Carbon nanotube composites for photovoltaic devices

White Paper

Summary

In a collaborative effort, the groups of Professor Stoddart and Professor Gruner are interfacing light sensitive polymers and molecules with for high performance carbon nanotube networks. This combination leads to structures that covert light into charge separated sates.

Preamble

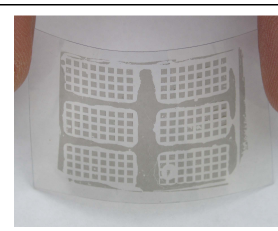
Novel photovoltaic and solar cell devices have gained prominence in recent years. In particular interest are so called third generation devices, that involve polymers and organic materials as components of the devices, trading cheap fabrication methodology for reduced efficiency. The group of Professor Stoddart has pioneered the interface of various light sensitive polymers and molecules with carbon nanotubes. The research group directed by Dr. George Gruner is working in the area of nano-scale electronic materials based on highly conducting networks of nanotubes and nanofibers, and room temperature fabrication techniques. Initial experiments by the Stoddart and Gruner group, on materials the are based on the combination of light sensitive materials and carbon nanotubes has led to evidences for charge separated states.

R/D objectives

The objective is to explore the electronic properties of composite materials, made of two components, a light sensitive component and carbon nanotubes, with special focus on the light induced response of the composites. Initial experiments indicate that charge separated states with long lifetime develop upon solar irradiation, thus offering opportunities for solar cell applications. The combination of novel chemistries, device architectures and fabrication routes constitute the core of the technology.

Light sensitive polymers and molecules The light sensitive polymer poly{(*m*-phenylenevinylene)-*co*-[(2,5-dioctyloxy-*p*-phenylene)vinylene]}, PmPV froms, upon irradiation by light an intermediate state with long lifetime. Porphyrin, the light-absorbing chromophore in chlorophyll plays a central role in photosynthesis.

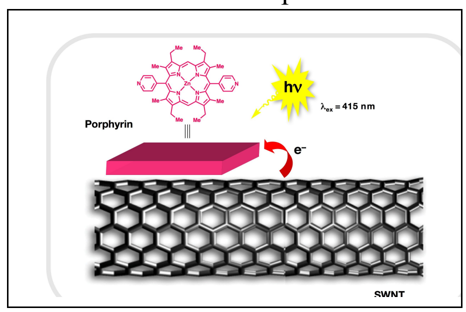
Carbon nanotube network fabrication – Room temperature fabrication techniques have been explored and demonstrated at UCLA. These fabrication routes enable large area conducting transparent layer or transistor array fabrication using cheap and simple printing or spraying processes, on a variety of surfaces, including transparent substrates and polymers. These developments are setting the stage of cheap fabrication routes.



Preliminary experiments

The two elements above can be combined into a composite architecture that leads, under the influence of visible light to charge separated states on the two components of the composit**.**

Carbon nanotube-PmPV composites have been fabricated, and the composite material has been used as the conducting channel of field-effect transistor (FET). The transistor configuration allows the direct evaluation of the charge transfer from the polymer to the nanotube network. UV-vis radiation leads to charge transfer form the polymer to the nanoubes, this charge transfer being detected by the modifications of the device characteristic. The device response correlates with the absorption characteristics of the polymer, demonstrating the functionality of the various components of the device architecture.
Porphyrin, the light-absorbing chromophore in chlorophyll plays a central role in photosynthesis. In a collaborative effort field effect transistor and resistor devices were fabricated with carbon nanotube conducting channels that are sensitive to electron donor or electron acceptor molecules. Light induced charge transfer has been observed directly, by monitoring the device characteristics. The strong correlation between the wavelength dependence of the device response and the optical absorption of porphyrin gives direct evidence of the charge transfer mechanism. By examining the changes in the device characteristics one can estimate the amount of charge transfer induced by light, the quantum efficiency and the photon-electron conversion ratio. Similar complex structures have been built using PmPV as the light sensitive part of the device architecture, and experiments on this system have also established the fundamentals of the photon-electron conversion process.



Proposed experiments

The materials that will be incorporated into the device architectuire include various porphyrins and PmPV derivatives and other light sensitive polymers. The experiments include the exploration of the spectral dependence of the charge separation, measurement of the photon-electronic conversion factors, the evaluation of the lifetime of the charge separated states. Photovoltaic cells will also be fabricated and evaluated.

Applications

Initial experiments summarized above have established that the composite materials can play the role of a charge separation layer in a solar cell configuration. The configuration has several advantages, associated with the intimate contact between the two materials that form the composite, and the high conductivity of the carbon nanotube network.

Chemistry and Device Work at UCLA

Federal grants support approximately 30 PhD students and postdoctoral associates' work at UCLA. The two group's expertise ranges from optics, device physics and engineering to materials science and chemistry, ensuring an interdisciplinary environment required for R/D in this area.

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Publications

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