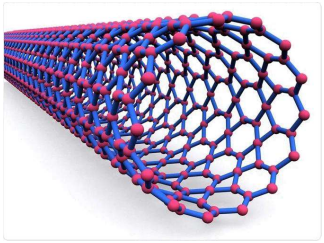
CARBON NANOTUBES (CNT): SYNTHESIS & APPLICATIONS



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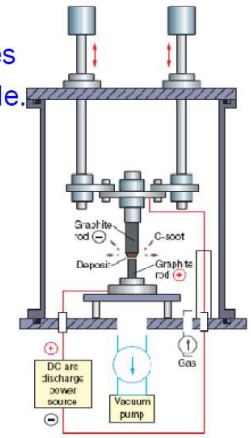
Synthesis of Carbon NanoTube

- Most widely used methodologies
  1. Arc-discharge method
  2. Laser ablation method
  3. Thermal synthesis
     - 3.1 Chemical vapour deposition
     - 3.2 Flame synthesis
  4. Plasma Enhanced CVD synthesis

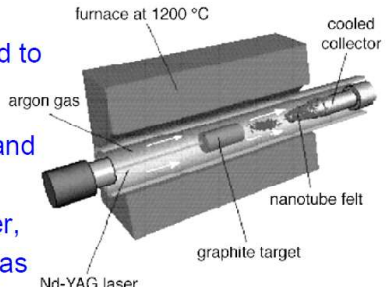
Arc-discharge Method

- Evaporation of graphite rod by applying a DC arc voltage in an inert gas (He).
- The evaporated anode generates fullerenes in the form of soot deposited on the cathode.
- The deposited product contains CNTs.
- MWCNTs are produced for pure graphite.
- Graphite rod with metal catalysts (Fe, Co) produced SWNTs.
- Methane or Hydrogen gas environments were found to be more effective for higher yield and crystallinity of MWNTs.



Laser Ablation Method

- High power laser was focused onto a carbon target (graphite) maintained at high temperature (1200°C) inside a (quartz) tubular furnace to vaporize carbon from the graphite target.
- An Inert gas (Argon at 500 torr) environment was maintained inside the tube, which carries the vapours from high temperature chamber into a cooled collector.
- A metal (1.2% Co / Ni) doped graphite (98.8%) source is used to produce SWNT.
- Other parameters for quantity and quality of CNTs are Type and amount of catalyst, Laser power, Temperature, Pressure, Inert gas

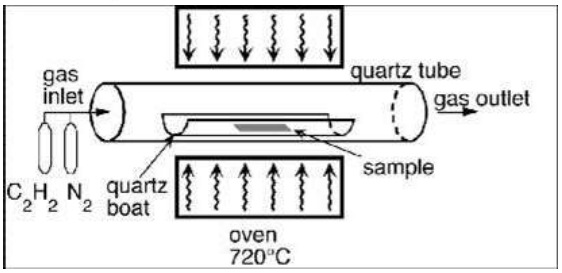


Chemical Vapour Deposition Method

Hydrocarbon + Fe/Co/Ni catalyst $\xrightarrow{550\text{-}750^\circ C}$ CNT

Steps:

- Dissociation of hydrocarbon.
- Dissolution and saturation of C atoms in metal nanoparticle.
- Precipitation of Carbon.



Choice of catalyst material?

Base Growth Mode or Tip Growth Mode?

- Metal support interactions

Controlled Growth by CVD

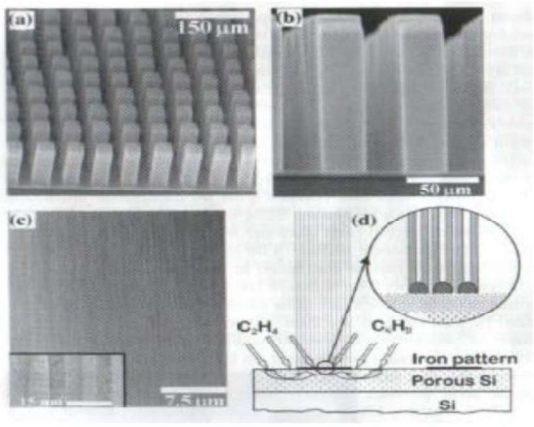
Methane + Porous Si + Fe pattern $\xrightarrow{CVD}$

a) SEM image of aligned nanotubes.

a) SEM image of side view of towers. Self-alignment due to Van der Walls interaction.

a) High magnification SEM image showing aligned nanotubes.

d) Growth Process: Base growth mode.



APPLICATIONS

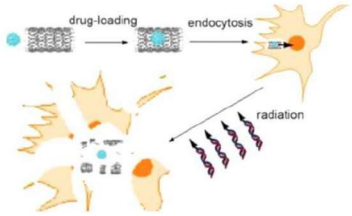
Carbon Nanotube can be used for a wide range of new and existing applications:

- Conductive plastics
- Flat-panel displays
- Gas storage
- Antifouling paint
- Structural composite materials
- Micro- and nano-electronics
- Radar-absorbing coating
- Technical textiles
- Ultra-capacitors
- Atomic Force Microscope (AFM) tips
- Batteries with improved lifetime
- Biosensors for harmful gases
- Extra strong fibers

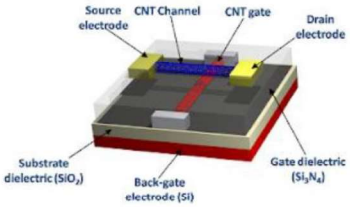
Bionics

Crisis 2.0 inspired body armor for soldiers –made of light weight high strength carbon nanotube composites

Bionic arm-Artificial muscles by contracting carbon nanoribbons

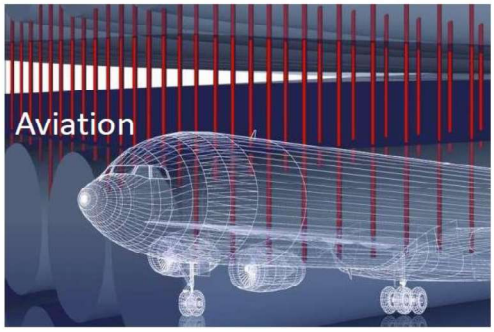


Using CNTs as carrier agents in Hyperthermia for cancer therapy

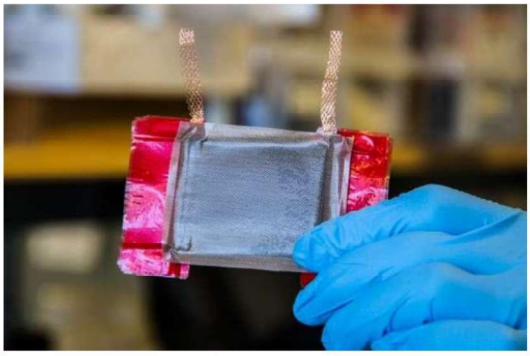


CNT based nano transistor

Removal of salt from seawater using carbon nanotube filters



advanced composite materials such as carbon fiber reinforced plastic—extremely light, durable materials that reduce the overall weight of the plane by as much as 20 percent compared to aluminum-bodied planes. Such lightweight airframes translate directly to fuel savings, which is a major point in advanced composites' favor.



Energy storage-battery based on CNT

Electronics

electronic packaging to meet electrostatic discharges (ESD) and high cleanliness and also to avoid Overheating

- **IC trays and Wafer Carriers**
- **IC test sockets**

Automotive

electrically conductive additives for automotive fuel system line components requiring **electrical conductivity**.

Thermoplastic exterior parts, such as fenders, mirror housings, and door handles

Aeronautic

flame retardant protection of fuel tanks and exhaust parts.

Construction

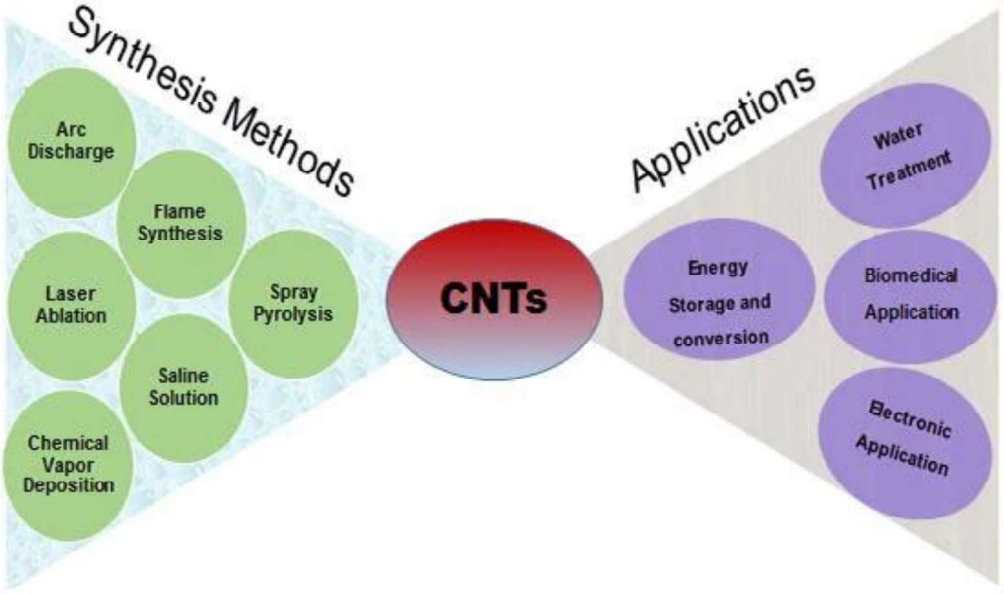
CNT provides protection for construction substrates, including **metal, concrete**, **wood**, **plaster** and **fiberboard**.

an array of **flexible** and **cost-efficient** solutions:

- Excellent thermal barrier even at low coating thicknesses
- Fast curing solutions and shortened curing time for off-site coating
- creating more design flexibility
- Better scratch resistance when handling
- No use of solvents or water
- Very low smoke density and toxicity

Sports

bike frames, hockey sticks, tennis rackets,
golf shafts, and skis.


Synthesis Methods
Arc Discharge
Flame Synthesis
Laser Ablation
Spray Pyrolysis
Saline Solution
Chemical Vapor Deposition
CNTs
Applications
Water Treatment
Energy Storage and conversion
Biomedical Application
Electronic Application