

Perspective on Basic (6.1) Research (in NanoTech) & DoD Challenges

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“Moving NanoTechnology from the Lab to the Field”

Arthur C. Clarke

Any sufficiently advanced technology is indistinguishable from *magic*.

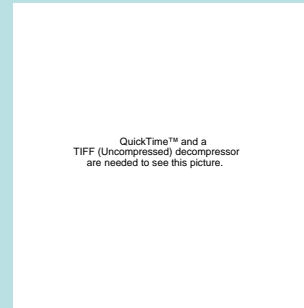
Richard Feynman (MIT '39)

APS Meeting, Dec. 1959

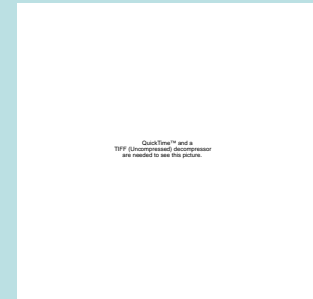
What would the properties of materials be if we could really arrange the atoms the way we want them? They would be very interesting to investigate theoretically. I can't see exactly what would happen, but I can hardly doubt that when we have some control of the arrangement of things on a small scale we will get an enormously greater range of possible properties that substances can have, and of different things that we can do.

Why Make Things Small?

- Faster
- Lighter
- Cheaper*
- More Energy Efficient
- Can Get into Small Places



10^6m



10^{-9}m

Novel Properties at the Nanoscale

* A single print character, e.g. the letter “a” on one page of the Washington Post is more expensive than ***1 transistor in your laptop!***

Some Magic: .357 Magnum Bullet,
22 layers of Kevlar Fabric





ISN Mission

“Use nanotechnology to dramatically improve the survivability of Soldiers.”

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.



*The Warfighter
is our **first**
customer – also
improved protection
for police, fire, first
responders*

Goal: **reduce weight carried** while **improving protection** from multiple threats, such as blast, ballistic, chemical/biological toxins, physical injury, climate, environment, terrain.

What the Army envisioned: Soldier Protection & Nanotechnology

(never tried before, may be useful,
high risk, maybe even “6.0” research)

NanoScience / NanoEngineering:

Properties become **size dependent** below some
critical length scale.

Novel phenomena in **low-dimensional structures**

Opportunities for Enhanced Protection:

New materials, new properties, new phenomena.

Hybrid material combinations ***unattainable*** in nature.

Hierarchical structures; gradients, sandwiches

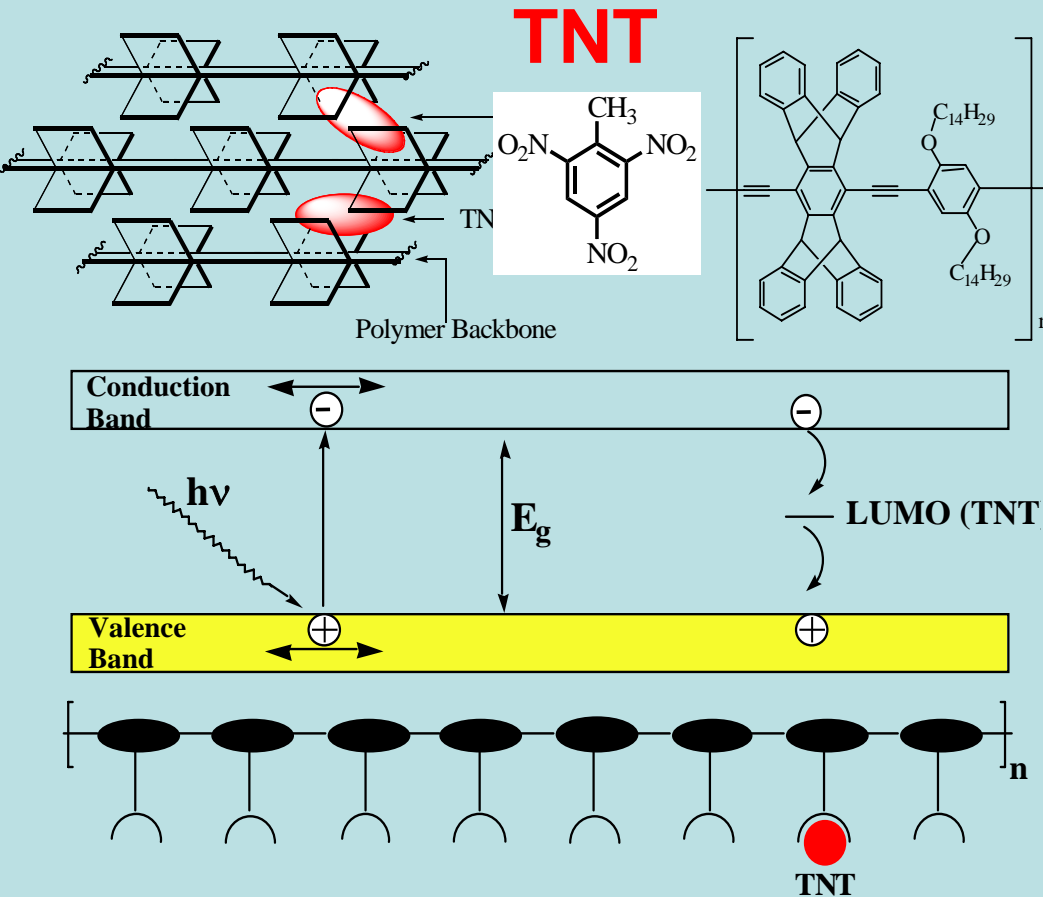
Dynamically tunable materials and properties

Fast responding systems with ***multifunctionality***

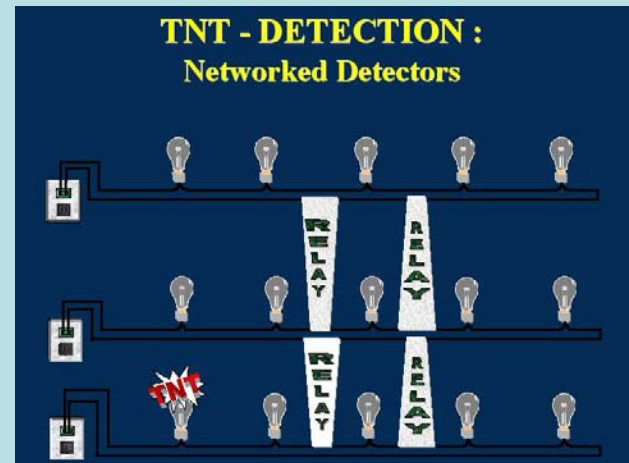
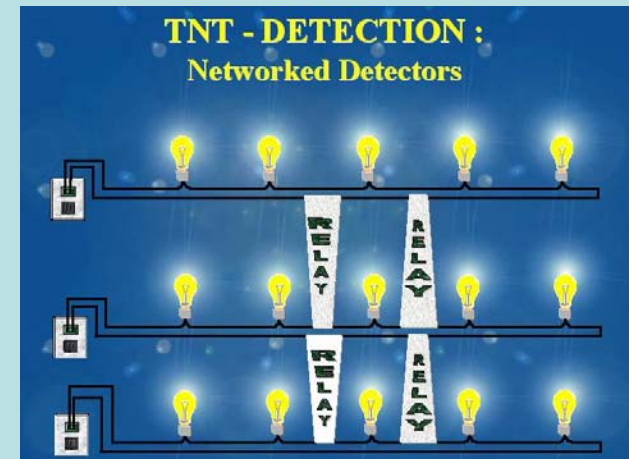
2003 Challenge: Detect IEDs

Electronic Polymers for Explosives Detection

- Rigid 3D Structure: Lock/key for TNT
- Fast Fluorescence Quenching in Thin Films



Excitations migrate along the polymer backbone and are quenched when they encounter an acceptor.



Nomadics Sensor Platform

(Licensed MEMS Technology)

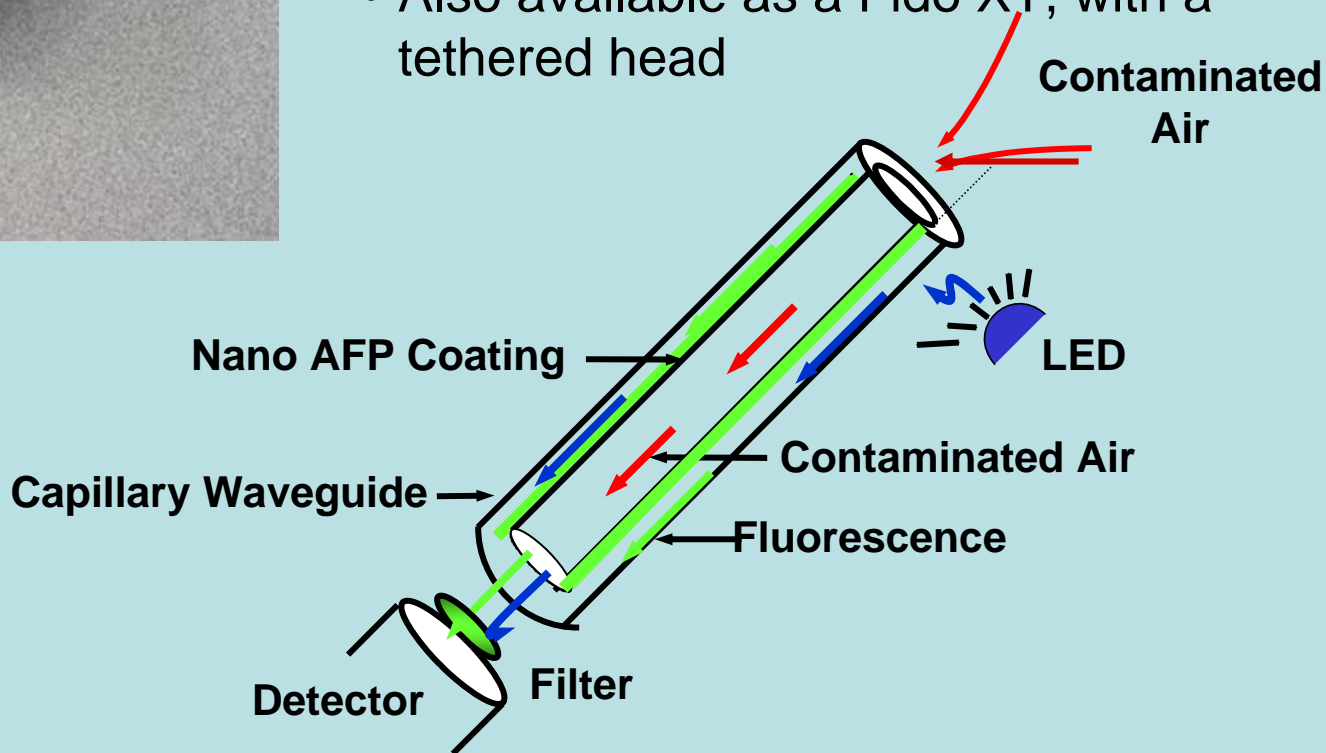
Fido X



- Ruggedized
- Integrated sampler
- Small: 10" x 5" x 2" (approx.)
- Light: 1.5 lbs (including battery)
- Five minute startup
- Audio and visual indications
- Also available as a Fido XT, with a tethered head

Software

- User friendly
- Integrated display
- Internal memory
- Calibration methods





Warfighter Assessment 2005 in Iraq

FIDO XT + iRobot PackBot



**Explosives
Detector**



**SAFETY
FROM
STANDOFF:
PackBot
carries the
sensor to the
vehicles, so
Soldiers
aren't
exposed.**



**THE DETECTION OPPORTUNITY:
Explosives leave invisible traces of
vapors which FIDO can sniff and detect.**

“The FIDO Sensor worked perfectly. With the physical setup forcing wind by the vehicles, FIDO was able to detect explosives 80 feet away. This allowed separation of the Soldiers and dog from the bomb, thus saving lives. . . .”

Single Wall Carbon Nanotubes

MOLECULAR PERFECTION & *EXTREME* PERFORMANCE

The Strongest Fiber Possible

Selectable Electrical Properties

Metallic Tubes Better Than Copper

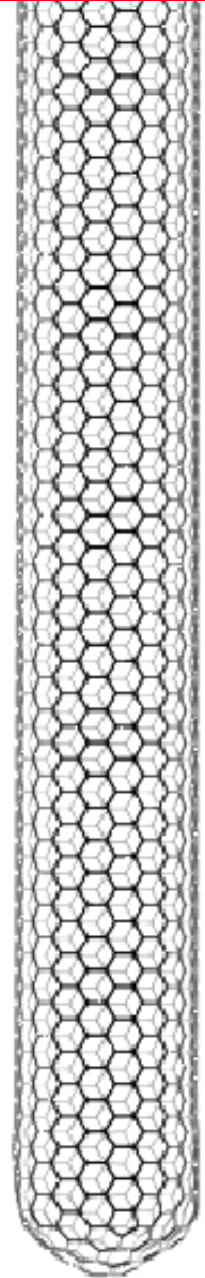
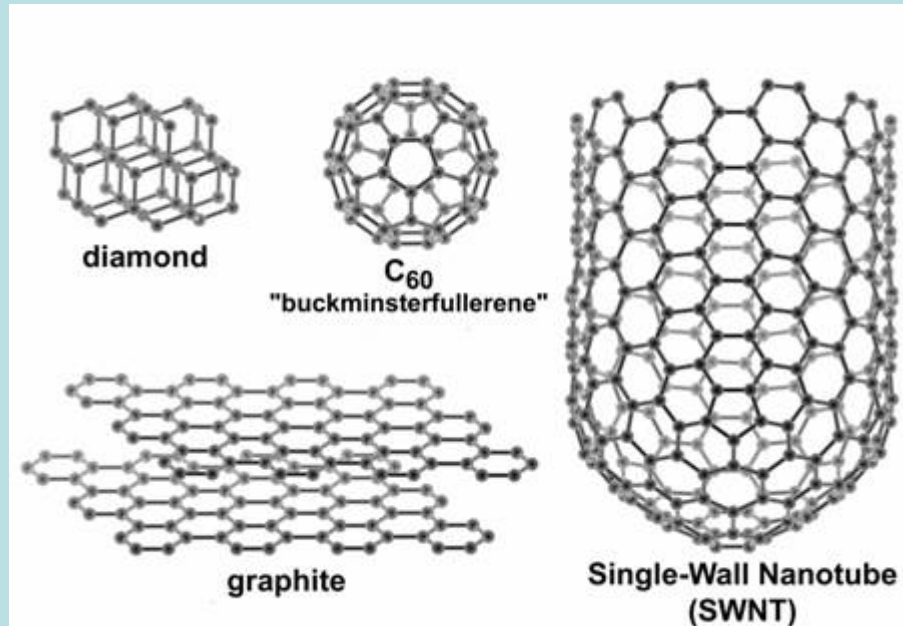
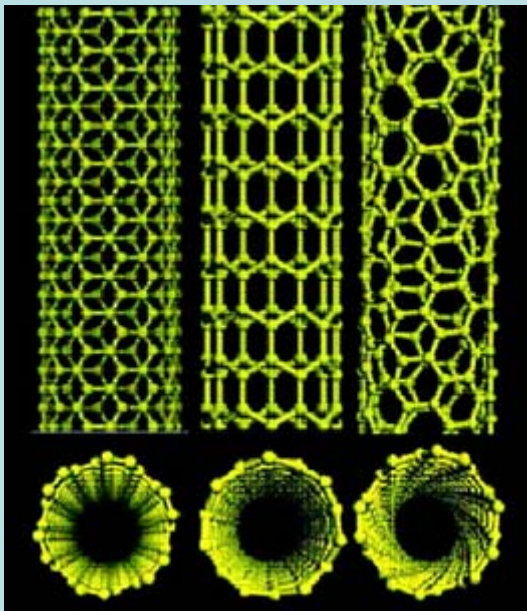
Semiconductors Better Than InSb or GaAs

Thermal Conductivity of Diamond

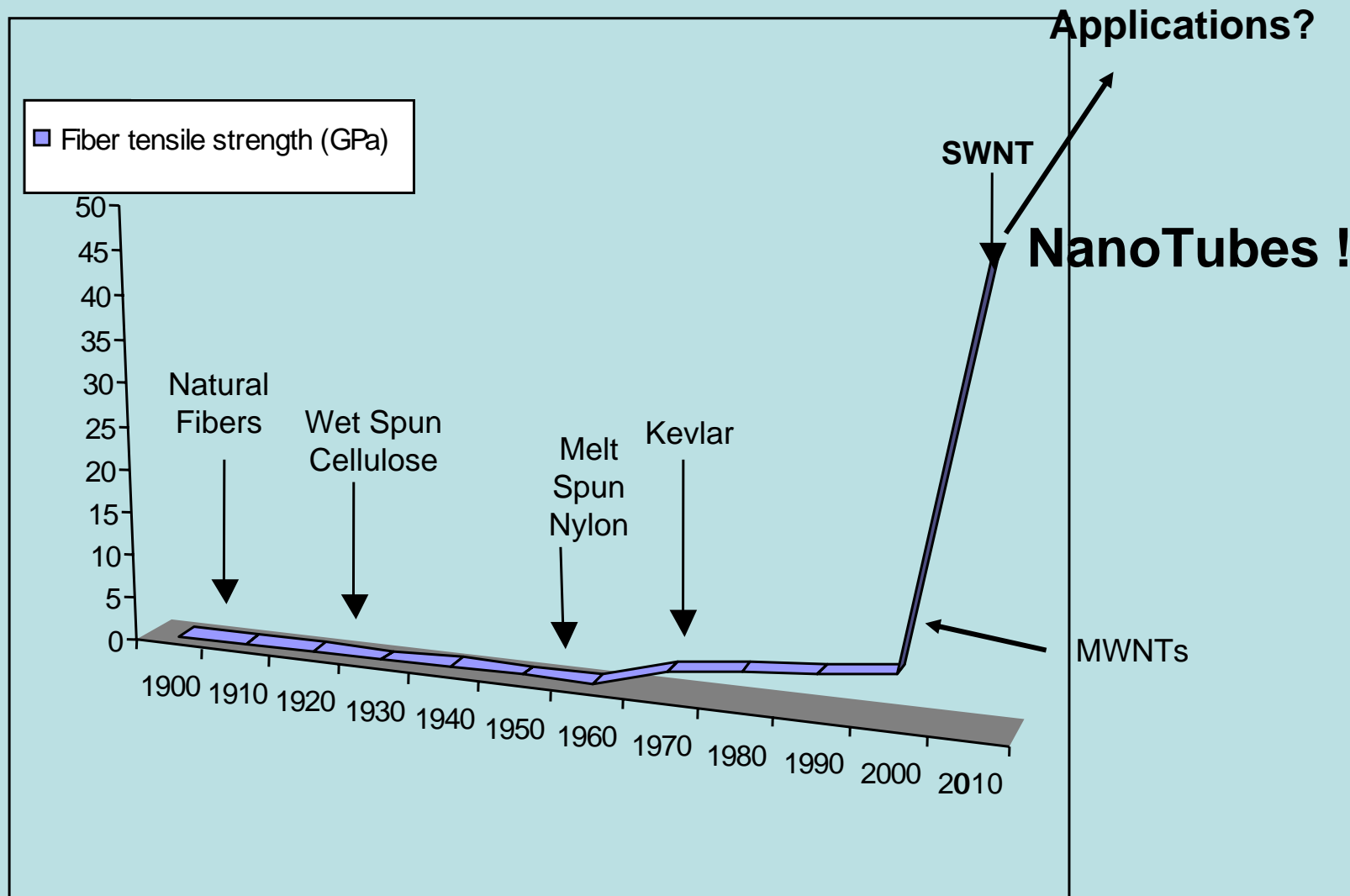
The Unique Chemistry of Carbon

The Scale and Perfection of DNA

The Ultimate Versatile Engineering Material



Magical Strength of SWNT Fibers

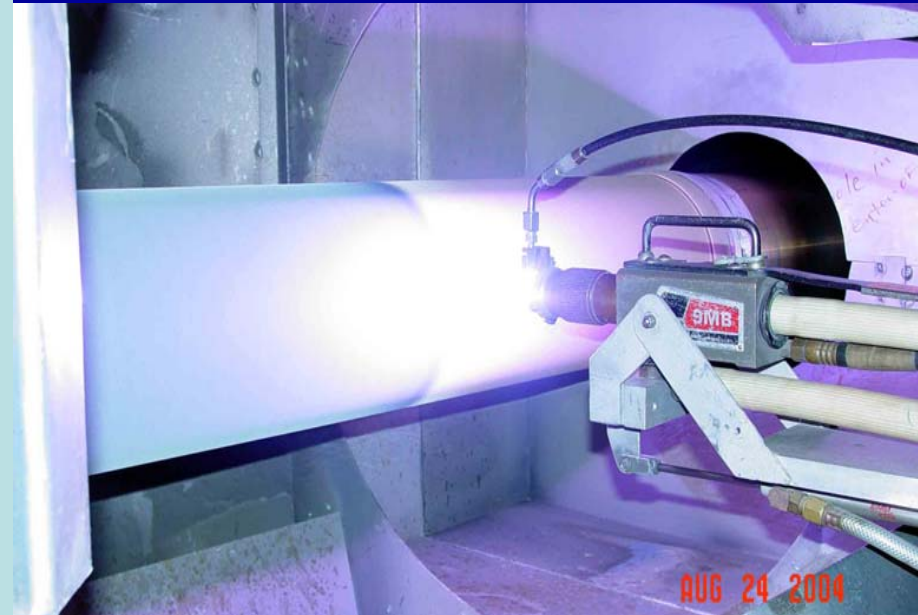


Big Nano Stuff: Main Propulsion Shafts

- Navy Problem: *Debris trapped in the staves grind the shafts*
 - Shaft life limited to ~ 1 yr
 - No existing coating could
 - Survive in the environment
 - Protect the shaft
 - Not create galvanic corrosion problems
- Solution: *Development of a revolutionary ceramic nanocomposite coating*
- Status:
 - Coated shafts tested in service on four ships
 - Inspection after five years shows no visible damage



Plasma Thermal Spray n-Alumina Titania Ceramic



Summary

- **Synergistic MIT, Army, Industry Partnership**
Trust & Mutual Understanding of Missions
- **Application driven 6.1 vision...Cross culture communication critical to success**
- **Innovative Leading-edge 6.1 Research Portfolio**
- **Accelerated Transitioning:**
via engaged Senior Leaders & Industry Partners

Nanotechnology-Enabled
Enhanced Survivability
for the Soldier