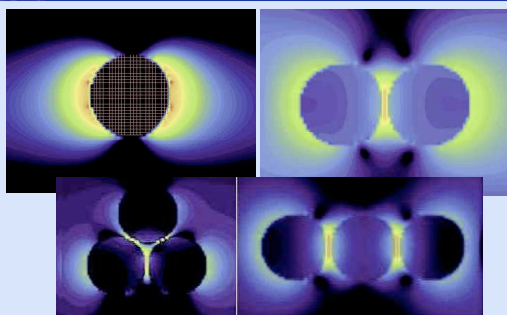
nanokryształy metaliczne charakteryzują się zmienną częstotliwością plazmową



Nanokryształ z metalu



Wzmocnienie plazmonowe





Pytanie/problem



CZY NANOTECHNOLOGIA MOŻE POPRAWIĆ NATURE?



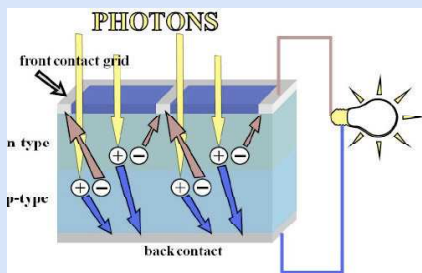
Energia słoneczna



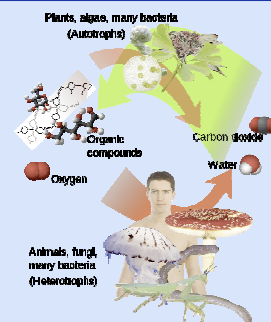
1 godzina Słońca – cały rok energii dla ludzkości



Ogniwo słoneczne



Fotosynteza



Fotosynteza

cyjanobakteria
(sinica)



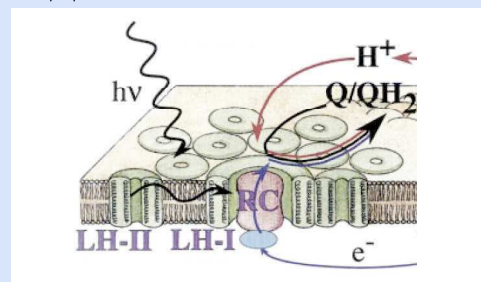
bakteria purpurowa

rośliny



Fotosynteza

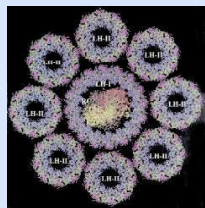
bakteria purpurowa





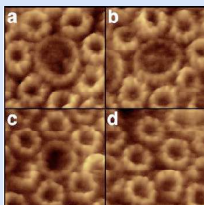
Fotosynteza

membrana – model



X. Hu, T. Ritz, A. Damjanovic, F. Autenrieth, & K. Schulten (2002) Q. Rev. Biophys. **35**, 1–62

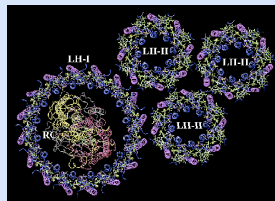
membrana – obraz AFM



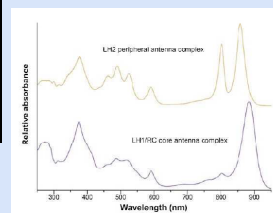
Scheuring S. & Sturgis J. (2005) Science **309**, 484–487



Przekaz energii



kaskadowy przekaz energii między antenami LH2, LH1 i centrum reakcji

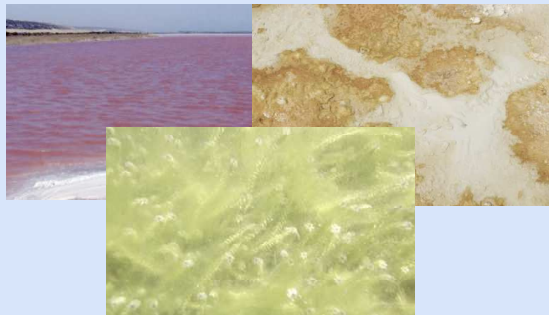


Fotosynteza

bakteria purpurowa: kompleks fotosyntetyczny LH2



Algi



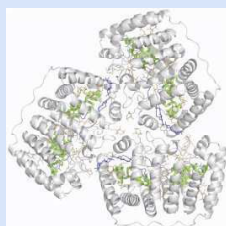
Kompleks fotosyntetyczny z alg



Amphidinium carterae



struktura (krystalografia promieni X)

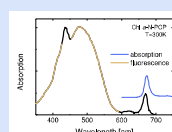
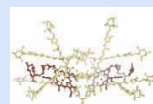


PCP

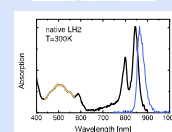


Kompleksy fotosyntetyczne

PCP

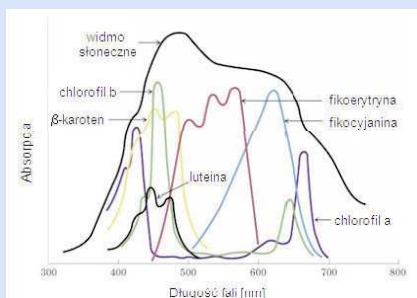


LH2





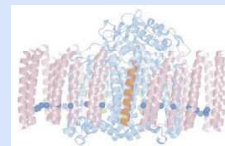
Kompleksy fotosyntetyczne



Kompleksy fotosyntetyczne

separacja ładunku

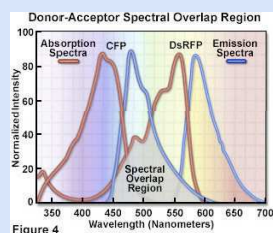
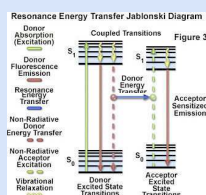
LH1+RC



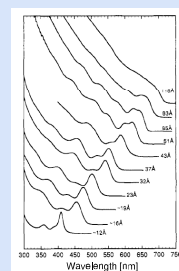
R. Cogdell, et al., Q. Rev. Biophys., 2006



Przekaz energii



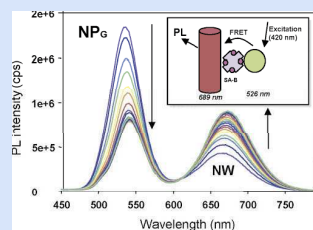
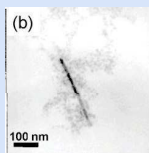
Nanokryształ z półprzewodnika



kontrola absorpcji



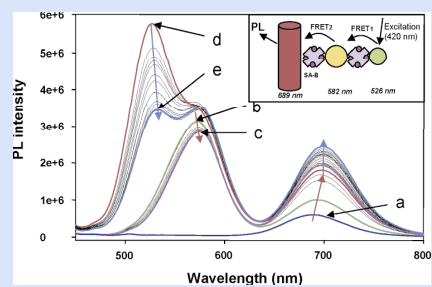
Przekaz energii



kaskadowy przekaz energii
w układzie nanostruktur
półprzewodnikowych



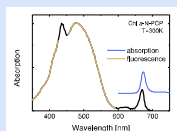
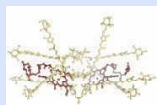
Przekaz energii



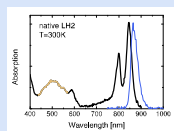


Kompleksy fotosyntetyczne

PCP



LH2

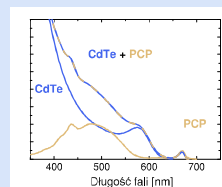


Układ hybrydowy

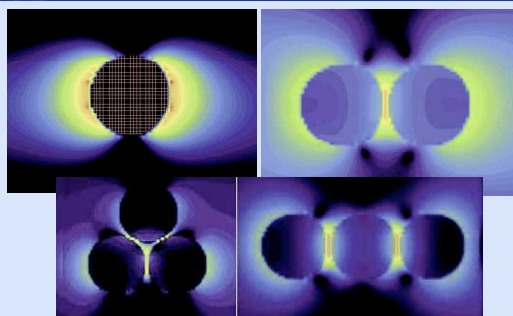


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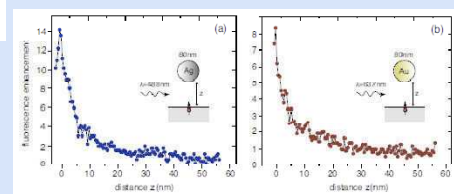
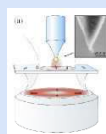
ZWIĘKSZENIE
ZAKRESU
WIDMOWEGO



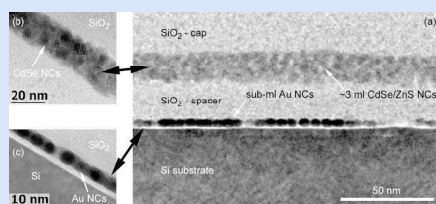
Wzmocnienie plazmonowe



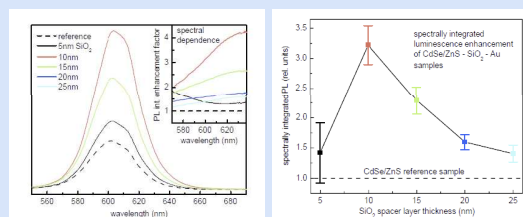
Wzmocnienie plazmonowe



Wzmocnienie plazmonowe

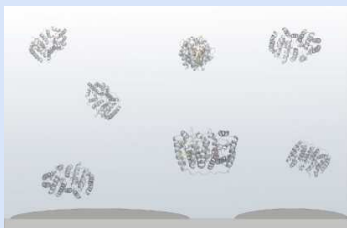


Wzmocnienie plazmonowe

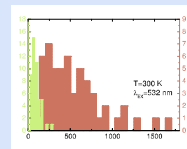
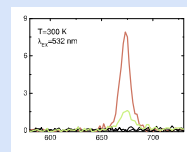
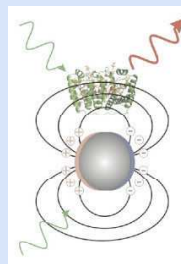




Układ hybrydowy

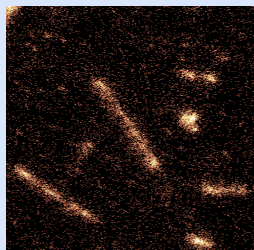
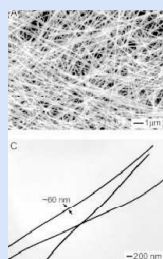


Układ hybrydowy

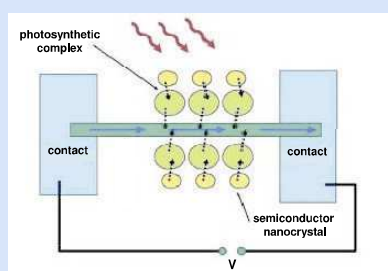


Układ hybrydowy

Ag nanowires



Ogniwo hybrydowe



A. Govorov, et al., Nano Letters 2005

Hybrid Nanostructures as a Stepping-Stone towards Efficient Artificial Photosynthesis

Fluorescence Intensity

Excitation Wavelength

welcome.fizyka.umk.pl