Flexible, Transparent, Conducting Nanotubes Advance Electronics, Sensors, Biomembranes

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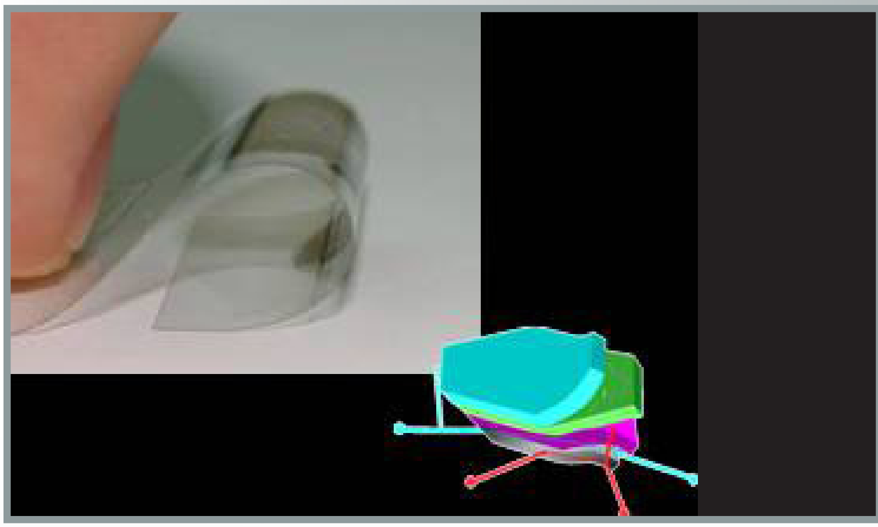

Technology Summary

Flexible transparent conducting coatings are of high commercial value today in low cost, flexible photovoltaic cells, large electronic LED displays, optics, and electromagnetic shielding. Currently, the carbon nanotubes that make up such coatings are highly conducting, but they absorb too much light in the visible region of the spectrum, which impedes their competition with current transparent conducting material, indium tin oxide (ITO). All of the indium component of ITO is exported from abroad. The continuously increasing cost of indium and its limited performance in flexible electronics due to high crystallinity call for an alternative, less expensive material to replace ITO as a transparent conducting coating in the flexible electronics of tomorrow.

A group of researchers at ORNL has developed a way to improve transparency by controlling the assembly of nanorods. The composites are assembled into macroscopic networks with high optical transmission and electrical conductivity. The high aspect ratio of these nanorods renders flexibility to their assemblies.

Buckypaper membranes made of aggregates of single-walled carbon nanotubes (SWNTs), each containing several hundred SWNTs, can be assembled like spaghetti on a mat in randomly aligned networks. Unfortunately, the optical transparency of these assemblies is far from optimal to compete with ITO coatings.

The ORNL researchers have overcome these limitations by realigning the nanotubes in composites for optimal transparency and electrical conduction. They begin with SWNTs of higher purity, to increase transparency. The SWNT bundles are grown longer, which gives them better potential conductivity, so fewer are required. The nanotubes are oriented and treated with solvents to straighten them, providing a smaller number of interconnections and therefore better conductivity and higher transparency.

The researchers have also developed methods for controlling the growth of vertically aligned, nanotube arrays to desired lengths, densities, and wall numbers. Processing methods for two- and three-dimensional integration of the nanotubes as electrodes and additives for flexible electronics utilize the multifunctional properties of these novel transparent electrodes.

Advantages

Such nanotubes are extremely strong, so the thin, interconnected membranes add strength to polymers. Flexible and transparent materials, they conformably bond to different surfaces well. These assemblies make excellent sensors, where the response could be read optically or electrically. Finally, the assemblies of these materials are biocompatible and can be dispersed with DNA, which has been shown to wrap single-walled carbon nanotubes, so the technology is promising for biosensors and biomaterials.

Potential Applications

The main benefits are in the nanotubes' low cost, higher flexibility than crystalline ITO, and compatibility with polymer processing for possible use in flexible electronics, including photovoltaic devices and touch screen displays. Transparent conductive nanotube electrodes can be applied to organic light-emitting diodes (OLEDs). Incorporation of nanotubes in the structure of photovoltaic and light-emitting devices was demonstrated to improve device efficiency. Hard polymer "glass" containing nanotube networks can be used for electrochromic windows, charge-dissipating plastic coatings, and others. They can also be used in stints, biomembranes, and sensors.

Patent

David B. Geohegan, Ilia N. Ivanov, Alexander A. Puretsky, Stephen Jesse, and Bin Hu, *Transparent Conductive Nano-Composites,* U.S. Patent Application 11/965, 651, issued December 27, 2006.

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