Carbon Nanotube in Solar Cells

Presented by : Hamed Fooladvand
Instructor : Dr. Abbasian

NANO Electronic Engineering Group
Electronic and Computer Engineering Department
The School of Engineering Emerging Technologies
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Outline

1. Introduction
2. CNTs Properties Useful for Solar Cells
3. SWCNTs & Introduce SCCNTs
4. approaches for the use of CNTs in solar cells

Solar cells Types

Crystal Silicon Solar cells

Single crystal silicon - Poly crystal silicon

Thin Layer Solar cells

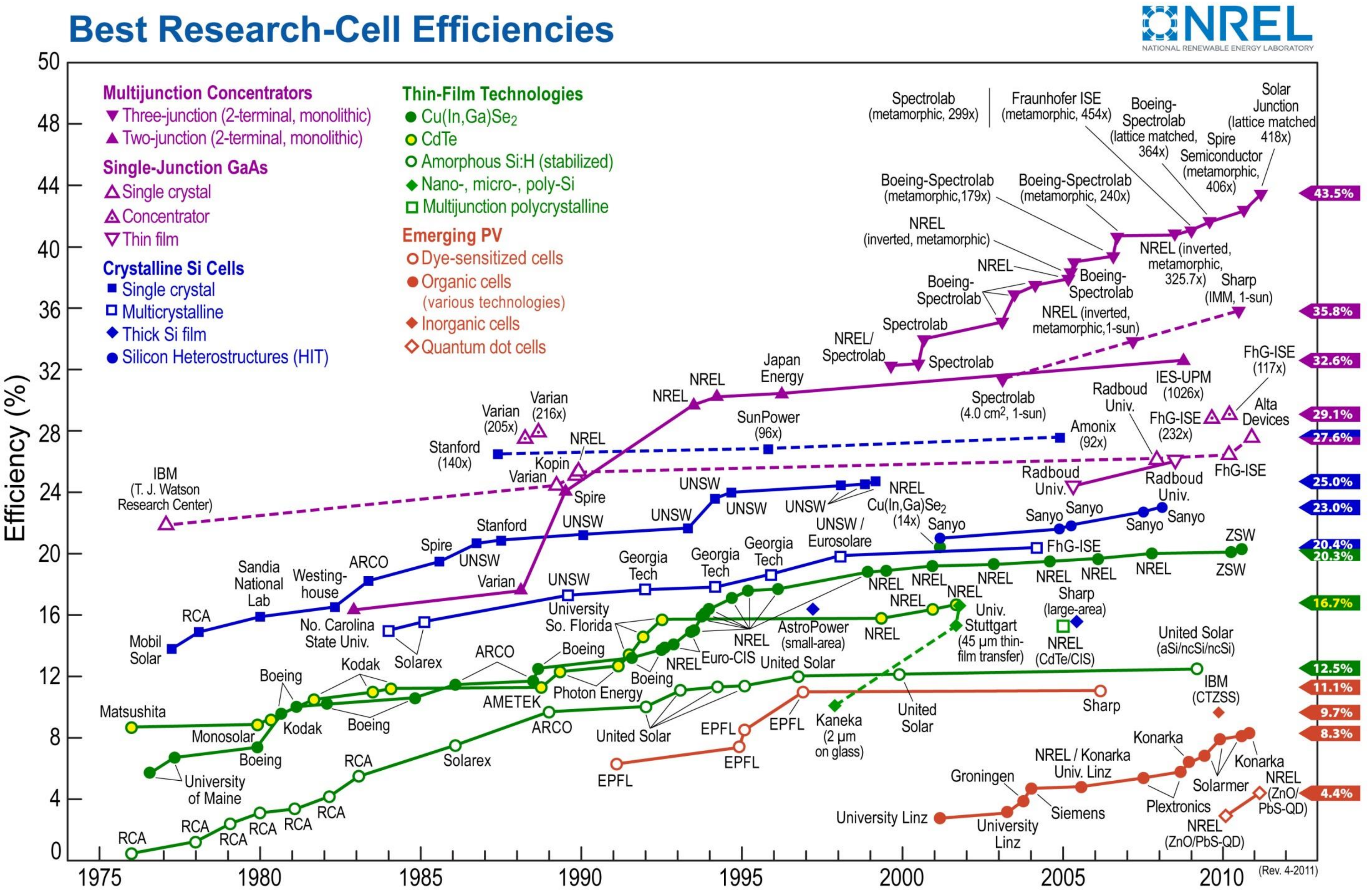
Thin Layer Si - CIS/CIGS – CdTe – MJGaAs - Mixed organic - DSSC

Quantom Dots Solar Cells

NANO structures Solar Cells

NW/DSSC - NW/QDSC - NP/QDSC – OHJSC - OBJSC - CNTSC

Best Research-Cell Efficiencies



Introduction

New initiatives are needed to harvest solar light energy with greater efficiency. Carbon nanotubes have emerged as new architectures for designing light-harvesting assemblies. Ways to utilize carbon nanotube assemblies as photoresponsive electrode materials and their role in the conversion of light energy into electricity are discussed.

PROPERTIES OF CARBON ALLOTROPES

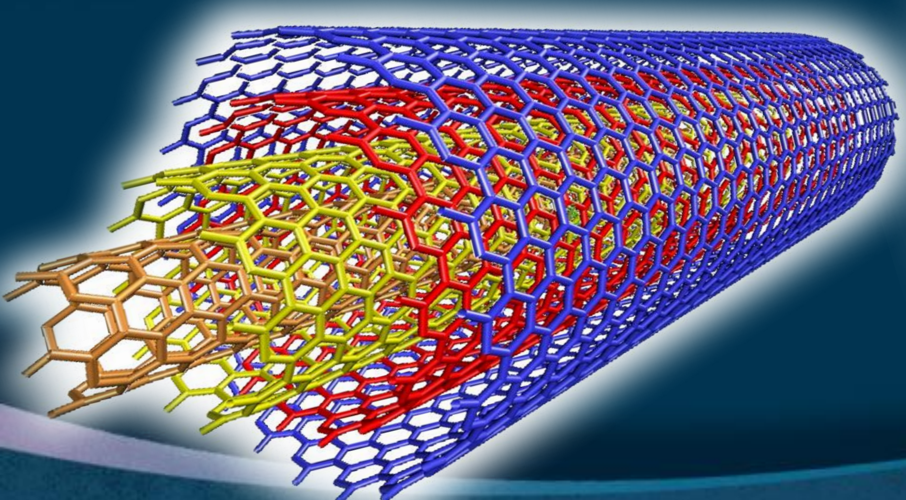
	Hardness	*Tensile strength*	*Conducts heat*	*Conducts electricity*
Coal	+	+	+	no
Graphite	++	++	+++++	+++++
Diamond	+++++	Not known	+++	no
Buckyballs	+++++	++++	+	+
Carbon Nanotubes	++++++	++++++	++++++	++++++

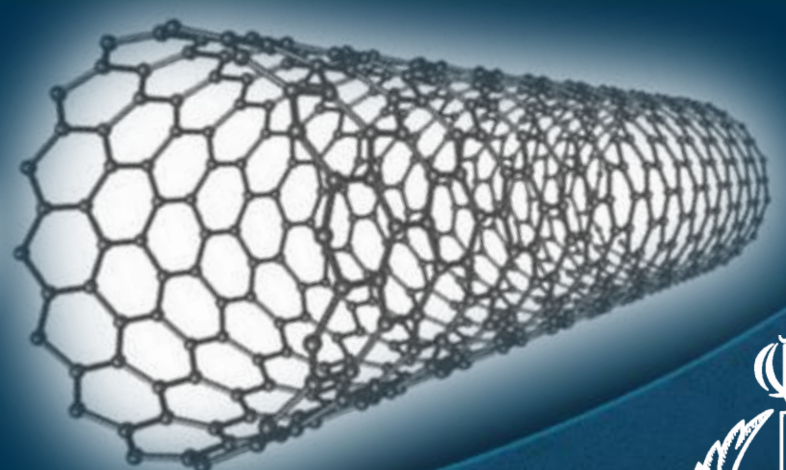
UNIQUE PROPERTIES OF CARBON NANOTUBES

- 200x stronger than steel of the same diameter
- The first synthetic material to have greater strength than spider silk
- Excellent conductors of electricity and heat
- Have huge potential for product development.

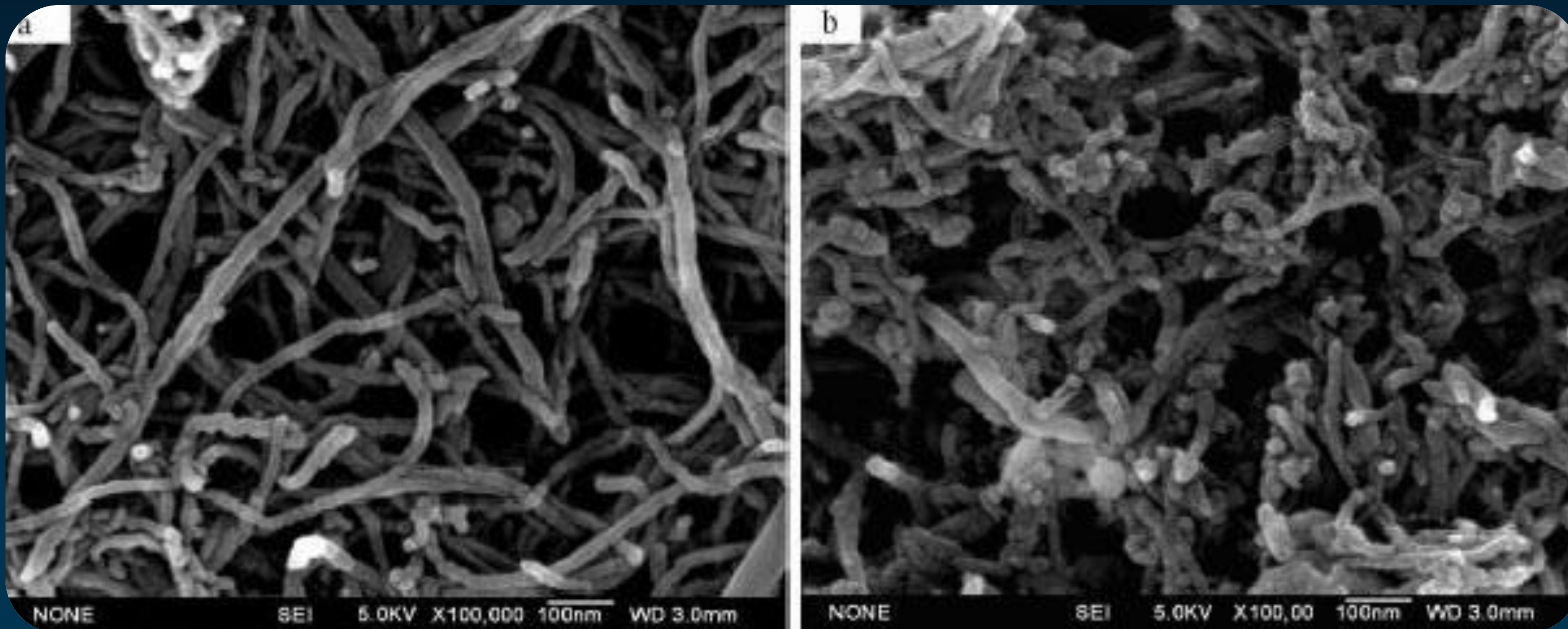
COVALENT BONDS IN CARBON NANOTUBES

- Carbon nanotubes are formed by a layer of hexagonally-arranged carbon atoms rolled into a cylinder
- Electrons are localised internally, and some can move along the length of the tube by ballistic transport
- Carbon nanotube diameter ~ 1nm
- Carbon nanotube length can be a million times greater than its diameter
- Carbon Nanotubes can be
  - single-walled (d = 1-2 nm), or
  - multi-walled (d = 5-80 nm).





SEM images of CNTs



SEM images of normal CNTs (a) and activated CNTs (b).

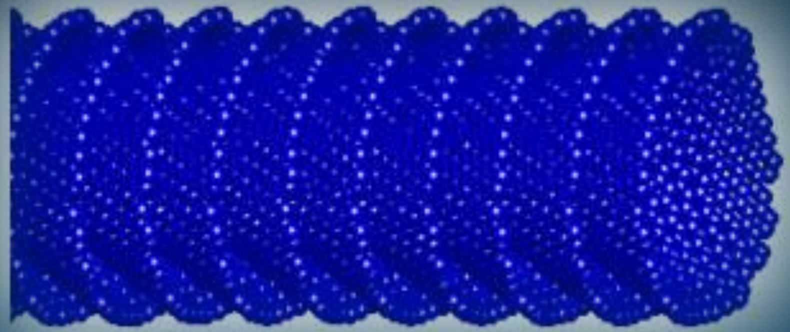
CNTs Properties Useful for Solar Cells

- High carrier mobilities (~1,20,000 $cm^2 V^{-1} s^{-1}$)
- Large surface areas (~1600 $m^2 g^{-1}$)
- Absorption in the IR range (E_g: 0.48 to 1.37 eV)
- Conductance - Independent of the channel length
- Enormous current carrying capability – 10^9 A cm^{-2}
- High Mechanical strength & Chemical stability

SWCNTs & Introduce SCCNTs

Two types of carbon nanotubes, SWCNTs and stacked-cup carbon nanotubes (SCCNTs), have emerged as possible candidates for light energy conversion.

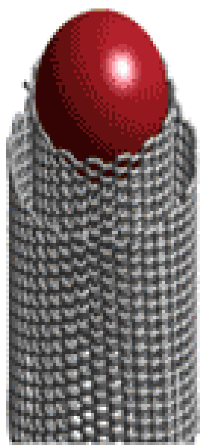
Artist's Depiction of SCCNTs



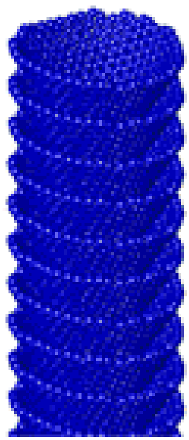
SCCNT morphology provides a large portion of exposed and reactive edges in the outer and inner surfaces of the hollow tubes.

Introduce SCCNTs

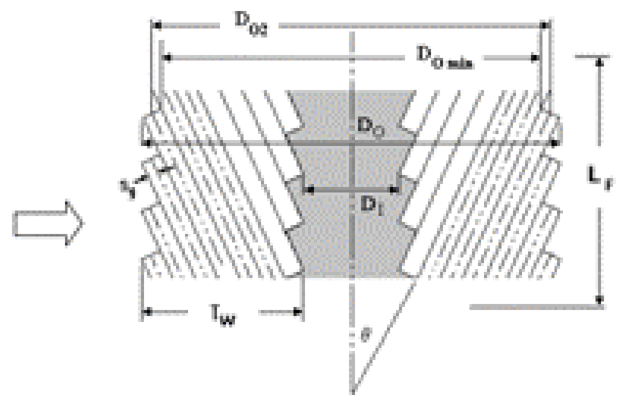
Comparison of Carbon Nanotubes



Multi-Walled Carbon Nanotube

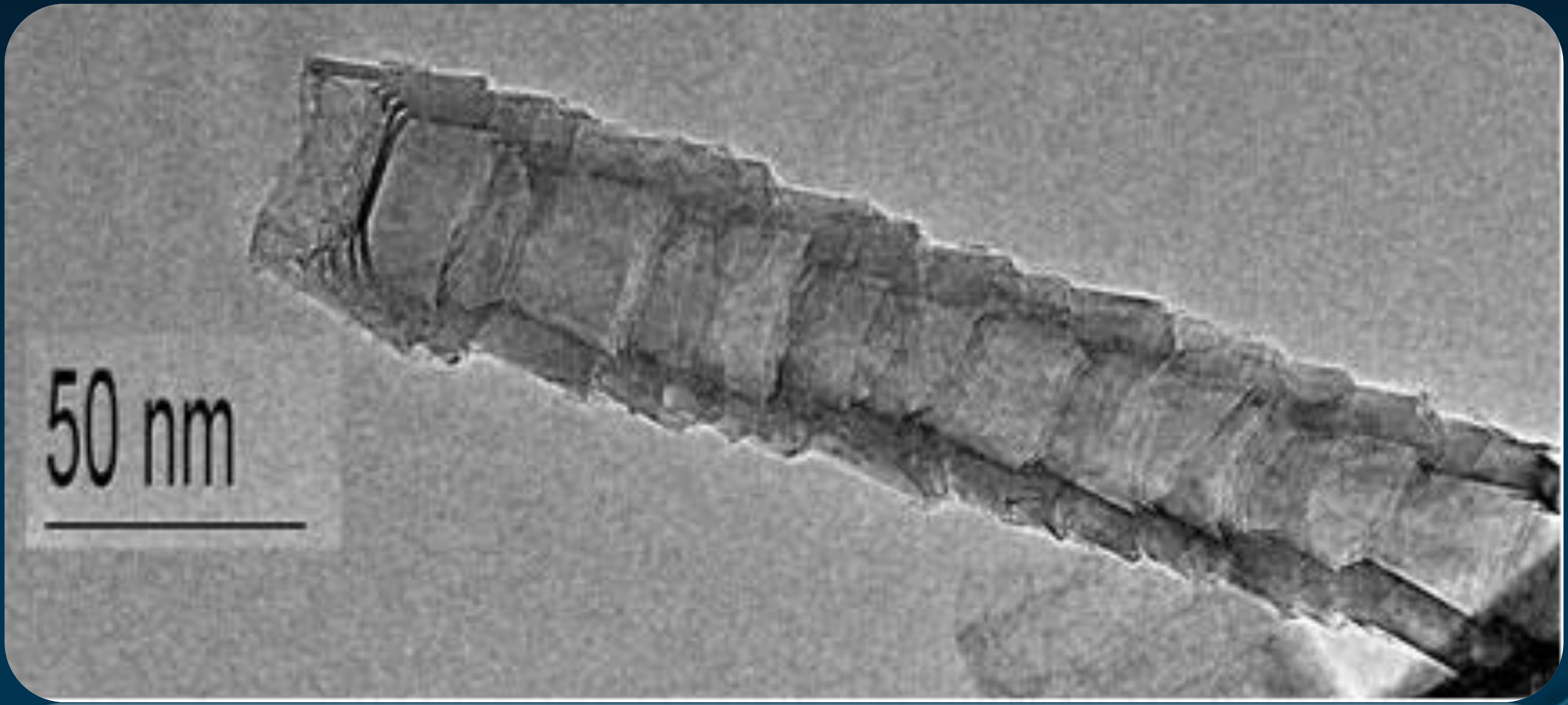


Pyrograf Products Stacked-Cup Carbon Nanotube



Cross sectional view showing the internal structure of Pyrograf Products Stacked-Cup Carbon Nanotubes

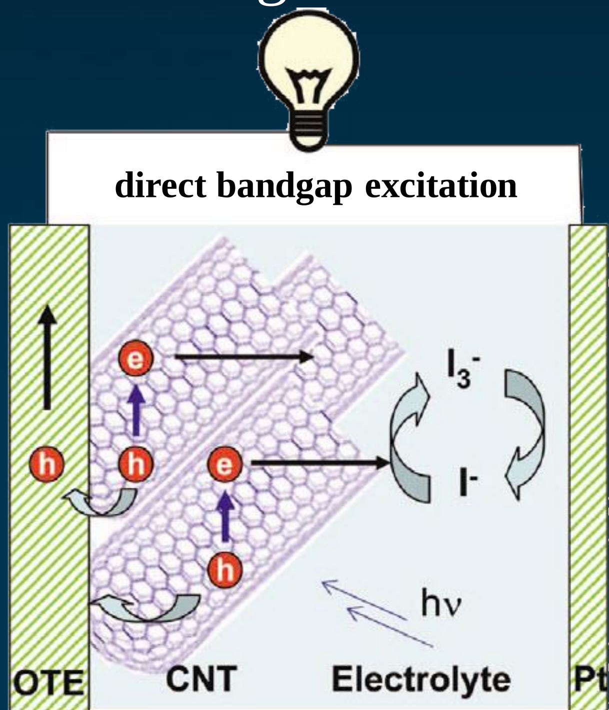
Introduce SCCNTs

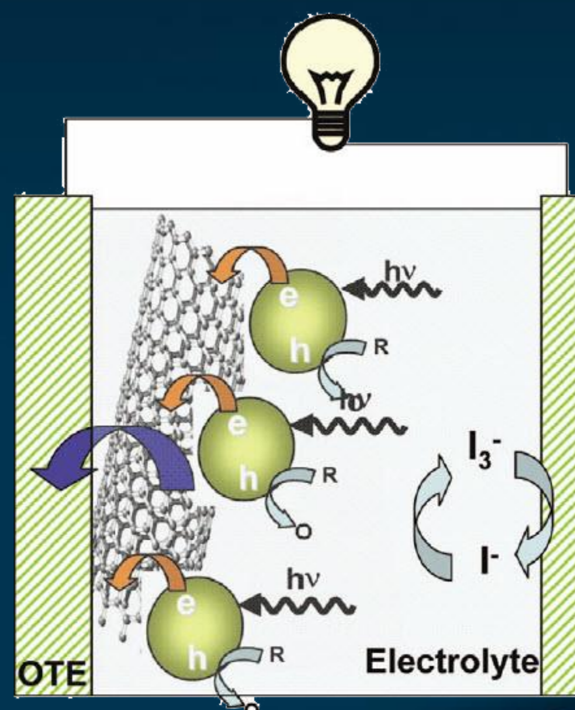


High Resolution TEM Image showing the stacked-cup structure

Two approaches for the use of carbon nanotubes in solar cells

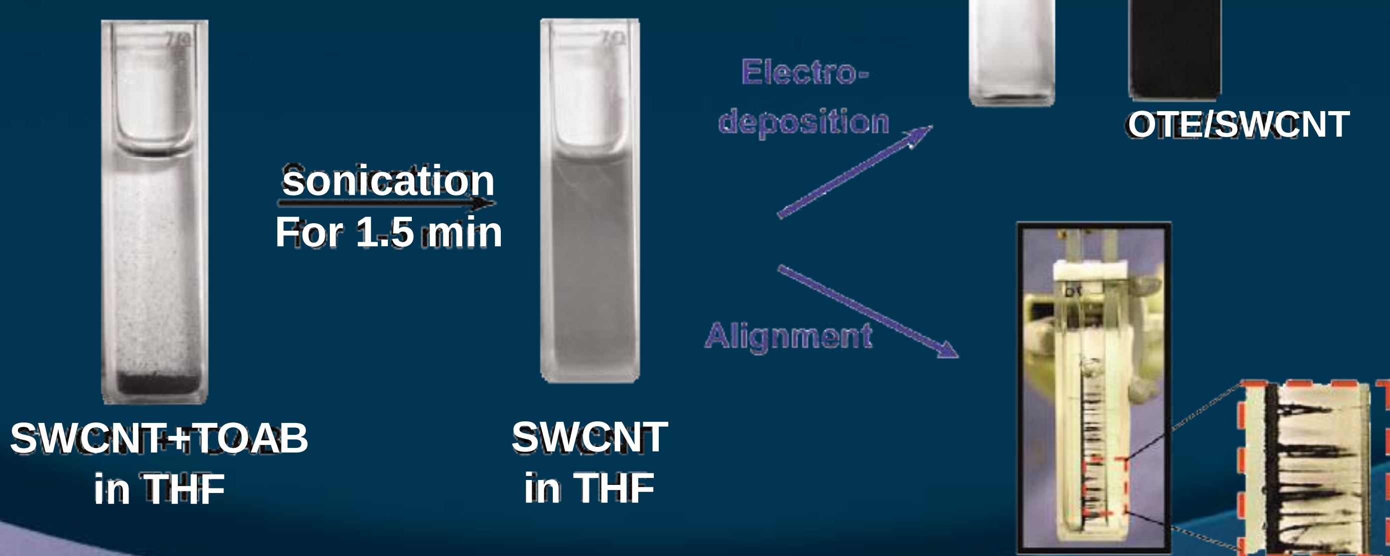
1. direct bandgap excitation of CNTs.
2. the use of conducting CNTs as conduits to improve the transport of charge carriers from light-harvesting nanoassemblies.



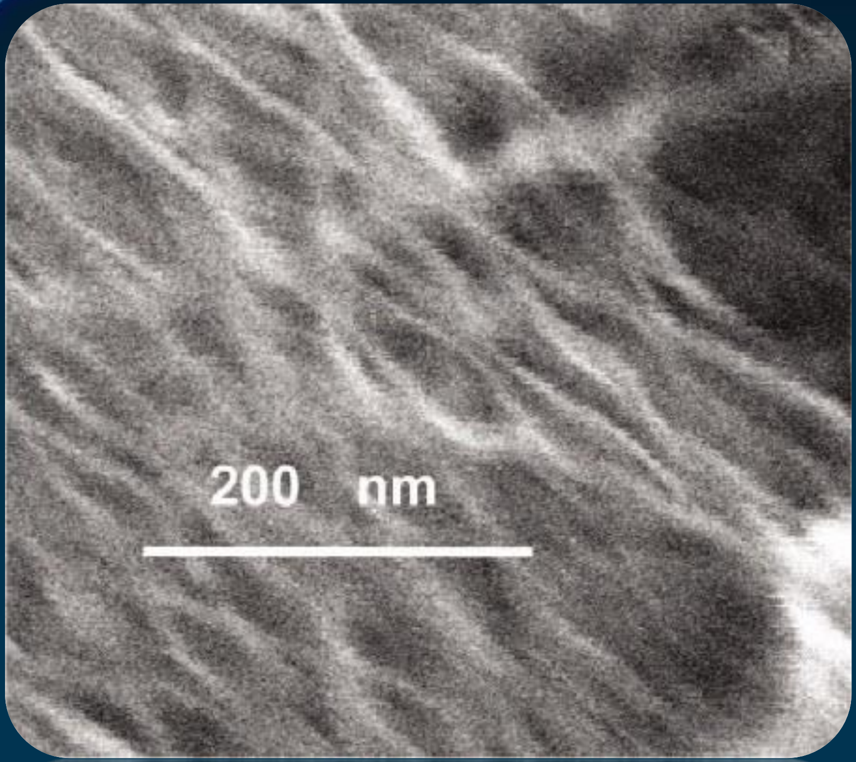


Electrodeposition of SWCNTs on conducting glass electrodes

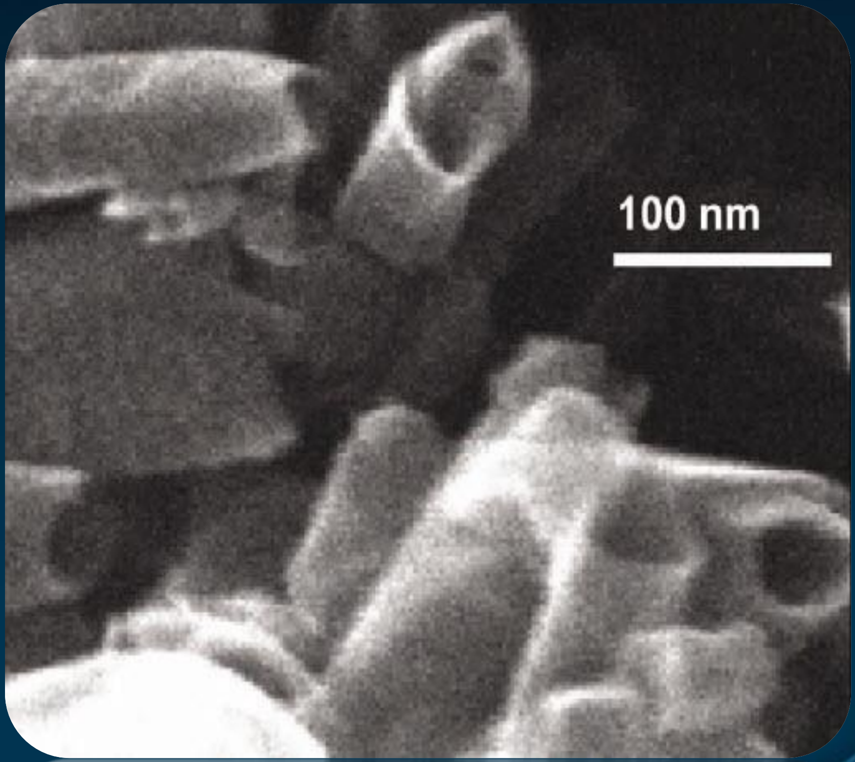
The first step to assemble carbon nanotubes on an electrode surface in the form of a thin film. There are various methods one can use to cast films of carbon nanotubes. An electrophoretic deposition method developed in our laboratory is very effective in casting films of carbon nanotubes.



SEM micrographs of electrophoretically deposited films



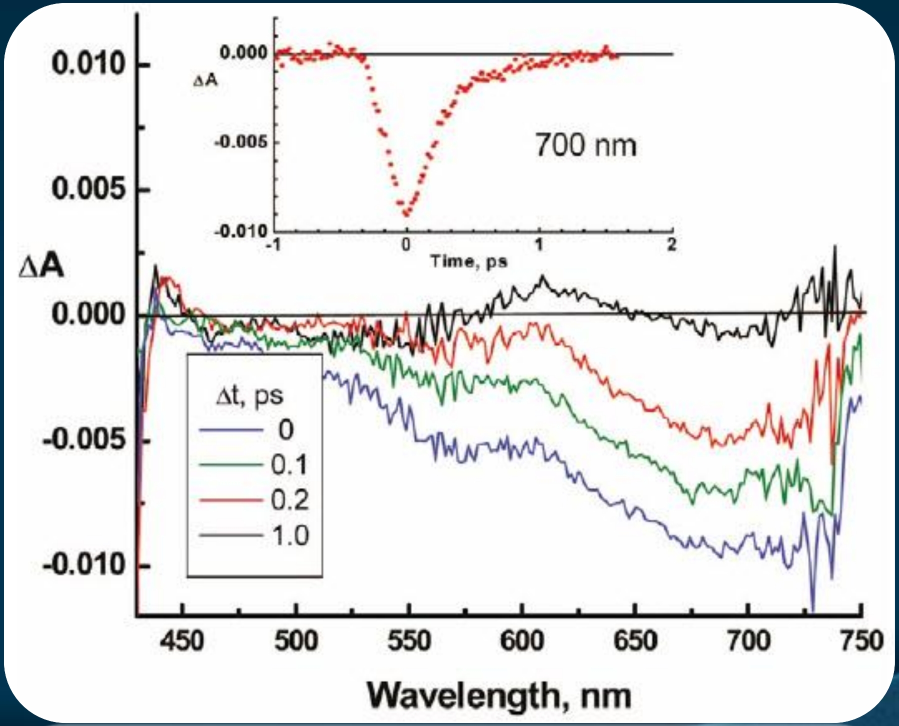
(a) SWNTs



(b) SCCNTs

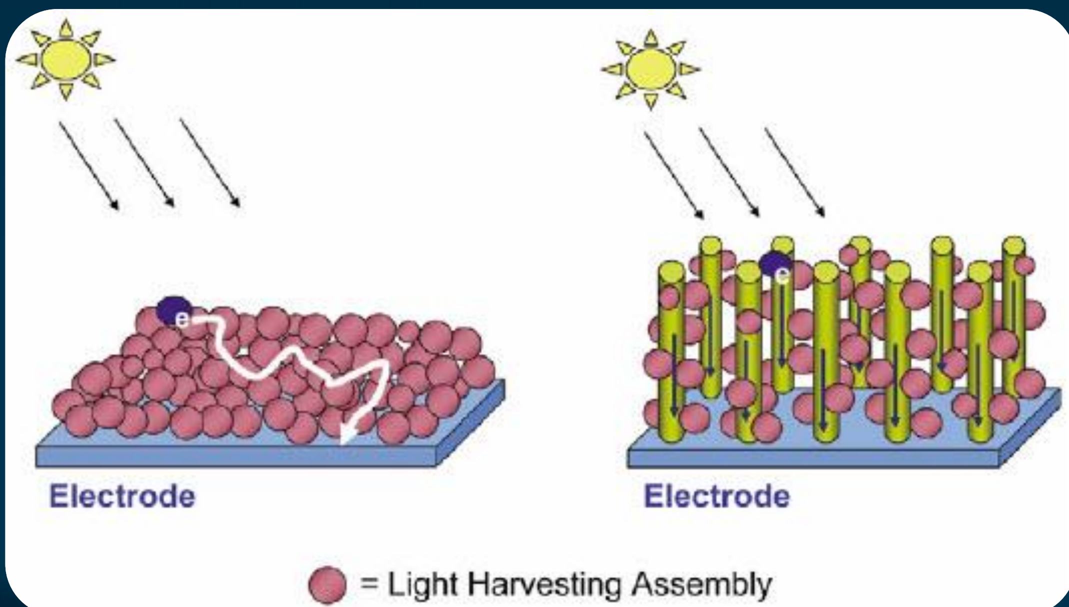
Photoinduced charge separation in SWCNT film

The charge separation in carbon nanotubes can be probed using femtosecond laser pump-probe spectroscopy. This technique is useful to investigate the ultrafast processes that occur following the excitation of carbon nanotubes or semiconductor materials.



SWCNT-semiconductor hybrids

In photoelectrochemical cells based on nanostructured or mesoscopic semiconductor films, the electron transport across particles is susceptible to recombination loss at the particle grain boundaries. The use of a nanotube support to anchor light-harvesting assemblies (e.g. semiconductor particles) provides a convenient way to capture photogenerated charges and transport them to the electrode surface.



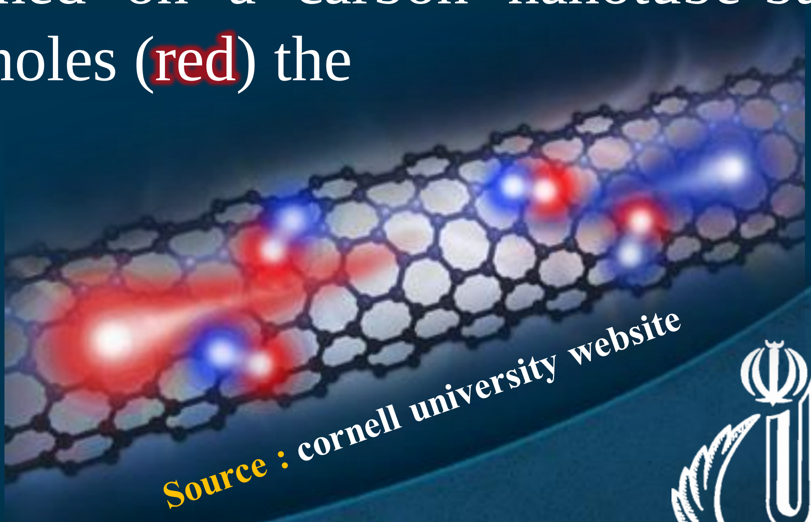
Concluding remarks

The examples discussed in this Presentation provide an insight into the unique photoelectrochemical properties of carbon nanotubes. Improving the charge separation in carbon nanostructure assemblies could aid in the development of next-generation, light-harvesting devices. Development of strategies to organize ordered assemblies of two or more components on electrode surfaces will be the key for improving the performance of photochemical solar cells. A concerted effort is needed to explore potentially useful hybrid light-harvesting systems and their implementation in the design of solar energy conversion devices.

NEW

Recent Research - Nanotube based photodiode

The researchers fabricated, tested and measured a simple solar cell called a photodiode, formed from an individual carbon nanotube. The researchers describe how their device converts light to electricity in an extremely efficient process that multiplies the amount of electrical current that flows. According to the team, this process could prove important for next-generation high-efficiency solar cells. When light is shined on a carbon nanotube-based photodiode electrons (blue) and holes (red) the positively charged areas where electrons were positioned before becoming excited release their excess energy to efficiently create more electron hole pairs.



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Prashant V. Kamat

Department of Chemistry & Biochemistry, Radiation Laboratory, Notre Dame Energy Center and Department of Chemical & Biomolecular Engineering, Notre Dame, IN 46556-5674, USA

Thank You !

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