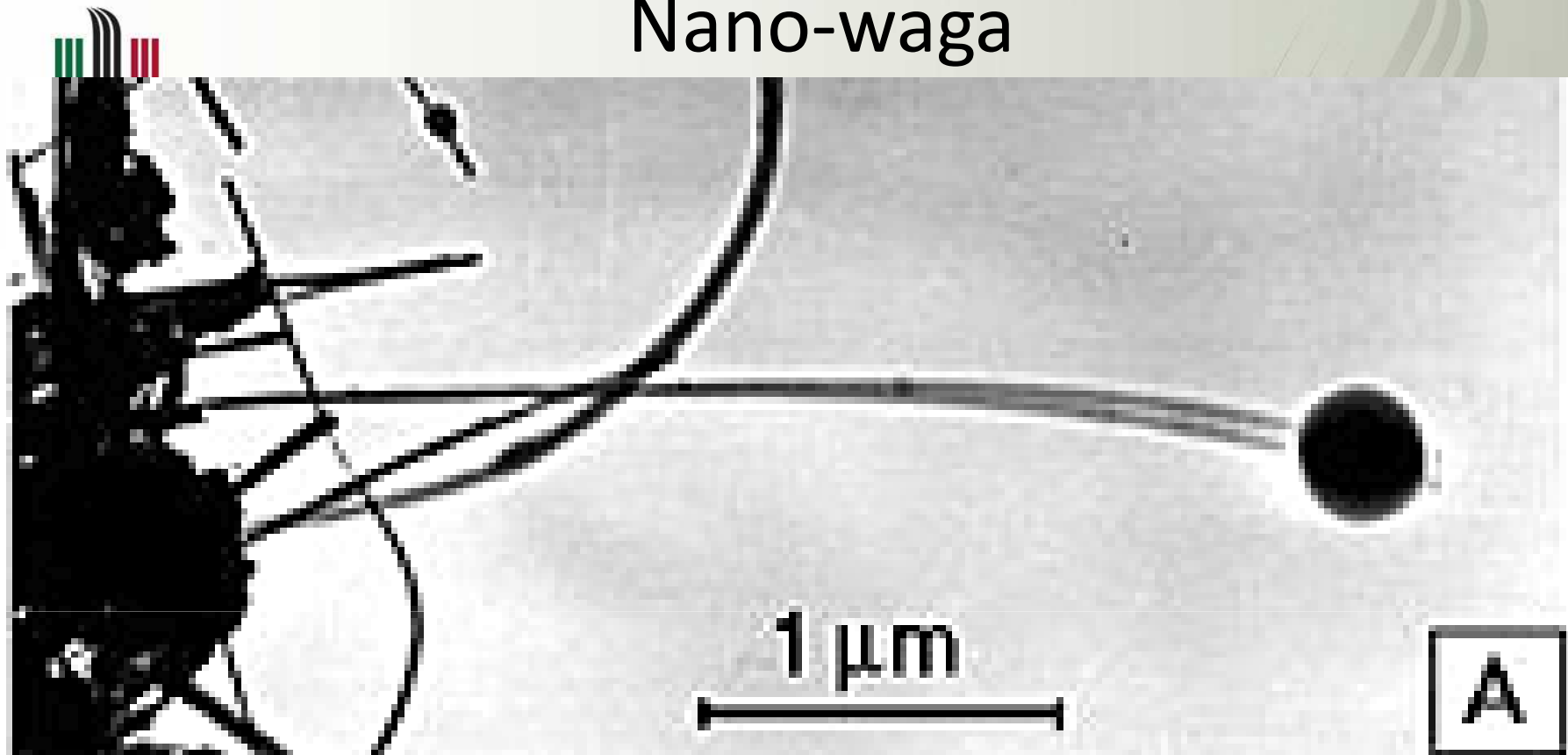




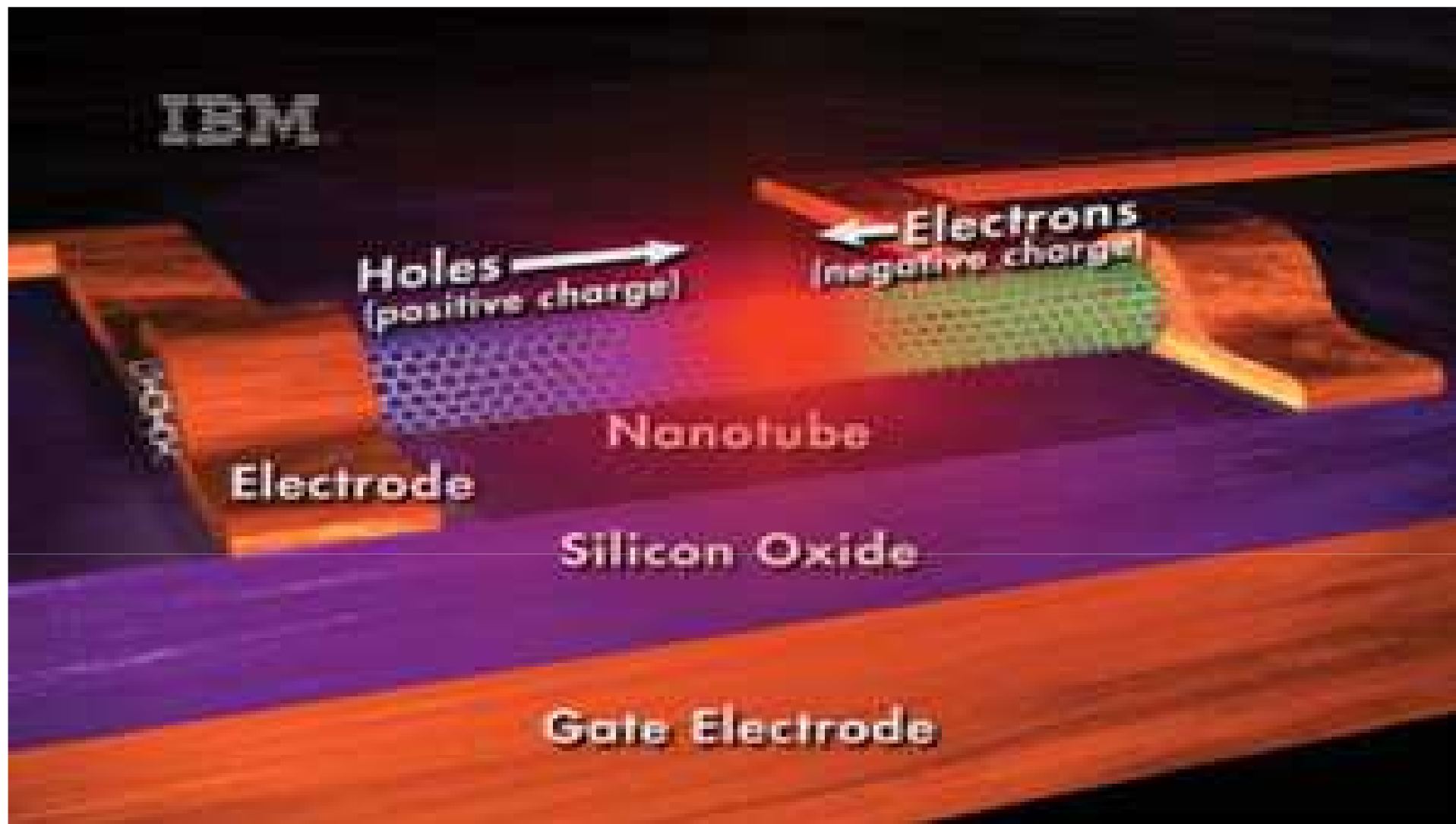
Nowe zastosowania w nanoelektronice

A. Kołodziej

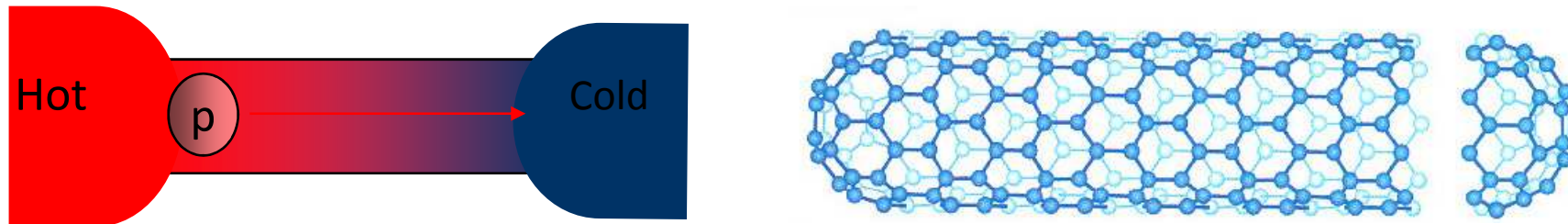
Nano-waga



Waga nanoskalowa do określania masy. Może służyć do ważenia wirusów i innych pod-mikronowych cząstek (obraz w TEM). Masa przyczepiona do końca nanotuby, przesuwa częstotliwość rezonansową. Jeżeli nanotuba jest skalibrowana (współczynnik sprężystości jest znany), możemy zmierzyć masę cząstki. Nano-waga może mierzyć obiekty femptogramowe do piktoqramowych.



Konfiguracja elementu złożonego z węglowej nanorurki , która emituje światło podczerwone po włączeniu. Światło podczerwone jest emitowane, gdy dziury łączą się z elektronami.



Długa droga swobodna (zaledwie kilka rozproszeń)/

Silne wiązanie SP² : duża prędkość dźwięku v

→ duże przewodnictwo cieplne: $k = Cv/3 \sim 6000 \text{ W/m-K}$

↑
Pojemność cieplna

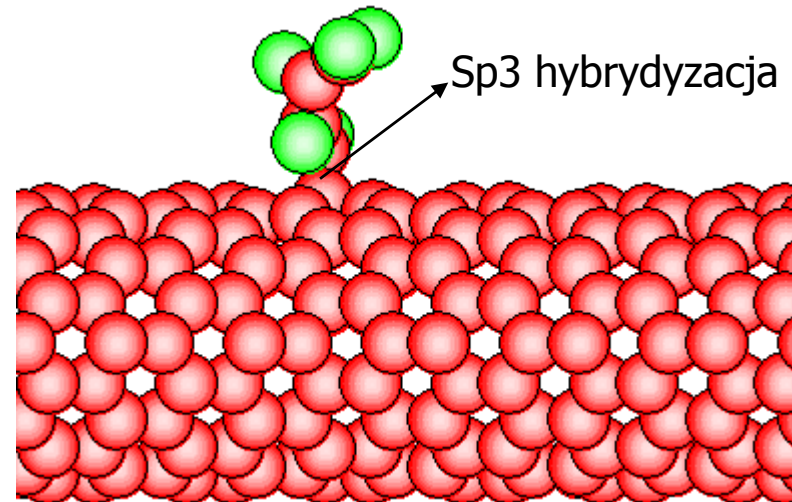
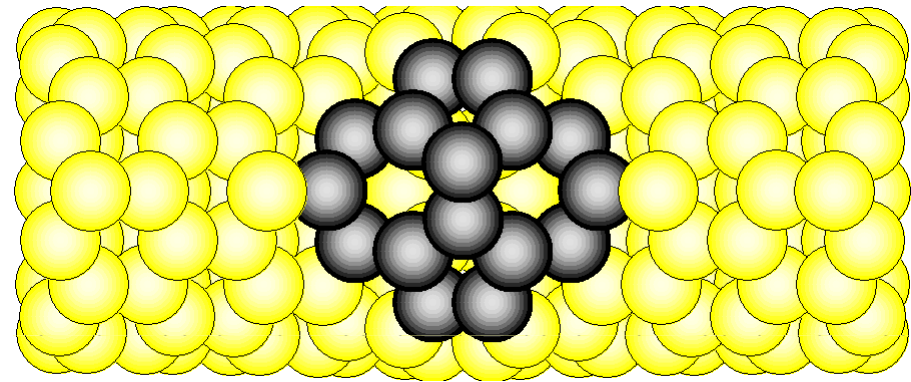
- Poniżej 30 K, przewodnictwo cieplne → $4G_0 = (4 \times 10^{-12}T) \text{ W/m-K}$,
liniowa zależność T (G_0 : Kwant termicznej przewodności)

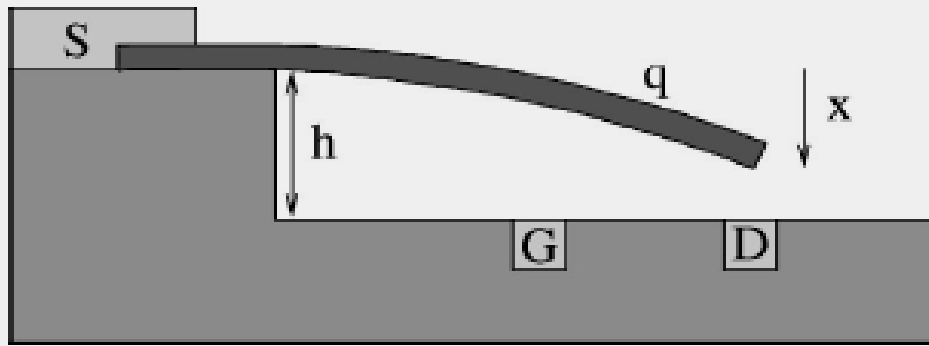


Błędy w nanorurkach węglowych (CNT)

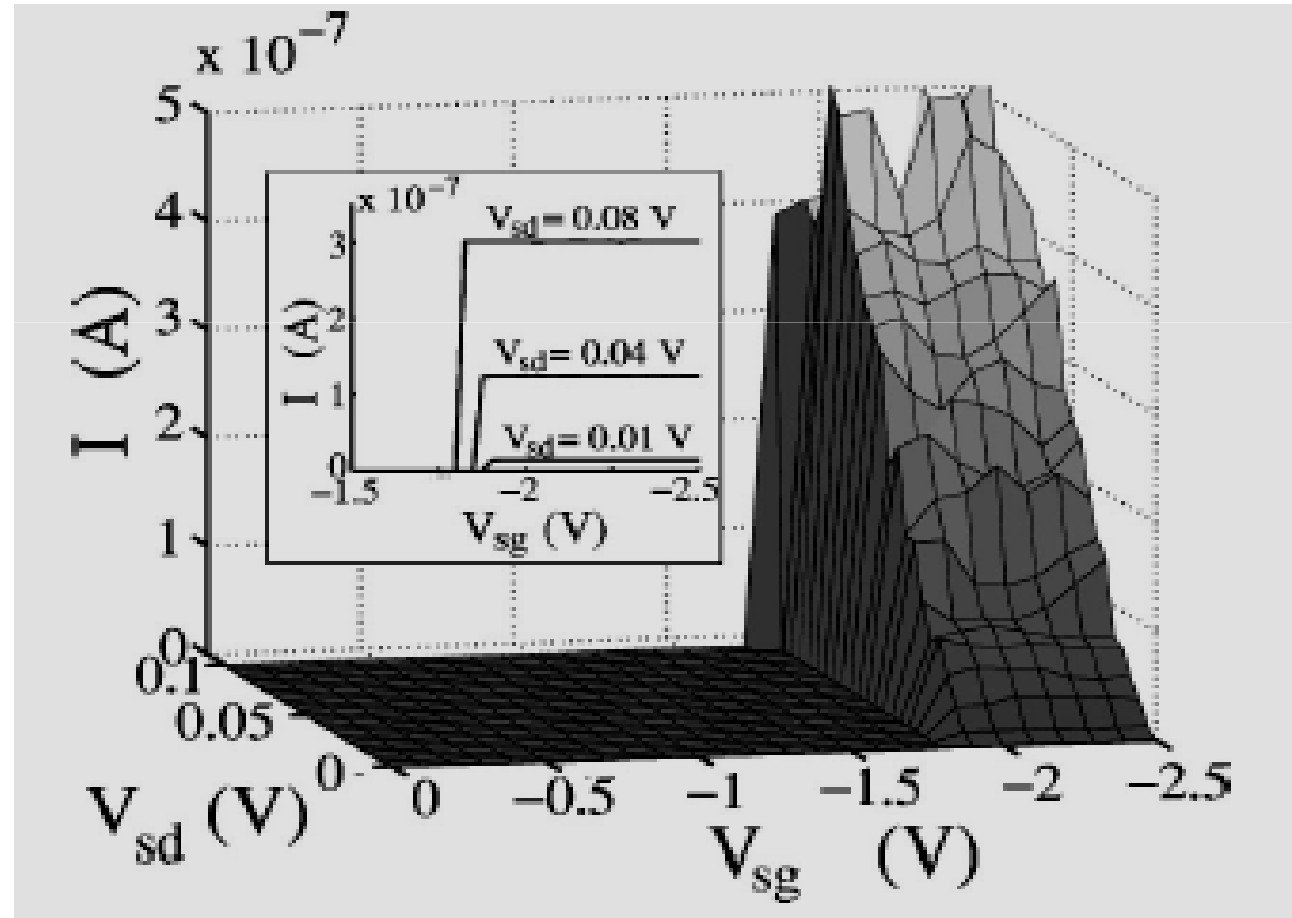
AGH

- Defekty punktowe typu wakansji
- Defekty topologiczne związane z błędami koordynacji, pentagony, heptagony, np. 5-7-7-5 defekt
- Hybrydazyjne defekty związane z potrzebnymi funkcjami



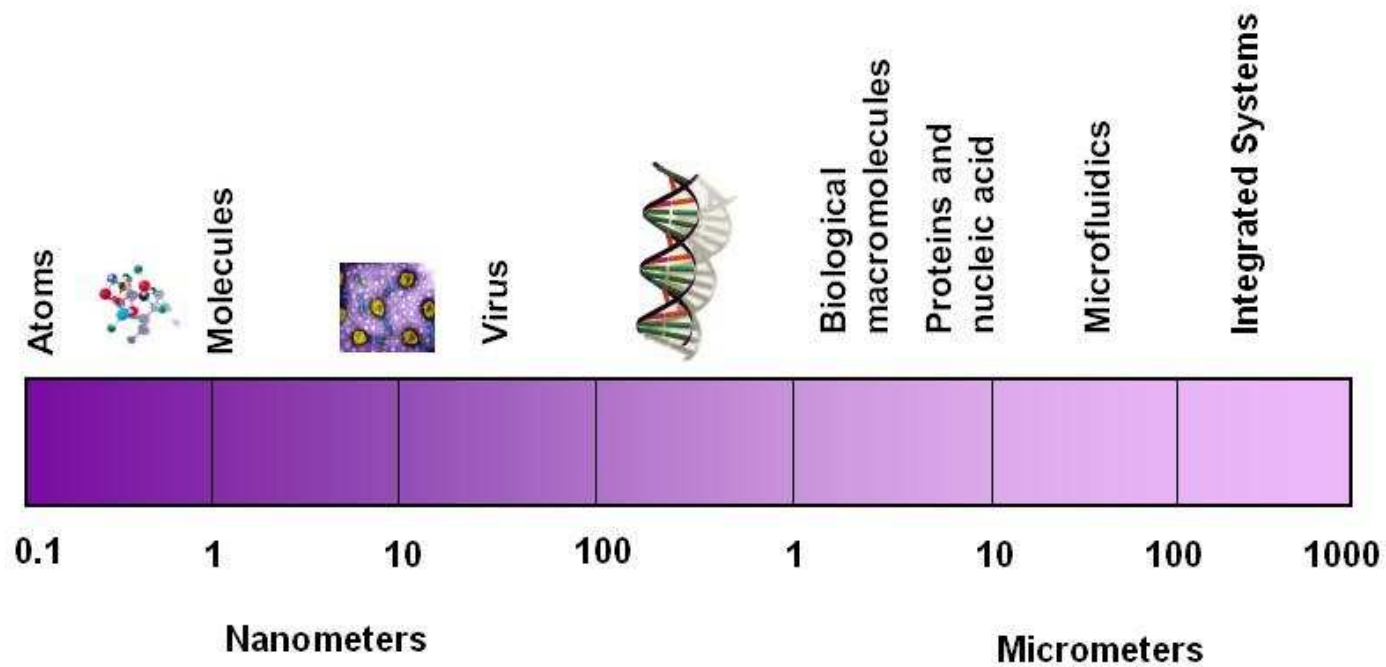


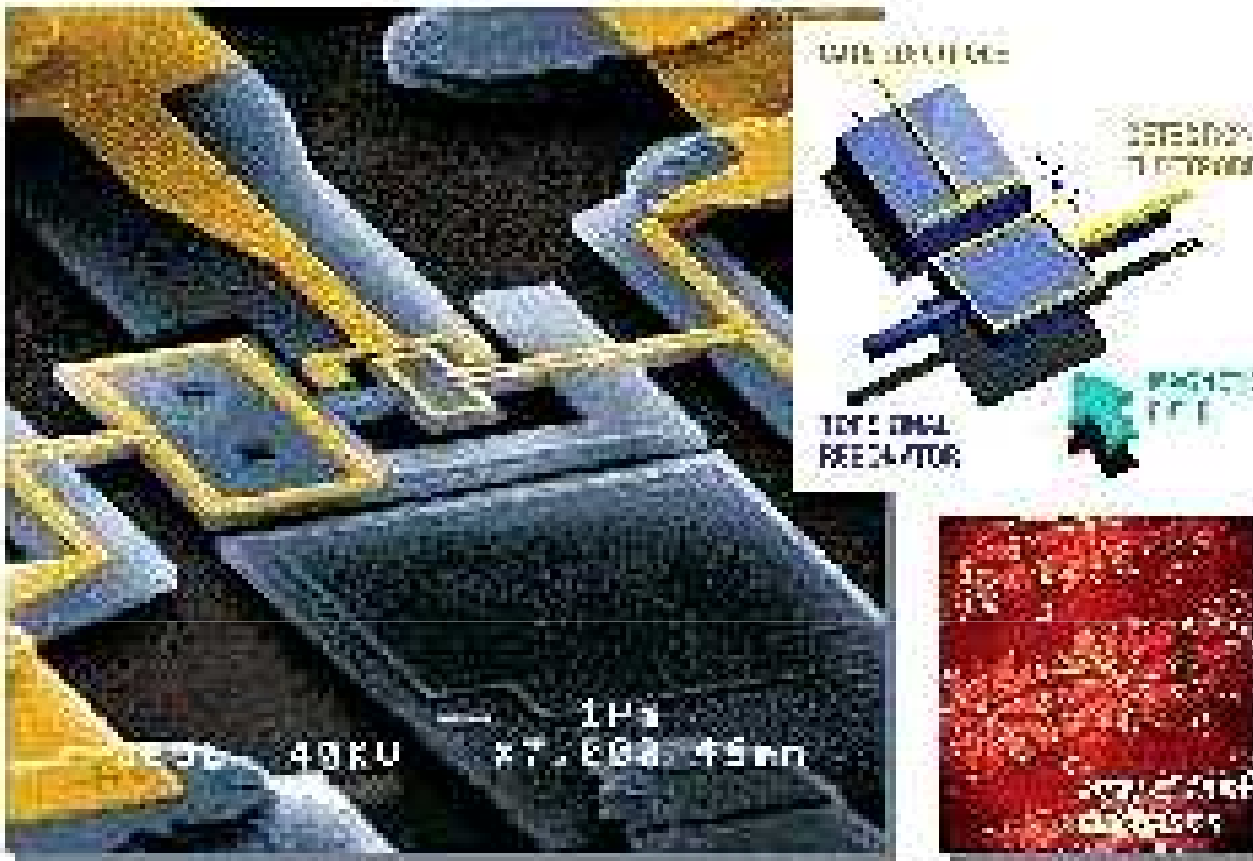
Nano przełącznik lub nano waga



Kinaret, Nord, and
Viefers
APL, V 62, #6, 2003

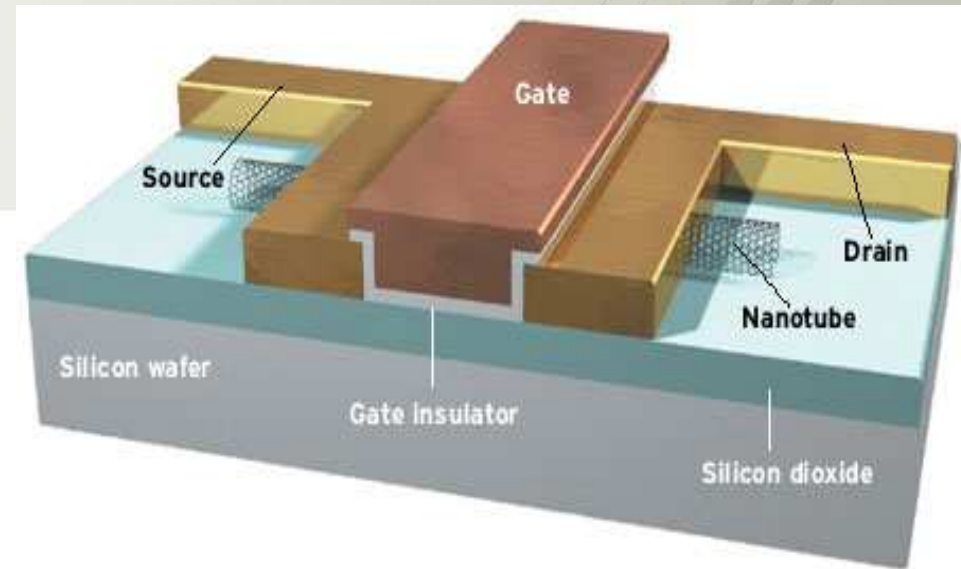
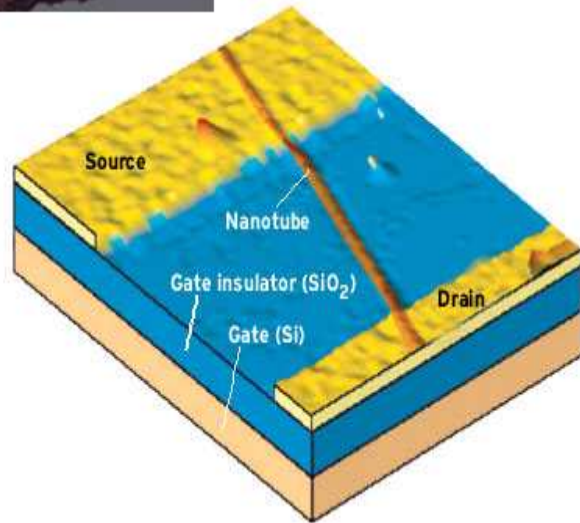
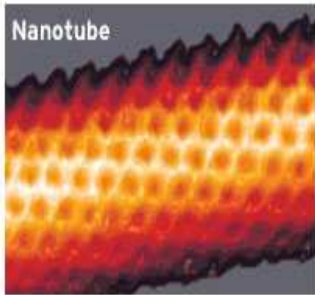
Virus, bakterija





Mechaniczny elektrometr w nano-skali złożony z toroidalnego mechanicznego rezonatora, elektrody detekcyjnej oraz elektrody bramki używanej do gromadzenia ładunku na mechanicznym elemencie.

CNT FETs

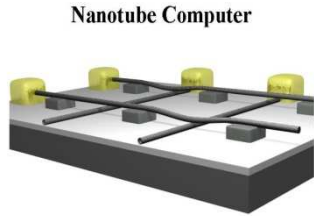


A single nanotube is the transistor channel between the two gold electrodes that form the source and drain. The gate is the heavily doped silicon substrate, separated from the device by a layer of silicon dioxide. The inset

[left] is a highly magnified scanning tunneling microscope image of a nanotube. In the absence of back scattering, the conductance is primarily ballistic. Additionally, due to 1-D curved surface, there are no dangling bonds and hence a surface passivation step is not necessary. The leads to the possibility of using other oxides as dielectric materials. the resulting device is a faster, smaller nanotube-based field-effect transistor.

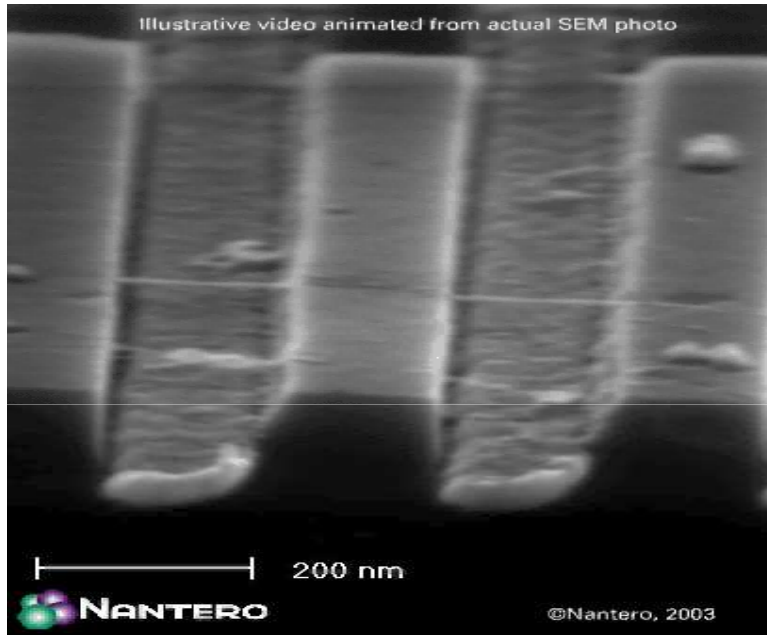
More advanced nanotube transistors have individual gates on top of the device, separated from the nanotube channel by a thin layer of silicon dioxide. Metal electrodes form the source and drain

Nantero: LSI (concept at Harvard)



- nan

Nanotube Device Concept



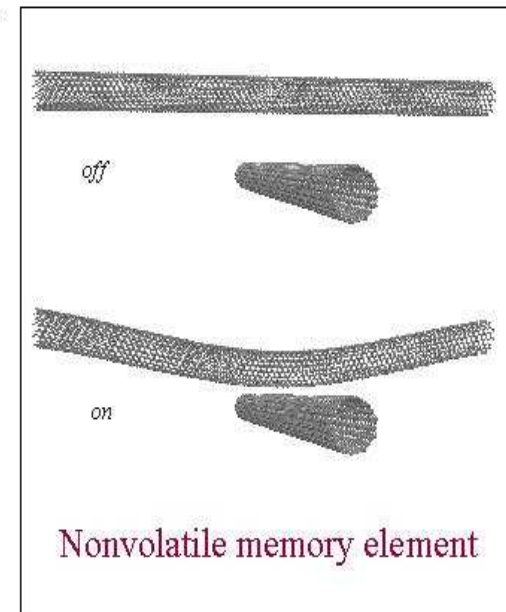
A suspended nanotube crossbar architecture is *intrinsically* bistable

OFF state: mechanical minimum

ON state: van der Waals minimum

Switching: biasing leading to electrostatic attraction or repulsion

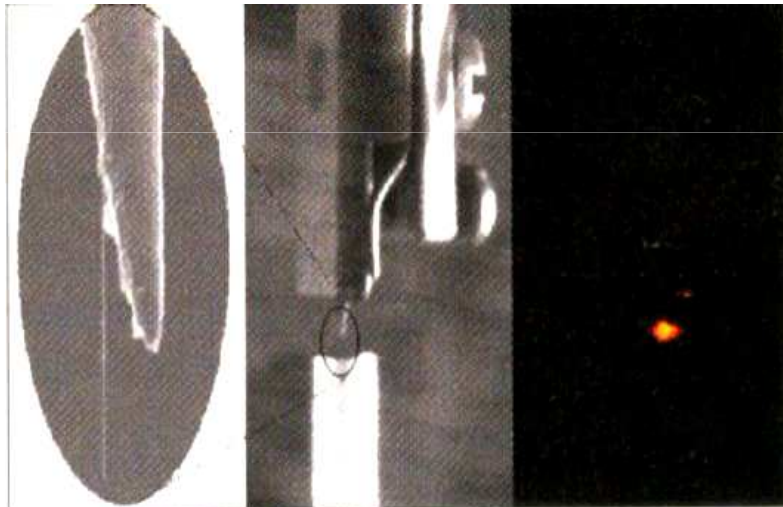
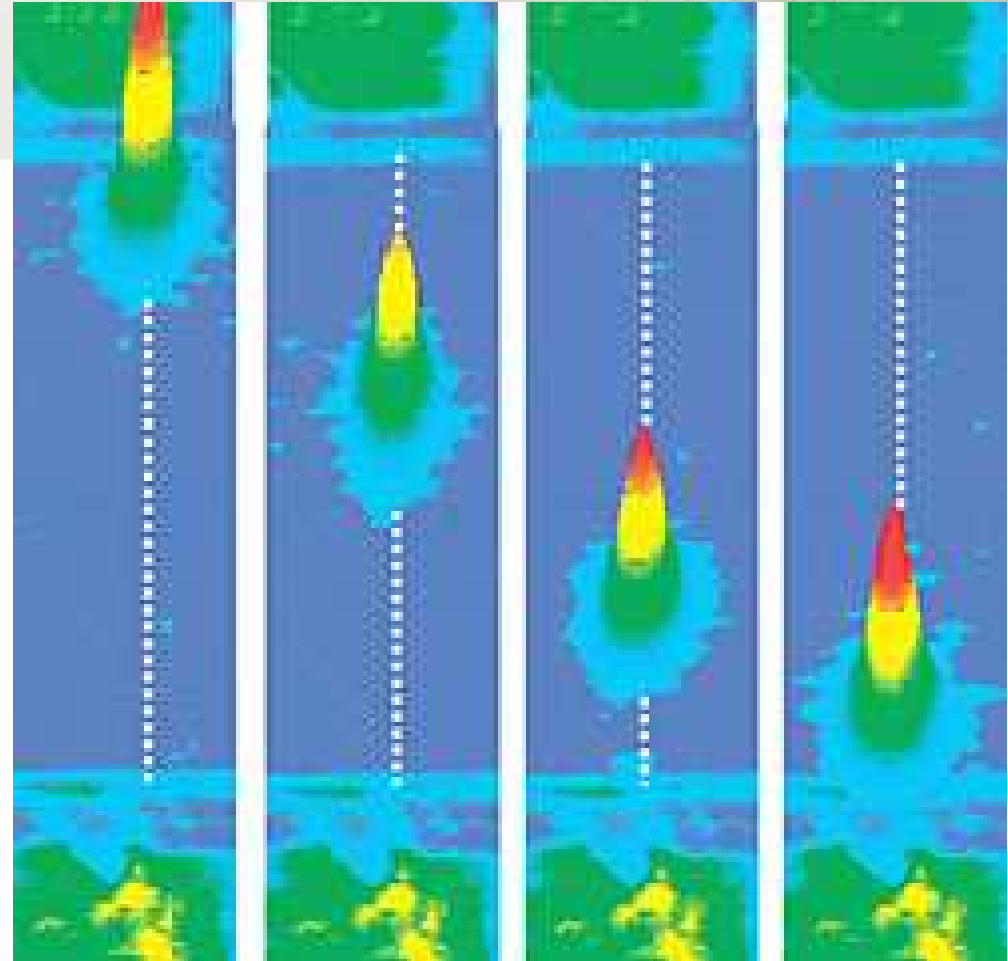
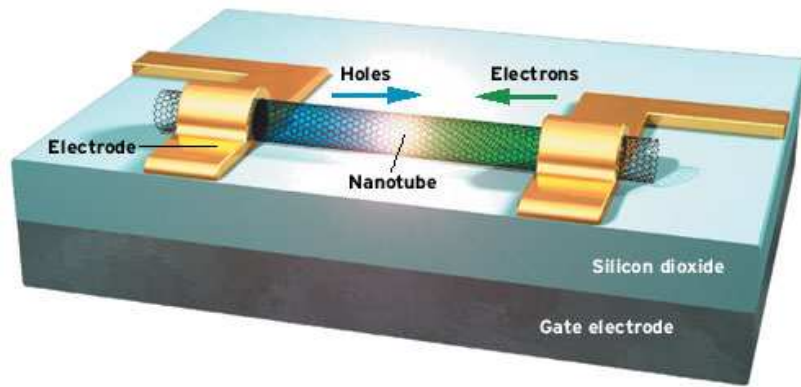
Reading: high/low junction resistance



Assembly of billions aligned and suspended nanotubes over the surface of a silicon wafer. The prototype uses electrostatically induced mechanical deformation of a conductive to alter its conductance. The Nantero system however, apparently eliminates the lower nanotube and substitutes a simple metallic electrode. The bent nanotube contacts the electrode, allowing detection of the nanotube's configuration simply by measuring the resistance between it and the electrode.

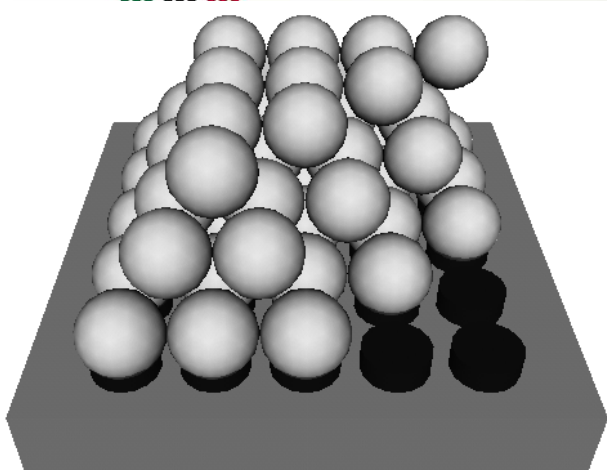


CNT FET LED



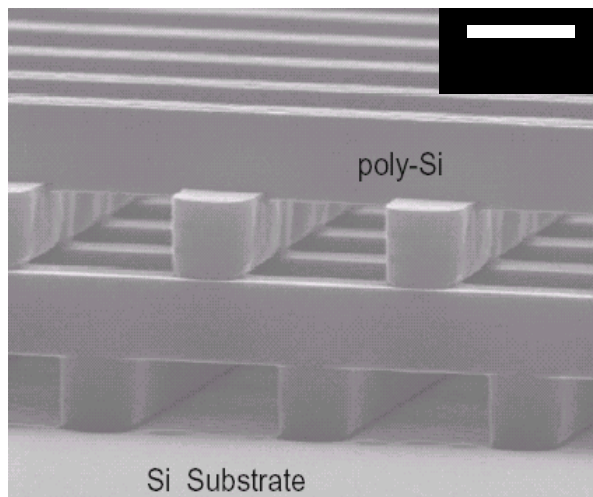
Adjusting the gate bias on the carbon-nanotube light source controls where along the nanotube the light is emitted. In this image, taken with an infrared camera, the point of light emission moves along the nanotube as the gate voltage changes.

Colloidal self-assembly



Nanoparticle Mediated Colloidal Epitaxy

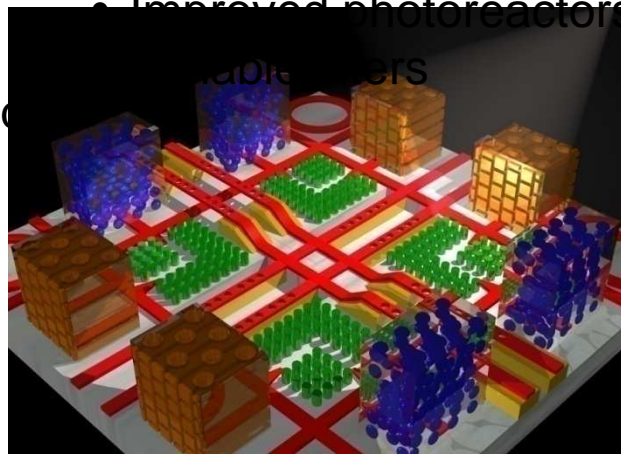
Lithography



Mesoscale Photonic Crystals

3-D Applications

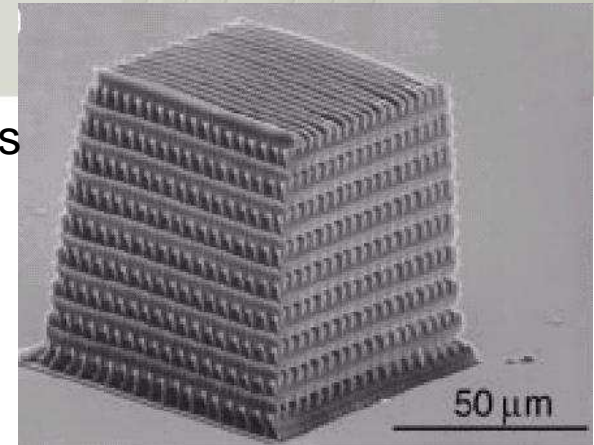
- Low-loss waveguides
- Optical cavities
- Zero-threshold microlasers
- Light-emitting diodes
- All-optical transistors
- Improved photoreactors



Prof. John Joannopoulos
<http://ab-initio.mit.edu/photons/index.html>

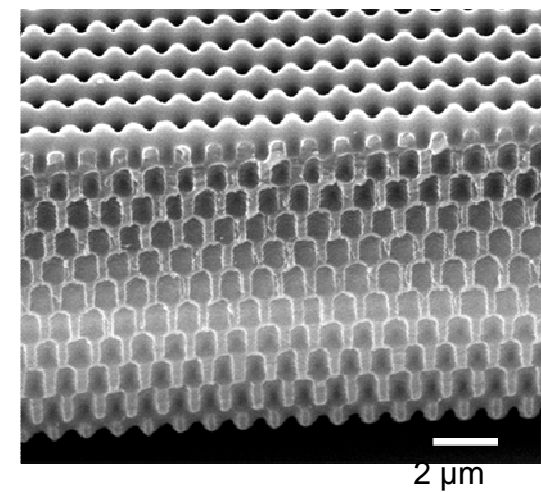
Turberfield A. J., *et al.*, *Nature* 2000
Wiltzius, P. *et al.*, *Chem. Mater.* 2002

Multiphoton polymerization

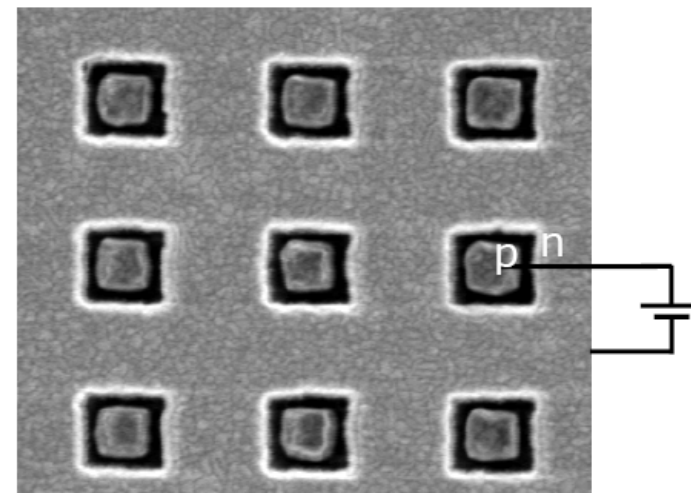
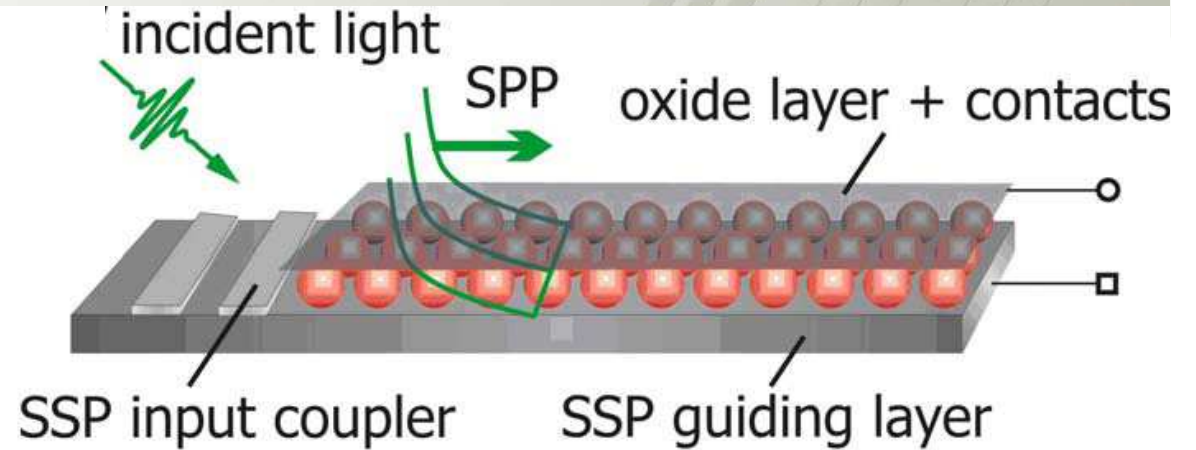
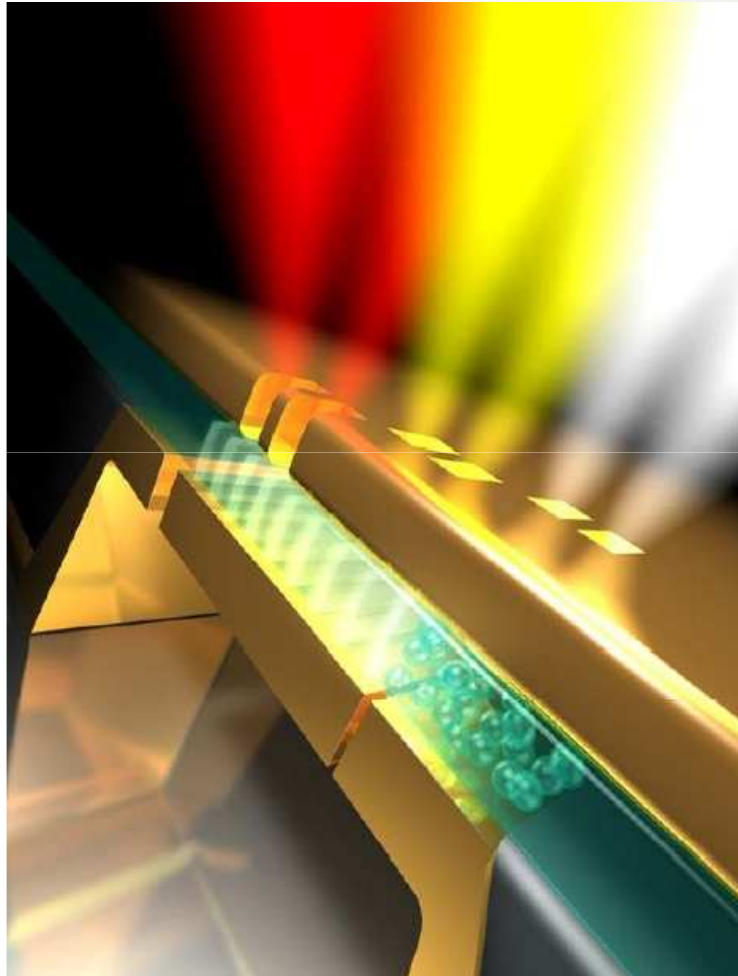


Cumpston et al. *Nature* 1999, 398, 51.

4-beam holography



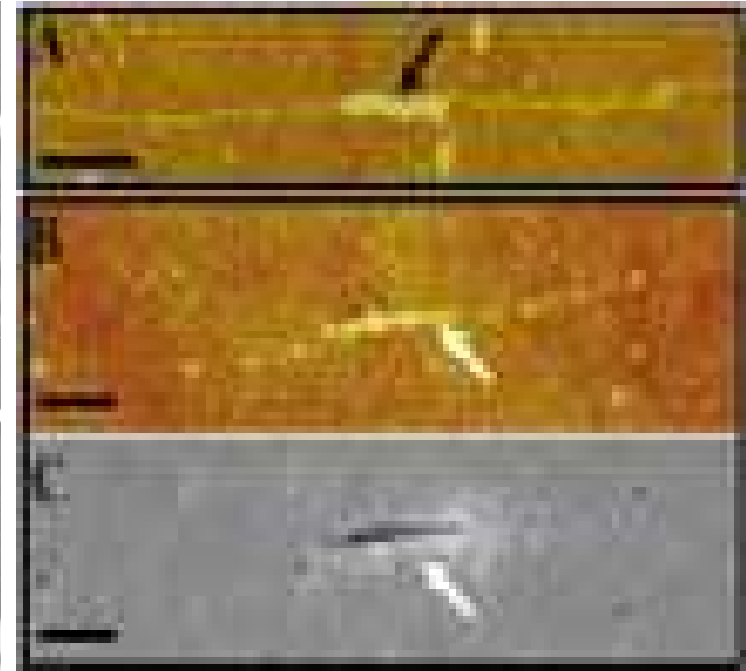
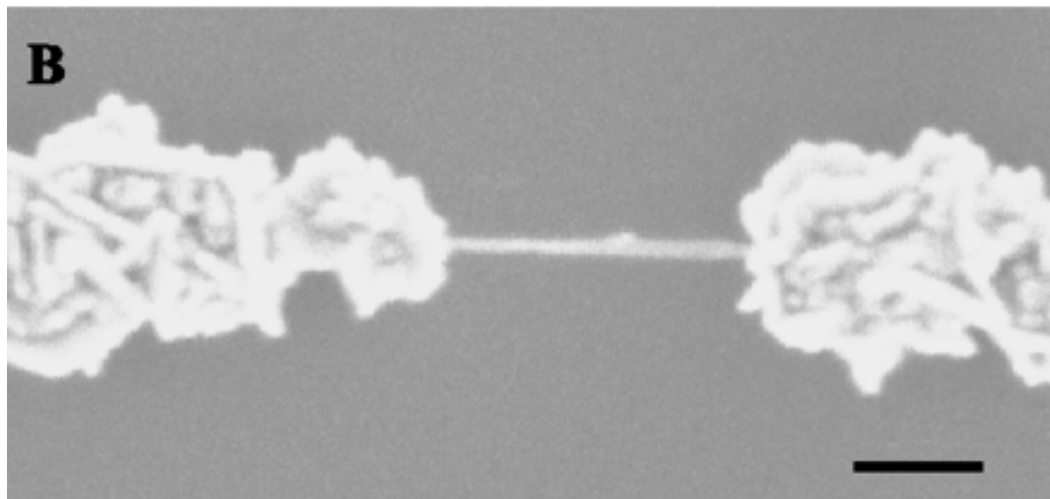
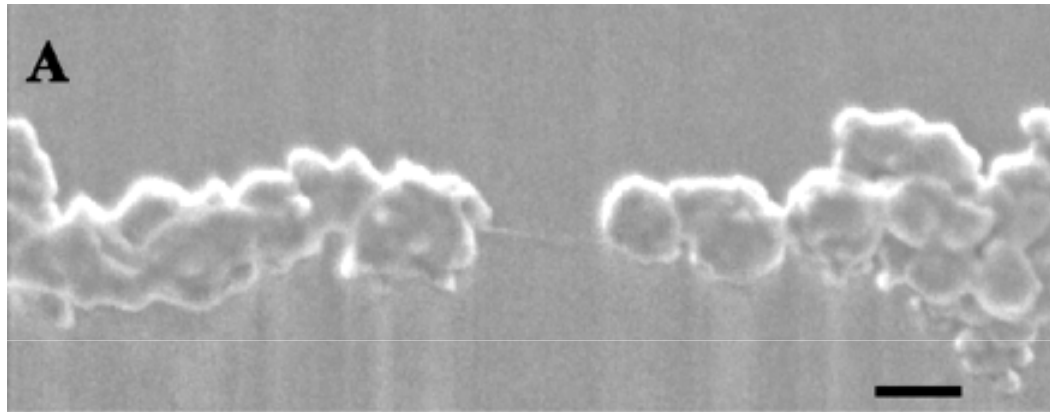
Scattering cross-section varies with dielectric spacer

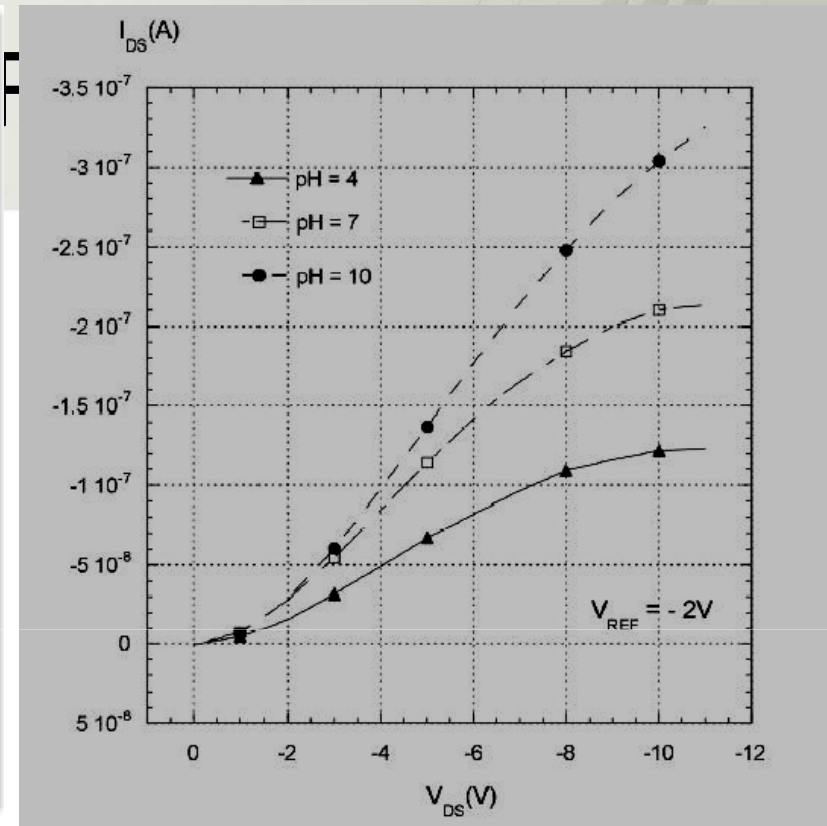
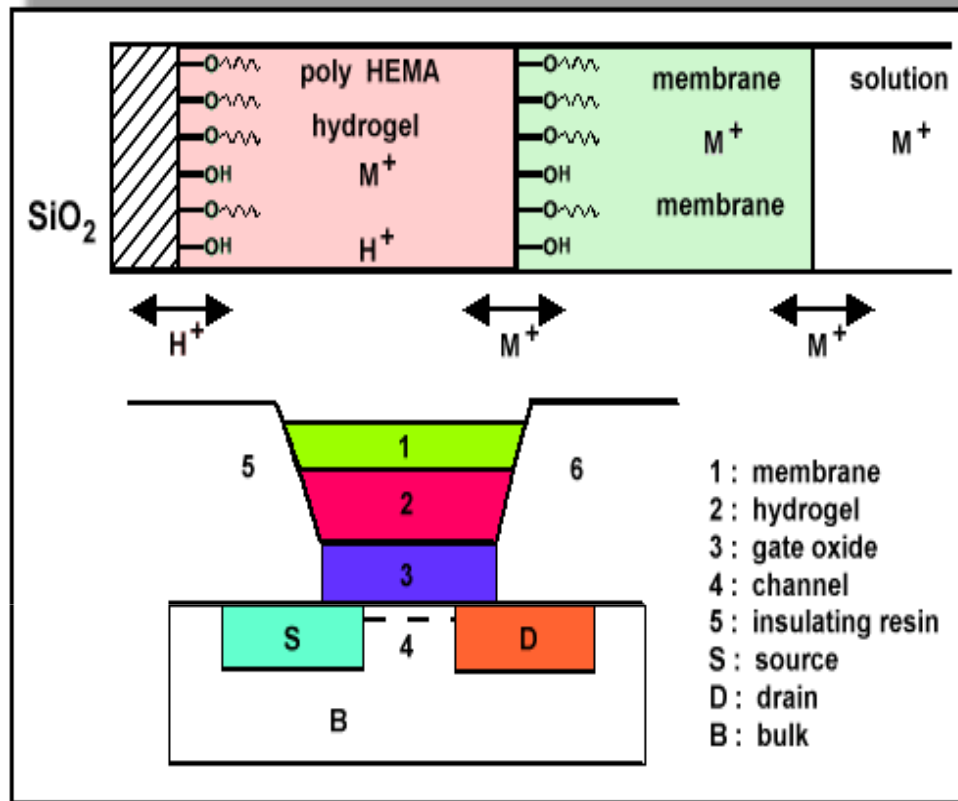


Samo-łaczenie na podstawie wzorca DNA

A protein is attached to a specific region of the DNA which directs a protein labeled carbon nanotube to bind to the DNA. Both the DNA and nanotube are coated with both protein and antibody layers to direct the assembly process. After the nanotube attachment, the unprotected DNA is attached to silver followed by electro deposition of gold grains to create wiring to the nanotube.

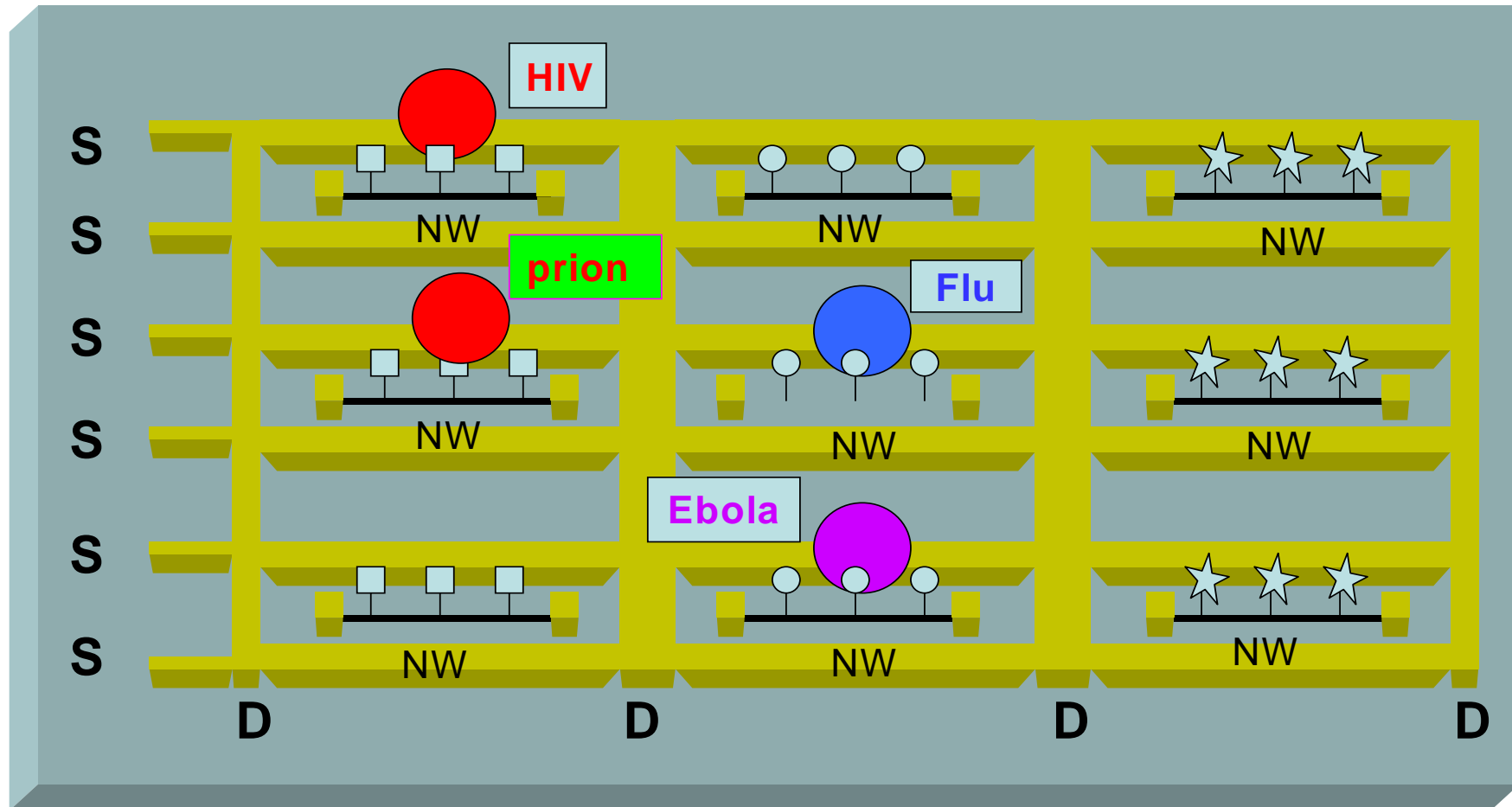
AGH



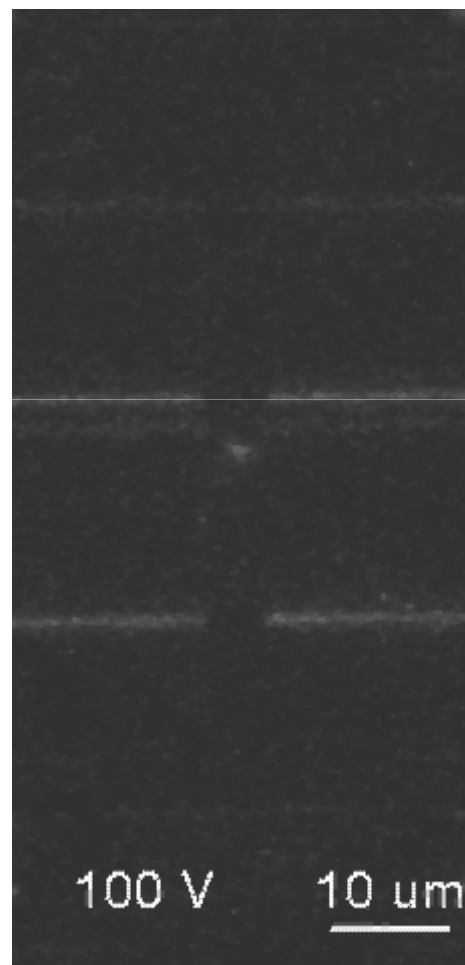


Chemical controlled sensors and FETs (Field Effect Transistors). Conductance is a function of the chemical environment. These devices can be selectively targeted towards detection of arbitrary chemical signals. If an array of these devices can be arranged into an arbitrary pattern, the array will "calculate" an arbitrary function of the chemical environment. Such devices operating at the molecular level can potentially be used to "program" higher performance electronic or electromechanical switches.

Parallel Detection and Diagnosis of Viruses Using Integrated Nanowire Sensors

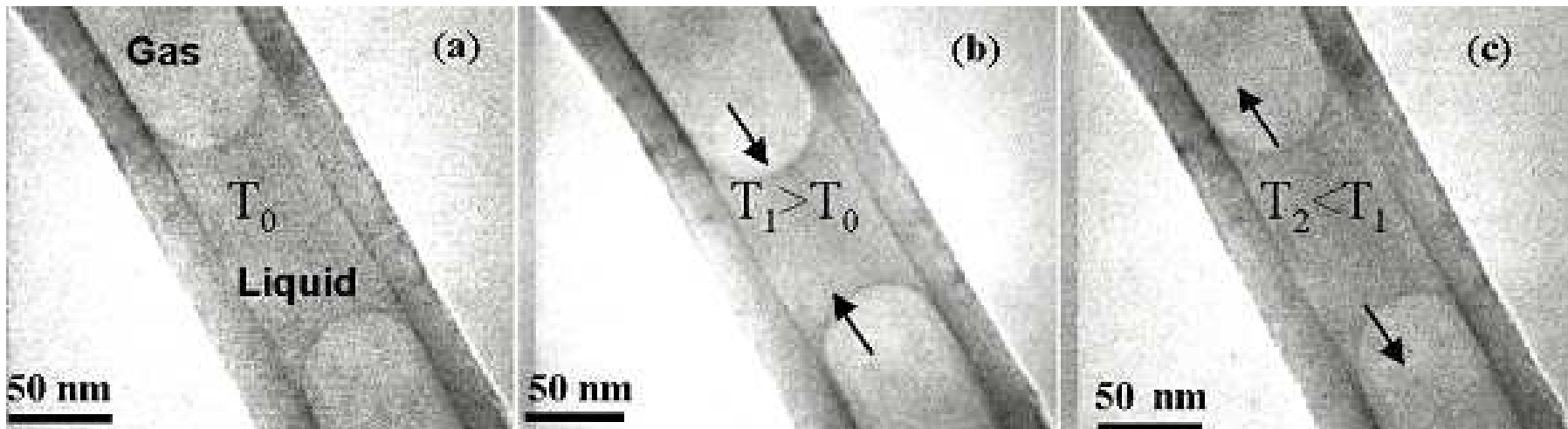
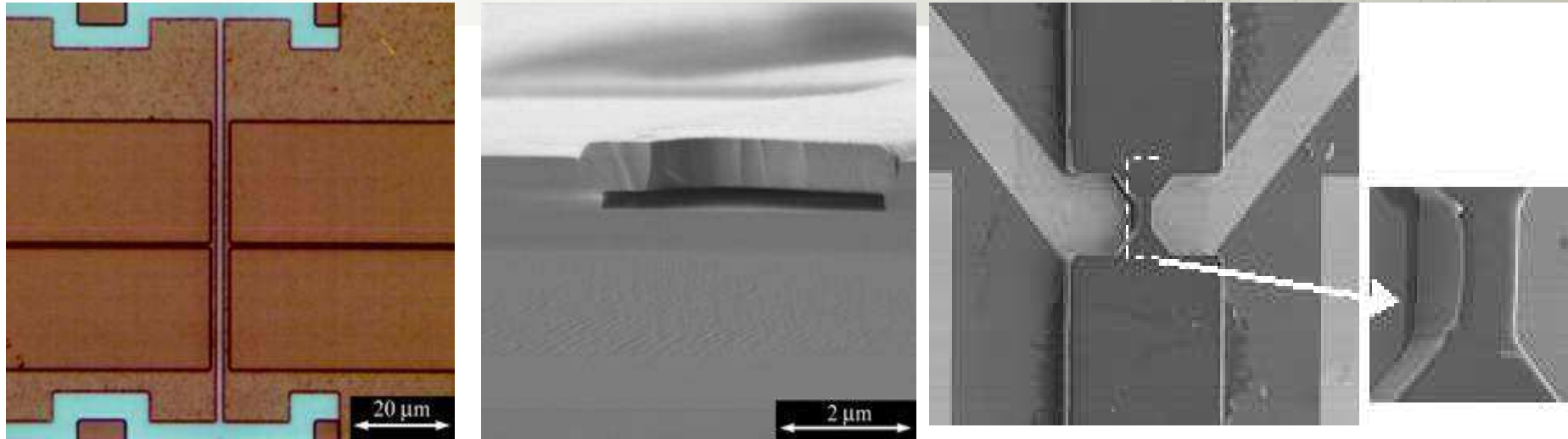


Dioda emitująca światło podczerwone





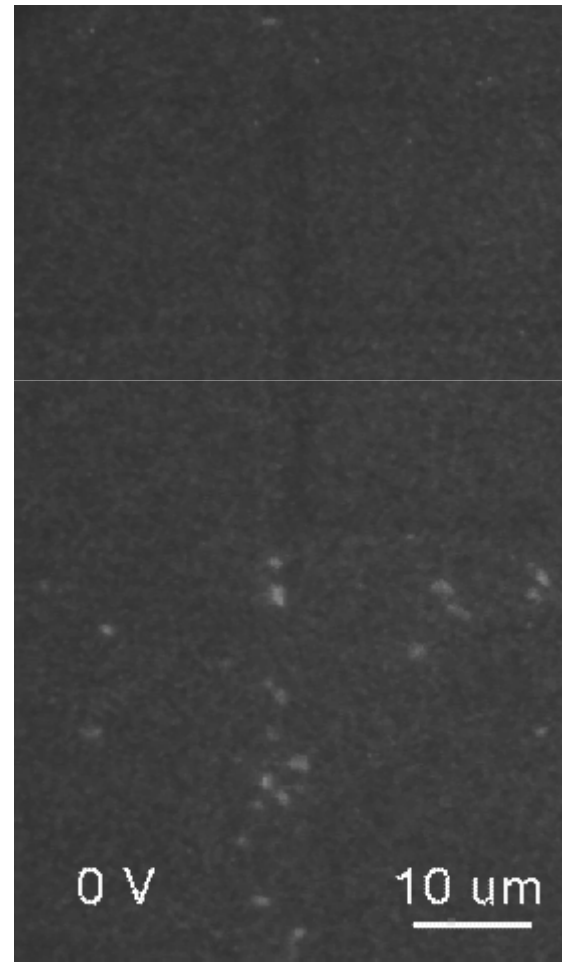
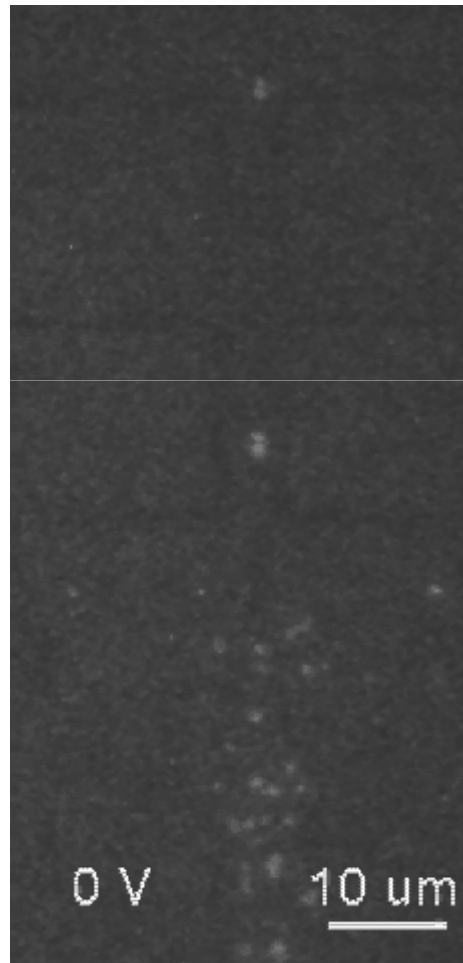
Mikrokanal wypełniony niebieską cieczą



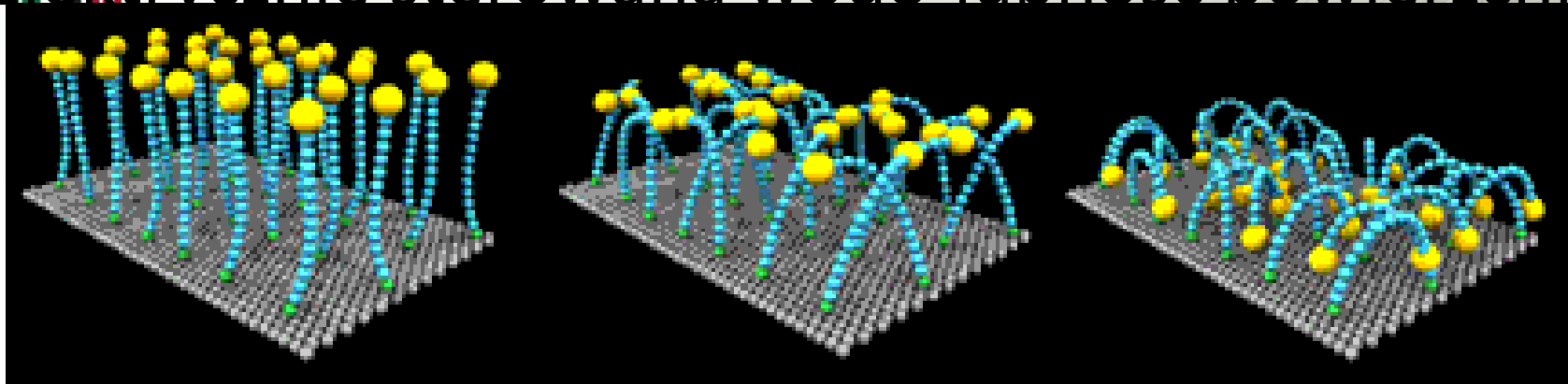
Termiczny akuator cieczowej wtyczki zawartej w nanorurce, Gogotsi et al.



Przepływy cieczy w mikrokanalach



Elektrycznie sterowana wodo-lubność powierzchni



- W przypadku braku powierzchniowego pola elektrycznego grupa CO_2H powoduje zakończenia molekuł MHAE tworzące wodoprzyjazzną powierzchnię.
- Gdy wartość pola elektrycznego wzrośnie, „stalks” molekuly MHAE zaginają się, tworząc wodoodporną powierzchnię.
- Elektryczne sterowanie wodolubnością powierzchni powinno być możliwe w skali nanometrycznej.
- Można sobie wyobrazić tablicę programowo konfigurowalnych przełączalnych powierzchni w nano skali.
- Do możliwych zastosowań należą:
 - nano materiały oraz molekularne rozpoznawanie
 - bezpośredni transport materiałów po tablicy przełączalnych powierzchni

• ...