

# **NANOFABRICATION RESEARCH LABORATORY: MEETING THE INTEGRATION CHALLENGE**

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## **ISSUES**

**Fundamental nanoscience-requires fabrication  
Nano materials integration-soft materials  
Facilities for integrated nano-systems  
Organizational issues w.r.t. universities**

## **NANOSCIENCE and NANOTECHNOLOGY**

**The science and art of arranging atoms and manipulating materials on the nanometer scale, and integrating nano-elements, to produce new properties and useful functions.**

**NST emerges from**

- 1) silicon-the drive to nanoscale yields faster computation, more memory and lower power consumption and**
- 2) manufacturing-the nano-scale is economically viable.**

## **RECENT GREAT DISCOVERIES**

**PROXIMAL PROBES - STM, AFM, NSOM**

**BUCKY BALLS AND NANOTUBES**

**NANOCRYSTALS**

**SINGLE MOLECULE DEVICES and SELF-ASSEMBLY**

# NANOPHYSICS DISCOVERIES

1. Quantization of electrical conductance~1988
2. Single electron structures and Coulomb blockade~1990
3. Thermal conductance quantum-determines maximum rate of heat transfer~1999
4. Nano crystalline-size dependent structural phase transitions~2001

## Making Nanotube Chips

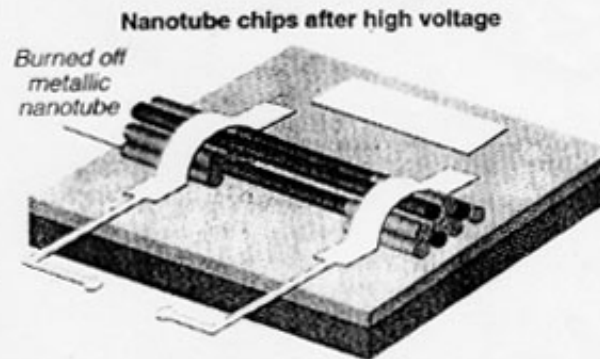
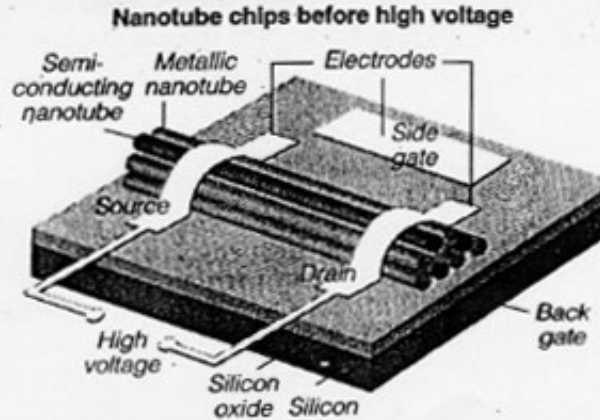
I.B.M. has figured out how to make transistors using carbon nanotubes — tiny cylinders of carbon atoms — by overcoming a technical problem that had previously made it impossible to use the technology.

❶ When nanotubes are produced they come in bundles of metallic and semi-conducting types. Only the semiconducting nanotubes can be used as transistors, so the problem is to get rid of the metallic nanotubes.

❷ What I.B.M. did was to deposit nanotube bundles on a silicon wafer.

❸ Using lithography, metal electrode pads were formed over the nanotubes.

❹ The silicon wafer was temporarily turned into an electrode making the semiconducting nanotubes insulating, which turned them "off" so that they could not conduct electricity.



❺ A high voltage was then passed through the electrodes, overloading the metallic nanotubes and vaporizing them in the process.

❻ Afterward, only the semiconducting nanotubes were left.

Source: IBM

NY Times, Jan. 2001

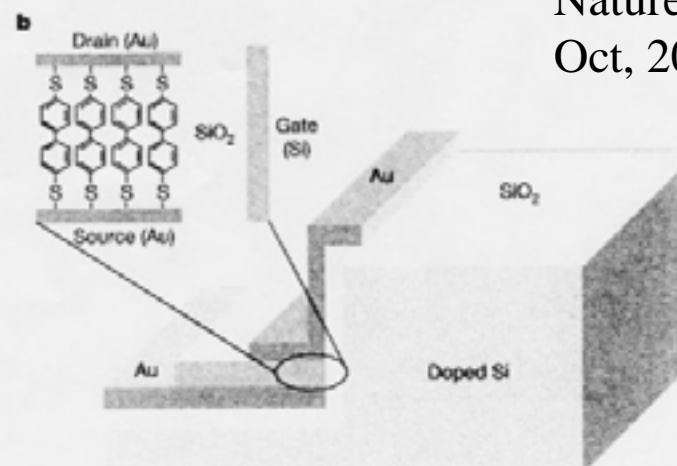
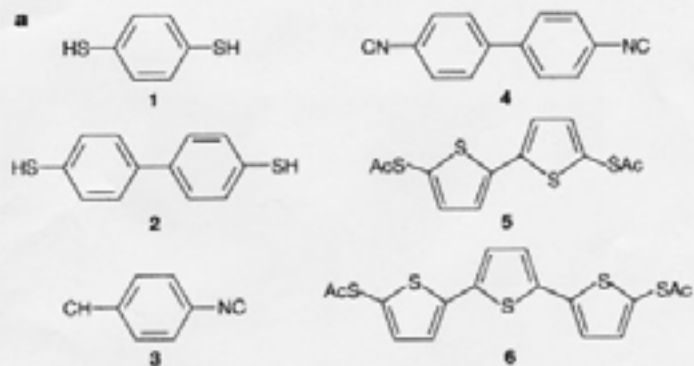
N.Y. Times  
Jan. 2001

# Self-assembled monolayer organic field-effect transistors

NATURE  
Oct, 2001

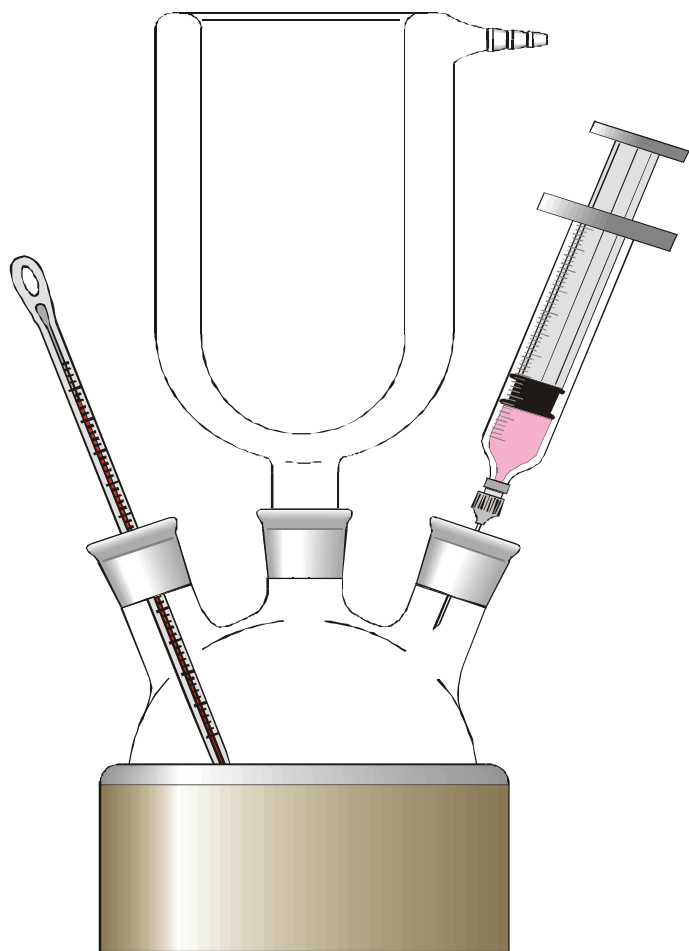
Jan Hendrik Schön, Hong Meng & Zhenan Bao

Bell Laboratories, Lucent Technologies, Mountain Avenue, Murray Hill,  
New Jersey

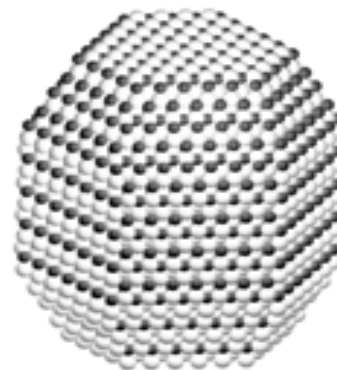


Nature,  
Oct, 2001

# Pyrolytic synthesis of CdSe nanocrystals\*



- Reaction solution (1.9:1 Cd:Se): 166 $\mu$ l Cd(CH<sub>3</sub>)<sub>2</sub>, 0.096g Se<sup>0</sup> and 10ml [CH<sub>3</sub>(CH<sub>2</sub>)<sub>3</sub>]<sub>3</sub>P (TBP) are injected into 12g [CH<sub>3</sub>(CH<sub>2</sub>)<sub>7</sub>]<sub>3</sub>P=O (TOPO)
- 360°C crystal nucleation, 300°C crystal growth
- Isolation by methanol precipitation



\*X. Peng *et al.* *J. Am. Chem. Soc.* **120**, 5343 (1998).

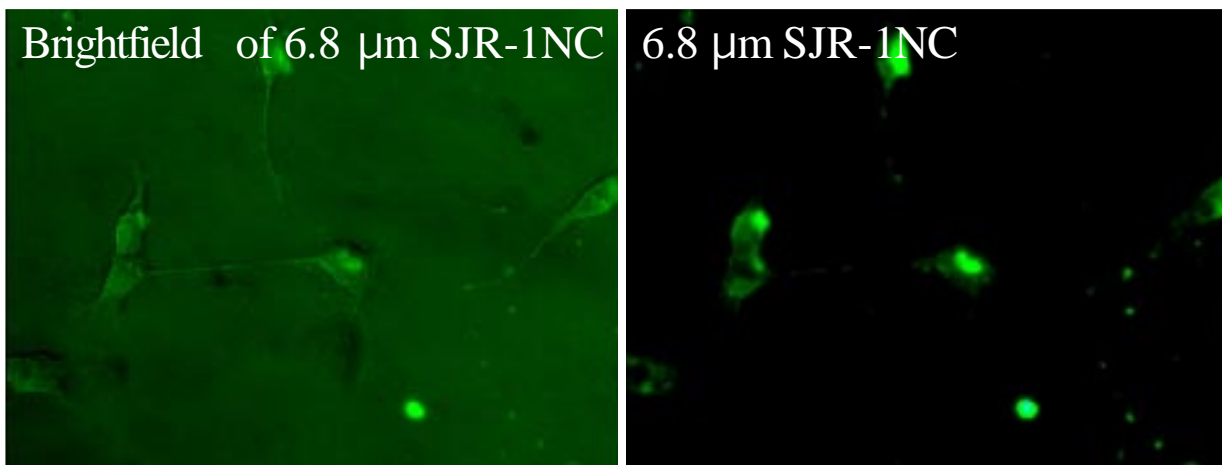
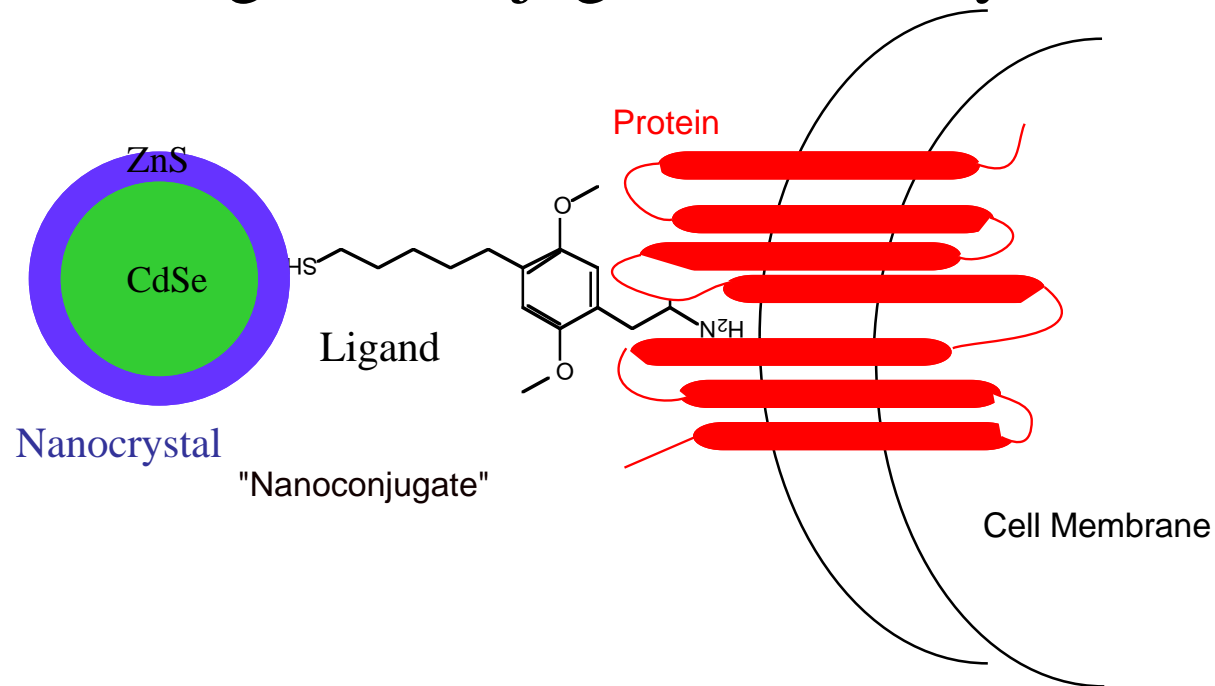
# CdSe Nanocrystals



CdSe Crystals in toluene. Left 19A to right 50A, illustrating the quantum shift of energy. Tadd Kippeny, S.J. Rosenthal, Vanderbilt University

S. Rosenthal, Vanderbilt  
Chemistry

# Labeling the Serotonin-2A Receptor Protein with Ligand Conjugated Nanocrystals



S. Rosenthal  
Nano-Neuro  
Group  
Vanderbilt  
University

# ORGANIZATIONAL ISSUES

Goal: The Center aspires to be the intellectual and operational focus of nanoscience and technology for the southeast and the U.S.A.

## Requirements:

- 1) Easy accessibility and availability, balanced with security requirements
- 2) Competent technical staff, able to deal with students, faculty
- 3) Opportunities for post-doc/grad student training with facilities
- 4) First-rate “in-house science”
- 5) Reasonable cost structure for users
- 6) More than user friendly, user inviting
- 7) Housing and transportation
- 8) Quick turn around-for clearance, for trying ideas

**A SCIENCE ENABLER**

**A TECHNOLOGY INNOVATOR**

**A PROPOSAL INCUBATOR**