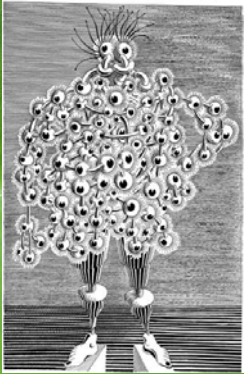


Nanotechnologia



Jacek.Szczytko@fuw.edu.pl Wydział Fizyki UW

Jak TO działa? <http://www.fuw.edu.pl/~szczytko/>



Google: Jacek Szczytko
 Login: student
 Hasło: *****

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Kwietniowa Wiedza i Życie 2010



ZMYŚLNE KROPKI

Wakacyjne pułki nanotechnologii (proteolizy, dostarczanie młodych do celu, terapia genowa i inżynieria genetyczna) – to tylko z kilku przykładów na szerokości nanotechnologii w medycynie.

W: **ARCHA WIEDZY, WISIA SZCZYTKO**

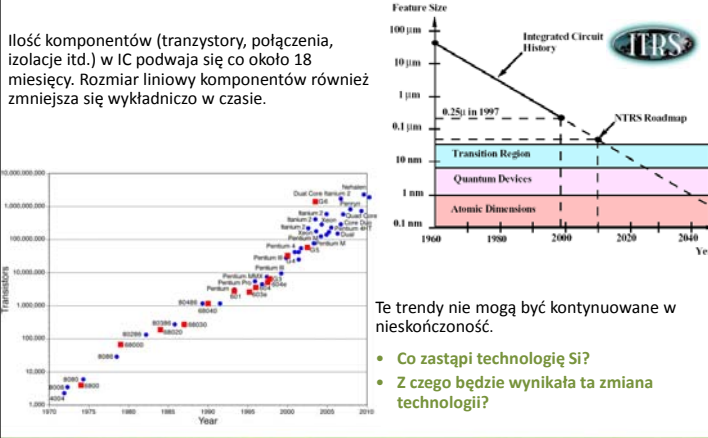
TAJEMNICZE OBIEKTÓW 0-WYMIAROWYCH

Wieloletnie badania nad nanotechnologią w dziedzinie fizyki i chemii, które doprowadziły do odkrycia nowych materiałów i urządzeń, które mogą być wykorzystane w wielu dziedzinach nauki i techniki.

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TRENDY: Prawo Moore'a

Ilość komponentów (tranzystory, połączenia, izolacje itd.) w IC podwaja się co około 18 miesięcy. Rozmiar liniowy komponentów również zmniejsza się wykładniczo w czasie.

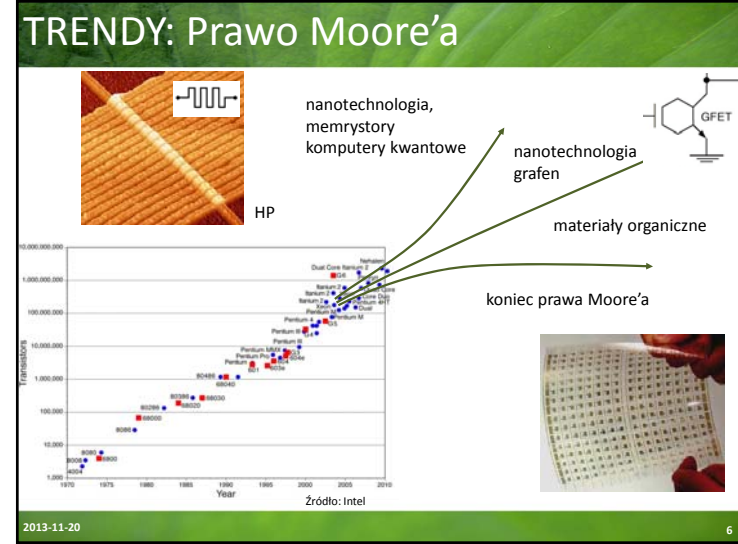
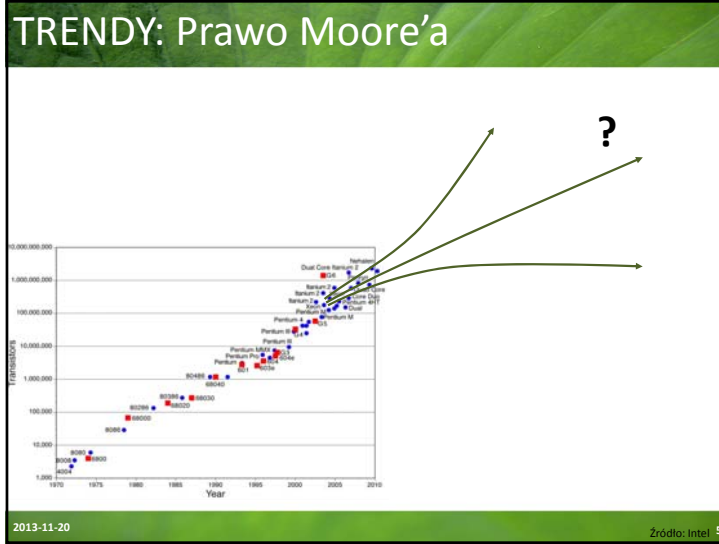


The graph shows a logarithmic scale of transistor counts (left y-axis, 1,000 to 10,000,000,000) and feature size (right y-axis, 100 μm to 0.1 μm) from 1970 to 2010. A dashed line represents Moore's Law, and a solid line represents the NTRS Roadmap. Key milestones include the 0.25 μm node in 1997 and the transition to Quantum Devices and Atomic Dimensions.

Te trendy nie mogą być kontynuowane w nieskończoność.

- Co zastąpi technologię Si?
- Z czego będzie wynikała ta zmiana technologii?

2013-11-20 Zródło: Intel 4



Nanotechnologia

2013-11-20

Nanotechnologia

10^{-9}
0,000 000 001

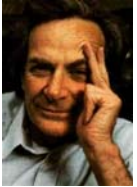
Nauka
Inżynieria
Technologia

a, b, c < 100 nm


WYDZIAŁ FIZYKI
UNIWERSYTET WARSZAWSKI

2013-11-20 8

Nanotechnologia




Richard P. Feynman, 1959
There's Plenty of Room at the Bottom
 Annual meeting of the American Physical Society at the California Institute of Technology (Caltech)



Norio Taniguchi of Tokyo science University first defined nanotechnology in 1974

"*Nano-technology* mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule."



Kim Eric Drexler, 1986
Engines of Creation (Grey goo)
Nanosystems: Molecular Machinery, Manufacturing and Computation

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WIZJA LOKALNA



STANISŁAW LEM
LOKALTERMIN
ROMAN



12.12.08
THE DAY THE EARTH
SHOOK
WIZJA LOKALNA

2013-11-20 10

Nanotechnologia na co dzień

Motoryzacja (Hummer H2 sport utility truck)



Budownictwo
Samoczyszczący się beton



Elektronika
Wyświetlacze OLED



Ubrania (Nano-Tex)



AGD
Samoczyszcząca się lodówka Samsung Nano SilverSeal



Kosmetyki




Sport



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Pokrycia NANO




Liść lotosu, photo: Y-T Cheng

pH 7.4
T = 26°C

Glucose = 0 g/L


Nature

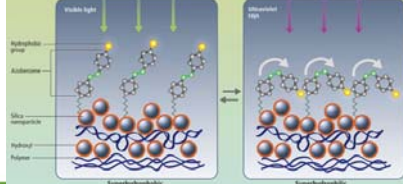
Glucose = 16.7 g/L



Żuk pustynny z Namib

na co dzień





Superhydrophobic

Scientific American

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Nanotechnologia na co dzień

 The Nobel Prize in Physics 2000



“The principal applications of any sufficiently new and innovative technology always have been - and will continue to be - applications created by that technology.”

Herbert Krömer

“Główne zastosowanie każdej nowej i innowacyjnej technologii zawsze było – i nadal będzie – zastosowaniem stworzonym przez tę technologię”

http://en.wikipedia.org/wiki/Herbert_Kroemer

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Nanotechnologia na co dzień

The \$585 suits that went on sale today (October 8, 2009) are treated with Titanium Dioxide, a chemical compound commonly used in cosmetics and toothpaste. According to company spokes-person Junko Hirohata, TiO2 has photocatalytic properties, meaning that it when exposed to light it breaks down organic materials.

Antiviral Business Suits Fight H1N1 Swine Flu With Science & Style




<http://www.haruyama.co.jp/>

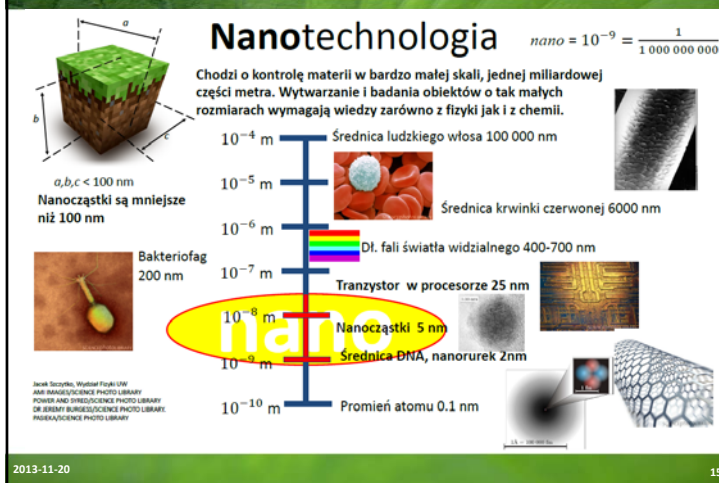
2013-11-20

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Nanotechnologia

$nano = 10^{-9} = \frac{1}{1\,000\,000\,000}$

Chodzi o kontrolę materii w bardzo małej skali, jednej miliardowej części metra. Wytwarzanie i badania obiektów o tak małych rozmiarach wymagają wiedzy zarówno z fizyki jak i z chemii.



- 10⁻⁴ m: Średnica ludzkiego włosa 100 000 nm
- 10⁻⁵ m: Średnica krwinki czerwonej 6000 nm
- 10⁻⁶ m: Dł. fali światła widzialnego 400-700 nm
- 10⁻⁷ m: Transzystor w procesorze 25 nm
- 10⁻⁸ m: Nanocząstki 5 nm
- 10⁻⁹ m: Średnica DNA, nanorurek 2nm
- 10⁻¹⁰ m: Promień atomu 0.1 nm

Additional notes:
 a, b, c < 100 nm: Nanocząstki są mniejsze niż 100 nm
 Bakteriofag 200 nm

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Dlaczego XXI w?



GORI
LOB
mili
mikro
nano

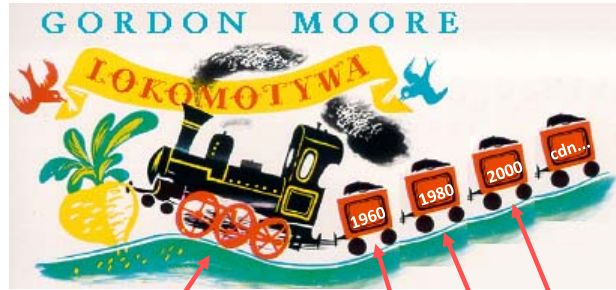
No-na-no?!!
To Nano!!!
Nano! Nano!
Nano! Nano!
Nano! Nano!
Nano! Nano!
Nano! Nano!
Czy jest na soli lekarz?

Parowóz dziejów
2000 cdn...

2013-11-20

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Dlaczego XXI w?

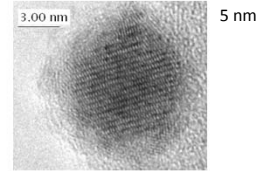


Parowóz dziejów
Przez ostatnie 40 lat na badania technologii krzemowej wydano bilion (ang. trillion) 10^{12} USD
mili mikro nano

2013-11-20

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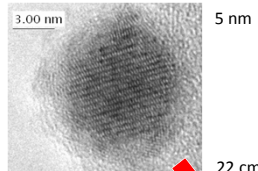
Nanotechnologia



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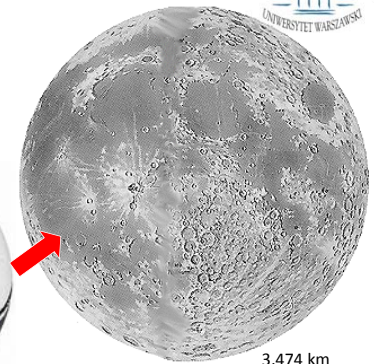
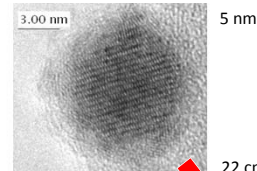
Nanotechnologia



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Nanotechnologia



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Nanotechnologia

| Group | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|--------------|----|----|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|--------|-----|-----|
| Period | | | | | | | | | | | | | | | | | | |
| 1 | H | | | | | | | | | | | | | | | | | He |
| 2 | Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| 3 | Na | Mg | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| 4 | K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| 5 | Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| 6 | Cs | Ba | * Lu | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| 7 | Fr | Ra | ** Lr | Rf | Db | Sg | Bh | Hs | Mt | Ds | Rg | Cn | Uut | Uuq | Uup | Uuh | Uus | Uuo |
| *Lanthanoids | | | * 57 La | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm | 63 Eu | 64 Gd | 65 Tb | 66 Dy | 67 Ho | 68 Er | 69 Tm | 70 Yb | | |
| **Actinoids | | | ** 89 Ac | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu | 95 Am | 96 Cm | 97 Bk | 98 Cf | 99 Es | 100 Fm | 101 Md | 102 No | | |

http://www.webelements.com/

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Efekty kwantowe

CdSe/ZnS 1-10 nm <http://www.nanopicoftheday.org/2003Pics/QDRainbow.htm>

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Studnia skończona

Wewnątrz studni: $-\frac{a}{2} < z < \frac{a}{2}$

$$-\frac{\hbar^2}{2m_0m_W} \frac{d^2}{dz^2} \psi(z) = (E_n - E_W) \psi(z)$$

$$\psi(z, t) = C \begin{cases} \cos(k_n z) \\ \sin(k_n z) \end{cases} e^{-i\omega_n t}$$

Bariera:

$$\frac{\hbar^2 \kappa^2}{2m m_B} = E_B - E_n = B$$

$$\psi(z) = D \exp(\pm \kappa_n z)$$

Warunki zszycia:

$$\frac{1}{m_B} \left. \frac{d\psi}{dz} \right|_{z=\frac{a}{2}} = \frac{1}{m_W} \left. \frac{d\psi}{dz} \right|_{z=\frac{a}{2}}$$

$$\frac{Ck}{m_W} \begin{cases} -\sin(k_n \frac{a}{2}) \\ \cos(k_n \frac{a}{2}) \end{cases} = -\frac{D\kappa}{m_B} \exp(k_n \frac{a}{2})$$

$k_n = \frac{1}{\hbar} \sqrt{2m_0m_W(E_n - E_W)}$

$\kappa_n = \frac{1}{\hbar} \sqrt{2m_0m_B(E_B - E_n)}$

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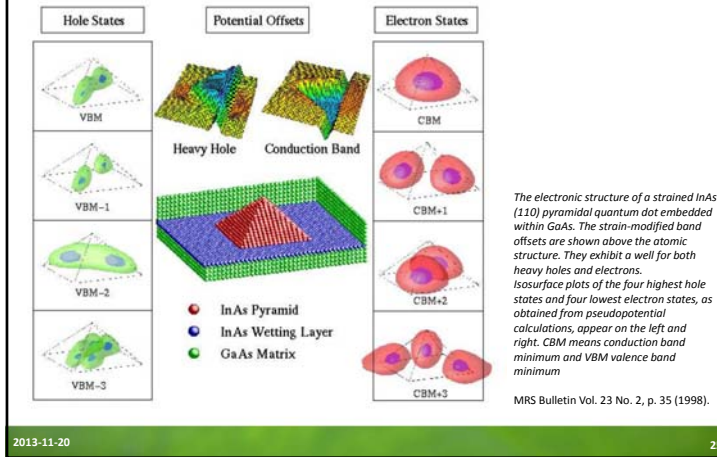
The development of the semiconductor laser diode after the first demonstration in 1962 J J Coleman Semicond. Sci. Technol. 27 (2012) 090207

Figure 5. Schematic diagrams depicting the evolution of the conduction band structure in the transverse direction: (a) double heterostructure, (b) separate confinement heterostructure (SCH), (c) graded-index separate confinement heterostructure (GRIN-SCH), (d) single quantum well heterostructure (QWH), and (e) multiple quantum well (MQW).

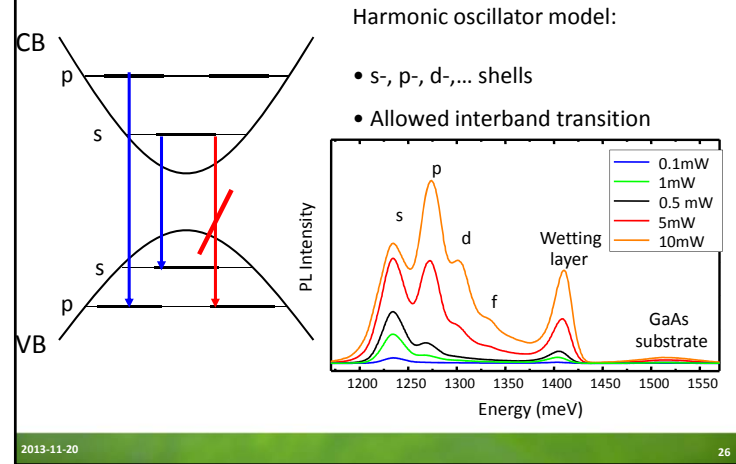
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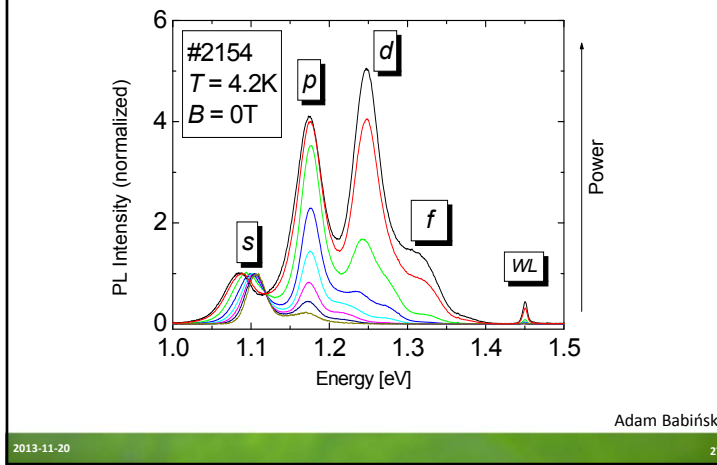
Potencjał harmoniczny 2D



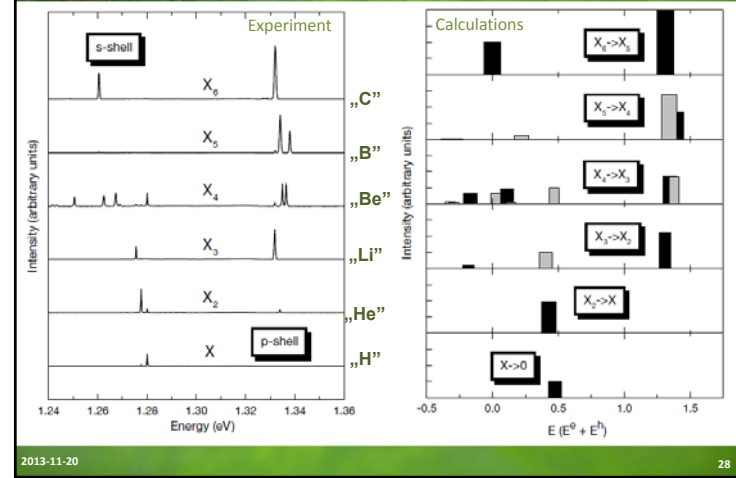
Potencjał harmoniczny 2D



Potencjał harmoniczny 2D



THE ARTICLE



Sferyczne kropki kwantowe

Przerwa energetyczna w sferycznych kropkach kwantowych [Brus, L. E. J. Phys. Chem. 1986, 90, 2555, Brus, L. E. J. Chem. Phys. 1984, 80, 4403]

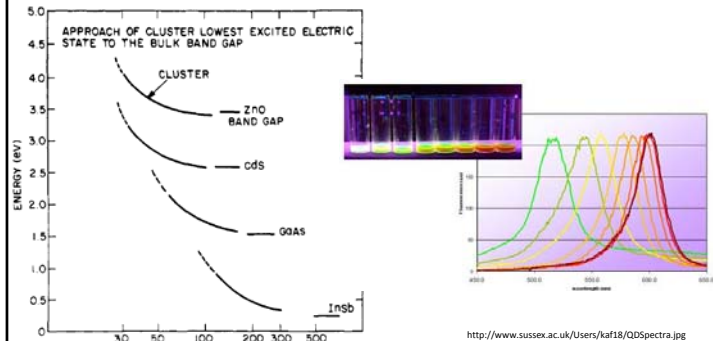


Figure 5. Calculated energy of the cluster lowest excited electronic state in relation to the bulk band gap. Adapted from ref 31.

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Sferyczne kropki kwantowe

Przerwa energetyczna w sferycznych kropkach kwantowych [Brus, L. E. J. Phys. Chem. 1986, 90, 2555, Brus, L. E. J. Chem. Phys. 1984, 80, 4403]

$$E_g^s(R) = E_g^{bulk} + \frac{\hbar^2 \pi^2}{2R^2 m_0} \left(\frac{1}{m_e} + \frac{1}{m_h} \right) - \frac{1.8e^2}{4\pi\epsilon\epsilon_0 R} \quad R - \text{średnica}$$

Lokalizacja kwantowa (quantum localization): mniejsza cząstka – więcej wektorów k potrzebnych do opisu stanu nośnika. Czyli cząstka w studni ZWIĘKSZA energię przerwy

Część kulombowska oddz. $e - h$ z uwzględnieniem polaryzacji (sfera) OBNIŻA energię. Potencjał obliczony dla funkcji w postaci $\Psi_n(r)$ ($n = 1$):

$$E_n = \frac{\hbar^2 k_n^2}{2m} = \frac{\hbar^2 n^2 \pi^2}{2mL^2} \quad \Psi_n(r) = \frac{C_n}{r} \sin\left(\frac{n\pi r}{R}\right)$$

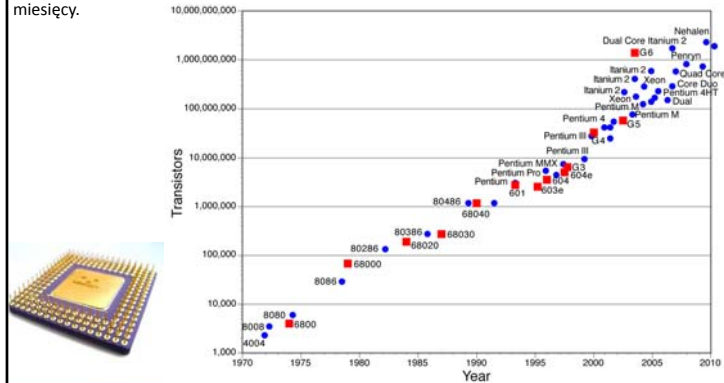


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TRENDY: Prawo Moore'a

Ilość komponentów (tranzystory, połączenia, izolacje itd.) w IC podwaja się co około 18 miesięcy.

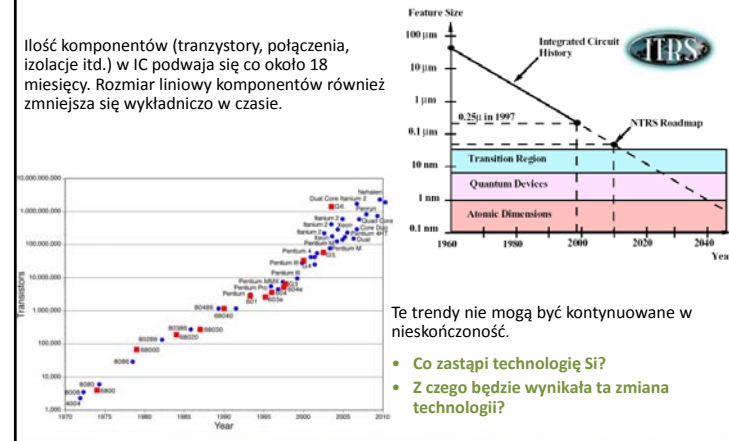


2013-11-20

Zródło: Intel 31

TRENDY: Prawo Moore'a

Ilość komponentów (tranzystory, połączenia, izolacje itd.) w IC podwaja się co około 18 miesięcy. Rozmiar liniowy komponentów również zmniejsza się wykładniczo w czasie.



Te trendy nie mogą być kontynuowane w nieskończoność.

- Co zastąpi technologię Si?
- Z czego będzie wynikała ta zmiana technologii?

2013-11-20

Zródło: Intel 32

Nanotechnologia

CO?

- Studnie, druty, kropki

JAK?

- Top-down, czyli (nano)technologia
- Bottom-up, czyli samoorganizacja

2013-11-20

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Nanotechnologia

CO?

- Studnie, druty, kropki

JAK?

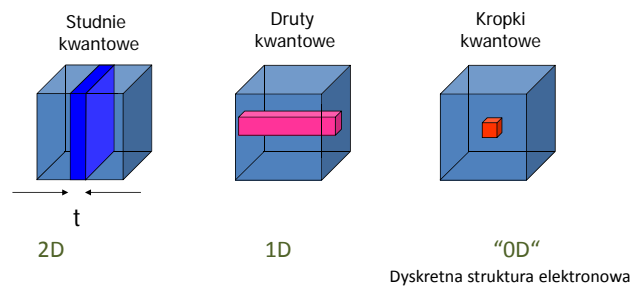
- Top-down, czyli (nano)technologia
- Bottom-up, czyli samoorganizacja

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Struktury niskowymiarowe

Low-dimensional Semiconductor Systems



Hubert J. Krenner

2013-11-20

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Bottom-up ↑



2013-11-20

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inżynieria
nanostruktur

Nano+bio

Nano i bio (gekon)



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Nano i bio (gekon)

50x




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

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Nano i bio (gekon)

100x

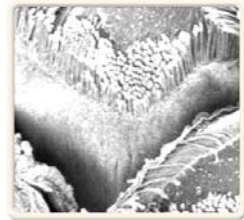


<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

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Nano i bio (gekon)

200x



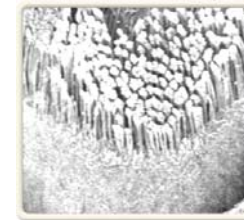
<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

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Nano i bio (gekon)

400x



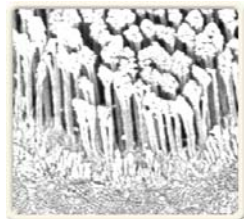
<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

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Nano i bio (gekon)

800x



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

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Nano i bio (gekon)

1500x



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

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Nano i bio (gekon)

3000x



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

2013-11-20

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Nano i bio (gekon)

6000x



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

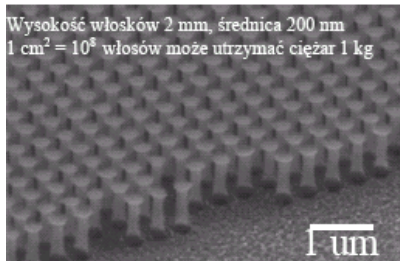
2013-11-20

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Nano i bio (gekon)

6000x

Wysokość włosków 2 mm, średnica 200 nm
 $1 \text{ cm}^2 = 10^8$ włosków może utrzymać ciężar 1 kg

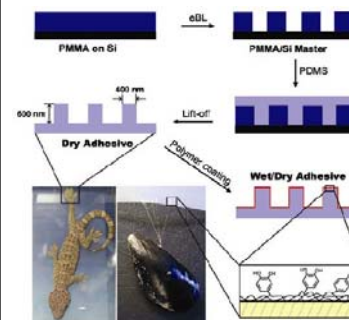


<http://www.microscopy.fsu.edu/primer/java/electronmicroscopy/magnify1/index.html>

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Nano i bio (gekon)



Nature 448, 338-341 (19 July 2007)

2013-11-20



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Nano i bio (DNA)

nature nanotechnology LETTERS PUBLISHED ONLINE 16 AUGUST 2009 | DOI: 10.1038/NNANO.2009.235

Placement and orientation of individual DNA shapes on lithographically patterned surfaces

Ryan J. Kershner¹, Luisa D. Bozano¹, Christine M. Mische¹, Albert M. Hung¹, Ann R. Fornoff¹, Jennifer N. Cha¹, Charles T. Rettner¹, Marco Bersani¹, Jane Frommer¹, Paul W. K. Rothemund^{1*} and Gregory M. Wallraff^{2*}

¹IBM Almaden Research Center, San Jose, California 95120, USA.

Figure 1 | The problem of random DNA nanostructure deposition and a lithographic scheme for addressing it. **a**, Synthetic scheme for DNA origami triangles (left) and atomic force microscopy height image (right) showing random deposition on mica. The triangles' edges are ~127 nm; scale bar, 100 nm. **b**, Fabrication of DNA origami binding sites. The inset highlights differentiation of the background and features (background/features) for the trimethylsilyl (TMS) monolayer and diamond-like carbon (DLC) films. Silanol groups occur in oxidized areas of the TMS monolayers. Features etched into the ~10-nm DLC template layer are 0.5–1.5 nm deep. No silicon is exposed; such surfaces have DLC features on a DLC background, and so we refer to them as 'DLC/DLC'.

2013-11-20 53

Nano i bio (DNA)

nature nanotechnology LETTERS PUBLISHED ONLINE 16 AUGUST 2009 | DOI: 10.1038/NNANO.2009.235

Placement and orientation of individual DNA shapes on lithographically patterned surfaces

Ryan J. Kershner¹, Luisa D. Bozano¹, Christine M. Mische¹, Albert M. Hung¹, Ann R. Fornoff¹, Jennifer N. Cha¹, Charles T. Rettner¹, Marco Bersani¹, Jane Frommer¹, Paul W. K. Rothemund^{1*} and Gregory M. Wallraff^{2*}

Figure 4 | Placement of triangles onto a variety of shapes. **a**, Scheme showing how one, two, three, four or six DNA triangles are expected to bind sites with the shape of a unit triangle, rhombus, trapezoid, double-sized triangle and heptagon. **b**, AFM of results on DLC/DLC unit triangle in ~100 nm. Yellow outlines highlight examples with well-oriented triangles bound. Scanning electron micrograph of Au/Cu islands on Si created by IBM using a similar electron-beam pattern. These IBM-generated patterns are used to calibrate the electron-beam dose (c) to optimize the sharpness of shapes and (d) to ensure complete resist removal (if incomplete, islands do not adhere). Scale bar, 1 μm.

¹IBM Almaden Research Center, San Jose, California 95120, USA. ²Department of Bioengineering, Computer Science, and Computational & Neural Systems, California Institute of Technology, Pasadena, California 91124, USA. *Present address: University of Wisconsin, Madison, Wisconsin 53706, USA (R.J.K.); The National Academies, Washington DC 20005, USA (C.M.M.); Department of Nanoeengineering, University of California, San Diego, California 92093, USA (A.M.H.); ILLIC, Center for Nanoelectronics, Ludwig-Maximilians-Universität, 80333 Munich, Germany (J.N.C.); Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania 19107, USA (P.W.K.R.); Department of Chemistry, University of California, San Diego, California 92092, USA (G.M.W.).

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Nano i bio (DNA)

nature International weekly journal of science

nature.com > Journal home > Table of Contents

Letter

Nature 459, 73–76 (7 May 2009) | doi:10.1038/nature07971 | Received 9 November 2008; Accepted 6 March 2009

Self-assembly of a nanoscale DNA box with a controllable lid

Figure 1 | Self-assembly of a nanoscale DNA box with a controllable lid. **a**, AFM images of DNA boxes. **b**, 3D atomic models of DNA boxes. **c**, AFM images of DNA boxes with lids. **d**, AFM images of DNA boxes with lids. **e**, Plot of height vs. q for DNA boxes.

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Nano i bio (DNA)

nature International weekly journal of science

nature.com > Journal home > Table of Contents

Letter

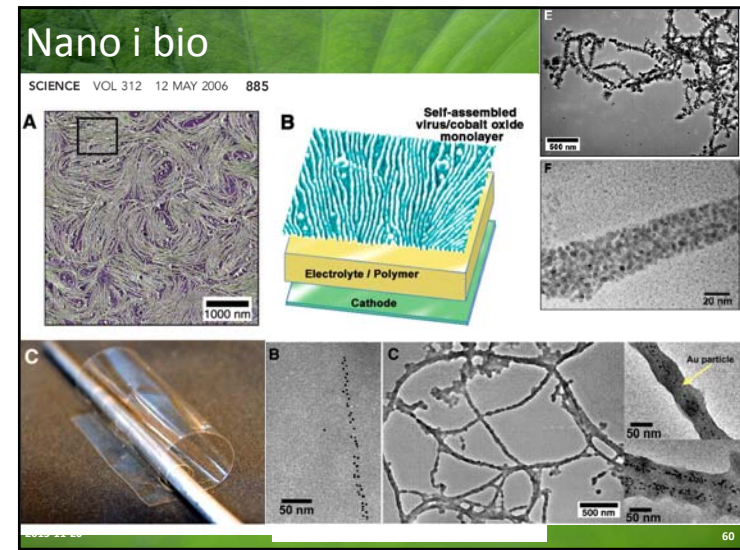
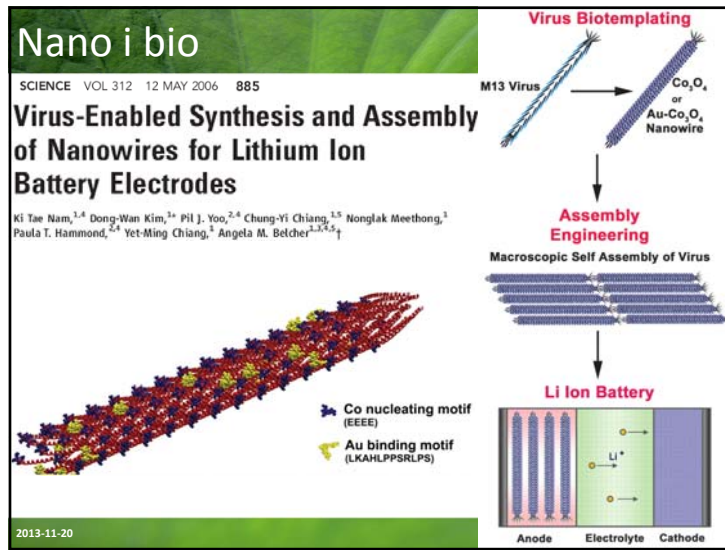
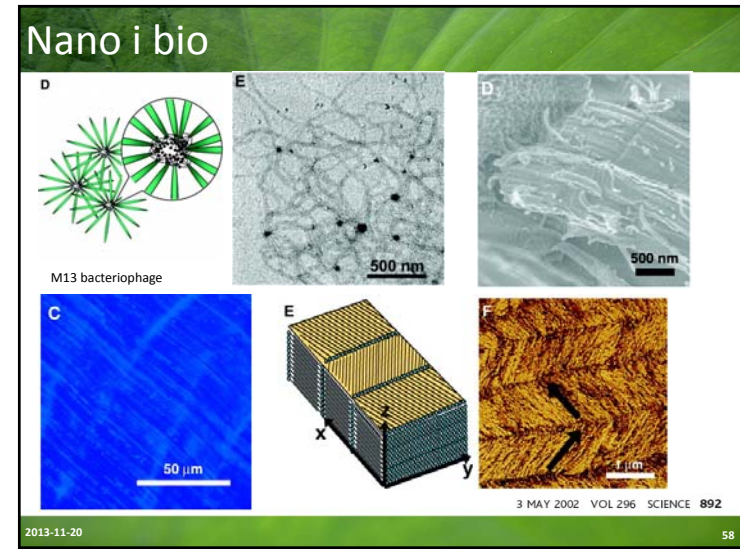
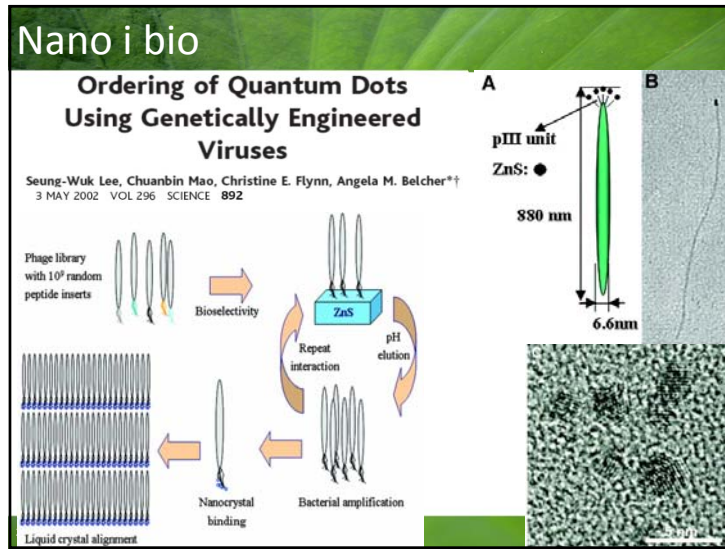
Nature 459, 73–76 (7 May 2009) | doi:10.1038/nature07971 | Received 9 November 2008; Accepted 6 March 2009

Self-assembly of a nanoscale DNA box with a controllable lid

Supplementary Figure 1. Mechanism for signal-induced opening of the DNA box.

a, An atomic model of the DNA box held closed by "locks" (orange and blue) that are double helices formed by two short strands protruding from the lid and the main box, respectively. Each "lock" has a small sticky-end where a "key" sequence signal can bind and open the "lock" by strand displacement. If both "locks" are opened the lid of the box is effectively opened (**b**). The reporter system for detecting the lid opening is a Cy3-Cy5 FRET system. In the closed state the two fluorophores are in close proximity resulting in FRET emission from Cy5 (red star) when Cy3 is excited. In the open state

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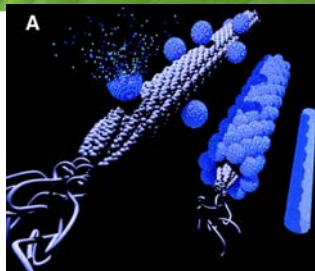


Nano i bio

SCIENCE VOL 303 9 JANUARY 2004 213

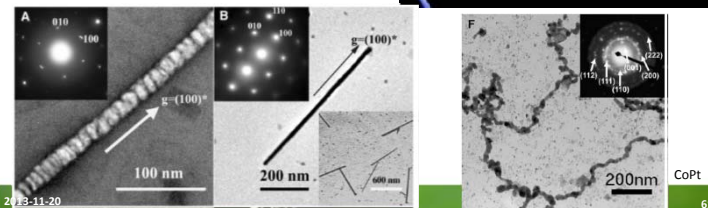
Virus-Based Toolkit for the Directed Synthesis of Magnetic and Semiconducting Nanowires

Chuanbin Mao,^{1*} Daniel J. Solis,^{4*} Brian D. Reiss,⁵ Stephen T. Kottmann,⁴ Rozamond Y. Sweeney,² Andrew Hayhurst,² George Georgiou,^{2,3} Brent Iverson,^{1,2} Angela M. Belcher^{2,3}



A

ZnS



B

F

CoPt

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Nano i bio

Magnetic Glyco-nanoparticles: A Unique Tool for Rapid Pathogen Detection, Decontamination, and Strain Differentiation

Kheireddine El-Rouboui,¹ Cyndee Gruden,¹ and Xuefei Huang^{1,*}
 J. AM. CHEM. SOC. 2007, 129, 13392–13393
 Published on Web 10/12/2007

JACS COMMUNICATIONS

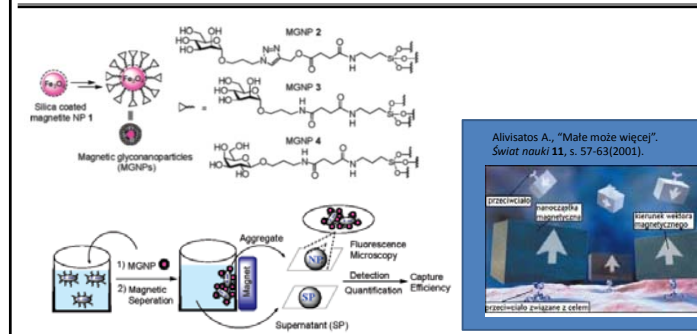


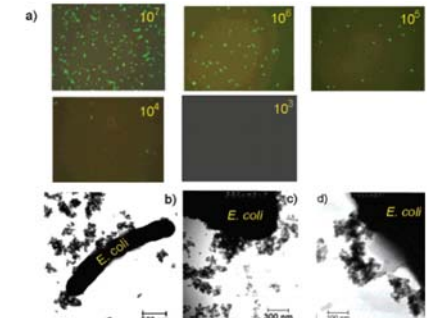
Figure 1. Schematic demonstration of pathogen detection by MGNPs.

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Nano i bio

Magnetic Glyco-nanoparticles: A Unique Tool for Rapid Pathogen Detection, Decontamination, and Strain Differentiation

Kheireddine El-Rouboui,¹ Cyndee Gruden,¹ and Xuefei Huang^{1,*}
 JACS COMMUNICATIONS
 Published on Web 10/12/2007



a)

b)

c)

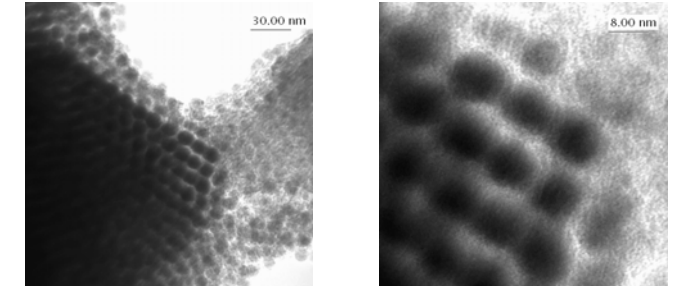
d)

E. coli

Figure 2. (a) Representative fluorescence microscopic images of captured *E. coli*. The concentration (cells/mL) of bacteria incubated with MGNP 3 is indicated on each image (see Supporting Information for experimental details). (b–d) TEM images of MGNP 3/*E. coli* complexes.

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Nano i bio




Nano-Co

Nano-Co

Synteza: Paweł Majewski, TEM: Jolanta Borysiuk

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Nano i bio



UNIVERSITAS
SOMMENSIS

Bacillus megatherium + nano Fe₃O₄

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Nano i bio

DNA w nanotechnologii

Uczonim udało się wykorzystać DNA do stworzenia kryształów złota. Dzięki temu osiągnięciu powstają zupełnie nowe materiały.

JAK POWSTAŁ KRYSTAŁ Z DNA?

- Do kulek złota (nanocząstek X i Y) o średnicy 10 nanometrów przytworzone nici syntetycznego DNA różnej długości.
- Nici DNA na cząsteczkach X i Y uzupełniają się, kiedy spotykają się w odpowiednich warunkach, łącząc się i powstaje podwójna helisa DNA znana ze wszystkich żywych organizmów.
- Po zamieszczeniu w wodzie w odpowiednich warunkach cząsteczek X i Y zaczęły one łączyc się.
- Łącząc się za pomocą DNA nanocząsteczki utworzyły kryształ złota. Powstała w ten sposób struktura o kształcie się w 3D, z nanocząsteczek w 5 proc. z DNA. Pozostałe 95 proc. wypełniła woda. Można roznie zastąpić innymi materiałami.

ZASTOSOWANIE

- Nowy materiał może przysłużyć do budowy supermateriałów i mikroczipów.
- Zastosowanie nowego materiału w laserach może zwiększyć ich potencjał.
- Z nowymi substancjami powstają wyjątkowo lekkie i silne.

Chad Mirkin z Northwestern University Brookhaven National Laboratory (BNL)
http://www.dziennik.pl/nauka/article116681/Naukowcy_stworzyli_materie_nieznana_dotad_na_ziemi.html

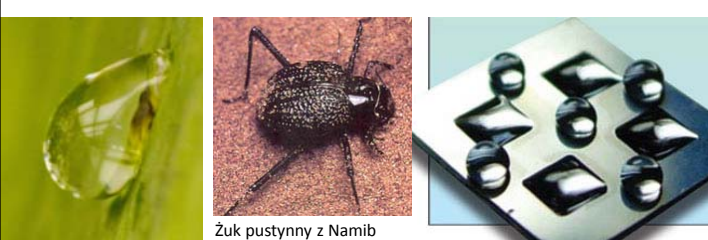
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Inżynieria nanostruktur

Nowe urządzenia


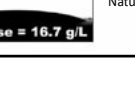
2013-11-20 67

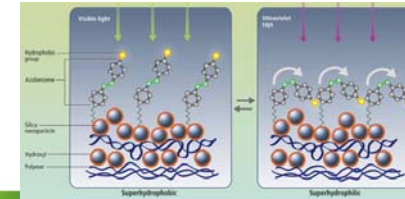
Pokrycia NANO



Żuk pustynny z Namib

Liść lotosu, photo: Y-T Cheng

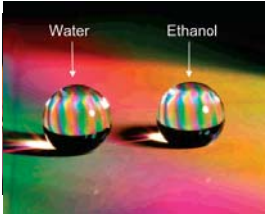
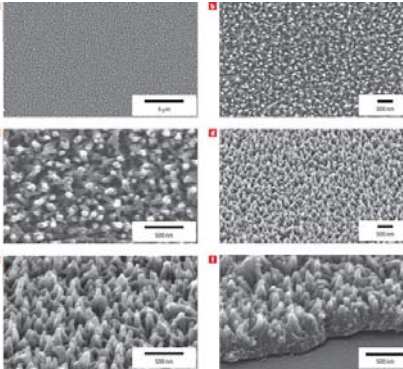
| | | |
|--------------------|---|------------------|
| pH 7.4 T = 26°C |  | Nature |
| | Glucose = 0 g/L | |
| |  | Superhydrophobic |
| | Glucose = 16.7 g/L | |



Scientific American 68

Pokrycia NANO

<http://www.nanowerk.com/spotlight/spotid=3032.php>

University of Wisconsin-Madison and Bell Laboratories

Nan-Rong Chiu, Chunmeng Lu, Jingjiao Guan, L. James Lee & Arthur J. Epstein
Nature Nanotechnology 2, 354 - 357 (2007) Published online: 27 May 2007

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Nano-barcode

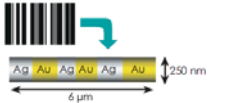
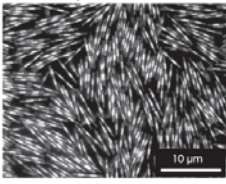
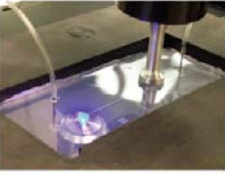
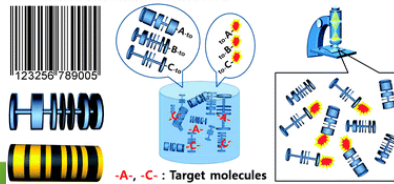





Figure 1. Optical microscope image of Nanobarcodes™ particles.

Figure 3. Microfluidic card in use. The card interfaces with the microscope, automated fluidics, an ultrasonic transducer for mixing, and a capture electromagnet with focusing cone (located beneath the card).

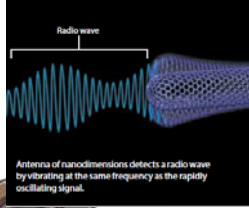
123256789005

-A-, -C- : Target molecules

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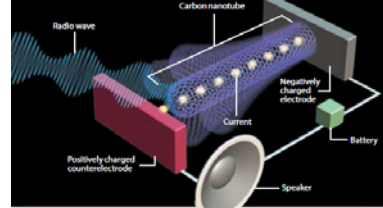
Nowe urządzenia

RECEPTION



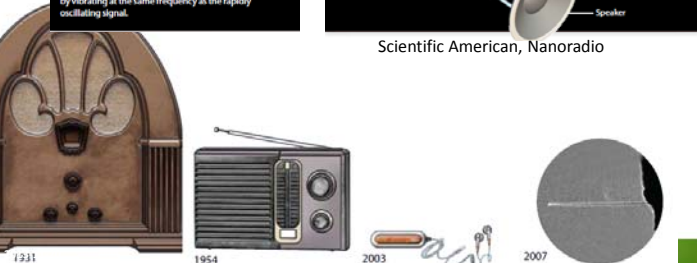
Antenna of nanodimensions detects a radio wave by vibrating at the same frequency as the rapidly oscillating signal.

NANOTUBE RADIO



Carbon nanotube
Radio wave
Positively charged counterelectrode
Current
Negatively charged electrode
Battery
Speaker

Scientific American, Nanoradio



1931 1954 2003 2007

71



Fotonika

2013-11-20 72

Biologiczne kryształy fotoniczne


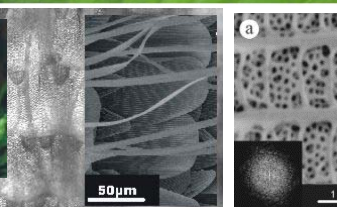
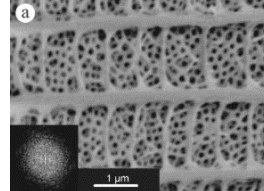



http://www.mfa.kfki.hu/int/nano/online/2002_butterfly/


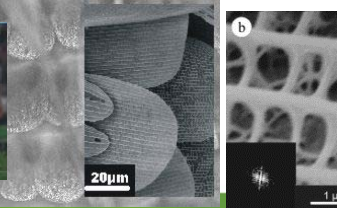
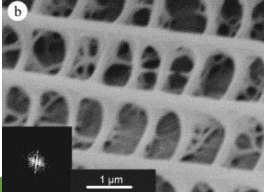



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Biologiczne kryształy fotoniczne

http://www.mfa.kfki.hu/int/nano/online/2002_butterfly/

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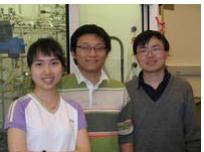
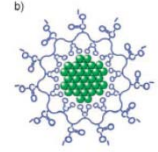
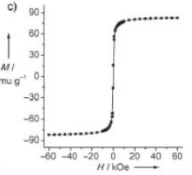
Magnetyczne kryształy fotoniczne

VIP Photonic Crystals DOI: 10.1002/anie.200701992

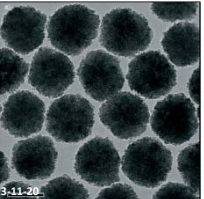
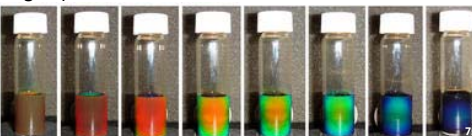
Highly Tunable Superparamagnetic Colloidal Photonic Crystals^{***}

Jianping Ge, Yongxing Hu, and Yadong Yin*

Angewandte Chemie

Fe_3O_4 120 nm

UCRIVERSIDE Newsroom

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Magnetyczne kryształy fotoniczne

VIP Photonic Crystals DOI: 10.1002/anie.200701992

Highly Tunable Superparamagnetic Colloidal Photonic Crystals^{***}

Jianping Ge, Yongxing Hu, and Yadong Yin*

Angewandte Chemie

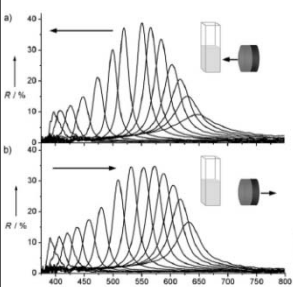
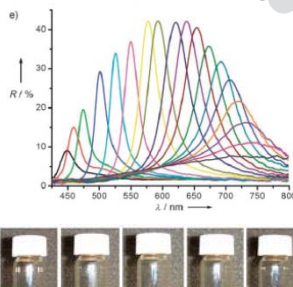
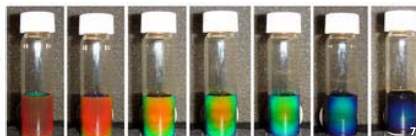



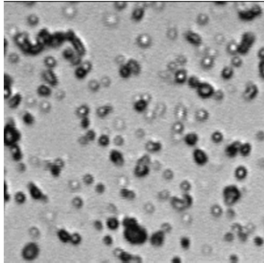
Figure 3. Reversible optical responses of 93 nm Fe_3O_4 colloidal photonic crystals to varying external magnetic field. Diffraction peaks blue-shift (a) as the magnet-sample distance decreases from 3.1 to 1.8 cm, and red shift (b) as the distance increases from 1.8 to 3.1 cm in step sizes of 0.1 cm in both cases.



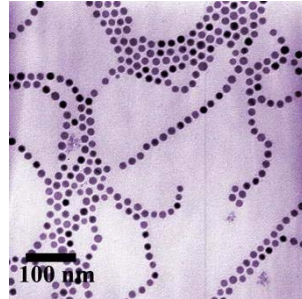
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Magnetyczne kryształy fotoniczne

Zawiesina nanomagnesów w polu magnetycznym



Piotr Habdas



Chains of 1 million magnetic nanoparticles have been assembled and disassembled in a solution of suspended particles in a controlled way, scientists at the National Institute of Standards and Technology (NIST) report.

<http://www.physics.emory.edu/~weeks/lab/pics.html>

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Co dalej?

- Nanotechnologia – kontrola materii w nanoskali – jest szansą dla nauk biologicznych i medycznych w badaniach, diagnostyce i terapii.
- Badania nad nanotechnologią i jej zastosowaniami prowadzą do problemów etycznych (ale jakie badania nie prowadzą?)
- Istnieją technologie niebezpieczne i akceptowalne społecznie (np. samochody) i bezpieczne i nieakceptowalne społecznie (np. energetyka jądrowa, GMO)
- Nowe technologie wymagają społecznej akceptacji – powinni o nią zabiegać sami naukowcy
- Dbanie o bezpieczeństwo nowych technologii jest w interesie społeczeństwa i samych naukowców

Inżynieria
nanostruktur

2013-11-20

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Podsumowanie

Demonstracja uliczna w Grenoble przeciwko otwarciu MINATEC (1 lipca 2006)

LE 1er JUIN 2006
TOUTES ET TOUS
A GRENoble
CONTRE L'INAUGURATION DE
MINATEC !



Jacek Majewski

„nanotechnologia = nekrologia
– przeciw nanoproszkom i nanorobotom”

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Podsumowanie



4/08/2007 2:48 © NICKINICI Cartoons www.nickinici.com.au

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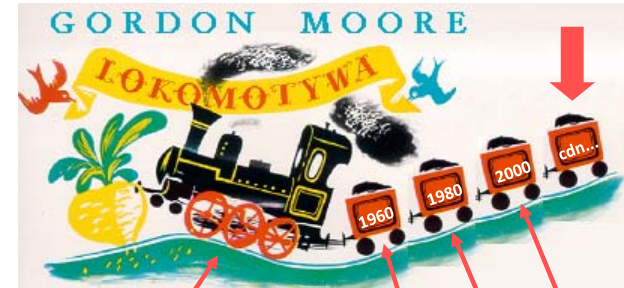
Podsumowanie



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Co dalej?



Parowóz dziejów

Przez ostatnie 40 lat na badania technologii krzemowej wydano bilion (ang. trillion) 10^{12} USD

mili

mikro

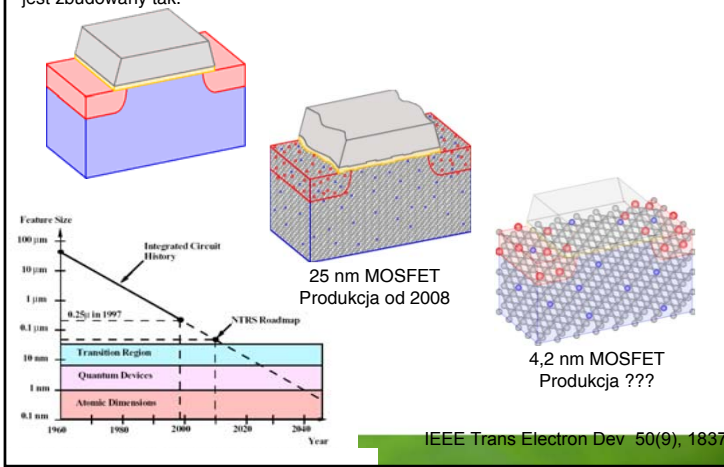
nano

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Granice miniaturyzacji?

Mylimy, że tranzystor jest zbudowany tak.



State-of-the-Art: Electronic Circuits

From macroscopic copper (~1 μm) to nanoscale electronics organic molecules (~0.3-3 nm)

Source

Gate

Drain

wire: C#CC1=CC=CC=C1C#CC2=CC=CC=C2C#C

diode: C#CC1=CC=C(C=C1)C(C)C2=CC=C(C=C2)C#C

transistor: (FET) C#CC1=CC=C(C=C1)C(C)C2=CC=C(C=C2)C#CC3=CC=C(C=C3)C#CC4=CC=C(C=C4)C#C

barrier: -CH₂- -CH₂CH₂-

≥4-terminal complex logic elements

≥3- and 4-terminal junction

6

Jaszowiec 06/06/05

Ile 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](#).**

Inżynieria nanostruktur

nano-bio

Synteza kropek kwantowych

CdSe/ZnS 1-10 nm <http://www.nanopicoftheday.org/2003Pics/QDRainbow.htm>

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Chemia!

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

Pracownia Elektrochemii

Nanogaleria

12 small images with captions in Polish, including: Nanorurki z polidoksyd w nanoscale, Nanokrystaliki palladu, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd, Nanokrystaliki palladu w matrycy z polidoksyd.

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Sferyczne kropki kwantowe

<http://www.medicine.tcd.ie/molecular-medicine/gallery/pictures/scientific-pictures.php>

Molecular Medicine
Department of Clinical Medicine

Scientific Pictures

Grid of scientific images including fluorescence microscopy and electron microscopy.

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Sferyczne kropki kwantowe

<http://www.microscopyu.com/articles/fluorescence/index.html>

MICROSCOPY U
THE SOURCE FOR MICROSCOPY ASSOCIATION

Fluorescence Microscopy

Grid of scientific images and a 'Review Articles' section with text about fluorescence microscopy.

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Nanorurki, nanowasy i kropki

TiO2 nanotube materials

5 nm
ZnO
nanocząstka Au 20 nm
Nanorurka Si
Wysokość włókno 2 mm, średnica 200 nm
1 cm² = 10⁶ włókno może utrzymać ciężar 1 kg
DNA
10.0 ps
www.ee.leeds.ac.uk/nanoms/modules1.php

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Kropki kwantowe + bio

T2-MP EVITAGS
Non-heavy Metal - InP Based, Water Stabilized Quantum Dots

A PbSe Quantum Dot as seen through a transmission electron microscope (TEM).

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

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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

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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

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Magnetyczne kropki kwantowe

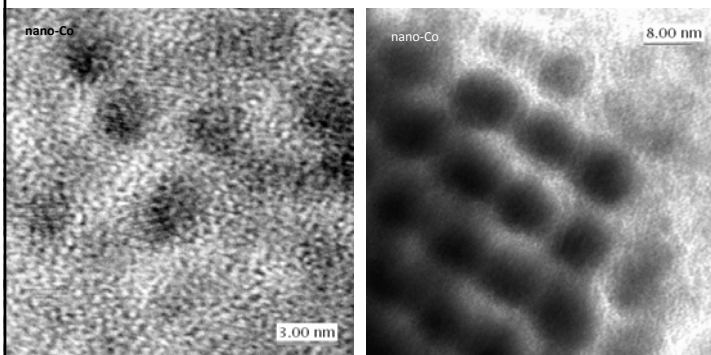
WYDZIAŁ FIZYKI
 Uniwersytetu Warszawskiego

Jacek Szczykło

Michał Bystrzejewski, Andrzej Huczko, Hubert Lange

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Magnetyczne kropki kwantowe



Jacek Szczytko

Pracownia Fizykochemii Dielektryków i Magnetyków
Ewa Górecka, Paweł Majewski, Jadwiga Szydłowska, Adam Króczyński

2013-11-20

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Magnetyczne kropki kwantowe



Photograph by Felice Frankel
© 2003 National Geographic Society. All rights reserved.
National Geographic magazine, November 2003

2013-11-20

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Magnetyczne kropki kwantowe

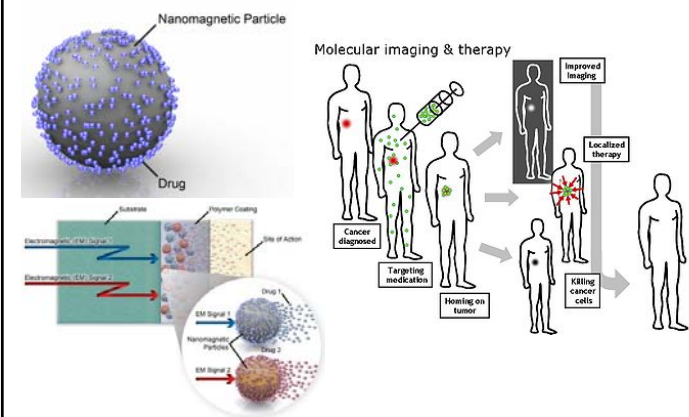


Akademia Górniczo Hutnicza

2013-11-20

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Magnetyczne kropki kwantowe



2013-11-20

http://www.biophan.com/index.php?option=com_content&task=view&id=262&Itemid=426 100

Magnetyczne kropki kwantowe

2013-11-20 http://www.biophan.com/index.php?option=com_content&task=view&id=262&Itemid=426 101

Magnetyczne kropki kwantowe

2013-11-20 C. Buzea et al. Nanomaterials and Nanoparticles: Sources and Toxicity. BioInterphases, 2007, 102

Zagrozenia



Paul Karason

Argyria

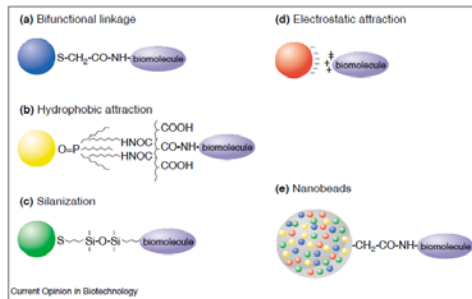
Nowe urządzenia

Glukometr z nanorurek, University of Illinois
<http://www.sciencedaily.com/releases/2004/12/041214081957.htm>

2013-11-20 Heath J., Davis M., Hood L., „Rak w sieci nano”, Świat Nauki 3, s. 32-39 (2010)

Sferyczne kropki kwantowe

Schematic illustration of bioconjugation methods. (a) Use of a bifunctional ligand such as mercaptoacetic acid for linking QDs to biomolecules [8**]. (b) TOPO-capped QDs bound to a modified acrylic acid polymer by hydrophobic forces. (c) QD solubilization and bioconjugation using a mercaptosilane compound [7**]. (d) Positively charged biomolecules are linked to negatively charged QDs by electrostatic attraction [9]. (e) Incorporation of QDs in microbeads and nanobeads [20**].



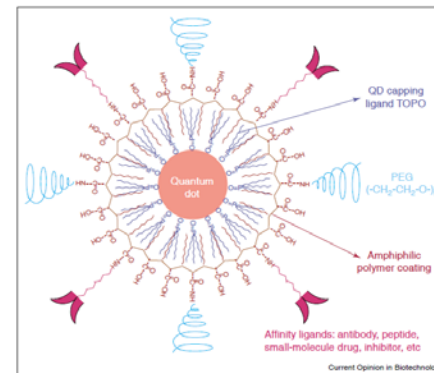
Luminescent quantum dots for multiplexed biological detection and imaging
W. Chan et al. Current Opinion in Biotechnology 2002, 13:40–46

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Sferyczne kropki kwantowe

In vivo molecular and cellular imaging with quantum dots Xiaohu Gao Current Opinion in Biotechnology 2005, 16:63–72



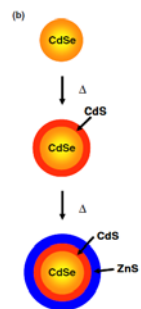
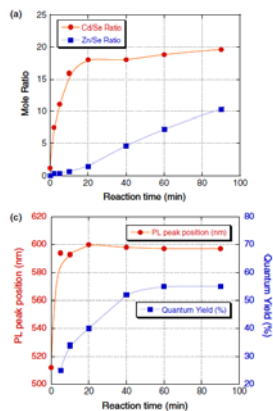
The structure of a multifunctional QD probe. Schematic illustration showing the capping ligand TOPO, an encapsulating copolymer layer, tumor-targeting ligands (such as peptides, antibodies or small-molecule inhibitors), and polyethylene glycol (PEG).

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Sferyczne kropki kwantowe

Synthesis of multi-shell nanocrystals by a single step coating process, Nanotechnology 2006



Quantum Yield = wydajność kwantowa

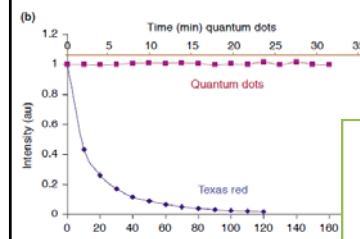
Wydajność kwantową fluorescencji definiuje się jako stosunek liczby wyemitowanych fotonów do liczby fotonów promieniowania wzbudającego, pochłoniętych przez substancję w tym samym czasie i tej samej objętości.

Figure 1. (a) Elemental ratios of Cd to Se and Zn to Se (measured by ICP), (b) a conceptual drawing of the CdSe core \rightarrow CdSe/CdS core/multi-shell structure, and (c) PL peak positions, and QYs of CdSe/CdS/ZnS nanocrystals taken at different time intervals during the reaction.

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Sferyczne kropki kwantowe

In vivo molecular and cellular imaging with quantum dots Xiaohu Gao Current Opinion in Biotechnology 2005, 16:63–72

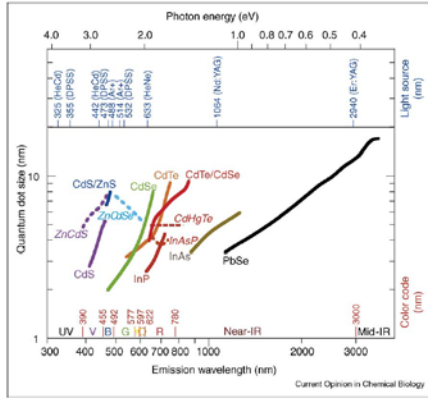


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Sferyczne kropki kwantowe

Current Opinion in Chemical Biology 2006, 10:423-429 *Nanoscale controlled self-assembled monolayers and quantum dots*

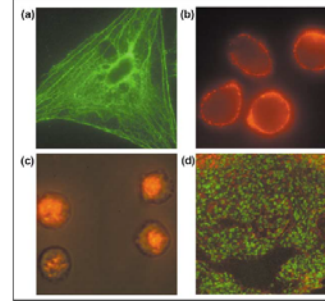


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Sferyczne kropki kwantowe

Figure 4

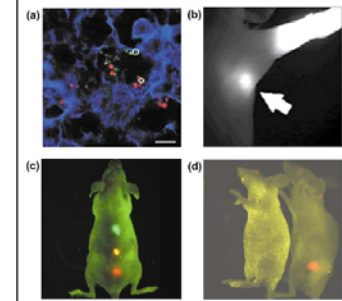


Fluorescence micrographs of QD-stained cells and tissues. (a) Actin staining (green QDs) on fixed 3T3 fibroblast cells. (b) Live MDA-MB-231 breast tumor cells labeled with a red QD-antibody conjugate targeting the urokinase plasminogen receptor. (c) Intracellular labeling of five mammalian cells using QD-Tat peptide conjugates [25**]. (d) Frozen tissue specimens stained with QDs (targeting the CXCR4 receptor, red) and a nuclear dye (green).

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In vivo molecular and cellular imaging with quantum dots
Xiaohu Gao Current Opinion in Biotechnology 2005, 16:63-72

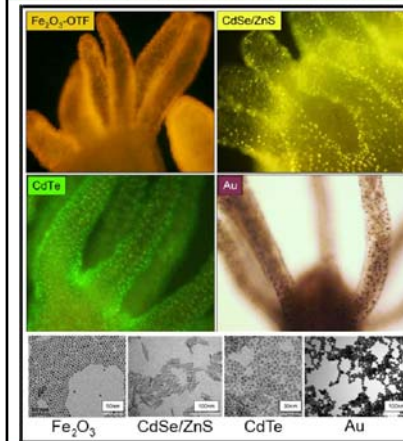
Figure 5



In vivo targeting and imaging with QDs. (a) Ex vivo tissue examination of QD-labeled cancer cells trapped in a mouse lung [44*]. (b) Near-infrared fluorescence of water-soluble type II QDs taken up by sentinel lymph nodes [42*]. (c) In vivo simultaneous imaging of multicolor QD-encoded microbeads injected into a live mouse [26**]. (d) Molecular targeting and in vivo imaging of a prostate tumor in mouse using a QD-antibody conjugate (red) [25**].

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Sferyczne kropki kwantowe



An Ancient Model Organism to Test In Vivo Novel Functional Nanocrystals
By Claudia Tortiglione
"Biomedical Engineering - From Theory to Applications", Edited by Reza Fazel-Rezaei

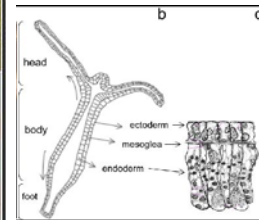


Figure 1. Anatomical structure of *Hydra vulgaris*

Figure 18. Labelling Hydra with nanocrystals

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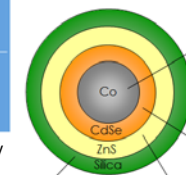
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Sferyczne kropki kwantowe

Magnetic Quantum Dot
What is MQD?

Justin Galloway

Composite with A Novel Structure for Active Sensing in Living cells

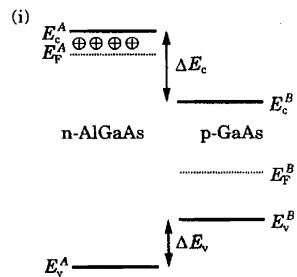


- Ⓞ Cobalt core: active manipulation**
 - diameter: ~10 nm
 - superparamagnetic NPs
 - manipulated or positioned by an external field without aggregation in the absence of an external field
- Ⓞ CdSe shell: imaging with fluorescence**
 - thickness: 3-5 nm
 - visible fluorescence (~450-700 nm)
 - ability to tune the band gap
 - by controlling the thickness, able to tune the emission wavelength, i.e., emission color
- Ⓞ Silica shell: bio-compatibility & functionalization with specific targeting group**
 - thickness: ~10 nm
 - bio-compatible, & non-toxic to live cell functions
 - stable in aqueous environment
 - ability to functionalize its surface with specific targeting group
- Ⓞ ZnS shell: electrical passivation**
 - thickness: 1-2 nm
 - having wider band gap (3.83 eV) than CdSe (1.91 eV)
 - enhancement of QY
 - CdSe (5-10%) ⇒ CdSe/ZnS (~50%)

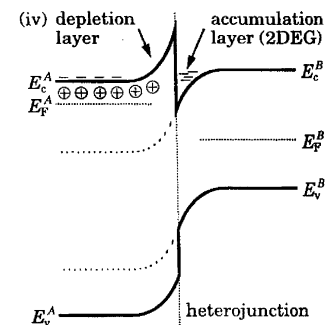
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Konstrukcja diagramów pasmowych



Konstrukcja diagramów pasmowych



Przesuwamy tymczasowo linie \bar{E}_c^A w E_c^A i \bar{E}_v^A w E_v^A , a następnie łączymy ze sobą w miejscu heterozłącza. Pojawiające się nieciągłości dopełniają szkic heterozłącza.

Kwietniowa Wiedza i Życie 2010

Struktury niskowymiarowe

Low-dimensional Semiconductor Systems

Studnie kwantowe

2D

Druty kwantowe

1D

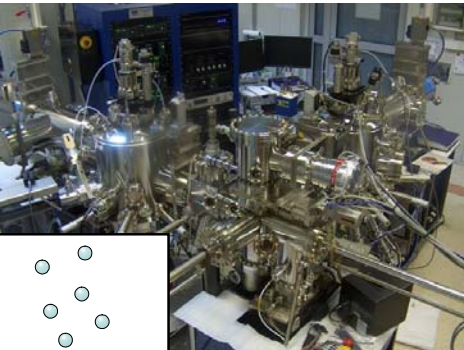
Kropki kwantowe

"0D"

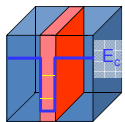
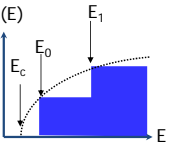
Dyskretna struktura elektronowa

Hubert J. Krenner

Jak się robi heterostruktury?



Quantum Well

MBE → Osadzanie z atomową precyzją warstw o różnym składzie lub domieszkowaniu

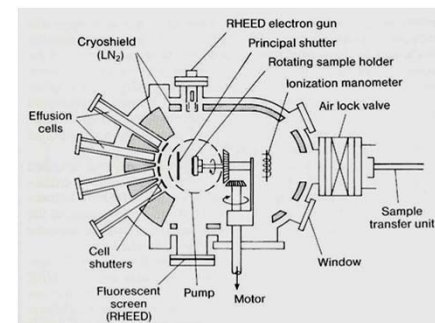
Hubert J. Krenner

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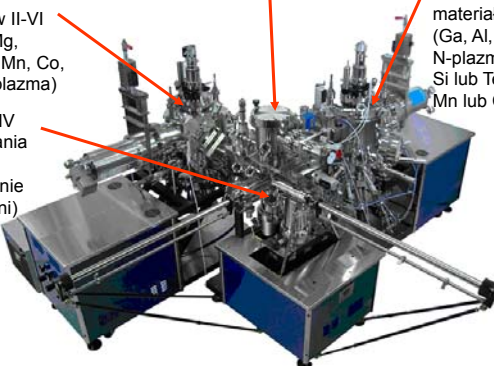
Jak się robi heterostruktury?

Wzrost warstw **MBE** jest monitorowany przez Reflection High Energy Electron Diffraction (REED). Komputer steruje przesłonami (shutterami) na froncie podgrzewanych komórek efuzyjnych, co pozwala na precyzyjną kontrolę wzrostu do poziomu pojedynczej warstwy atomowej.

Wzrost warstw z jamami kwantowymi (quantum wells), kropek kwantowych (quantum dots) – struktury LD, LED.



Jak się robi heterostruktury?



komora UHV wzrostu materiałów II-VI (Zn, Cd, Mg, S, Se, Te, Mn, Co, ZnCl₂, N-plazma)

komora UHV wzrostu materiałów III-V (Ga, Al, In, As, Sb, N-plazma, Si lub Te, Be lub Zn, Mn lub Cr lub Co)

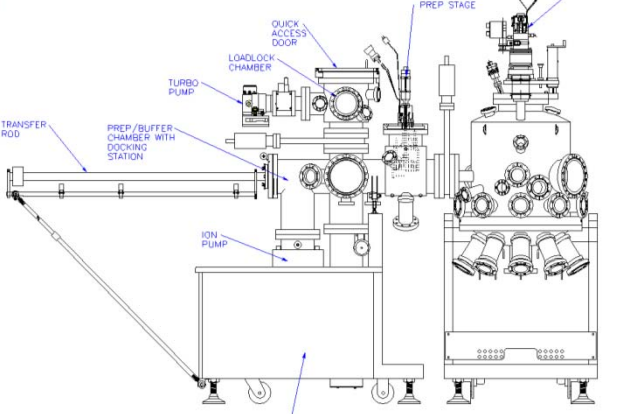
komora UHV przygotowania podłoży (odgazowanie powierzchni)

komora załadunkowa

Urządzenie MBE - do epitaksji z wiązek molekularnych (2 komory wzrostu) producent SVTA (USA). Zakup przez Wydział Fizyki w r. 2010, program CePT

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Jak się robi heterostruktury?



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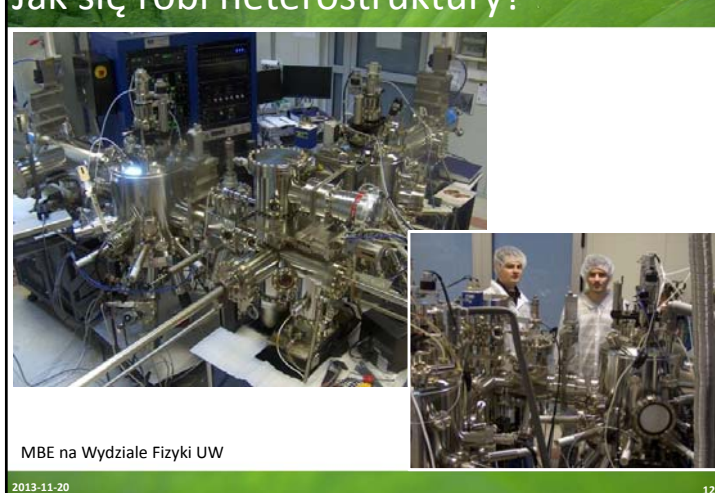
Jak się robi heterostruktury?



MBE na Wydziale Fizyki UW

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Jak się robi heterostruktury?



MBE na Wydziale Fizyki UW

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Jak się robi heterostruktury?

Reaktor Metal-Organic Chemical Vapour Epitaxy (MOCVD) w Zakładzie Fizyki Ciała Stałego



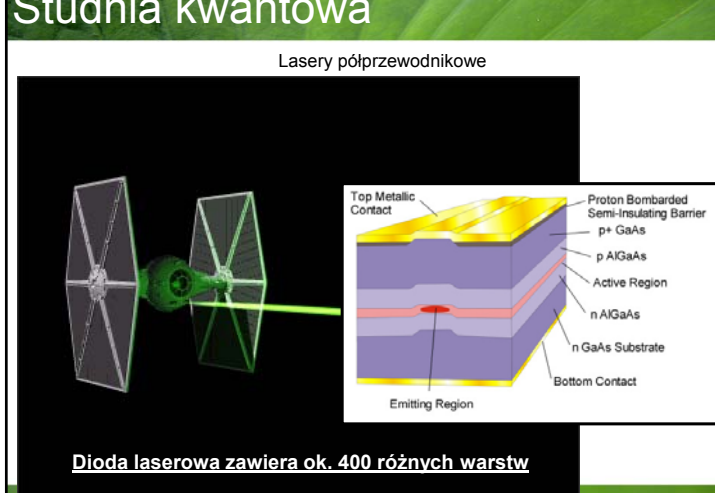
Aixtron CCS 3x2

Heterostruktury GaInSb, AlGaInAs and AlGaIn.

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Studnia kwantowa

Lasery półprzewodnikowe



Top Metallic Contact

Proton Bombarded Semi-insulating Barrier

p+ GaAs

p AlGaAs

Active Region

n AlGaAs

n GaAs Substrate

Bottom Contact

Emitting Region

Dioda laserowa zawiera ok. 400 różnych warstw

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Studnia kwantowa

Więcej: <http://britneyspears.ac/lasers.htm>

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Struktury niskowymiarowe

Low-dimensional Semiconductor Systems

Studnie kwantowe

2D

Druty kwantowe

1D

Kropki kwantowe

"0D"
Dyskretna struktura elektronowa

Hubert J. Krenner

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Druty kwantowe

Figure 9 Quantum wire fabrication based on nanoscale etching and re-growth

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Druty kwantowe

2 Au cap on the top of whisker and the interface structure

3 Au cap on the top of whisker and the interface structure

Fig. 3) Growth contains three components: (I) Beside diffusion through the droplet (I) and diffusion on the droplet surface (II), there is a strong surface diffusion component (III) along the whisker. So material is coming from the surrounding of the whisker.

<http://www.mpi-halle.mpg.de/~mbe/>

Photo by Peidong Yang/UC Berkeley, courtesy of Science

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Struktury niskowymiarowe

Low-dimensional Semiconductor Systems

Studnie kwantowe

2D

Druty kwantowe

1D

Kropki kwantowe

"0D"
Dyskretna struktura elektronowa

Hubert J. Krenner

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Quantum Dot

Hubert J. Krenner
Walter Schottky Institut and Physik Department E24, TU München

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Synteza kropek kwantowych

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Synteza kropek kwantowych



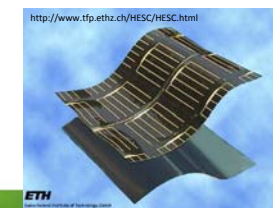
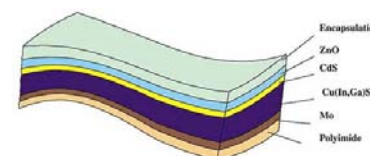
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Energia



Cu(In,Ga)Se₂ (also called CIGS) compound semiconductor
solar electricity conversion efficiency of 12.8%



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Nanotechnologia

CO?

- Studnie, druty, kropki

JAK?

- Top-down, czyli (nano)technologia
- Bottom-up, czyli samoorganizacja

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Nanotechnologia

CO?

- Studnie, druty, kropki

JAK?

- Top-down, czyli (nano)technologia
- Bottom-up, czyli samoorganizacja

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Top-down ↓

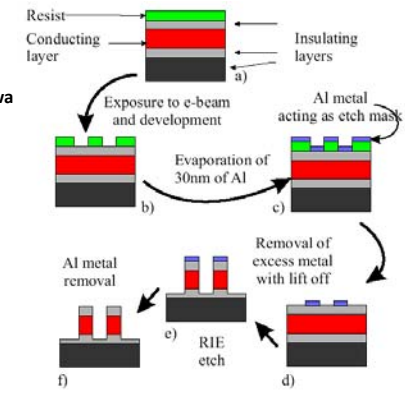


Vincent Laforet/The New York Times

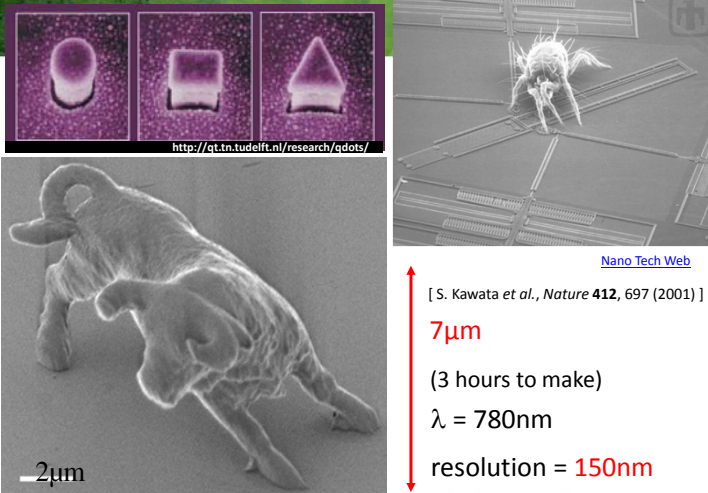
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Jak To jest zrobione?

1. **Dominuje technologia krzemowa**
2. **Obecne układy ~ 10⁹ - 10¹⁰ tranzystorów**
3. **Podłoża - 300mm, ~ 10³ chipów**
4. **Fotolitografia, naświetlanie, trawienie etc**
5. **Typowo ~20 masek, 150 - 200 kroków procesów**



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<http://gt.tn.tudelft.nl/research/gdots/>

[Nano Tech Web](#)

[S. Kawata *et al.*, *Nature* **412**, 697 (2001)]

7μm

(3 hours to make)

λ = 780nm

resolution = 150nm

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Jak To jest zrobione?

Focus Ion Beam



IEM-9320 Focused Ion Beam System



Norsam Technologies, Inc.

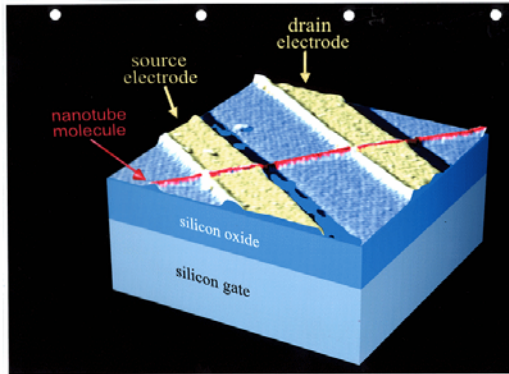
1 μm (micron)

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

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Jak To jest zrobione?

Nanotubes as molecular quantum wires



Cees Dekker

TU Delft DIMES

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Nanotechnologia

CO?

- Studnie, druty, kropki

JAK?

- Top-down, czyli (nano)technologia
- Bottom-up, czyli samoorganizacja

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