

Nanotechnologia III i IV

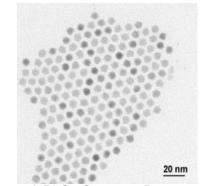
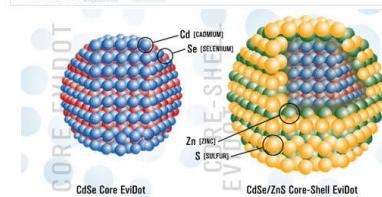
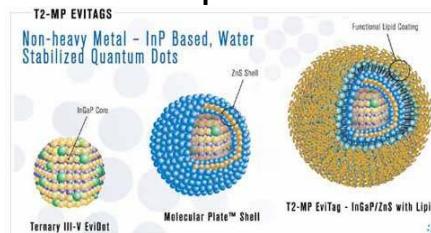
Jacek.Szczytko@fuw.edu.pl <http://www.fuw.edu.pl/~szczytko>



1. Nanotechnologia III i IV.
 - a. Nanorurki
 - i. Węgiel i nie tylko
 - ii. Pokrócone zasady
 - b. Nanomaszyny
 - c. nano+bio
 - d. molekuly

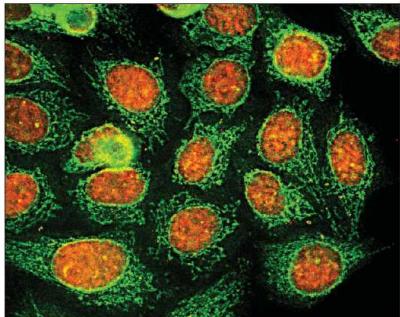


Kropki kwantowe + bio



<http://www.evidenttech.com/>

Kropki kwantowe + bio



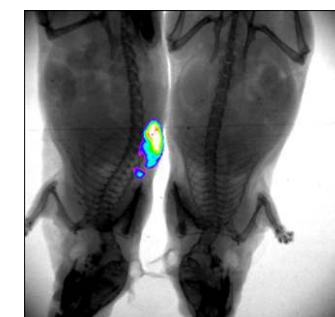
Double duty. Green quantum dots cling to mitochondria in the cytoplasm; orange ones label proteins in the same cells' nuclei.

Science, Vol 300, Issue 5616, 80-81 , 4 April 2003

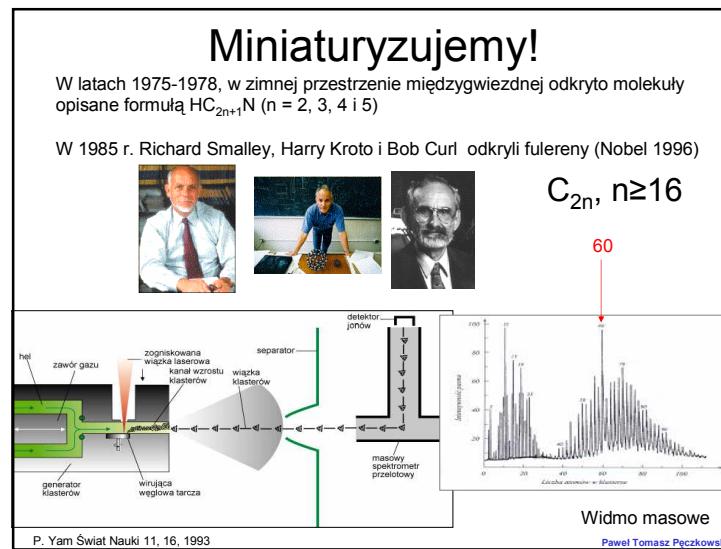
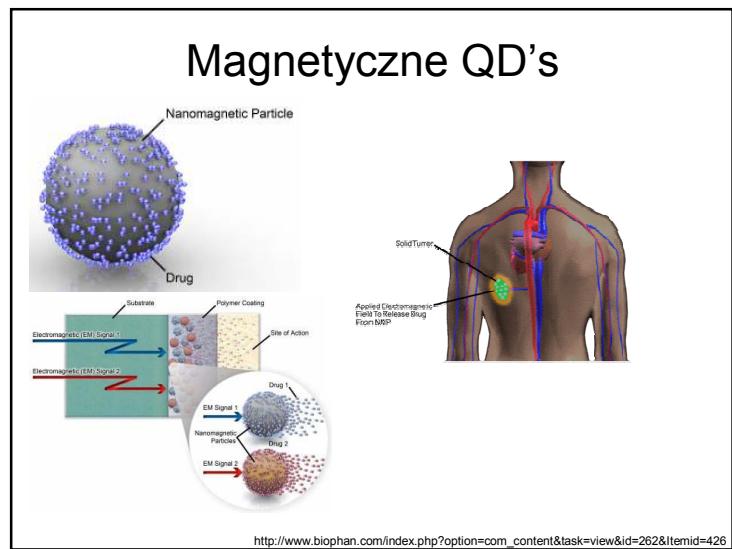
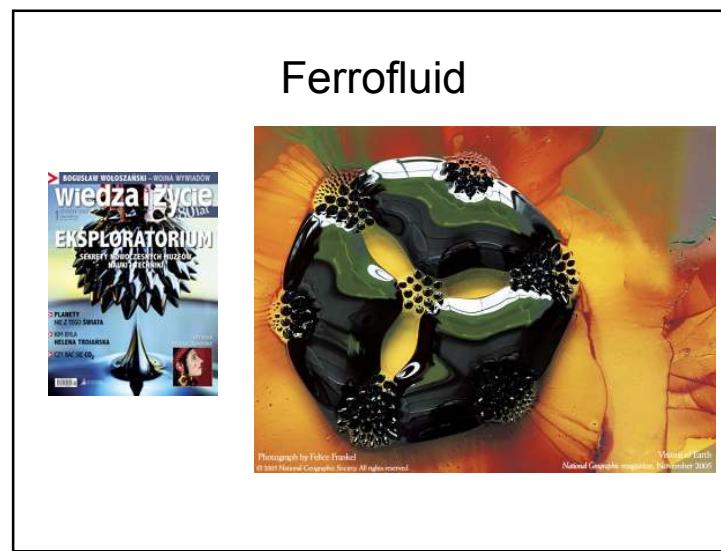
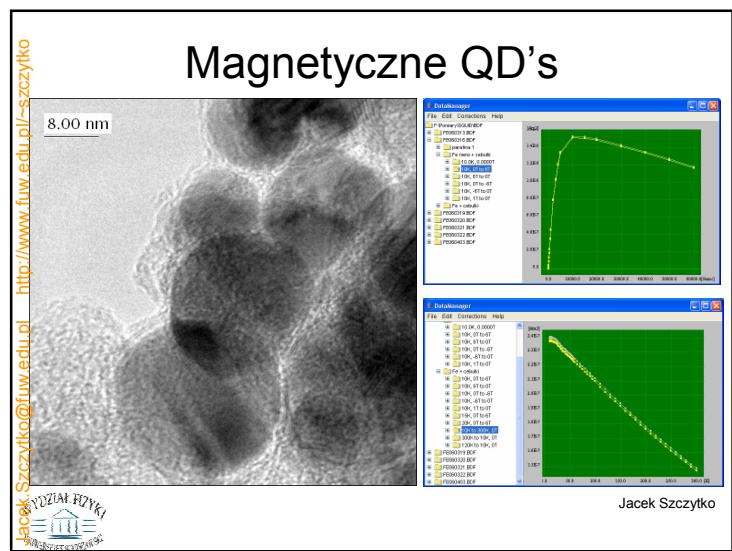
Kropki kwantowe + bio

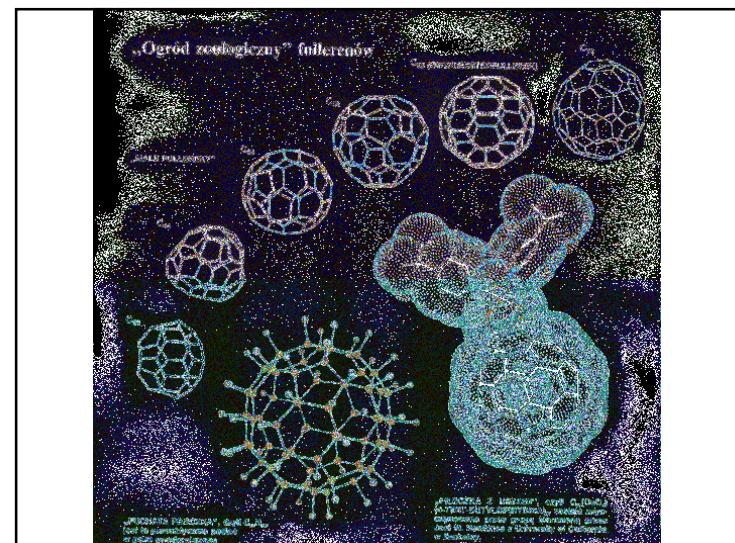
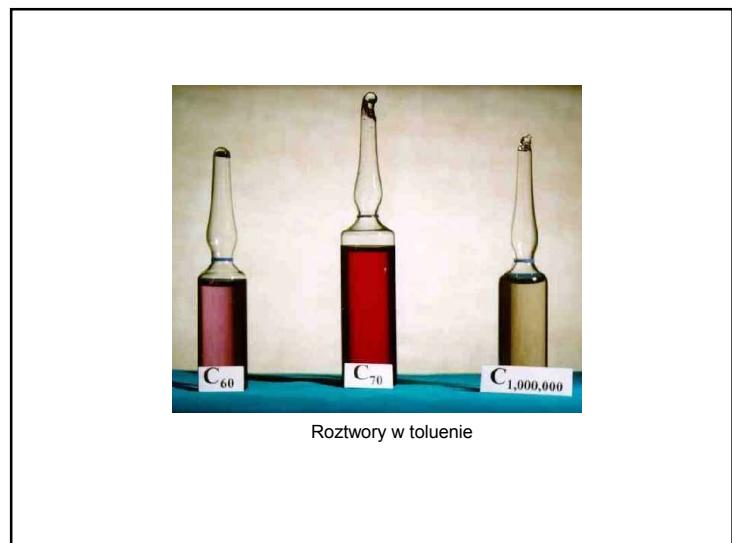
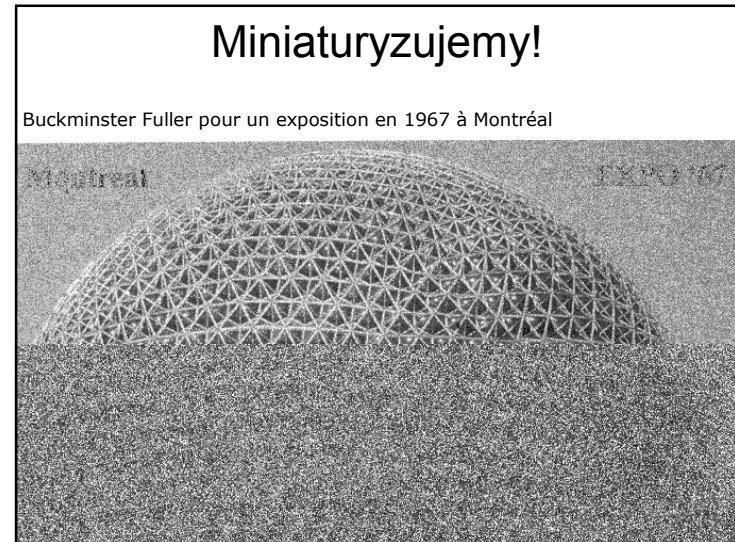
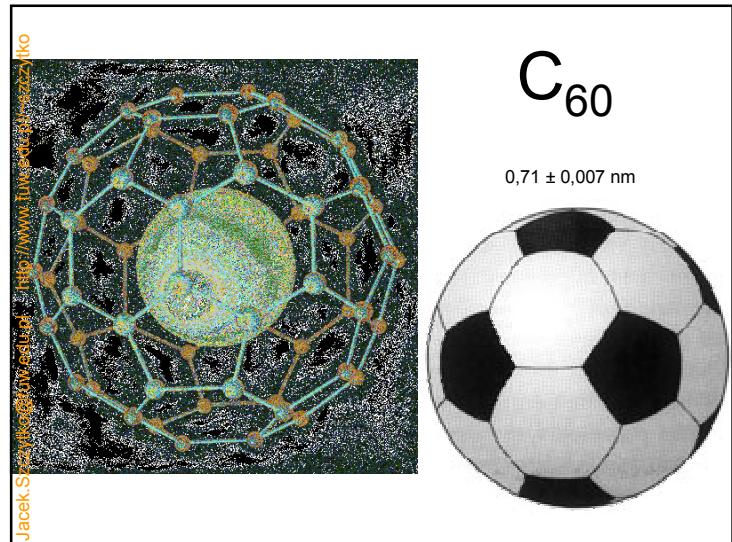


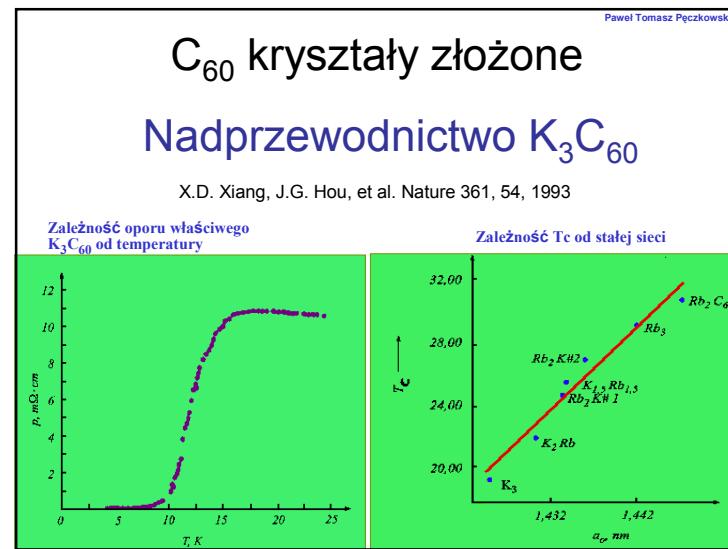
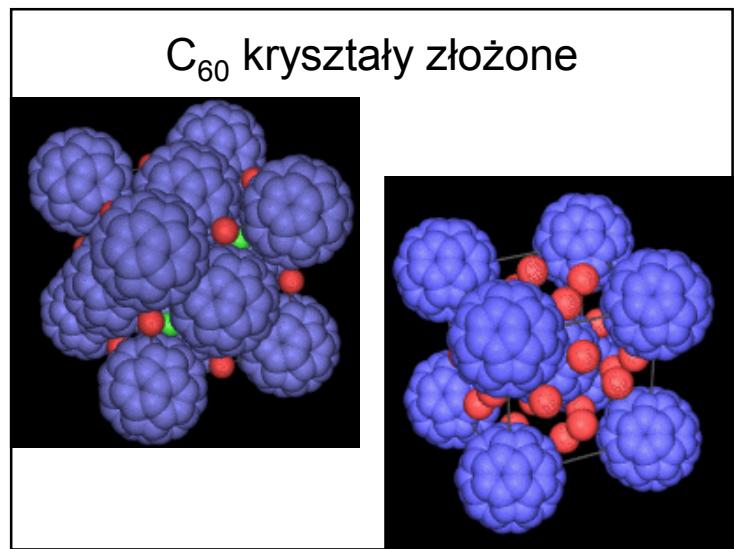
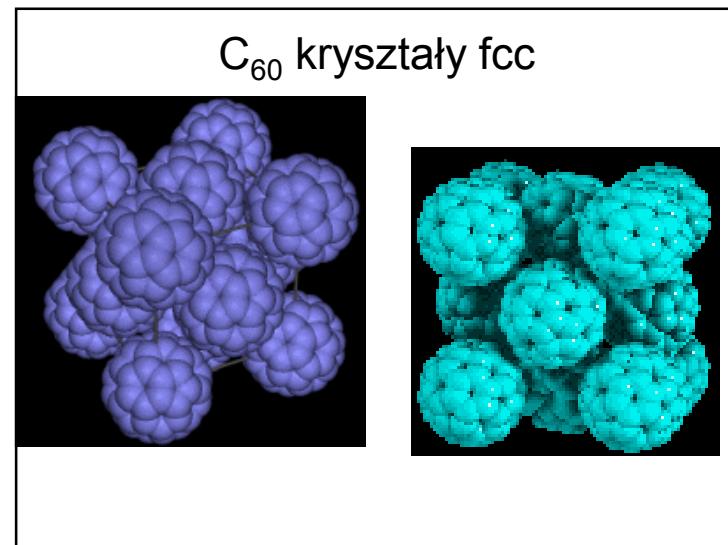
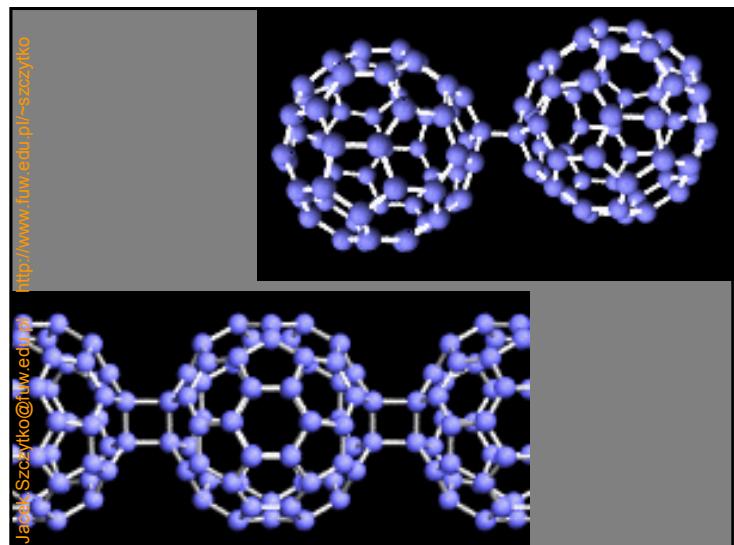
Bull's-eye. Red quantum dots injected into a live mouse mark the location of a tumor.



Science, Vol 300, Issue 5616, 80-81 , 4 April 2003







Paweł Tomasz Pęczkowski
<http://www.fuw.edu.pl/~szczytko>

Fullerenes

C₆₀

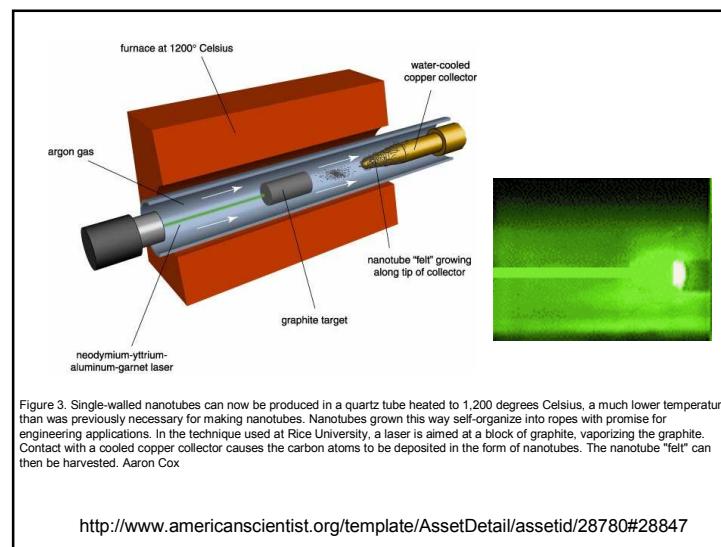
C₇₀

C₈₀ isomer

nanotube

...
 Iijima Nature 354, 56, 1991

W 1991 roku japończyk Sumio Iijima oglądając za pomocą mikroskopu elektronowego w Laboratorium Badań Podstawowych Firmy NEC w Tsukubie w Japonii próbki rozmazanej sadzy dostrzegł w niej dziwne nici o rozmiarach rzędu nanometrów nazwane później nanorurkami.



Orientacja nanorurek

Nanorurki można sobie wyobrazić jako warstwy atomów węgla (takie jak w graficie), które zostały zrolowane.

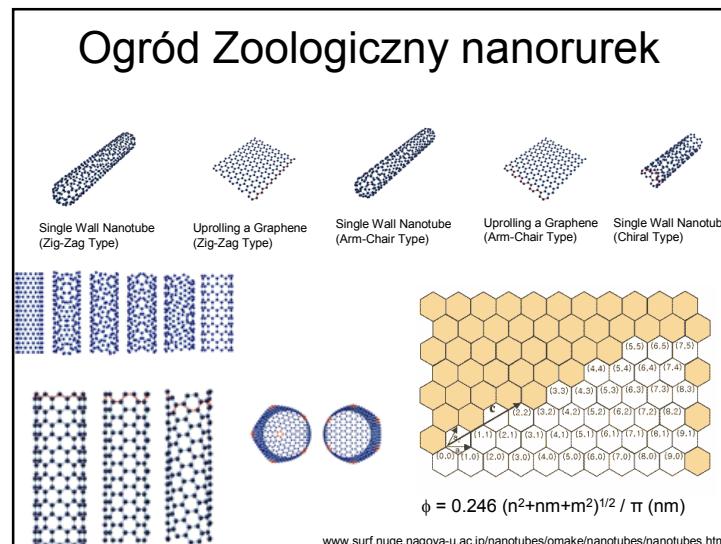
Rozróżniamy orientacje:

- Armchair
- Zig-zag
- Chiral

Orientacja jest zdefiniowana przez wektor chiralny (n,m)
 $c_h = n \mathbf{a} + m \mathbf{b}$

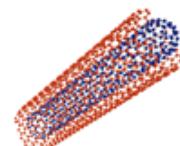
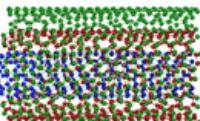
J.Basak, D.Mitra, S.Sinha „Carbon nanotube: the next generation sensors” presentation

Paweł Tomasz Pęczkowski



Ogród Zoologiczny nanorurek

Nanorurki wielościenne



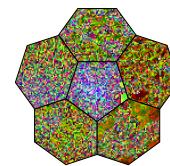
www.surf.nuqe.nagoya-u.ac.jp/nanotubes/omake/nanotubes/nanotubes.html

Jacek.Szczytko@fuw.edu.pl http://www.fuw.edu.pl/~szczytko

Ogród Zoologiczny nanorurek

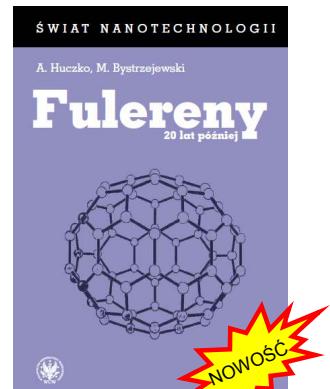
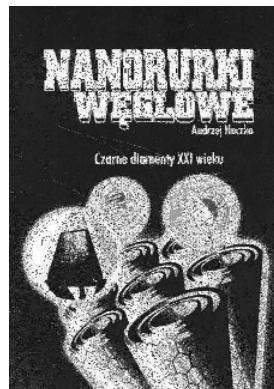
<http://www.chem.uw.edu.pl/>
Pracowni Fizykochemii Nanomateriałów
Dr hab. Andrzej Huczko

Wydział Chemiczny
UL. PASTEURA 1
02-093 WARSZAWA



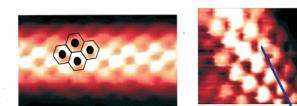
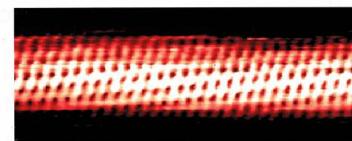
"Wstęp do Nanotechnologii"
(15 godzin, wtorki, godz. 13.45-15.15, sala 118, Chemia Fizyczna, Wydział Chemiczny).
1 wykład 7 listopada

Ogród Zoologiczny nanorurek

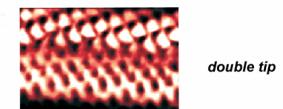
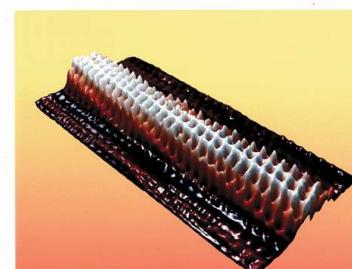


Nanorurki z bliska

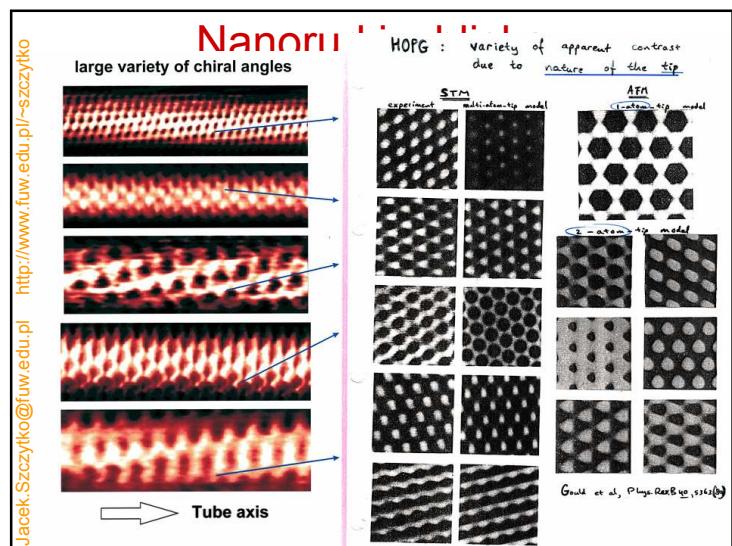
Atomic resolution on the nanotubes



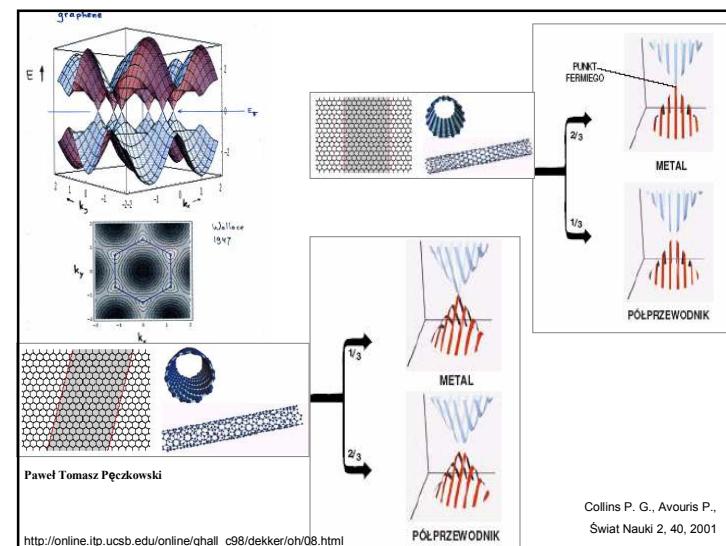
triangular lattice:
dark dots correspond
to centers hexagons



TU Delft
DI-MES



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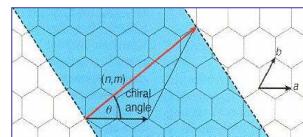


Podwójna osobliwość elektryczna nanorurek

W zależności od orientacji CNT mogą przejawiać właściwości metaliczne lub półprzewodnikowe

- > Nanorurki SWCNT o konfiguracji zig-zag są metalami gdy

$$\frac{1}{3} \cdot n = \text{liczba całkowita}$$



- > Nanorurki chiralne o wskaźnikach (n,m) są przewodnikami o charakterze metalicznym, gdy spełniona jest następująca zależność

$$(2n + m) = 3 \cdot q$$

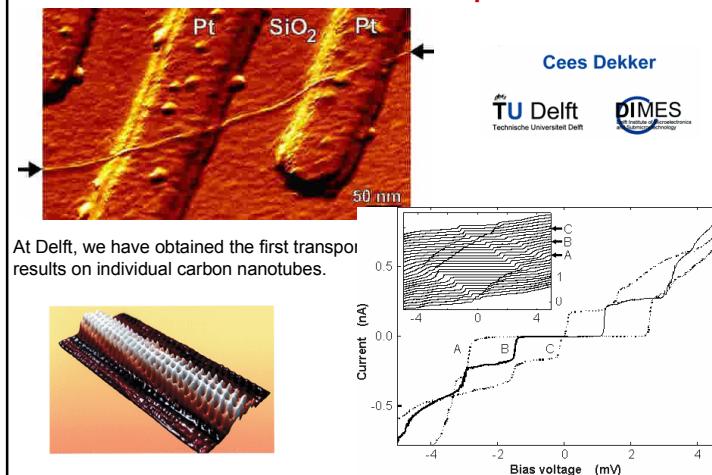
gdzie q jest liczbą całkowitą.

Gdy warunek ten nie jest spełniony, CNT jest półprzewodnikiem.

Wynika stąd, że SWCNT o wskaźnikach (n,n) wykazują przewodnictwo metaliczne

Paweł Tomasz Pęczkowski

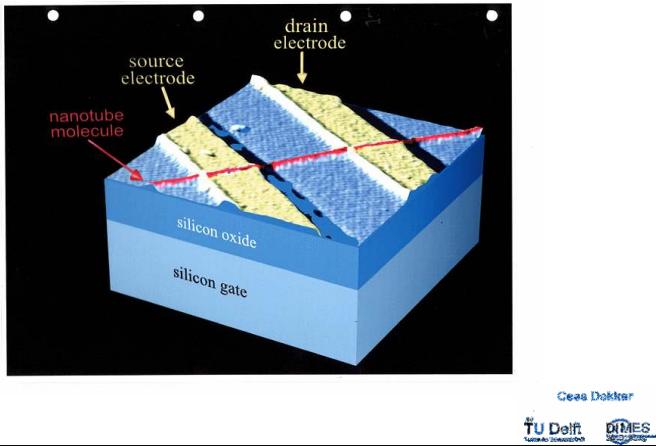
Nanotubes as molecular quantum wires



Nanotubes as molecular quantum wires

Jacek.Szczytko@fuw.edu.pl <http://www.fuw.edu.pl/~sz>

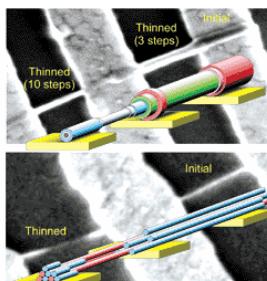
卷之三



Nanotranzystor IBM

“CONSTRUCTIVE DESTRUCTION”

1. The scientists deposit ropes of "stuck together" metallic and semiconducting nanotubes on a silicon-oxide wafer,
 2. Then a lithographic mask is projected onto the wafer to form electrodes (metal pads) over the nanotubes. These electrodes act as a switch to turn the semiconducting nanotubes on and off,
 - 3 Using the silicon wafer itself as an electrode, the scientists "switch-off" the semiconducting nanotubes, which essentially blocks any current from traveling through them,
 - 4.. The metal nanotubes are left unprotected and an appropriate voltage is applied to the wafer, destroying only the metallic nanotubes, since the semiconducting nanotubes are now insulated,
 5. The result: a dense array of unharmed, working semiconducting nanotube transistors that can be used to build logic circuits like those found in computer chips.



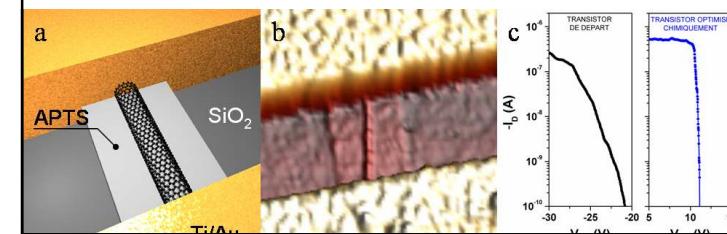
Yorktown Heights, N.Y., April 27, 2001 ... IBM scientists developed a breakthrough transistor technology that could preview how computer chips can be made smaller and faster than what is currently possible with silicon.

Nanotranzystory

www-drecam.cea.fr/scm/lem/LEM_eng/

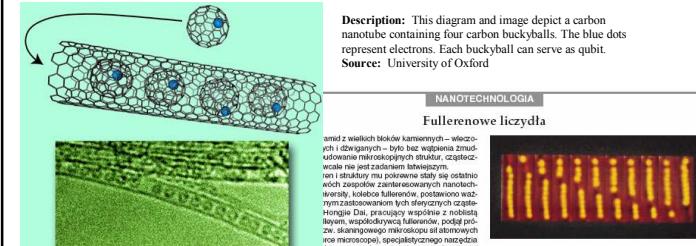
AFM picture of carbon nanotubes on a silicon substrate. Nanotubes specifically adhere to pattern of amine silane (APTS) cast on the surface.

Drawing (a) and AFM picture (b) of a self- assembled carbon nanotube transistor. After sticking to the APTS pattern, the nanotube was connected with source and drain electrodes (Ti/Au). The doped silicon substrate is



Nanoliczydła

Description: This diagram and image depict a carbon nanotube containing four carbon buckyballs. The blue dots represent electrons. Each buckyball can serve as qubit.
Source: University of Oxford



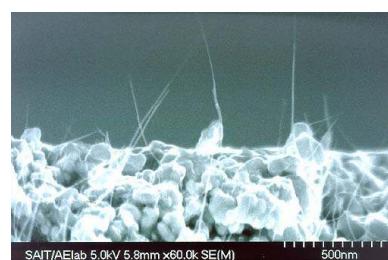
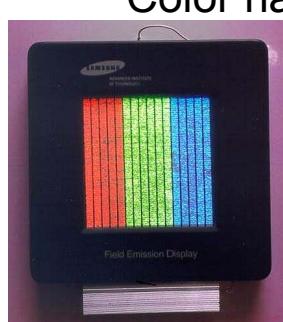
Page 10

Wysokość koniczynki pełnej zazwyczaj nie przekracza 10 mm. Wysokość koniczynki częściowo zasianej jest mniejsza o połowę. Koniczynka pełna ma grubie igły (o średnicy konicówka dochodzącej do 1,5 mm) i długie, lekko zakrzywione, przylatujące do nich nerkowate części skafid fullerenowe (szafirki). Wysokość koniczynki częściowo zasianej jest mniejsza o połowę. Koniczynka częściowo zasiana ma grube igły (o średnicy konicówka dochodzącej do 1,5 mm) i długie, lekko zakrzywione, przylatujące do nich nerkowate części skafid fullerenowe (szafirki).

w Włoskim Uniwersytecie, Zatrudniony został w zespole koncentrycznych zwójów grafowej „statki drucakogłowy oczkach”. Po zwieleniu konwoju takiego kijastuca czaszka faleronowa otrzymuje wygodną znak. Te niezwykle rurki rzeczywiście niezwykle utrzymują wykorzystanie fulerenu do realizacji mieru amfibologicznych – budowy liliowych liczydeł [polonyz]. James Gimzewski i kolejny z laboratorium badawczego firmy IBM wprowadziły nową teknikę [C. do rozwijanych liczydłowych na powierzchniach

tmają manipulowanie atomami, ale nie jestem w pełni zadowolony z tego, co mówią o tym badaniach. Czyżbyśmy zresztą nie mogliby też tworzyć światła nowego typu kohärency? Daniel Cohen, z którym rozmawiałem, powiedział mi, że choć próbował, nie udało się im zrealizować nienowoczesnego eksperymentu z użyciem wibracji do poziomu tego kształtu.

Nantero



(above): A field-emission display using carbon nanotubes.

(above): A cross section image, made with a scanning electron microscope, of a carbon nanotube cathode. The nanotubes are aligned perpendicular to the substrate and are embedded into a metal electrode. (Courtesy, Samsung Advanced Institute of Technology, Korea)

Wyświetlacz nano CRT
Carbon Nanotube (CNT) Motorola

Nano-anteny

Receiving and transmitting light-like radio waves: Antenna effect in arrays of aligned carbon nanotubes

Y. Wang^{a)} and K. Kempa
Boston College, Chestnut Hill, Massachusetts 02467

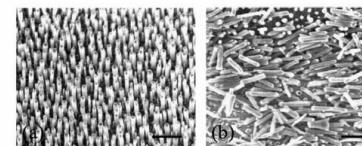


FIG. 1. Aligned (a) and scratched (b) random arrays of MWCNTs. In this study we use only the random arrays, to reduce the internanotube diffraction effects. Scale bars, 1 μ m.

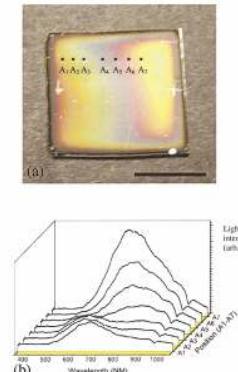
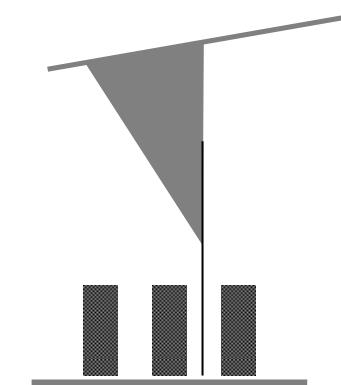
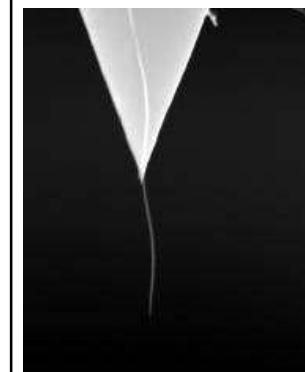


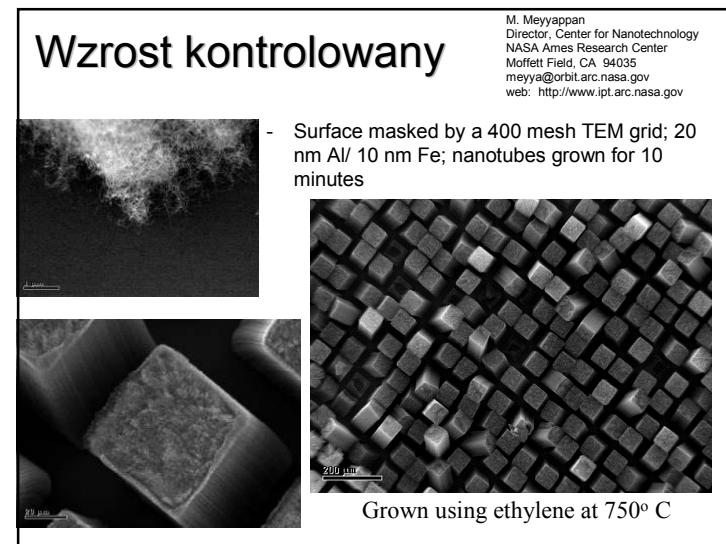
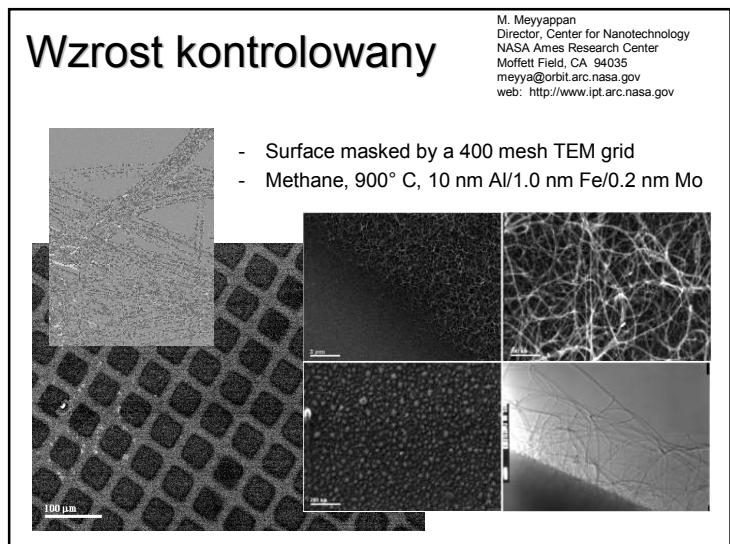
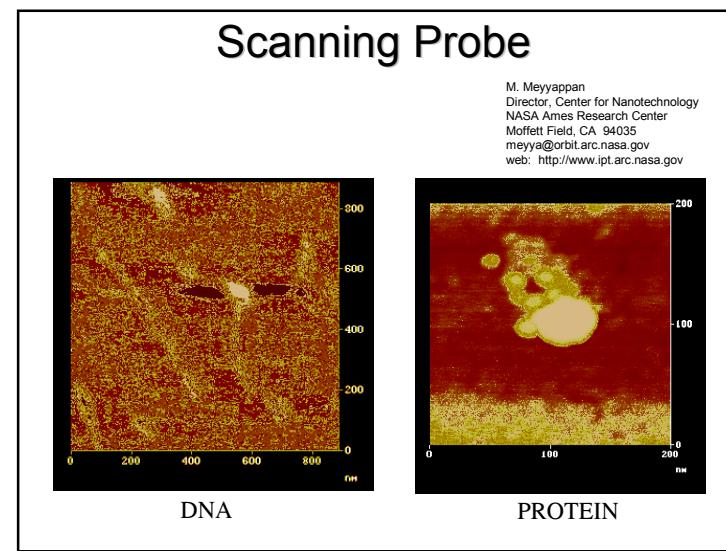
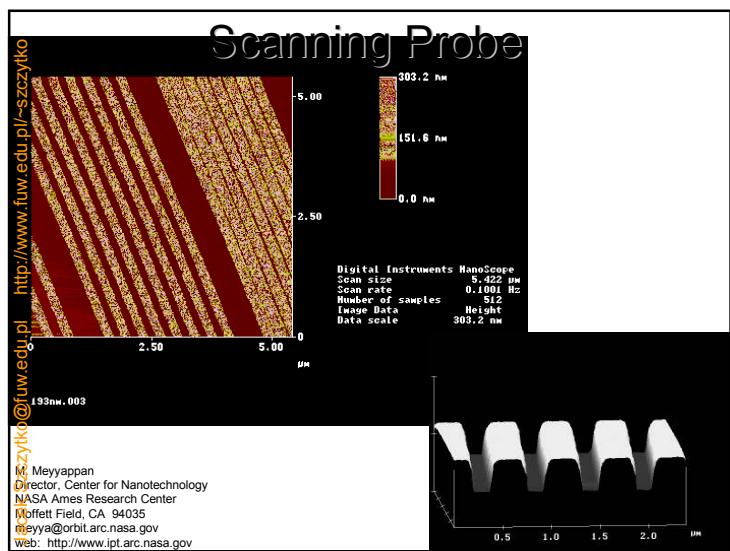
FIG. 3. (Color) Antenna length effect. (a) Luminescence colors from the antenna array of MWCNTs. λ_1 - λ_7 are the selected positions where the length and optical measurements were carried out. Scale bar, 1 cm. (b) Reflected light intensity vs radiation wavelength measured in selected points on the sample shown in (a).

Color nanotube display

Scanning Probe

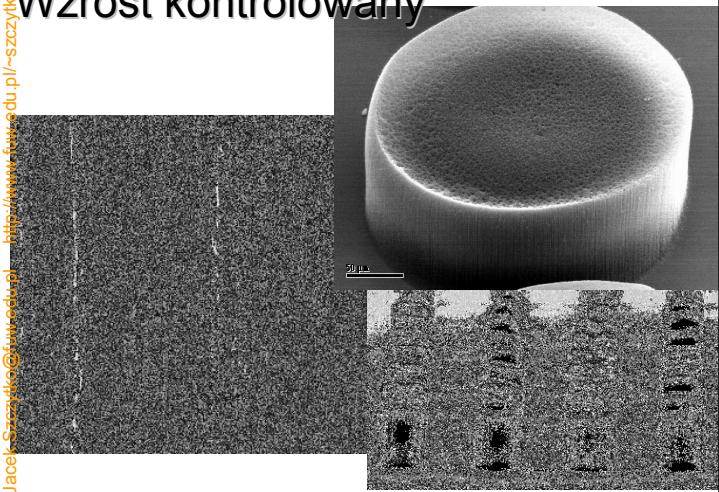
M. Meyyappan
Director, Center for Nanotechnology
NASA Ames Research Center
Moffett Field, CA 94035
meyya@orbit.arc.nasa.gov
web: <http://www.ipr.arc.nasa.gov>





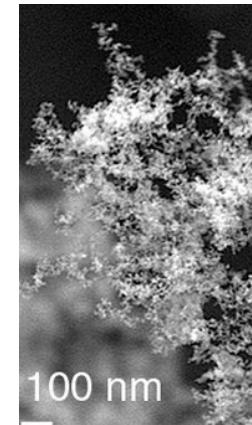
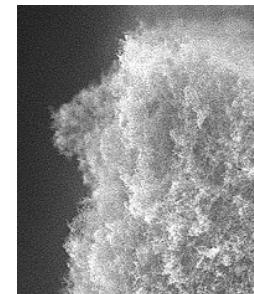
Wzrost kontrolowany

Jacek Szczętko@fuw.edu.pl http://www.fuw.edu.pl/~szczetko/

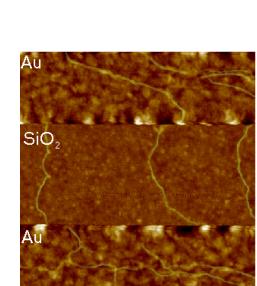


Nanopianka

Nanopianka węglowa jest... magnetyczna!
Physics News 678, March 26, 2004

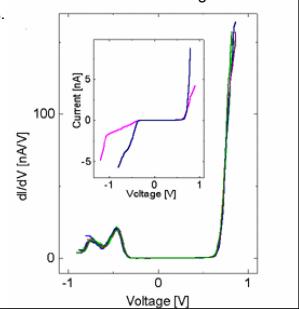


Dr Andrei Rode , Australian National University



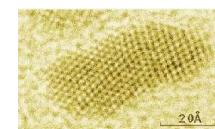
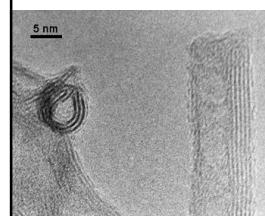
Conductance measurements on lambda DNA fragments

Fragments of lambda DNA with a length of 1.5 micron (4500 base pairs) were deposited on gold electrodes spaced by about 250 nm. By AFM imaging single DNA molecules were found between the electrodes. The measured resistance between the electrodes was found to be larger than 200 GOhm. Below is an AFM image of DNA over gold electrodes.



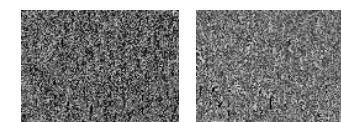
Inne nanorurki i nanowąsy

TiO₂ nanotube materials

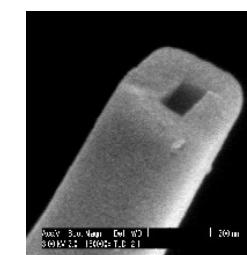


nanocząstka Au

ZnO



ZnO

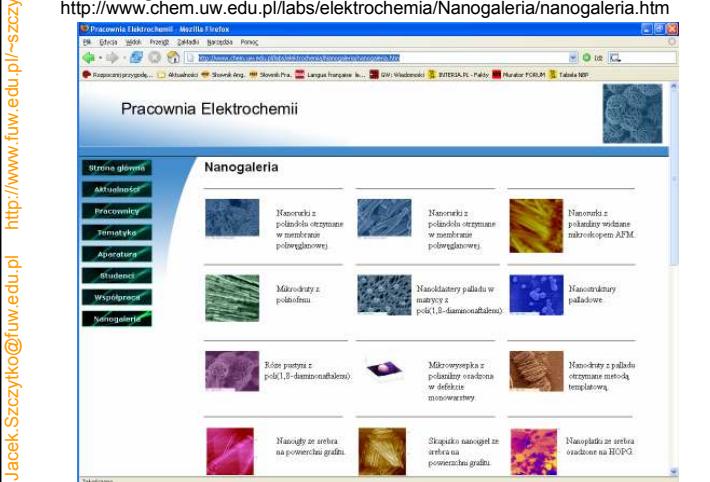


Nanorurka Si

www.ee.leeds.ac.uk/nanomsc/modules1.php

Wydział (nano)Chemii UW

<http://www.chem.uw.edu.pl/labs/elektrochemia/Nanogaleria/nanogaleria.htm>

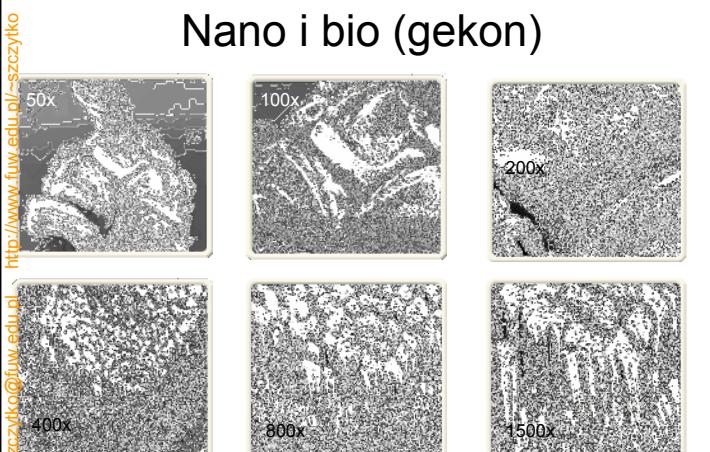


Jacek.Szczytko@fuw.edu.pl http://www.fuw.edu.pl/~szczytko

Nano i bio (gekon)



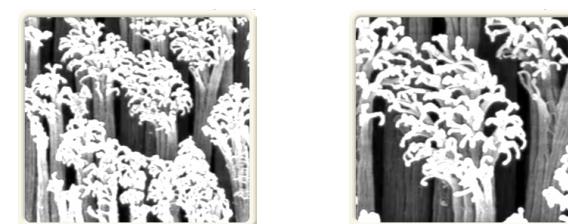
Nano i bio (gekon)



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<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

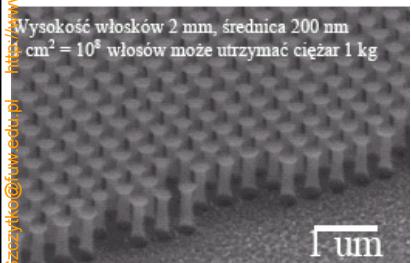
Nano i bio (gekon)



<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

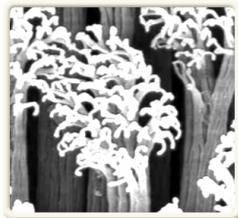
Nano i bio (gekon)

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<http://www.fuw.edu.pl/~szczytko>



Wysokość włosów 2 mm, średnica 200 nm
 $cm^2 = 10^8$ włosów może utrzymać ciężar 1 kg

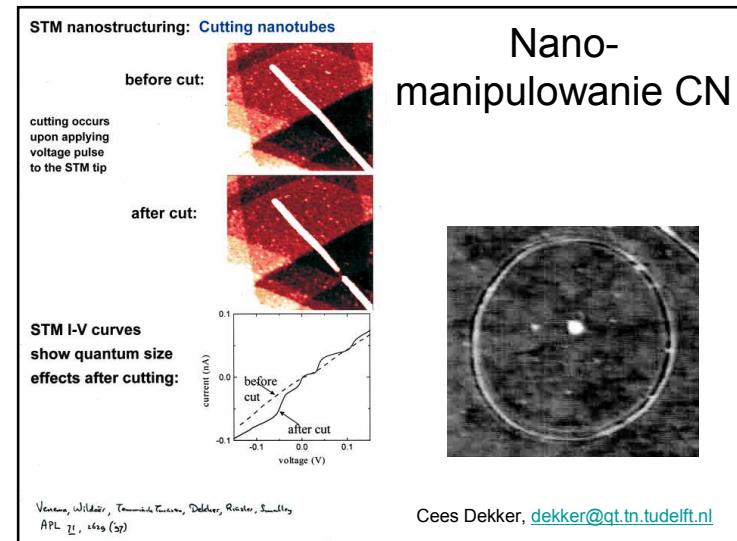
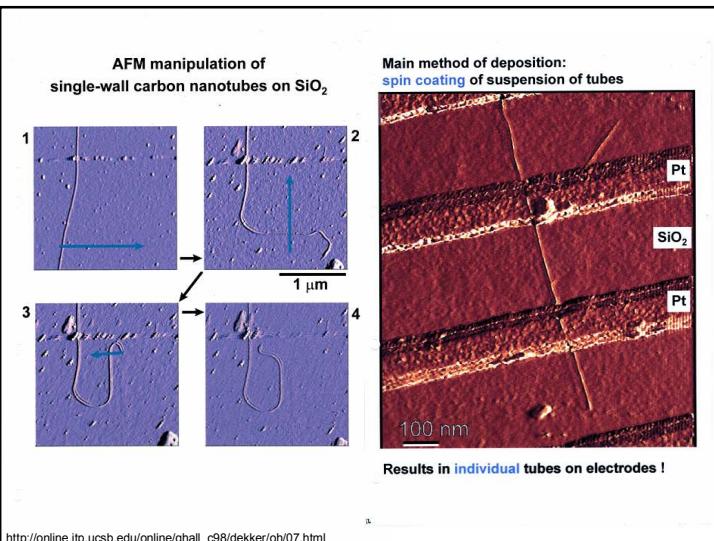
6000x

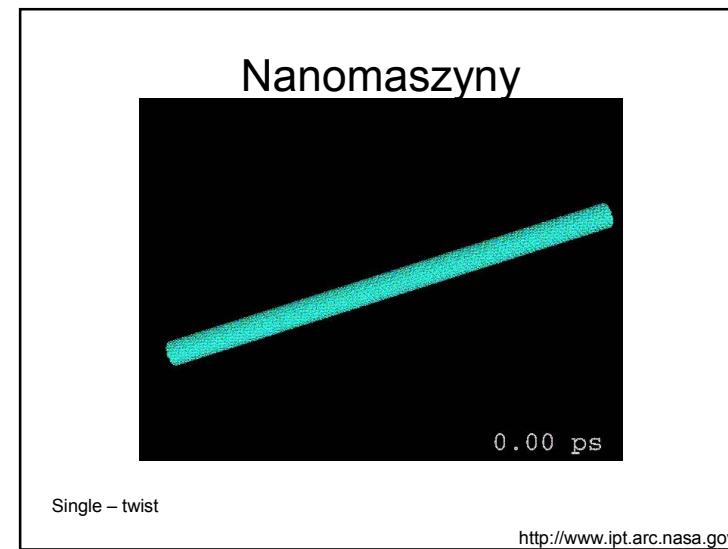
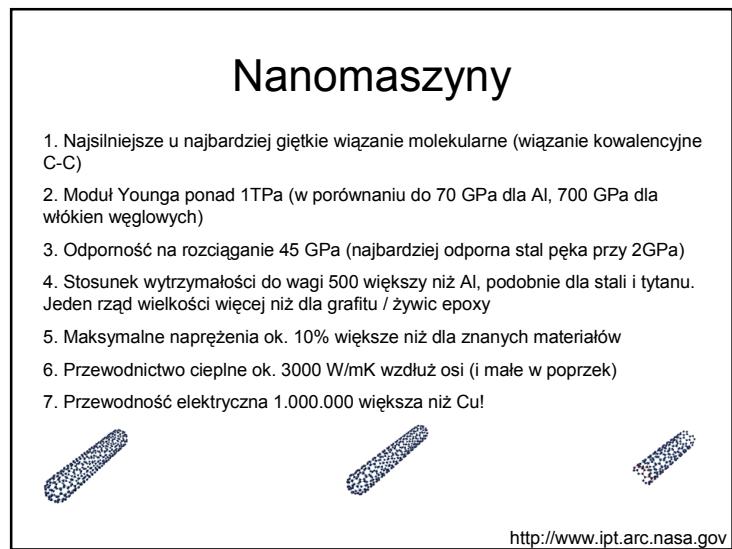
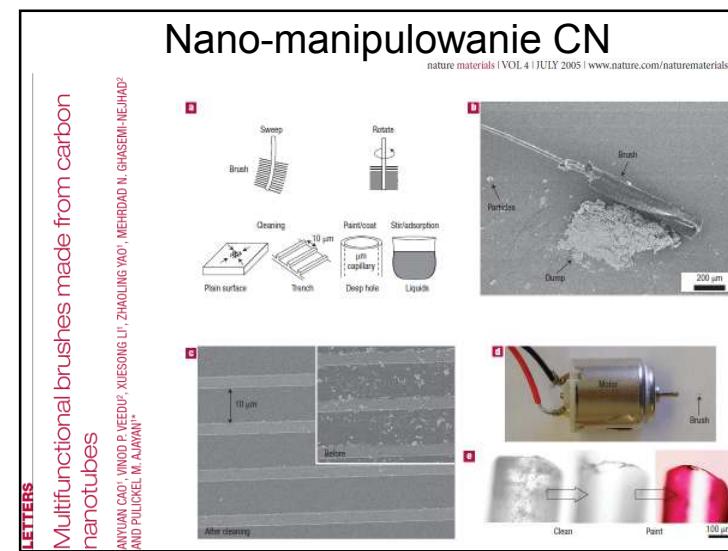
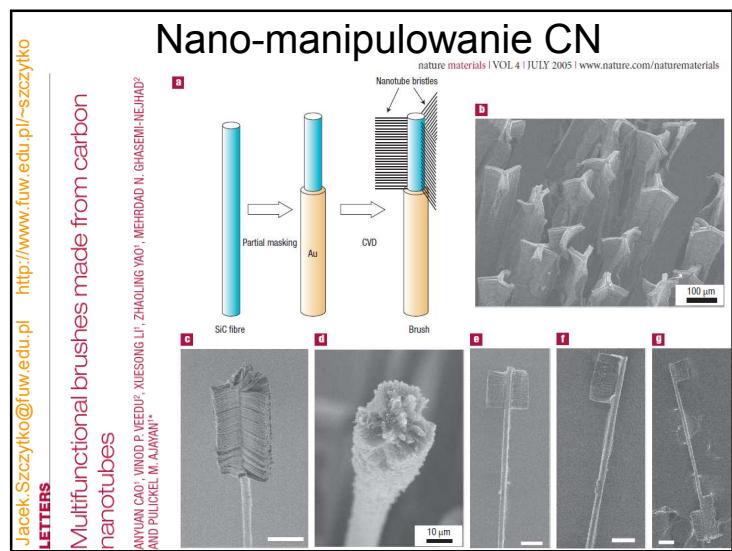


Paweł Tomasz Pęczkowski

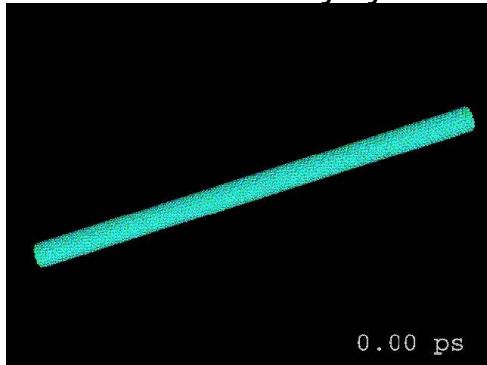
<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

nano-Manipulowanie nanomaszyny





Nanomaszyny

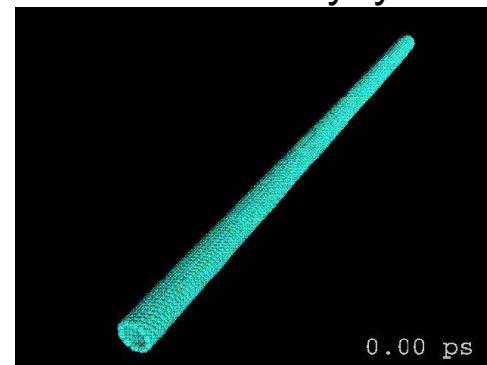


0.00 ps

Single – bend

<http://www.ipt.arc.nasa.gov>

Nanomaszyny

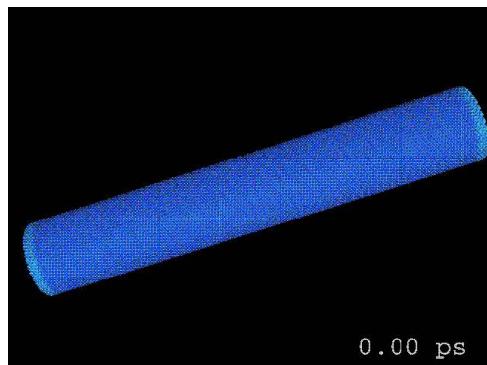


0.00 ps

Single – compress

<http://www.ipt.arc.nasa.gov>

Nanomaszyny

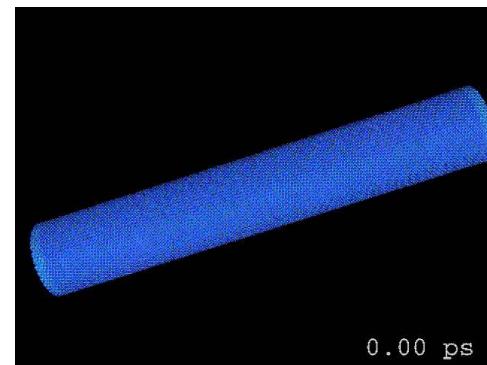


0.00 ps

Multi – twist

<http://www.ipt.arc.nasa.gov>

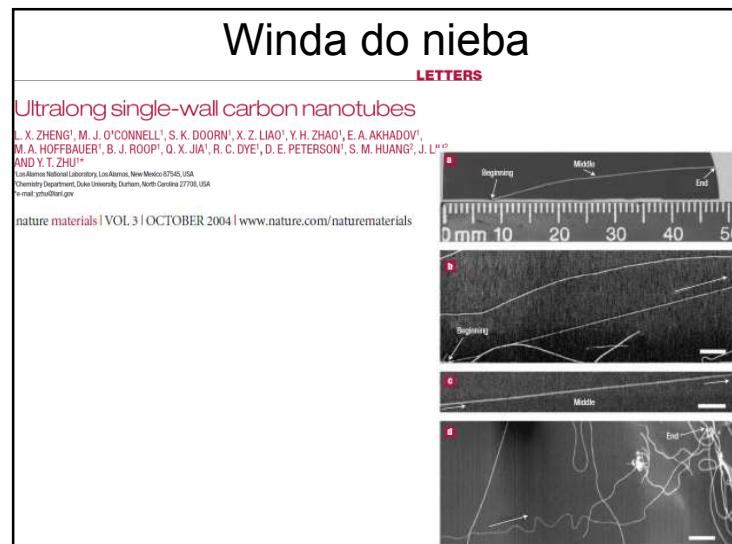
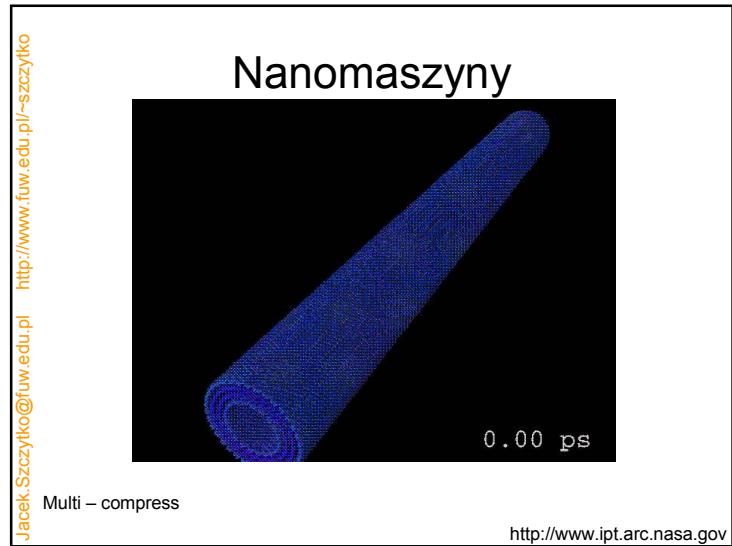
Nanomaszyny



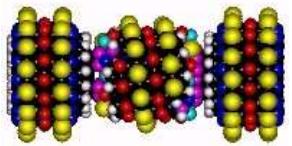
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Multi – bend

<http://www.ipt.arc.nasa.gov>

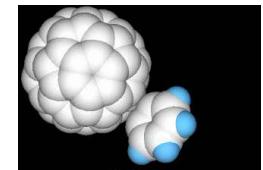


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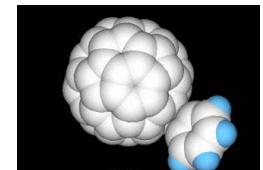


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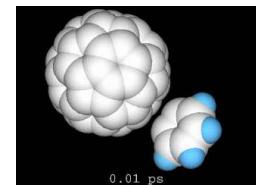
Benzen + C₆₀



Za wolno



Za szybko

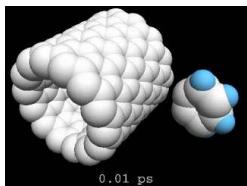


W sam raz

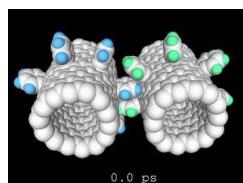
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Nanomaszyny

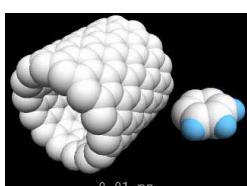
Benzen + CN



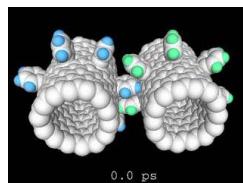
W sam raz



Gear Rotation in a Vacuum 200 rot/ns



Za wolno

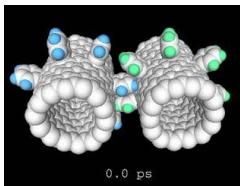


Gear Rotation in a Vacuum 50/70/100 rot/ns

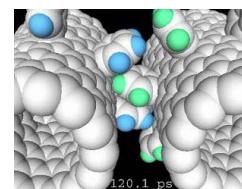
<http://www.ipt.arc.nasa.gov>

Nanomaszyny

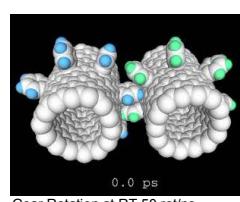
Nanomaszyny



Gear Rotation at RT 50/70/100 rot/ns

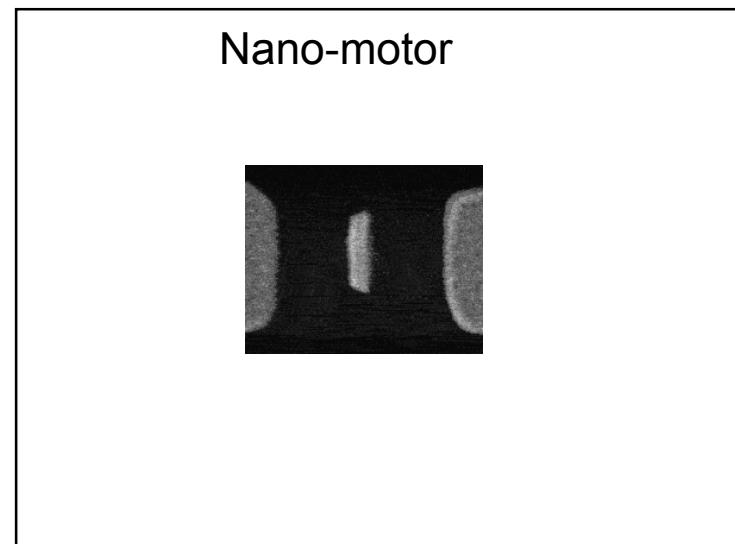
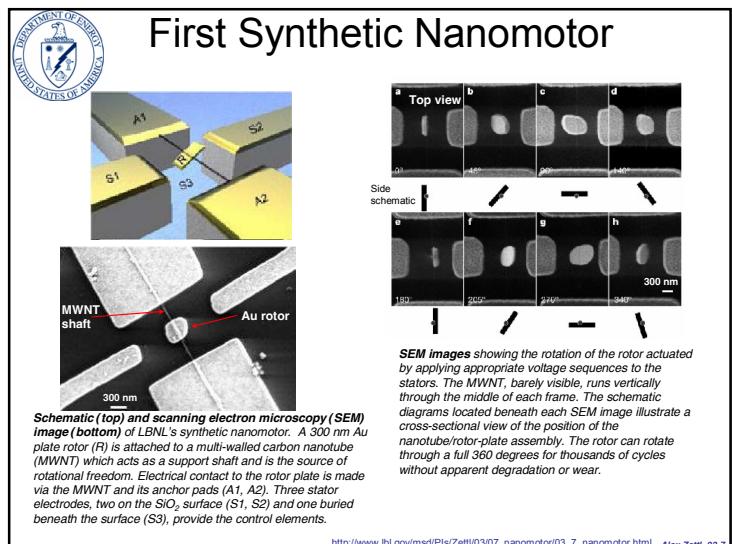
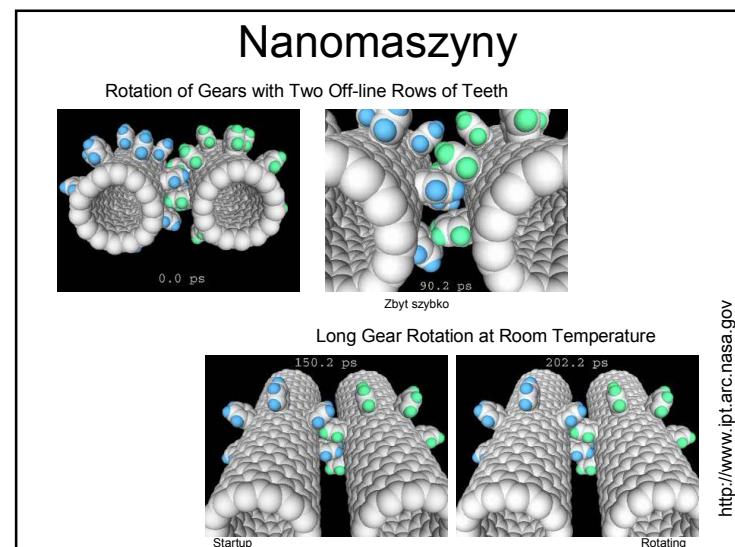
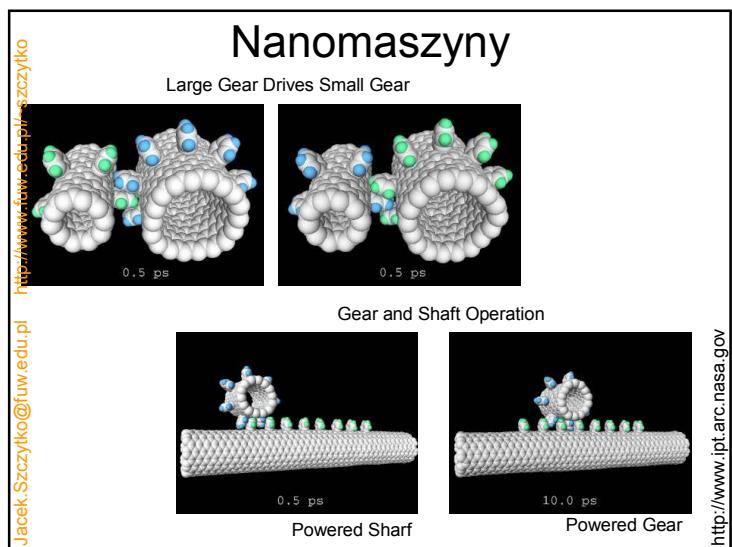


Too fast > 100 rot/ns

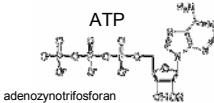


Gear Rotation at RT 50 rot/ns

<http://www.ipt.arc.nasa.gov>



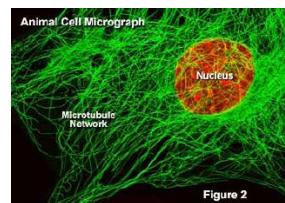
Model for the Kinesin Mechanism



[mov-muscmysinmotrev6.mov](http://www.fuw.edu.pl/~szczekko/mov-muscmysinmotrev6.mov)

[mov-procmotconvkinrev5.mov](http://www.fuw.edu.pl/~szczekko/mov-procmotconvkinrev5.mov)

Kinesin is a dimeric motor protein that travels processively towards the microtubule plus end by taking 8 nm steps, which corresponds to the distance between adjacent alpha/beta tubulin binding sites. We have sought to define the structural changes in the motor that explain the direction of movement and the basis of head-head coordination during processive motility.



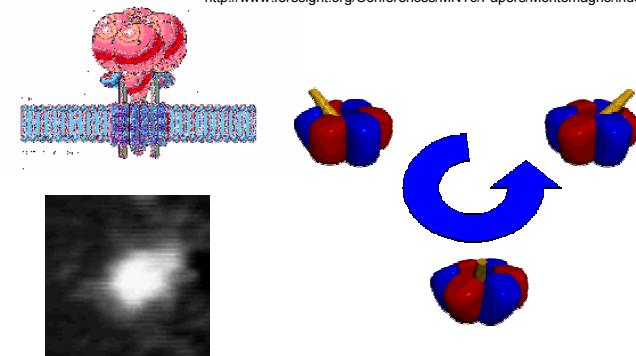
http://valelab.ucsf.edu/research/res_mec_overv.html

http://www.sns.gov/workshops/nni_05/presentations/050617_pincus_philip_nni05.pdf

Jacek Szczętko@fuw.edu.pl

Nano i bio (ATPaza)

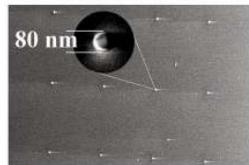
<http://www.foresight.org/Conferences/MNT6/Papers/Montemagno/index.html>



<http://www.linkclub.or.jp/~hiikoysd/ryohei/papers.html>

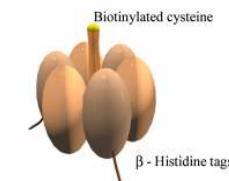
Bio-nano-silnik (ATPaza)

A

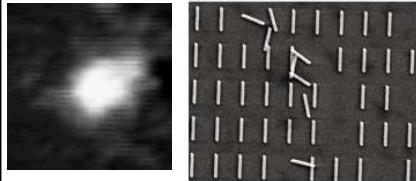


<http://www.linkclub.or.jp/~hiikoysd/ryohei/papers.html>

B

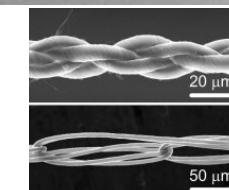
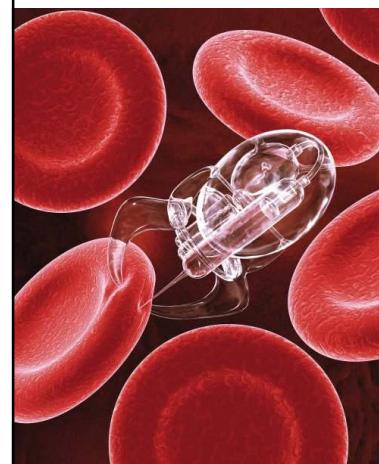


C

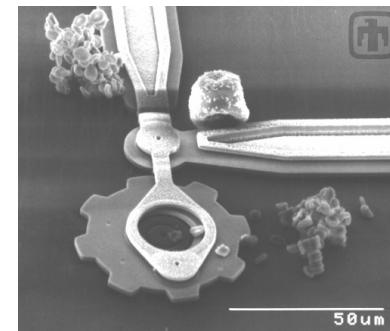
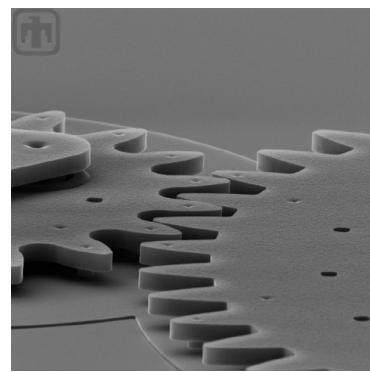
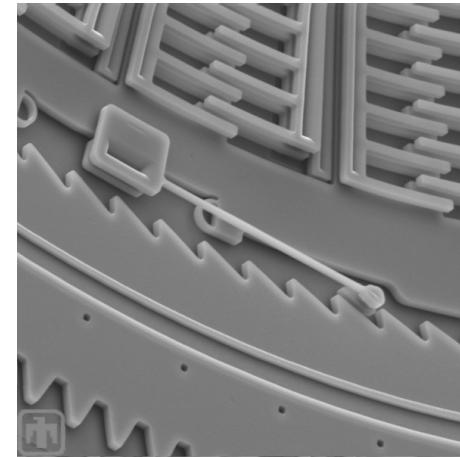
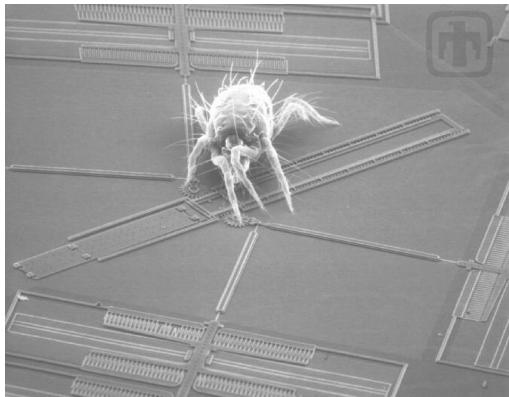


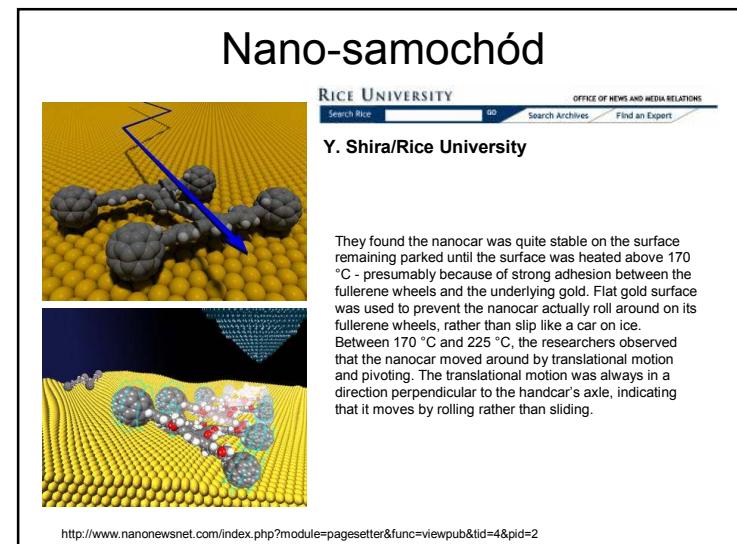
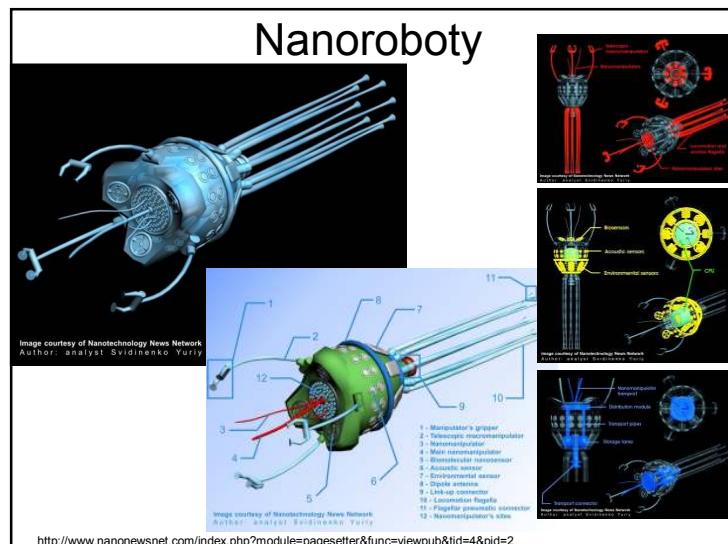
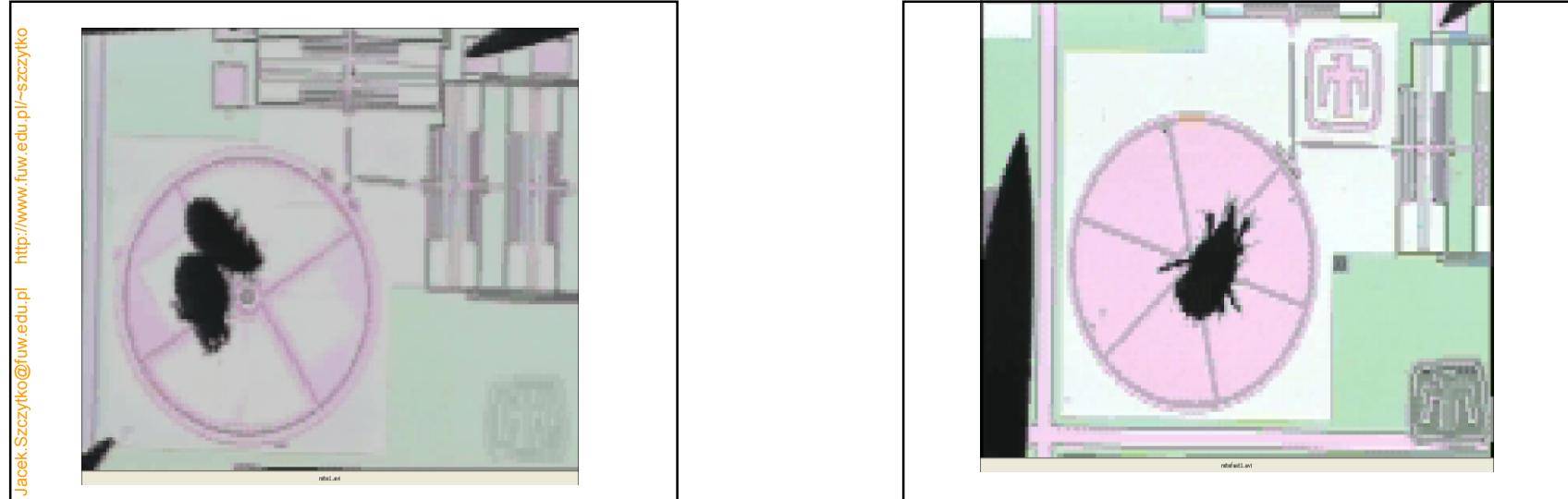
<http://www.foresight.org/Conferences/MNT6/Papers/Montemagno/index.html>

Nanoroboty

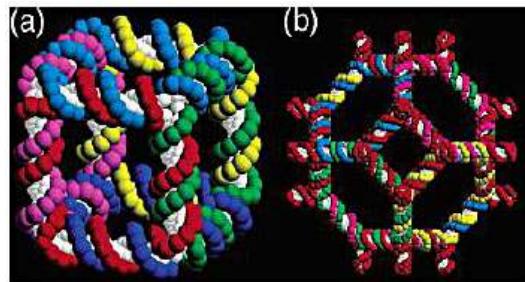


Nano Tech Web



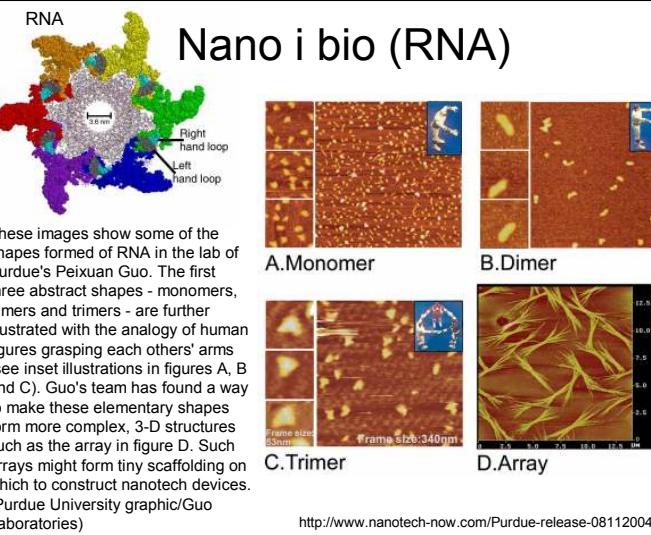


Nano i bio (DNA)



DNA

Filmik [protein_nanotubes.mov](#)

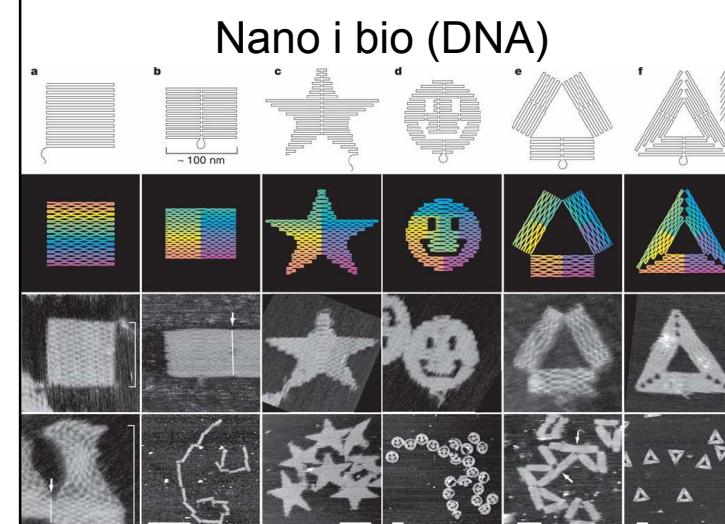
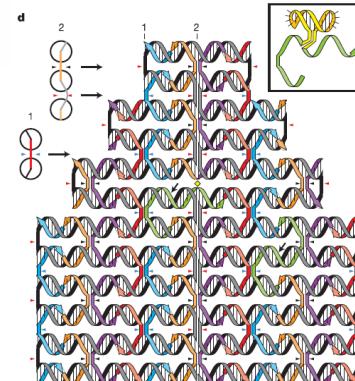


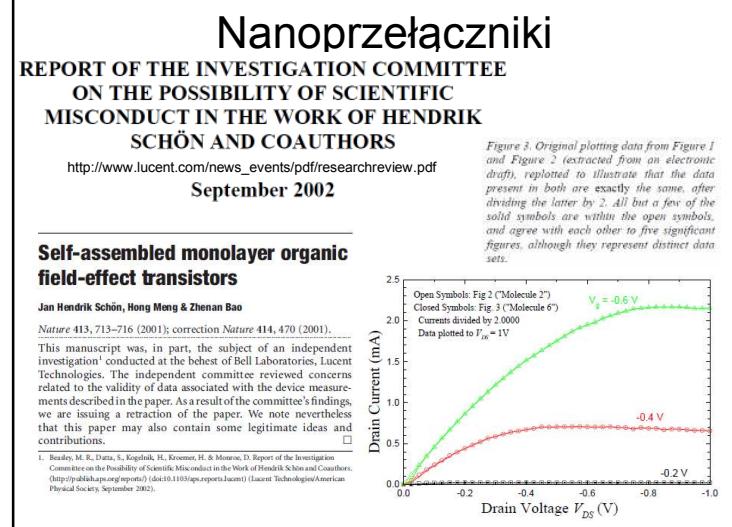
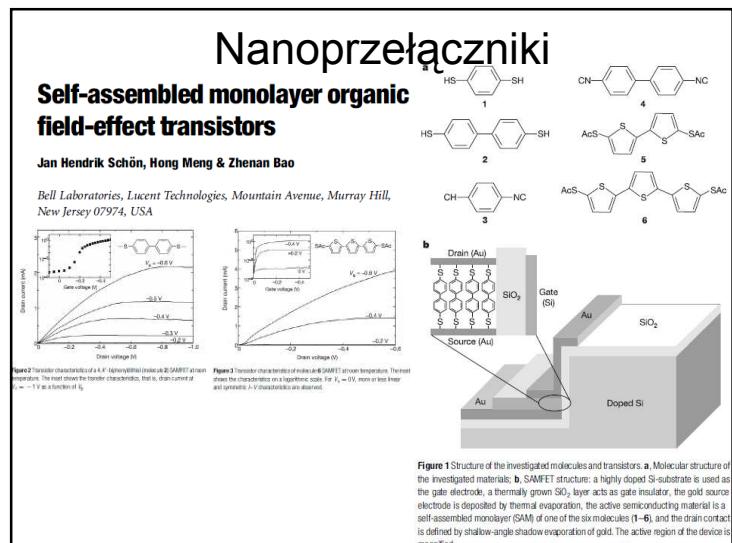
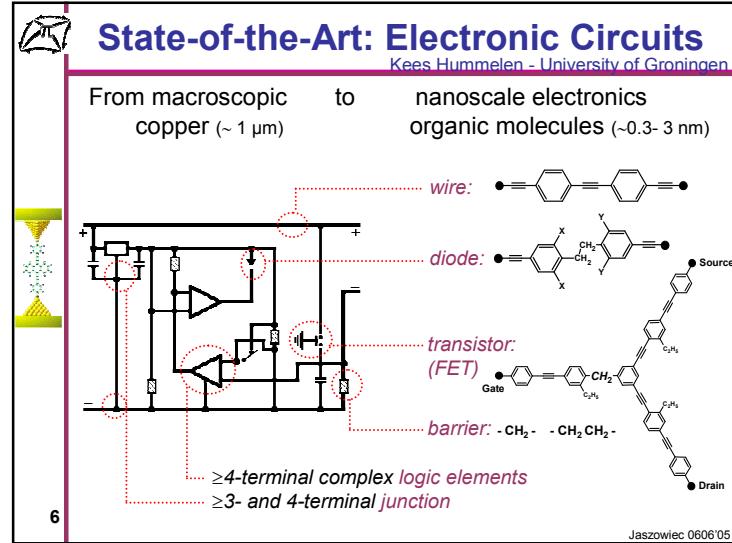
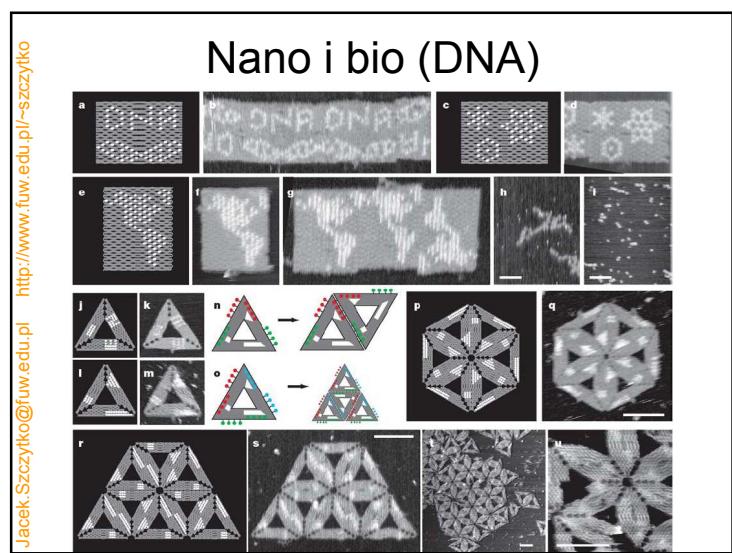
Nano i bio (DNA)

Vol 440|16 March 2006|doi:10.1038/nature04586

Folding DNA to create nanoscale shapes and patterns

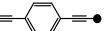
Paul W. K. Rothemund¹





State-of-the-Art: Electronic Circuits
Kees Hummelen - University of Groningen

From macroscopic copper ($\sim 1 \mu\text{m}$) to nanoscale electronics organic molecules ($\sim 0.3\text{-}3 \text{ nm}$)

wire: 

diode: 

transistor: (FET) 

barrier: $-\text{CH}_2-$ $-\text{CH}_2\text{CH}_2-$

≥ 4 -terminal complex logic elements
 ≥ 3 - and 4-terminal junctions

Jaszowiec 0606'05

6

<http://www.fuw.edu.pl/~szczyzy/>

State-of-the-Art: Electronic Circuits
Kees Hummelen - University of Groningen

3-terminal junctions: 'Tour' wires^[1]
M.A. Ratner et. al.^[2]
"...failure to measure transport when built on meta-positions..."

≥ 4 -terminal: junctions ... no examples logic elements, AND-gate:

AND circuit diagram

Ain	Bin	Cout
1	1	1
0	1	0
1	0	0
0	0	0

C. Joachim et. al.^[3]
"...molecules remain based on 3-branch molecules..."

[1] J.Am.Chem.Soc., 1998, 120, 8486. [2] Ann. NY. Acad. Sci., 2002, 960, 153. [3] Chem. Phys. Lett., 2003, 367, 662.

7

Pamięć atomowa

<http://www.ipt.arc.nasa.gov/dastorage.html>

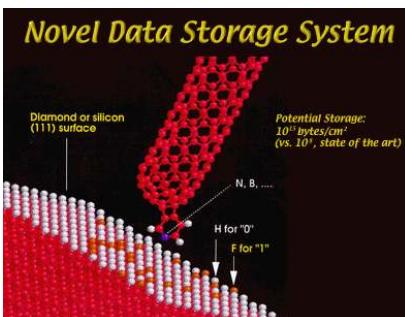
A novel data storage system capable of 10^{15} bytes/cm 2 is being explored. In this system, H atoms would be designated as 0 and F atoms as 1. A tip that can distinguish between 0 and 1 rapidly and unambiguously is being investigated.

Novel Data Storage System

Diamond or silicon (111) surface

Potential Storage: 10^{15} bytes/cm 2 (vs. 10^4 , state of the art)

N, B, ..., H for "0" F for "1"



Pamięć atomowa

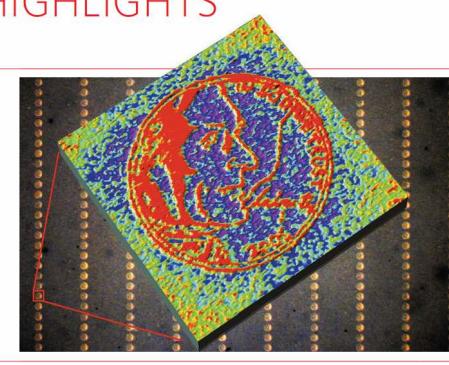
nature
Vol 443/5 October 2006

RESEARCH HIGHLIGHTS

The big draw
Angew. Chem. Int. Ed. 45, 1-4 (2006)
Fifty-five thousand pens, all writing at once, have been used to draw the same number of images of Thomas Jefferson in a square centimetre. Each portrait (pictured) is drawn with lines of dots 80 nanometres wide.

The 'pens' are silicon nitride tips attached to cantilevers and fixed side by side into a vast array by Chad Mirkin of Northwestern University in Evanston, Illinois, and his colleagues.

They used this equipment to perform massively parallel dip-pen nanolithography, in which 'ink' on the tips is transferred to a substrate at nanoscale resolution. This has a number of possible applications, and its use as a tool to build protein arrays for biological research is being explored.



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<http://www.fuw.edu.pl/~szczytko>

Ille bitów na atom?

Laser Light Microwave

a. **b.** **c.** **d.** **e.** **f.**

Illustration showing how to transform an electron from its usual state in an atom (a), in which it exists in a cloud of possible positions surrounding the positively charged nucleus (indicated by a plus sign), to a "Trojan state" (f), in which the electron orbits the nucleus like a planet around the sun. The name comes from Trojan asteroids, the asteroids which orbit the sun in the same orbit as Jupiter but in a place either ahead or behind the planet. To create a Trojan electron, researchers would first use laser light to put the electron into a "circular Rydberg state" in which the electron exists in a thin donut of possible positions (b). Then, a microwave beam would subsequently change the shape of the donut (c-e), shrinking the range of possible positions for the electron and ultimately causing the electron to shrink into a small droplet (or alternatively, a shortened sausage) of possible positions. This droplet then orbits the nucleus like a planet around the sun. Although not yet achieved experimentally, researchers believe that current technology could be applied to create Trojan electrons. The figure is not to scale—the circular Rydberg and Trojan states are actually hundreds of thousands of times farther away from the nucleus. In addition, the figure essentially shows just the top half of the probability cloud for the Trojan electron.

In recent computer simulations, researchers formed the word "optics" by calculating the electron cloud for a specially prepared $n=50$ state. In the image above, the intensity of the letters represents the relative probability for finding the electron at that place, and the color denotes the phase (relative point in the cycle) of the electron wave associated with that point in the cloud. (Image courtesy Carlos Stroud, University of Rochester, and Michael Noel.) This research is described by Carlos Stroud and Michael Noel in the April 1999 issue of [Optics and Photonics News](#).

W kolejnym tygodniu

Spintronika

Photograph by Felipe Fraga
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 National Geographic magazine, November 2007
 Volume 172

SPTN

W kolejnym tygodniu

Spintronika

FNP Fundacja na rzecz Nauki Polskiej
Nagroda FNP 2006 w obszarze nauk ścisłych:
 prof. dr hab. Tomasz Dietl z Instytutu Fizyki PAN oraz
 Instytutu Fizyki Teoretycznej Uniwersytetu Warszawskiego za
 opracowanie potwierzonej w ostatnich latach teorii
 rozcieńczonych półprzewodników ferromagnetycznych oraz
 zademonstrowanie nowych metod sterowania
 namagnesowaniem;

Alexander von Humboldt Research Award in Germany (2003),
 Agilent Technologies Europhysics Prize (2005)