# DEVELOPING A NEED FOR NANOSAFETY: PRESENTING THE UNKNOWNS

**Dr. Walt Trybula**
Director of Nanomaterials Application Center
Texas State University

**Dr. Dominick E. Fazarro**
Sam Houston State University

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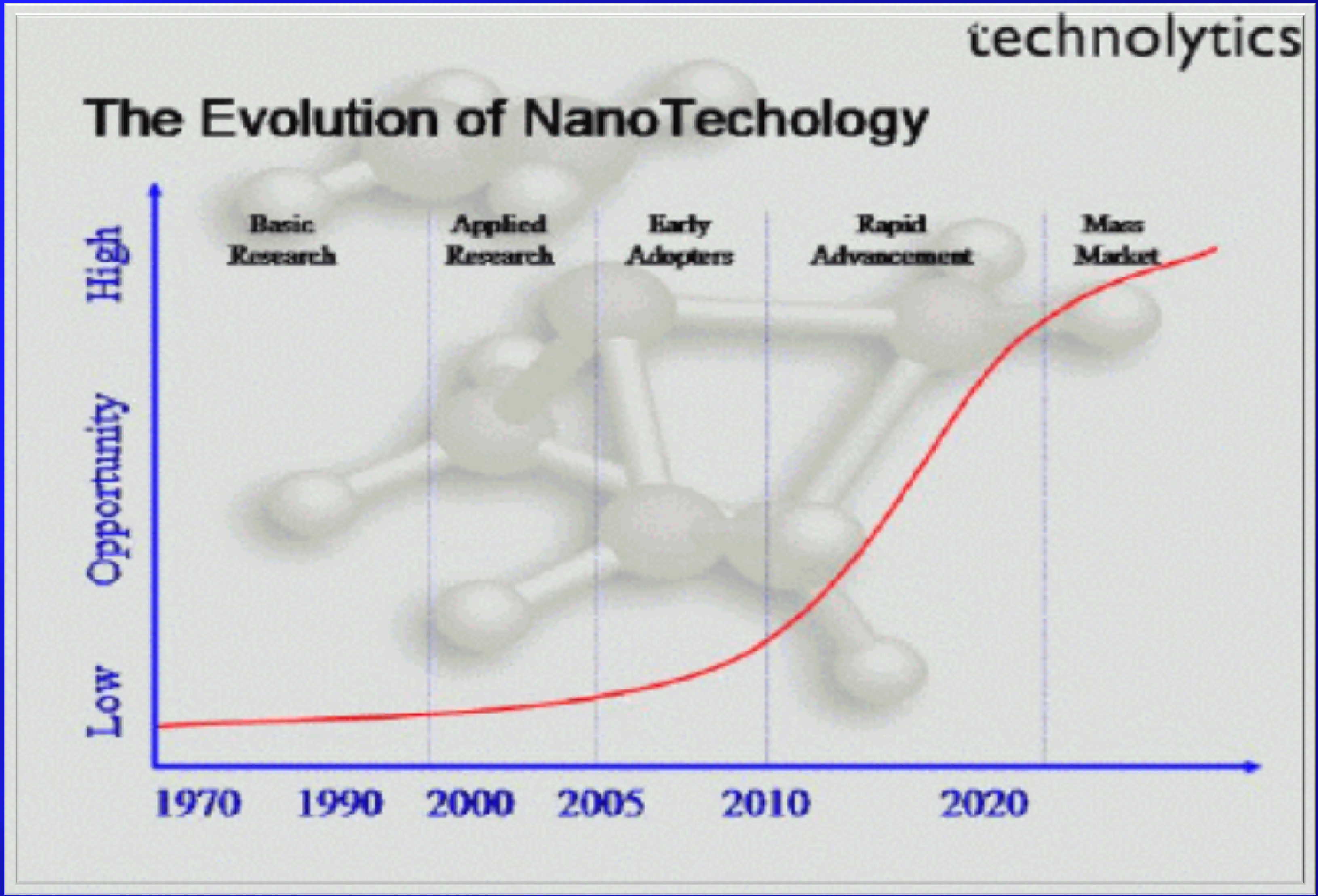
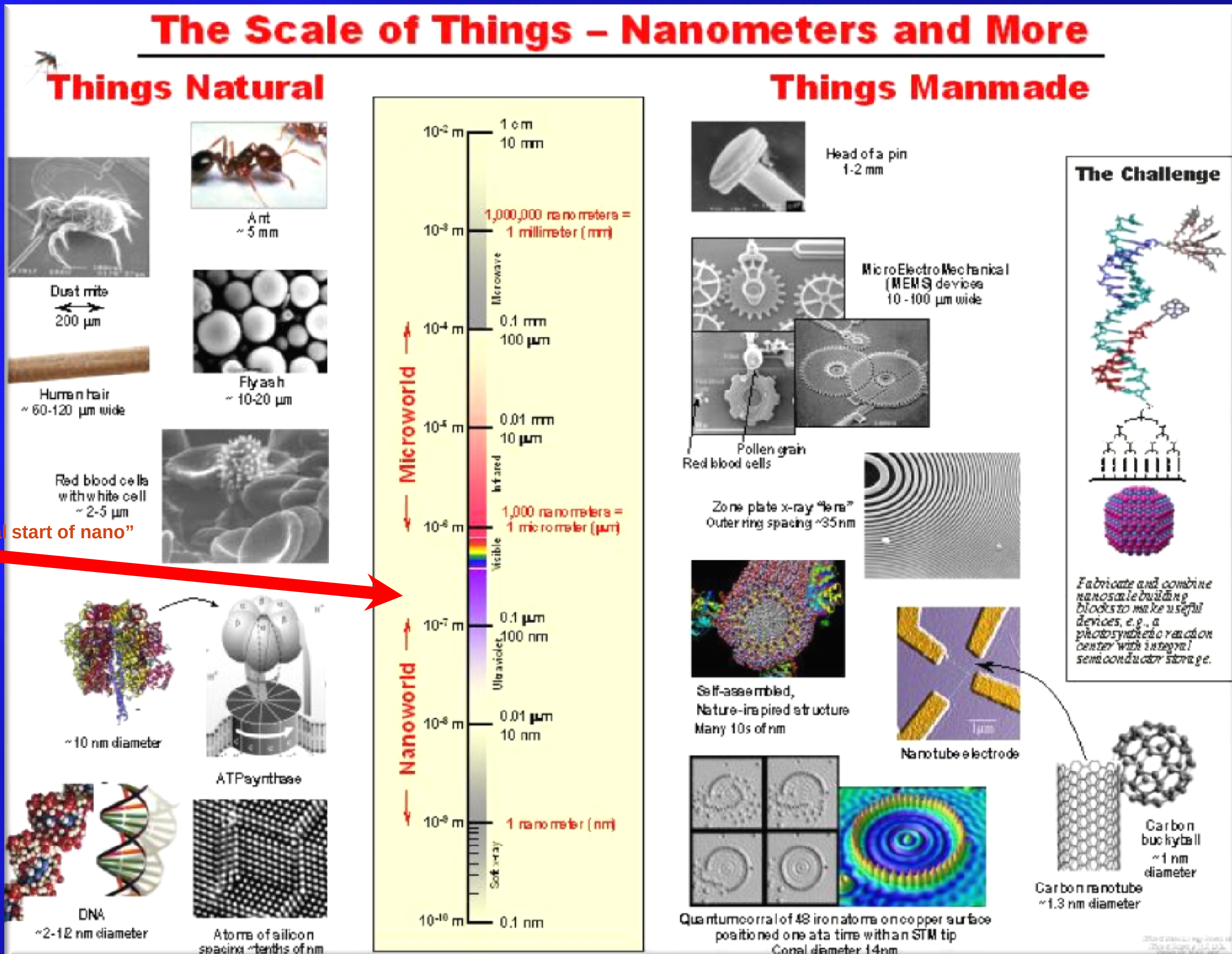
# Structure of Presentation

- Why is nano not size?
- Nano Technology
  - Material properties – some examples
- Projected applications
  - Examining properties of "nano" products
- Business Implications
- Nanosafety Education
- Comments & Questions

We are entering an unknown revolution which must be carefully taken with caution. This presentation is beginning of many presentations to discuss the issues of nano safety-Fazarro




Coleman, Kevin (2003). Nanotechnology and the Fight Against Terrorism. *Technolytics*




"Traditional start of nano"

Courtesy Office of Basic Energy Sciences,
Office of Science, U.S. Department of Energy

Ref: Life on Earth

# Nano is <u>not</u> size

## Example from Semiconductors

- Current technology is 90nm node
  - For logic (microprocessors):
    - Half pitch is 130nm (minimum line width)
  - For memory:
    - Half pitch is 90nm (minimum line width)
- If *nano* is size, then memory semiconductors should have different properties from logic ones based on the difference in the size of the conductors (lines).
- Both circuits perform the same way. So <u>*nano* is not only size</u>. There are numerous other examples, like Cu conductivity at 40nm or particle cleaning at 50nm.

# Definition of Nanotechnology

Nanotechnology refers to research and technology development at the atomic, molecular, and macromolecular levels aimed at creating and using structures, devices, and systems that have novel properties and functions because of their small size.[1]

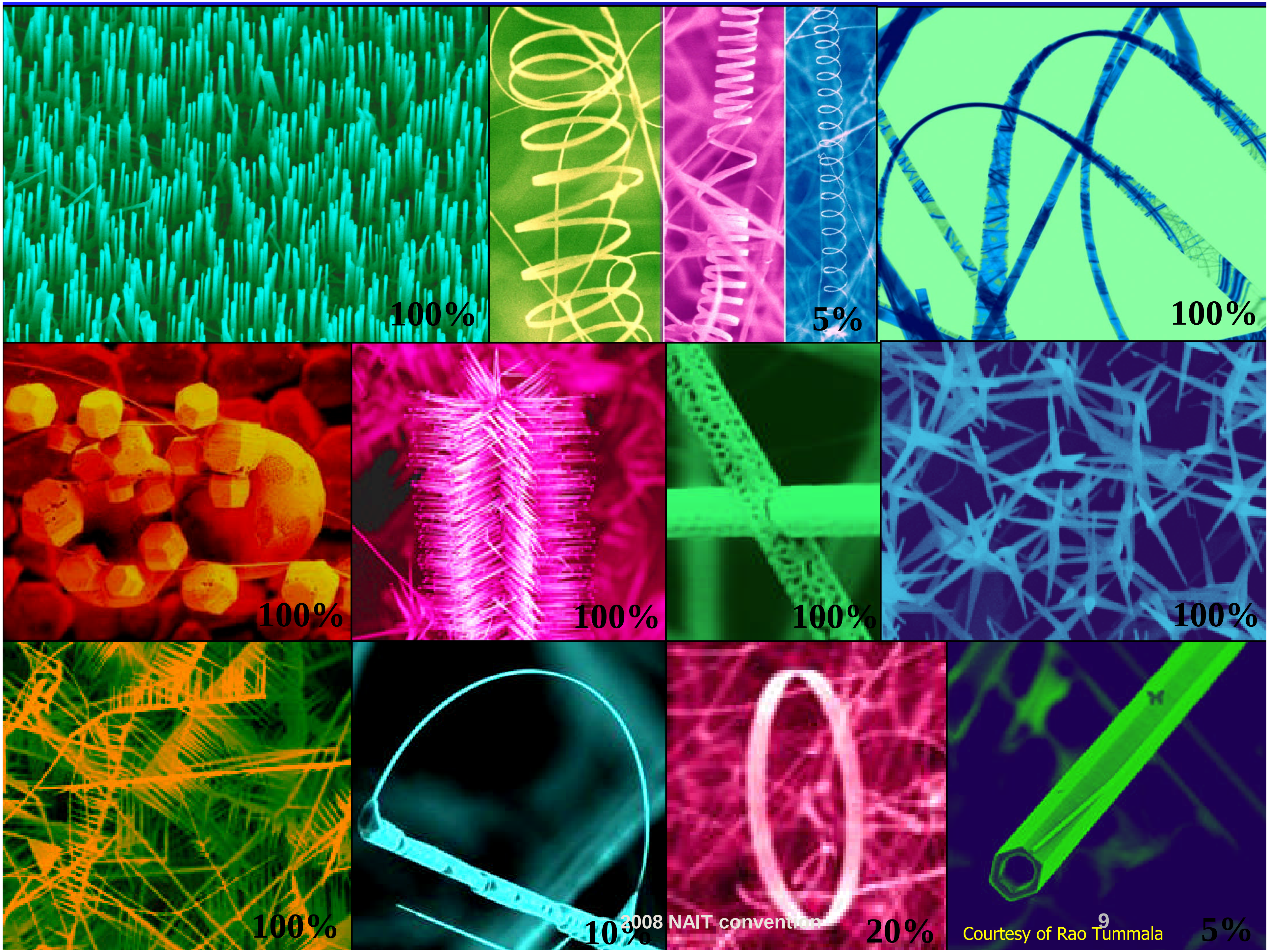
[1] Nanotechnology Standards Panel of ANSI

# Nano

This is a new world!!!

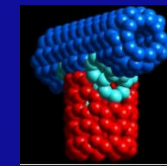
- Some things will be familiar
- Others will be totally unknown or unexpected
- Caution will be required before proceeding rapidly forward

Let's explore some examples of materials



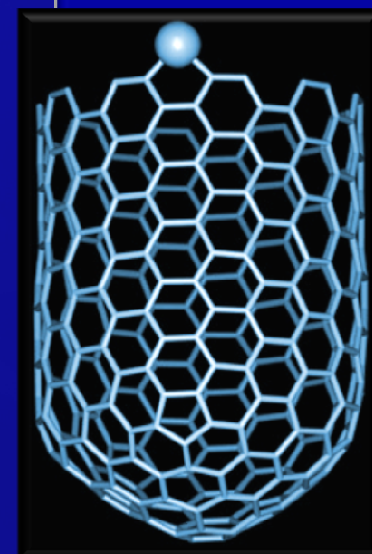
Courtesy of Rao Tummala

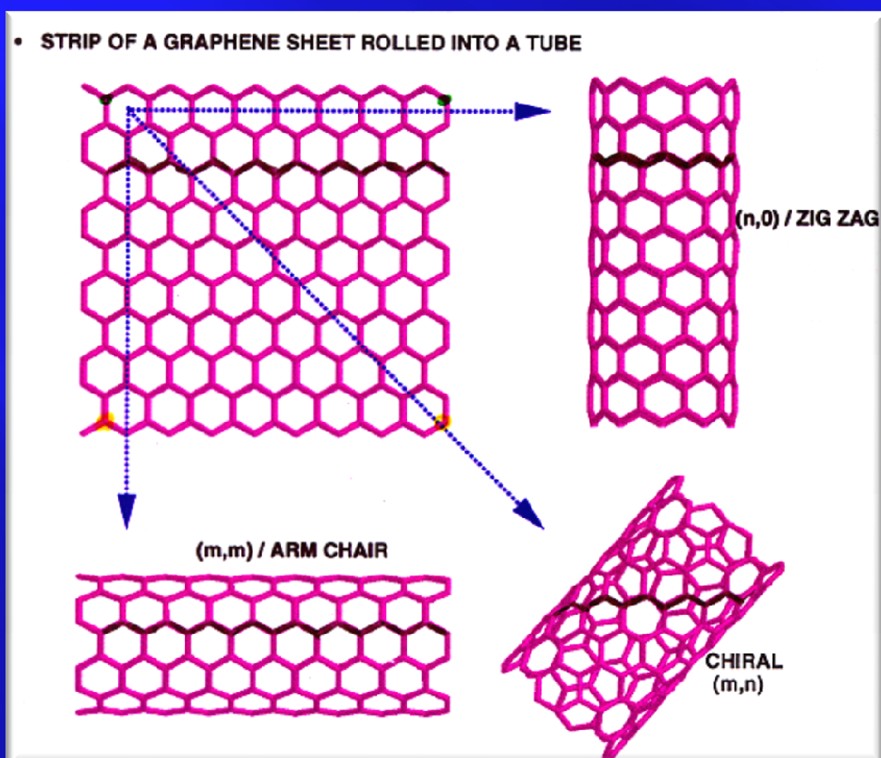
# Carbon Nanotube



**CNT** is a tubular form of carbon with diameter as small as 1 nm.
Length: few nm to microns.

**CNT** is configurationally equivalent to a two dimensional graphene sheet rolled into a tube.






**CNT** exhibits extraordinary mechanical properties: Young’s modulus over 1 Tera Pascal, as stiff as diamond, and tensile strength ~ 200 GPa.

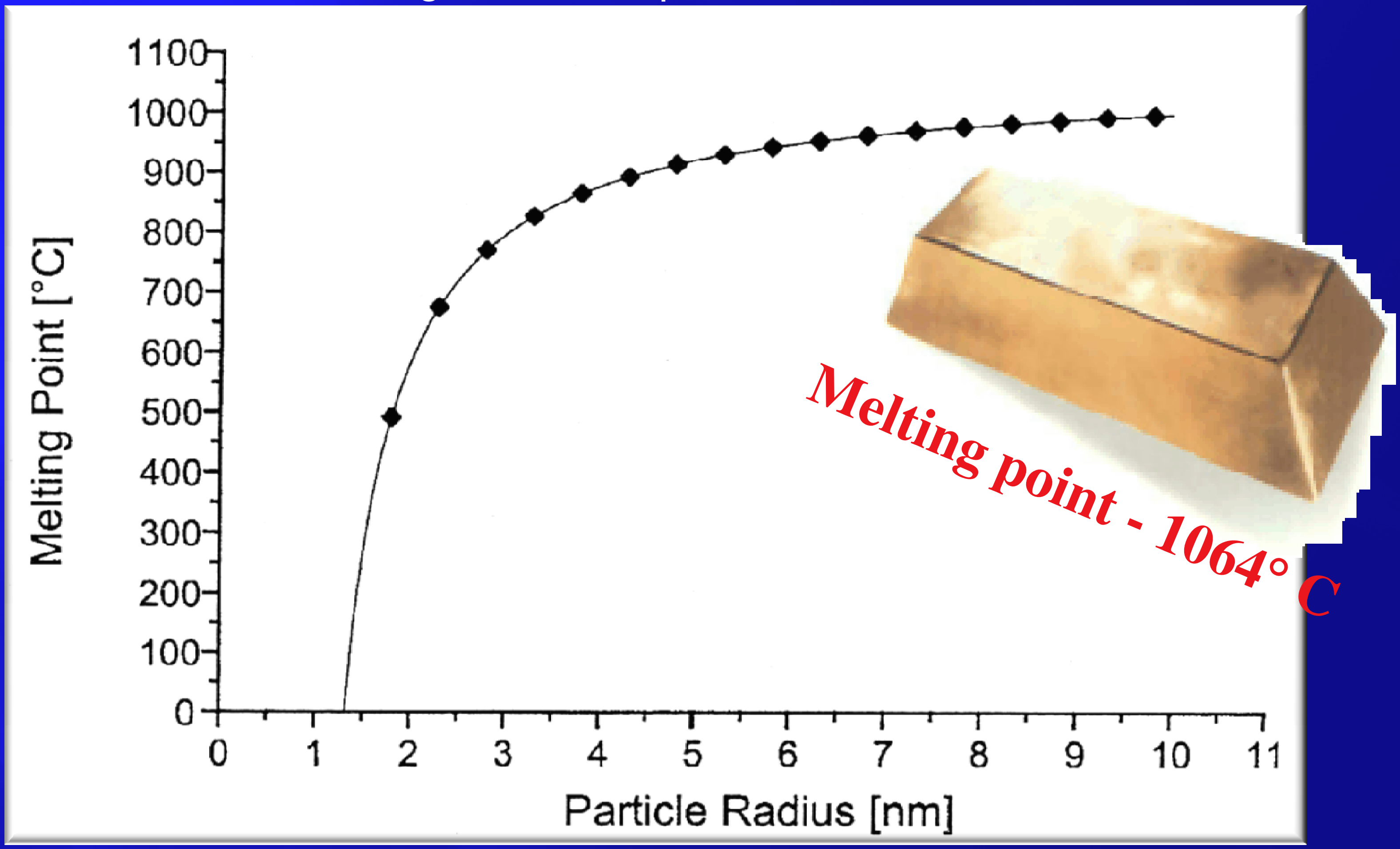
**CNT** can be metallic or semiconducting, depending on chirality.



Courtesy of M. Meyyappan

# Melting Point is <u>not</u> Constant !

Melting Point is Dependent on Particle Size




*Source: K.J. Klabunde, 2001*

NASA Ames

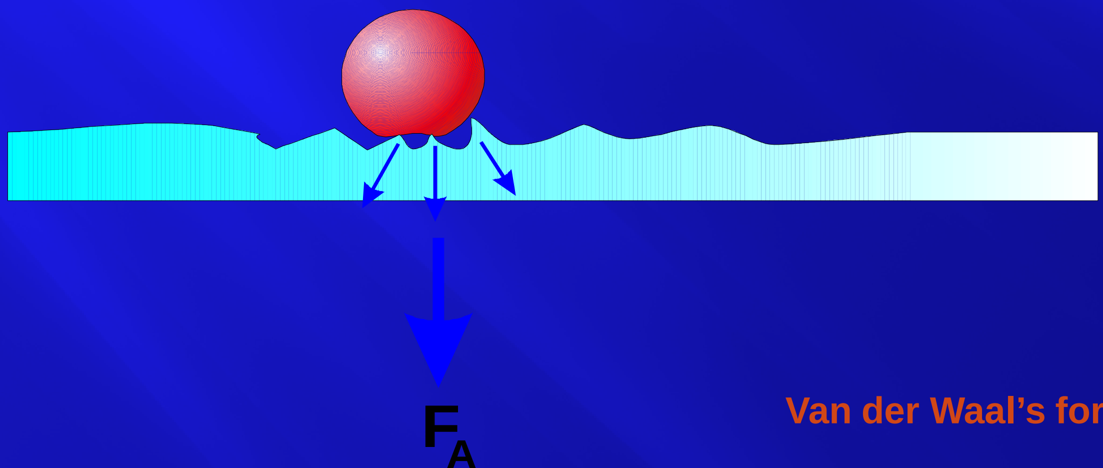
# Color is size dependent!

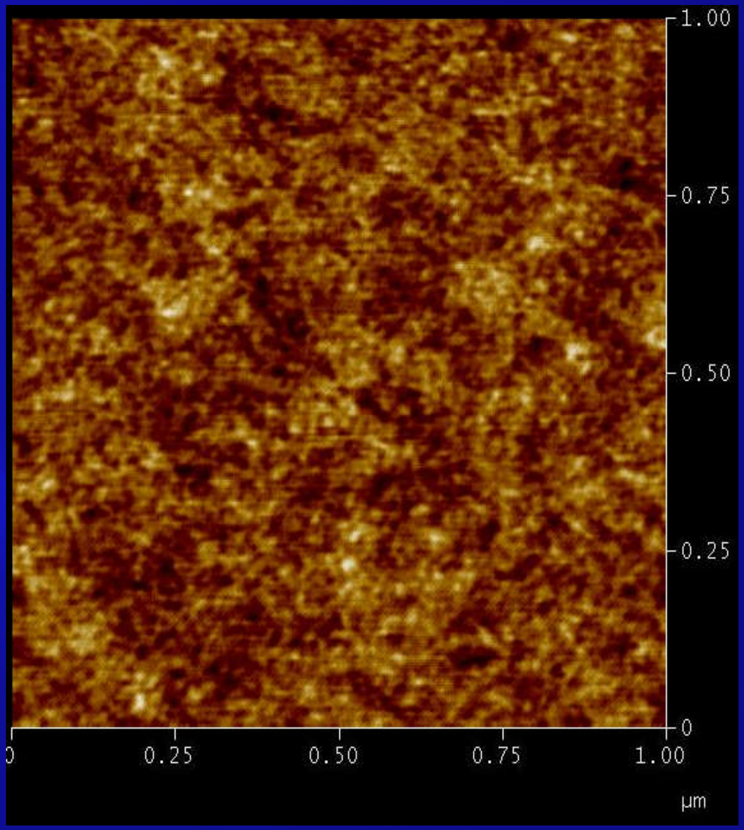
Quantum Dot Rainbow
Source: Andrey Rogach
**References:**
Yu. P. Rakovich, J. F. Donegan, S. A. Filonovich, M. J. M. Gomes, D. V. Talapin, A. L. Rogach, A. Eychmüller. "Up-Conversion Luminescence via a Below-gap State in CdSe/ZnS Quantum Dots." *Physica E* , 17, 99-100.2003

**Description:**
Semiconductor nanocrystals, also called colloidal quantum dots, typically have a size between ~1 and 10 nm and lie in the transition regime between bulk solids and molecules. A demonstration of the size-dependent properties of semiconductor nanocrystals is the continuous change of their emission color as shown by the range of CdSe nanocrystal emission spectra.
A fascinating application for this type of property is to attach the particles to specific molecules that are attracted to cancerous sites. When a surgeon operates and illuminates the area with UV light, the cancerous cells are highlighted by the glowing particles. The surgeon can ensure that the cancerous cells are removed.

# Cleaning nano is different !

- Multiple contact points
- Reduces the total adhesion forces
- Higher roughness leads to higher available surface




Van der Waal's forces become the dominant about 60nm.

# Projected Applications

# Nano Technology Applications?

- In the next slide, there is a picture that shows 12 "nano" technology applications identified in 2004.
- Examples of each of the selected items will be discussed and identified as nano or not nano.
- Additionally, each of the nano applications will be identified by difficulty of manufacturing into the following categories:
  - Properties where anything is acceptable
  - Properties but requiring some precision of assembly
  - Size dependent properties but no precision assembly needed
  - Size dependent properties with precision of assembly required

# Nano Technology Applications


1 - Organic Light Emitting Diodes (OLEDs) for displays

2 - Photovoltaic film that converts light into electricity

3 - Scratch-proof coated windows that clean themselves with UV

4 - Fabrics coated to resist stains and control temperature

5 - Intelligent clothing measures pulse and respiration

6 - Bucky-tubeframe is light but very strong

7 - Hipjoint made from biocompatible materials

8 - Nano-particle paint to prevent corrosion

9 - Thermo-chromic glass to regulate light

10 - Magnetic layers for compact data memory

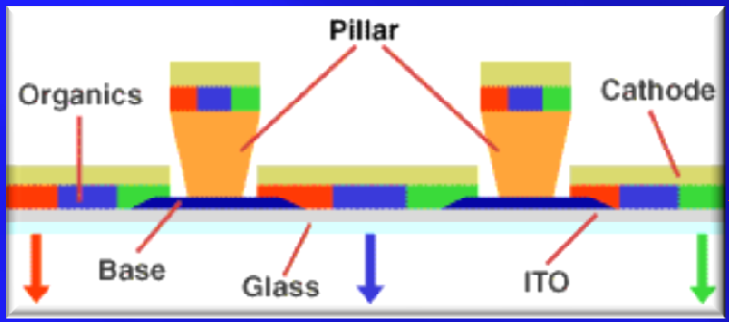
11 - Carbon nanotube fuel cells to power electronics and vehicles

12 - Nano-engineered cochlear implant

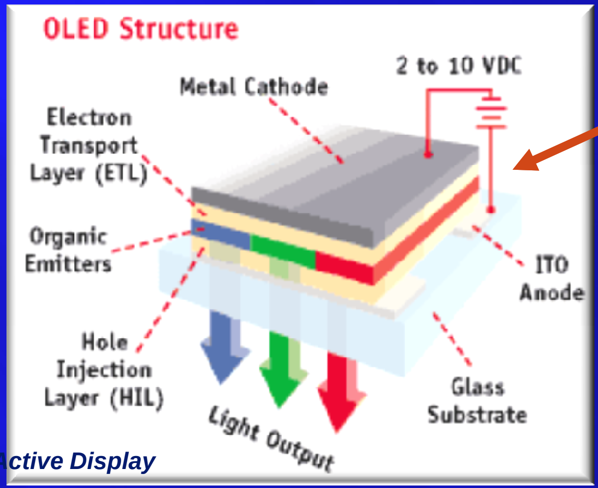
**Compiled by Jo Twist, BBC News On-Line, July 28, 2004**

# Organic Light Emitting Diodes

*Passive Display*




Emitter Layer ~100nm




*Active Display*

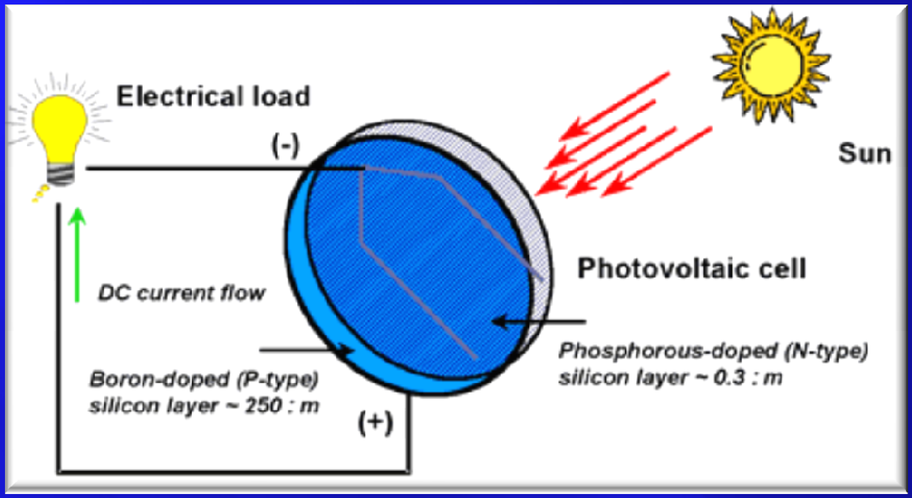
**OLED, unlike LCD, are self luminous. Consequently, they do not required backlighting, diffusers, or polarizers. There are two types of OLEDs.**

**The passive matrix OLED display is an array with pixels connected by intersecting conductors. This structure can be readily applied to existing high volume manufacturing.**

**The active matrix OLEDs have electronics incorporated into the back plane, which enables it to be used in high-resolution applications.**

Figures from http://komar.cs.stthomas.edu/qm425/01s/Tollefsrud2.htm

# Photovoltaic Film



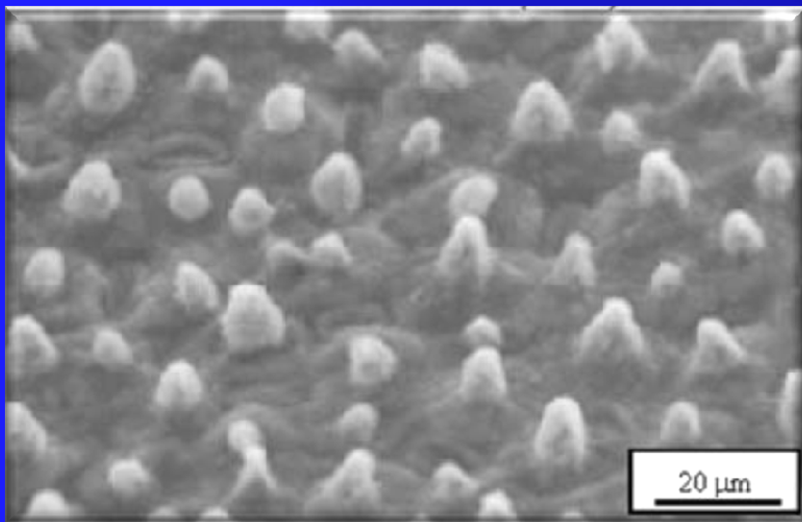

**A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact, called the P-N junction.**

**When sunlight strikes the surface of a PV cell, this electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load. The voltage is constant, between 0.6 and 0.5 volts, but the total power is a function of size. Cells can be connected in either parallel or series to produce higher voltages, or higher current.**

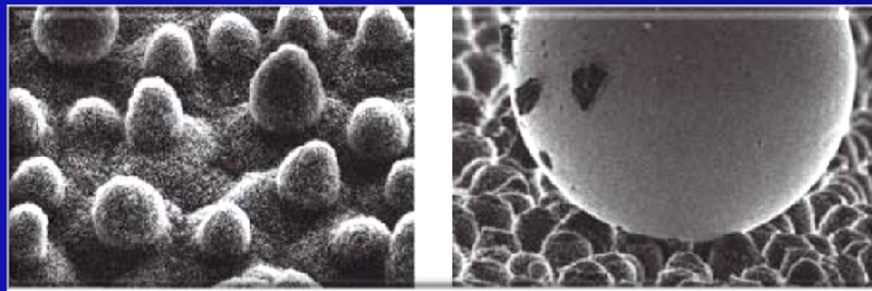
**Thin film photovoltaic cells use layers of semiconductor materials only a few micrometers thick, attached to an inexpensive backing such as glass, flexible plastic, or stainless steel. Semiconductor materials for use in thin films include amorphous silicon (a-Si), copper indium diselenide (CIS), and cadmium telluride (CdTe)**

**Constant changes**
**http://www.fsec.ucf.edu/pvt/pvbasics/**

# Window Coatings




SEM image of lotus leaf



SEM image of self-cleaning glass

Ref: Dr. Helmut Hohenstein of Institut fur Fenstertechnik

There is a great interest in the design and development of the so-called “hygienic surfaces”, referring to surfaces that not only provides biocidal activity but also to those that are easy to clean and even self-cleaning.

Achieving these properties on a surface is possible by means of coatings and treatments on specific surfaces, and in which nanotechnology plays a key role. Most of these coatings acquire their biocidal/self-cleaning capacity by incorporating specific nanoparticles: basically silver (Ag) and titanium oxide (TiO 2 ).

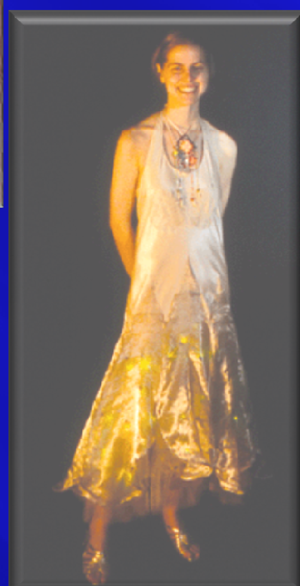
Ref: Nano Tsunami - Hygienic surfaces, biocidal and self-cleaning coatings

# Smart Fabric

## Interactive fabric

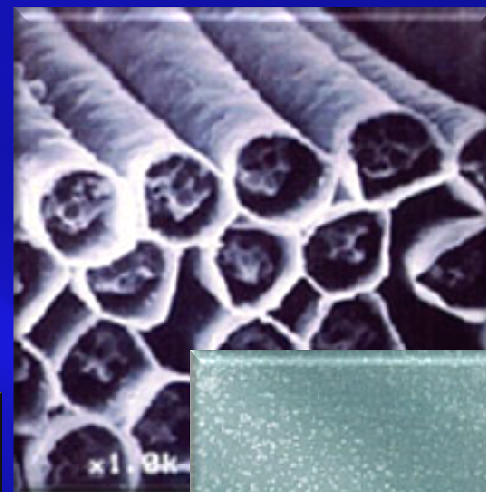
Electric Plaid: a handwoven, color-changing textile. Photo by International Fashion Machines.

Journal of Materials
Vol.57, No. 7



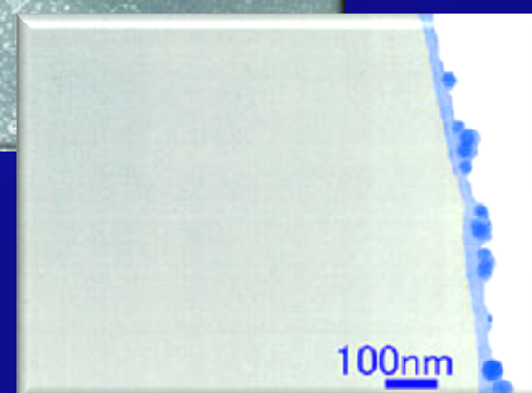
Firefly dress

## Passive fabric



SEM photograph of functional material coating on polyester fiber surface

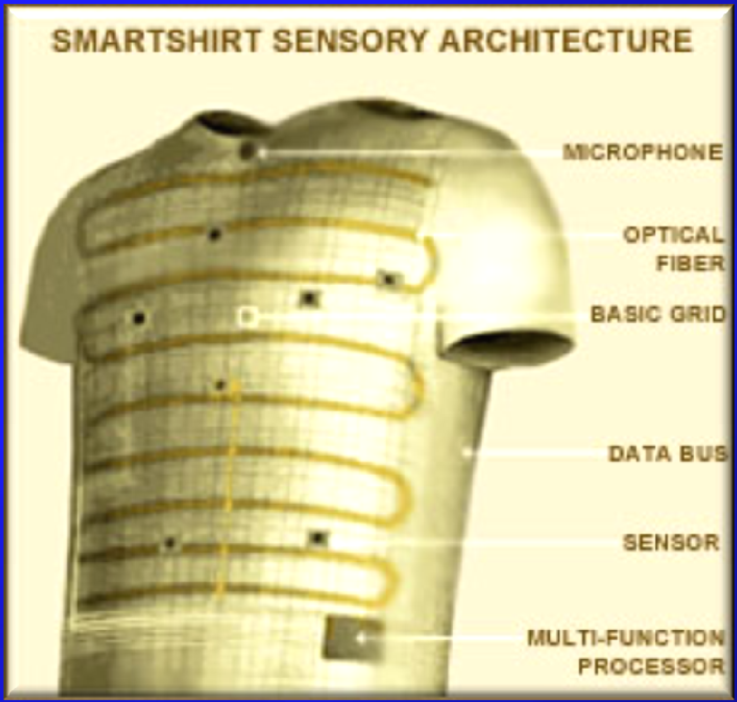
SEM photograph of the fiber surface coated with functional material




TEM photograph of a cross-section of fiber coated with functional material

Ref: Toray Institute

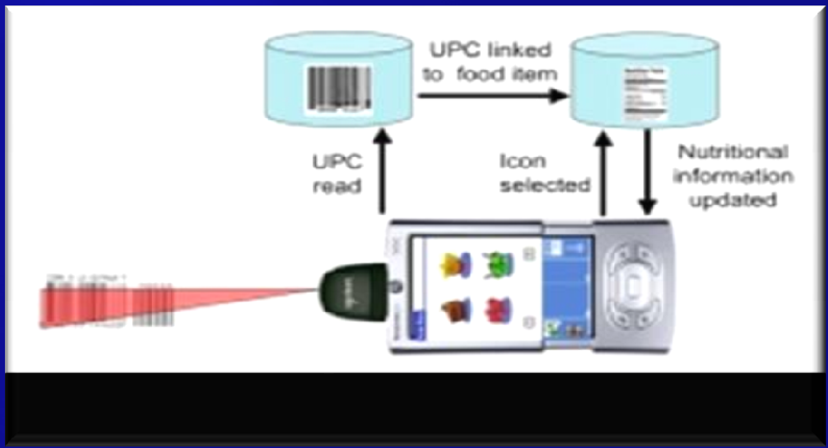
# Med-Bio Monitoring




http://www.fibre2fashion.com/news/NewsDetails.asp?News_id=11705


**Untethered signal transmission permits remote monitoring**

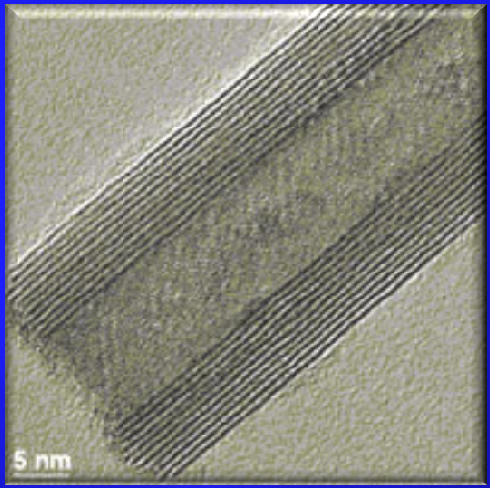
**Dietary tracking with remote sensing**



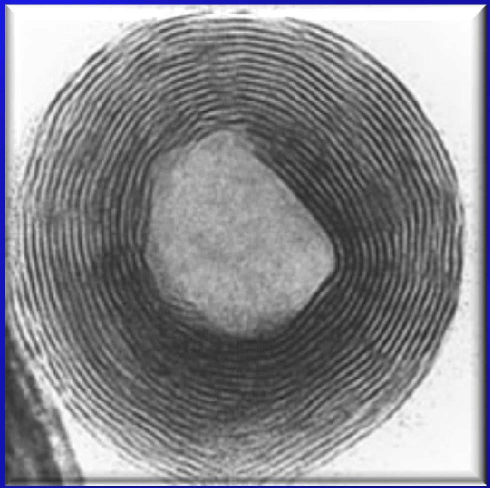

**Ref. http://www.cs.indiana.edu/surg/Projects/TRIGGERS_SURG_Page/TRIGGERS.html**

# Stronger Materials

IsraCast has recently tested one of the most shock-resistant materials known to man. Five times stronger than steel and at least twice as strong as any impact-resistant material currently in use as protective gear.




Certain inorganic compounds such as $WS_2$, $MoS_2$, $TiS_2$ and $NbS_2$ that normally occur as large flat platelets can be synthesized into much smaller nano-spheres and nano-tubes which they named inorganic fullerene-like nanostructures (IF)



The "Onion like" nano-structure of the IF materials, is the result of a sophisticated manipulation on the original layered material. This unique structure is responsible for its remarkable strength and durability

The material withstood the shock pressures generated by the impacts of up to 250 tons per square centimeter. The rendering above is of a possible armor vest. (Material production is currently a few kilograms per day.

Ref. http://www.isracast.com/tech_news/091205_tech.htm

# Med-Bio Prosthetics

Ref: http://www.defensetech.org/archives/cat_medic.html

**Requirements:**

Breakthroughs in
- •neural control,
- •sensory input,
- •advanced mechanics and actuators, and
- •prosthesis design and integration (Ref.)

Other Requirements:

Significantly enhanced computing power

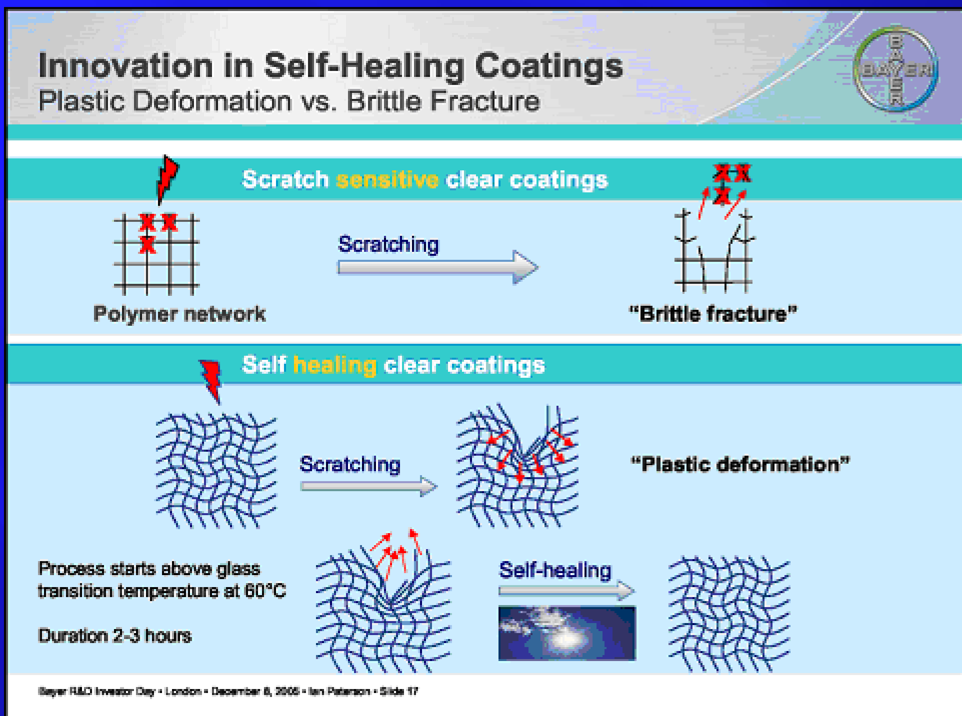
Reduced power consumption

New electronic interfaces
- •Analog to neural converters (A to N)
- •N to A converters
- •Digital to neural converters (D to N)
- •N to D converters

**Note: DARPA is also working on complete arm replacements with neural control.**

# Self Healing Paints

Nisson will start offering a self-healing paint. After an encounter that creates scratches to the paint, the paint starts to reform itself over the scratch. An overnight reformulation should occur over night.




Ref. http://www.timesonline.co.uk/article/0,,3-1901520,00.html

Ref. http://www.bayer.com/medien/pages/4248/20051208rdinvestordaypaterson_automotive.pdf

# Nano Based Memory Devices

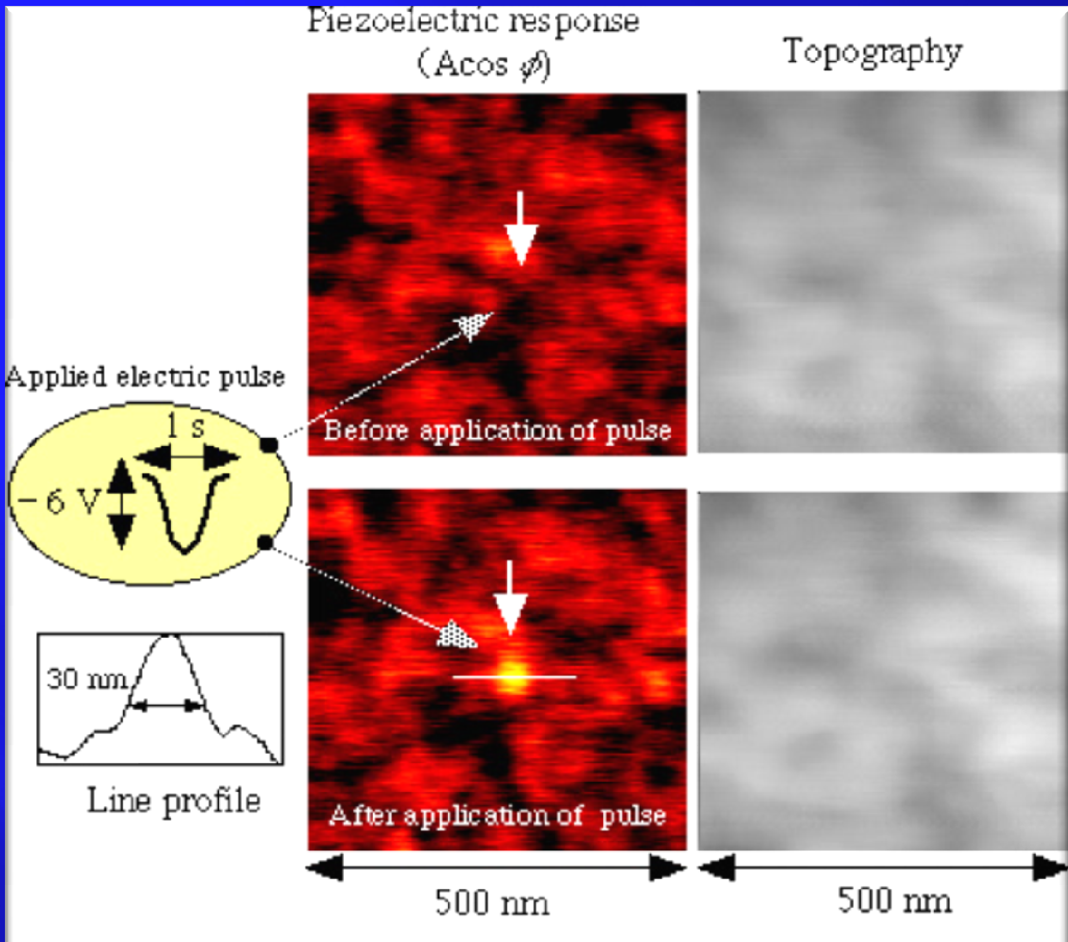


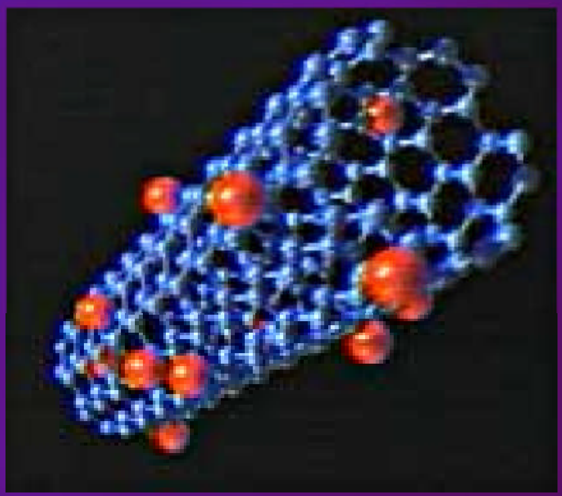

**Figure 4.** Piezoelectric response and topographic images of the ferroelectric copolymer film observed before and after the application of electric pulse.

**IBM Millipede Memory. 2D multistack architecture with multibits per cell. Requires uniform thin polymer thickness for high density. Rewritable with no wear on polymer after 106 cycles. Multi-tip provides fast speed, but the initial cost will not be inexpensive.**

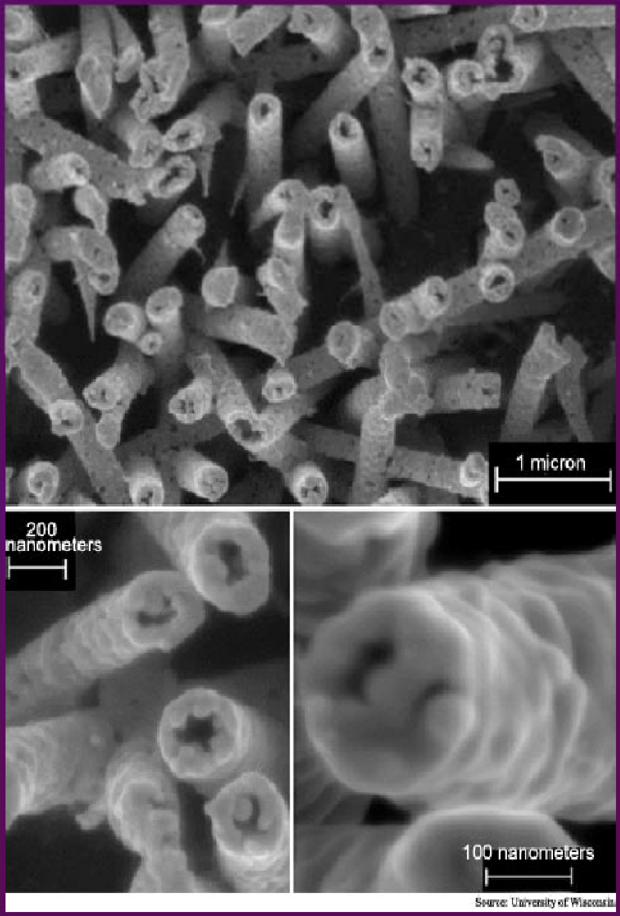
**http://www.foresight.org/Conferences/MNT05/Papers/Matusige/**

**Ref. http://www.ieee-virtual-museum.org/collection/tech.php?id=2345954&lid=1**

# CNT Fuel Cells

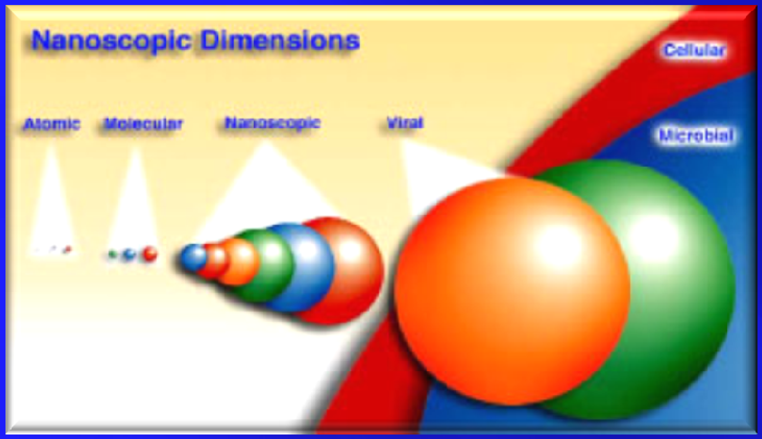


http://www.pbs.org/newshour/bb/science/july-dec03/hydrogen_10-20.html



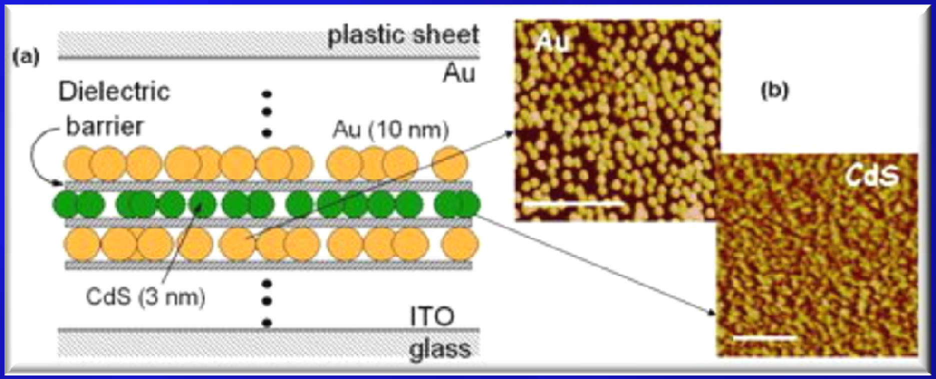

http://www.trnmag.com/Stories/2004/092204/Fuel_cell_converts_waste_to_power_092204.html

# Med-Bio Active Devices




Ref: http://nano.med.umich.edu/projects/dendrimers.html

**Artificial sense of touch**




Ref: http://www.physorg.com/news69155876.html

**Cochlear Implants**

Tissue compatibility coatings
Finer electrodes
On-board signal processing
Very low power

Ref: Deb Newberry

# Nano Everywhere

- The number of nano products is over 600 as of April 2008
- There are hundreds of available consumer products being spawned as companies manipulate matter at the atomic level, according to The Project on Emerging Nanotechnologies, a Washington, D.C. initiative associated with the Woodrow Wilson International Center for Scholars.
- The group released a products inventory containing descriptions of more than 200 consumer goods purportedly made with some type of nanotech process or nanomaterial.
- Link to Nanotechnology Consumer Products Inventory

http://www.nanotechproject.org/index.php?id=44&action=view

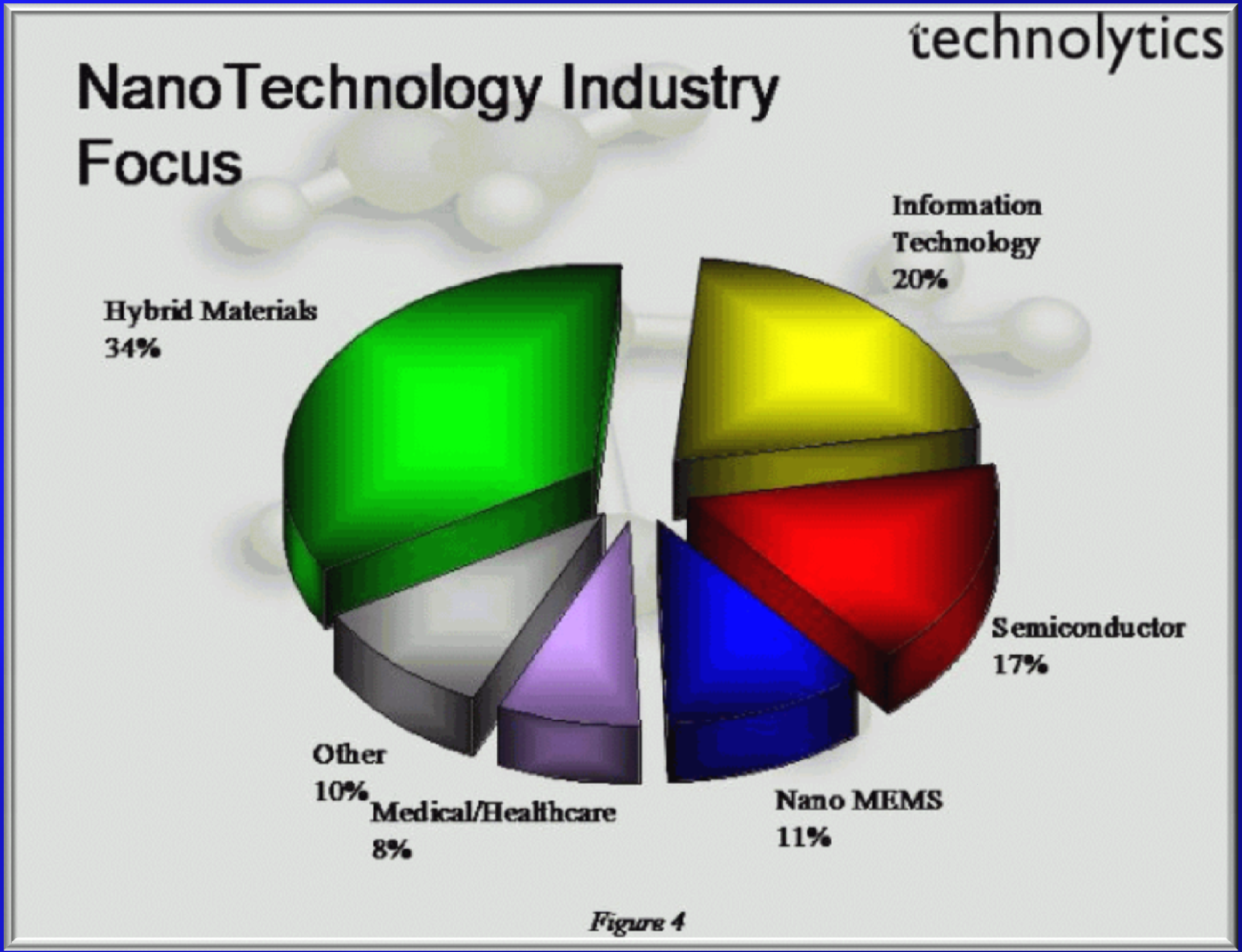
# Business Implications

# Opportunities

"The Future Ain't What It Used to Be…"

- Yogi Berra

"It's a whole lot more!" - Walt

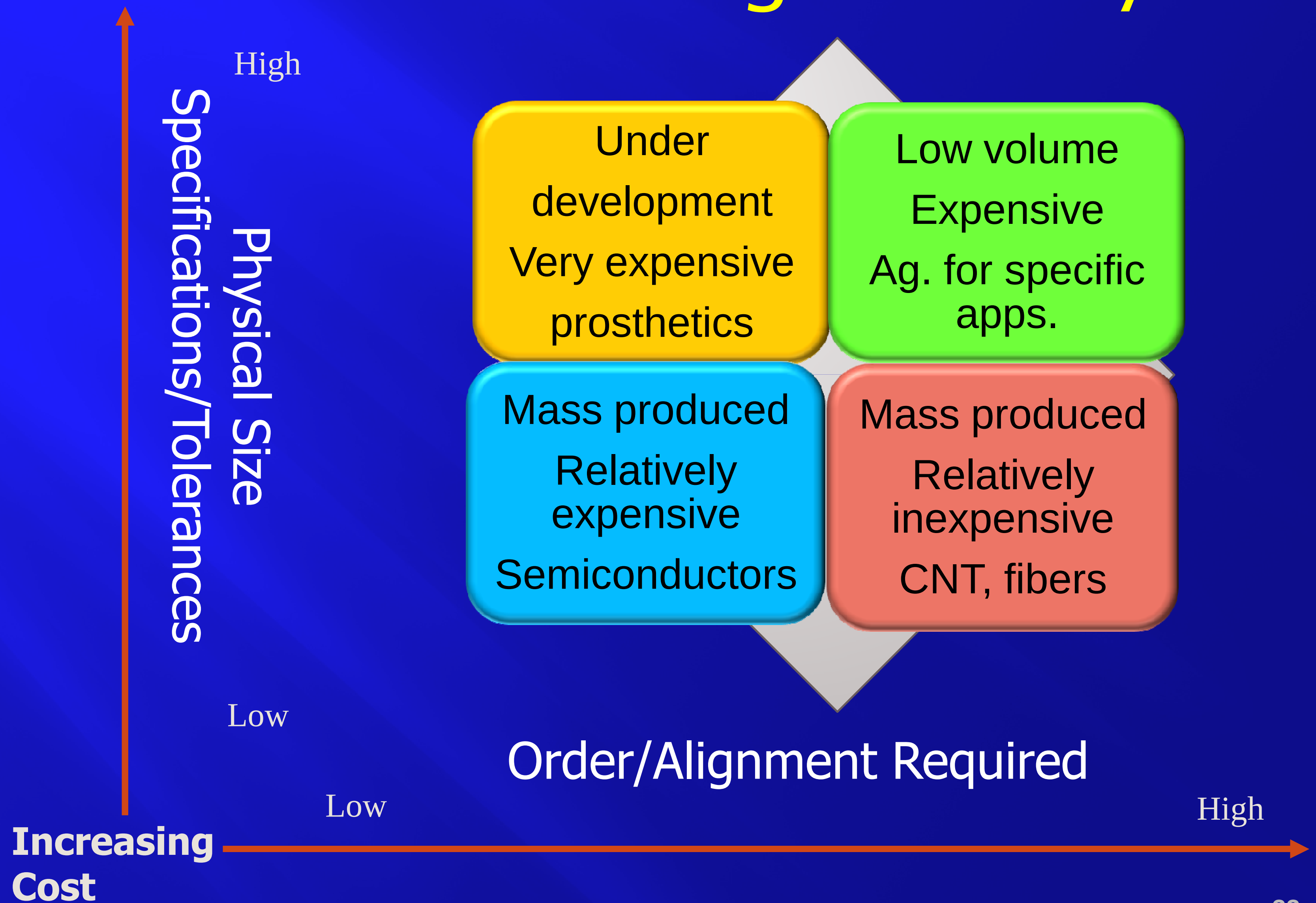



Coleman, Kevin (2003). Nanotechnology and the Fight Against Terrorism . *Technolytics*

# Business Implications

- Nanotechnology requires expensive measurement equipment
- Collaboration is a key to maintaining control of the technology
- Nanotechnology product development requires sophisticated processes
- Nanotechnology has the potential to enhance our future through innovative products
- Safety in development, manufacturing and application is paramount

# Opportunities and Challenges of Nano facing Industry



# Nanosafety Education

# Dilemmas

- Lack of proposed funding-Safety education
- Concentrated initiatives from industry
- Lack of research data on nanoparticles
- NO DEFINED DIRECTION

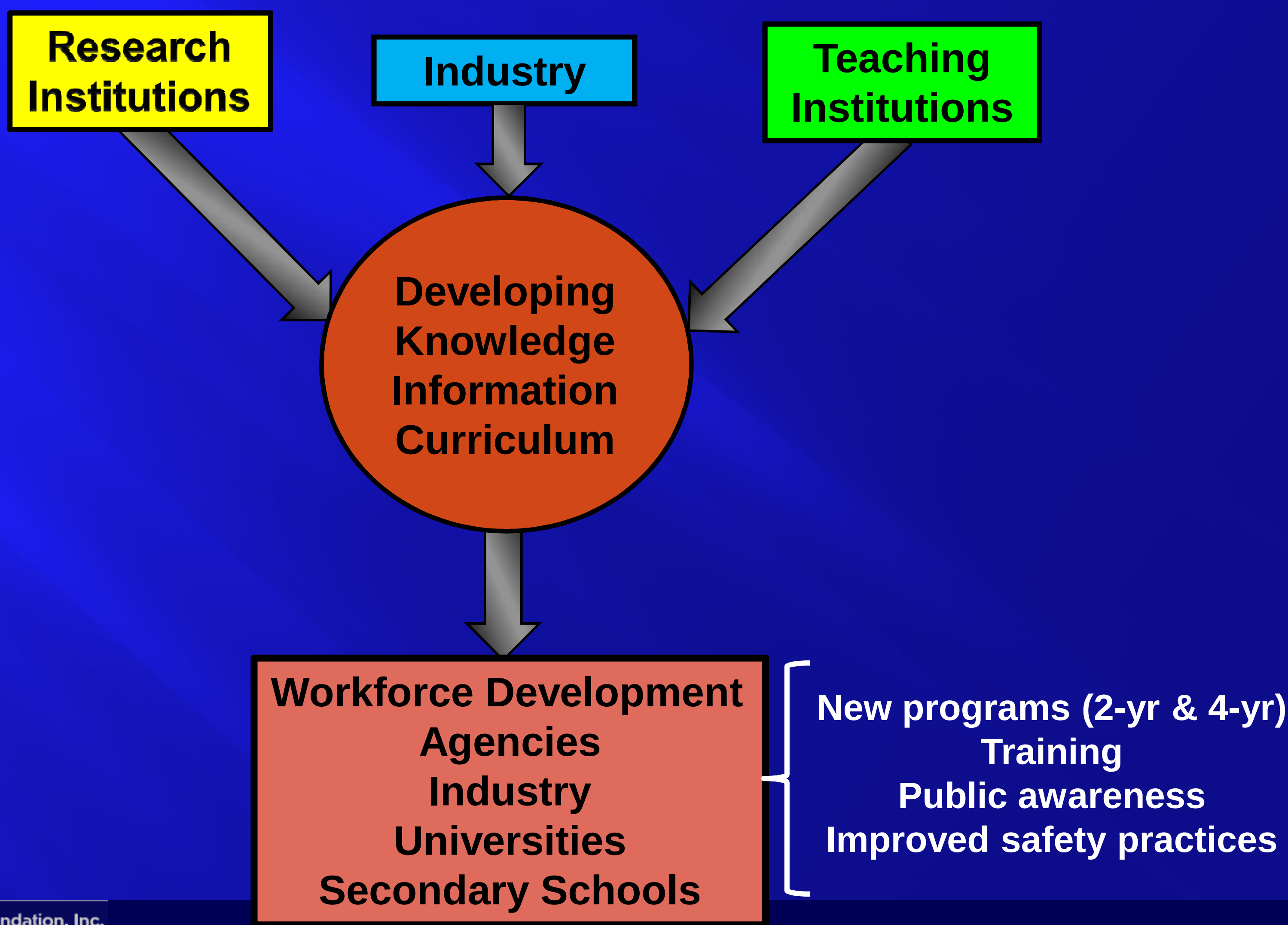
# What is the first step?

- Laterally diffuse a safety agenda/initiative
  - Use a catalyst professional organization
- Build collaborations with industry and academia
- Design research studies to convert data/info. into knowledge management

# Lateral Diffusion of Nano Safety Knowledge

- Must be proactive in our strategies
- Aggressive risk-takers
- What do we need to educate the public?
  - Collaborations
    - Research and Teaching oriented institutions
    - Secondary schools (The future)
    - Industries who are involved with nano products
    - State and federal workforce agencies

# Lateral Diffusion Model

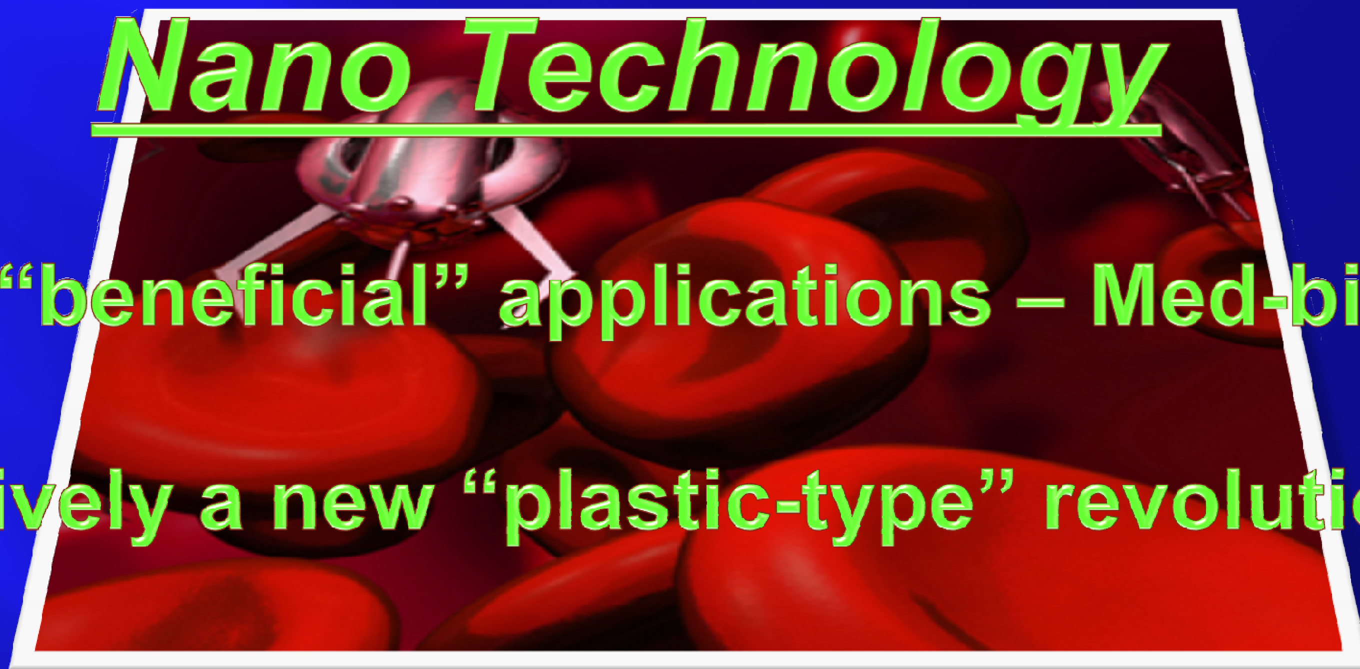


# Summary

- Nano Technology is all about properties and not size → nano is not size.
- Employing novel properties will permit development of devices with novel functions that are impossible as the macro scale → size is nano.
- The existing materials property handbook does not apply in the nano realm. We need to develop an entirely new handbook.
  - Without this fundamental information on materials, novel developments will be challenging.

# Something to think about????

## *Nano Technology*



**First "beneficial" applications – Med-bio?**

**Effectively a new "plastic-type" revolution?**

# Questions????

# Comments

# Thank You

# Contact us @

Walt Trybula
w.trybula@txstate.edu

Dominick E. Fazarro
def003@shsu.edu