Nanotechnology Partnership Forum

Nanotechnology Electronics

John W. Pettit

Technology Overview

Carbon Nanotubes

Rolled up sheets of sp2 bonded carbon atoms, termed graphene, that display remarkable electronic, mechanical and physical properties

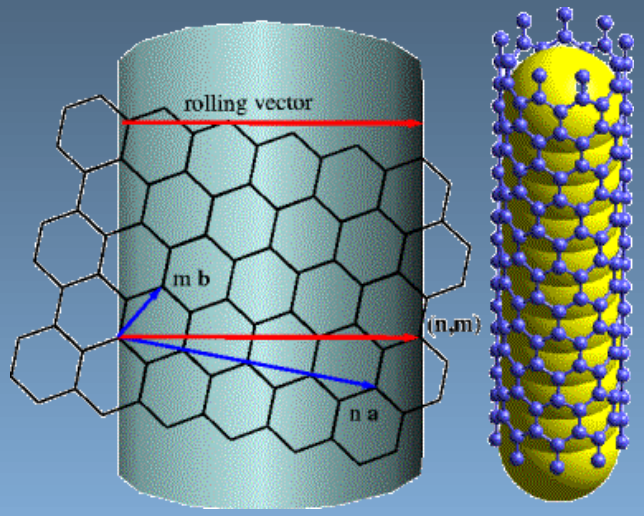
Quantum Dots

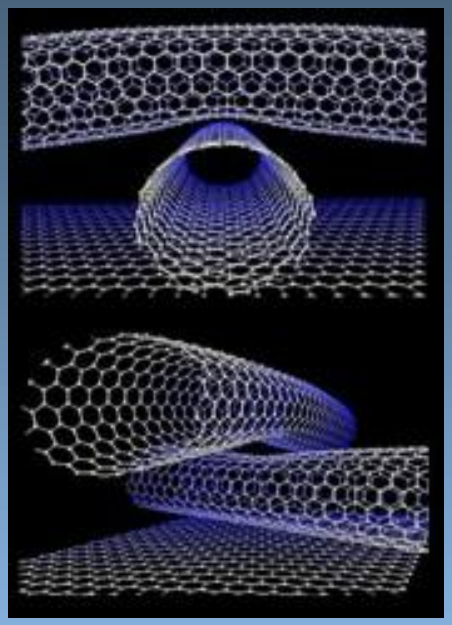
Tiny spheres of semiconductor or metal that are smaller than the Bohr radius of an electron-hole pair that gives rise to quantum confinement effects, the so called “Artificial Atom”

Intrinsically Conducting Polymers

Polymers with a conjugated ring of alternating single and double bonds so that the p electrons become delocalized and carry charge

Carbon Nanotubes

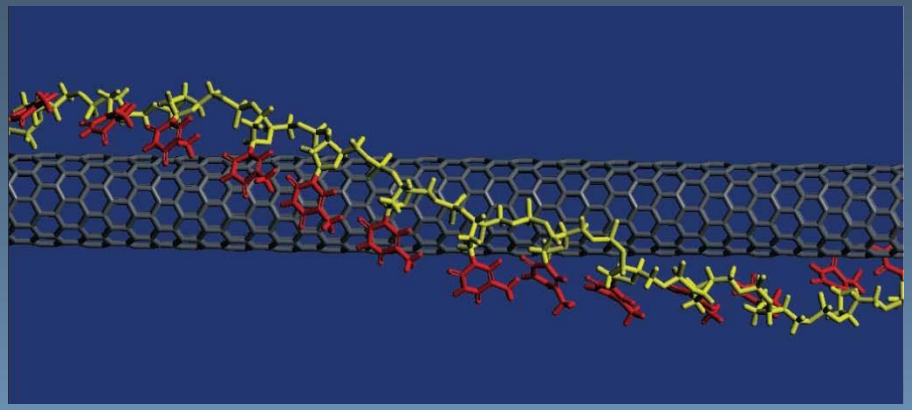




Twist, or chiral vector, is described in terms of two basis vectors a and b and by indices “n” and “m” along these vectors.

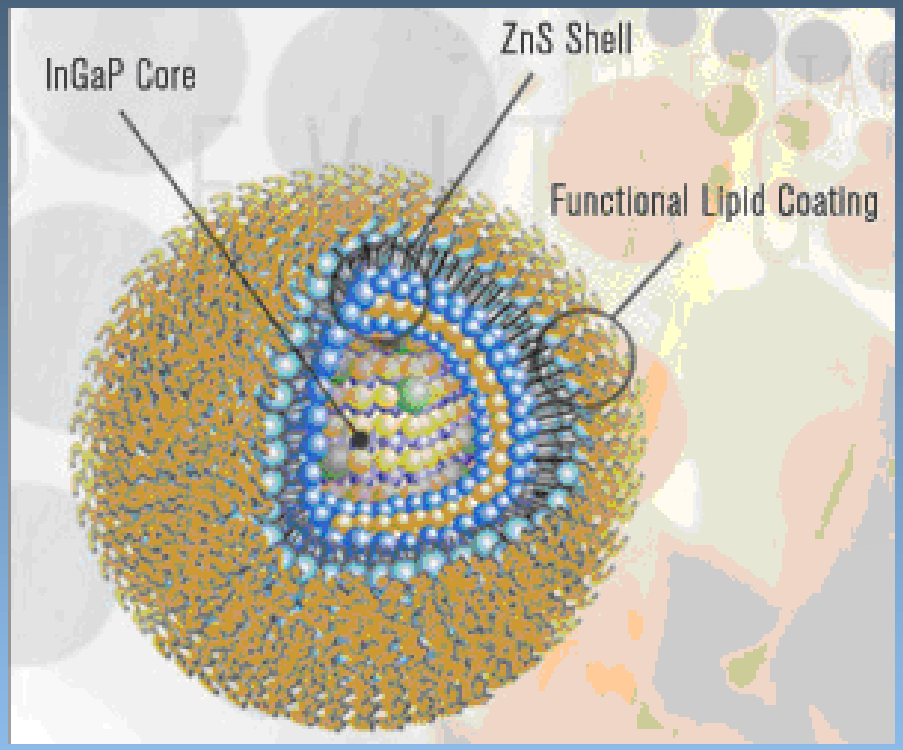
Carbon nanotubes can be engineered to be semiconducting with varying bandgaps or metallic with zero or very small bandgap

Nanotube Dispersions and Liquid Phase Processing



- Nanotubes are very hard to disperse due to weak forces that become very strong at the nanoscale
- Wrapping the nanotubes with DNA as seen above, is one very effective means to create quality dispersions.
- This opens up the ability to create sensors, electronic devices and even entire systems from nanotubes using liquid phase processing techniques. Molecular self assembly is possible.
- The impact of this ability cannot be overstated in terms of ease of fabrication and reduced costs compared to conventional semiconductor processing.

Quantum Dots



Core-Shell Quantum dots from Evident Technologies

Quantum Dots are semi-conducting material that is smaller than the electron-hole radius, 1 to 10 nanometers typically, and interesting quantum confinement phenomena result.

Applications

High Performance Electronics

Carbon Nanotubes are ideal one dimensional conductors, exhibiting ballistic conduction, extremely high charge mobility and the highest figure of merit field effect transistor was made with a carbon nanotube

Extreme sensitivity of charge acting near the surface of a carbon nanotube makes them exquisitely sensitive detectors. Functionalization of carbon nanotubes by various means makes them detectors of gases, biological materials.

Abundant field emission at low voltage from carbon nanotubes makes them useful for electron sources in numerous devices and display systems.

Applications Continued

Sensitive, miniature and low cost sensors

• Carbon Nanotubes are sensitive to even one atom adsorbed on its surface through a charge transfer mechanism that modulates the Fermi level of the nanotube
• This effect can be used to create a large number of sensors by affixing the nanotube with something that will capture or respond to the material of interest and then modulate the nanotube's charge.

Fluorescence Detection

Nanotubes fluoresce with direct bandgap transitions
Quantum Dots fluoresce efficiently by providing a barrier coating that prevents charge transfer.
Numerous biological detection methods are possible

Applications Continued

Nanotube Memory and Logic Devices

Carbon nanotubes have been used to create digital memory devices and logic circuits.

Energy Storage and Supercapacitors

The large surface area to volume of carbon nanotubes allow them to store enormous amounts of hydrogen for use in energy storage or electronic charge for use in very large capacitors.

Field Emission Displays

The abundant low voltage electron field emission of carbon nanotubes can be used to drive display devices and this has been demonstrated with the anticipation that commercial products shall soon be on the market.

Applications Continued

Optoelectronic Devices

• Direct bandgap optical transitions and bandgap engineering are some of the properties that will permit the creation of new highly effective optoelectronic devices

• Photoconductive sensors with carbon nanotubes and quantum dot and conductive polymer composites have shown dramatic results.

• Highly efficient, low cost, flexible and reliable solar cells have been demonstrated.

• Electroluminescent devices have been demonstrated where the carbon nanotubes emit light upon stimulation by an appropriate current source. LED and possibly Laser devices may be possible.

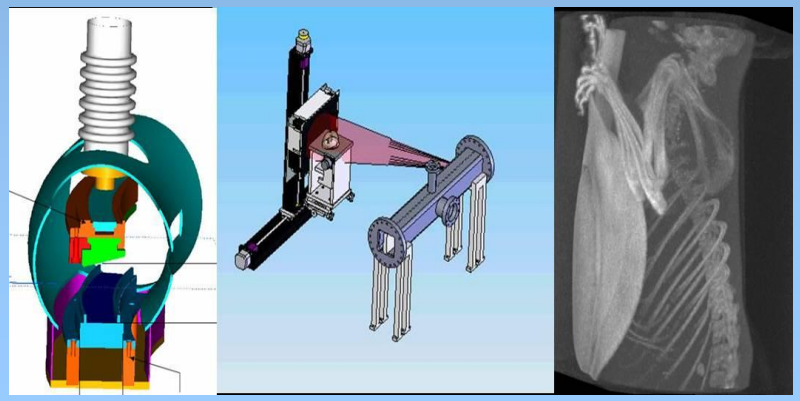
Commercial Products are Emerging

nanocomp TECHNOLOGIES, INC.

Electrically conducting and extremely strong nanotube yarn

Conductive and transparent coatings for electric shielding and EMI protection

Xintek Nanotechnology Innovations



Multi-pixel X-ray sources using arrays of carbon nanotube field emitters

Business Partnerships and Collaboration Opportunities

Pettit Applied Technologies has several ventures ongoing and is actively engaging partners, investors, and Government sponsors:

- Next Generation micro and nano scale sensors and systems for DNA analysis and other biological assays, especially miniature, field portable and rapid turn around instruments.
- High temperature and hostile environment electronics for military, industrial and commercial applications

We have a network of potential partners, investors and collaboration opportunities and can help entrepreneurial companies connect with these entities.

Contact Information

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