

Double-Walled Carbon Nanotube Electrodes for Electrochemical Sensing

Carbon nanotubes have gained considerable attention due to their exceptional electronic, mechanical, and chemical properties. Their unique features such as the ability to carry large current densities, fast electron-transfer kinetics, low overpotential and minimum surface fouling make them very attractive for electrochemical sensing applications. Extensive research efforts in this respect have been focused on multiwalled nanotubes due to their ease of production. Researchers at the King Mongkut's University of Technology in Thailand, and at Rensselaer Polytechnic Institute and Southern Illinois University in the U.S. have recently reported on the electrochemical properties of electrodes fabricated using spun fibers of double-walled nanotubes (DWNTs). These electrodes showed reversible and faster electron-transfer kinetics in electrochemical reactions compared to multiwalled nanotubes and standard glassy carbon electrodes. The detection capabilities of the DWNT electrodes for chemical species such as hydrogen peroxide, ascorbic acid, and electroactive neurotransmitters such as dopamine were studied. The results indicated that this simple architecture of the DWNT fiber could be used as effective electrochemical sensors for determining the presence of a variety of single species, as well as distinguishing multiple species of ascorbic acid and dopamine which are often found in realistic biological environments.

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Size-Dependent Lithium Miscibility Gap in Nanoscale Li_xFePO_4

Lithium iron phosphate (LiFePO_4) has emerged as a promising lithium-ion-battery cathode material for use in various applications including power tools, hybrid cars, and more recently, plug-in hybrid cars. While its superior safety and power capabilities have driven its use in these applications, the exact mechanism by which lithium is inserted is not well understood. This is complicated by the two-phase nature (i.e., the lithiated and the delithiated phases) of this material. The existence of a single-phase region through which lithium transport can occur, first reported in 2004, has remained a matter of controversy in this field. A recent report by Meethong and coworkers from the Material Science and Engineering Department at MIT sheds new light in this area. Using careful electrochemical experimentation and material synthesis, the authors show that the miscibility gap contracts with decreasing particle size and increasing temperature. The systematic change in the miscibility gap allows the authors to predict that the gap will disappear below a particle size of 15 nm at room temperature. The authors attribute the changes in the miscibility gap partly

to the existence of a coherent interface between the two phases. If confirmed, the study suggests that the impact of nanomaterials in this cathode goes far beyond the well-understood length-scale effects and opens new possibilities in the synthesis of battery materials using nanotechnology.

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Tuning Optical Properties of Aluminum Oxide

The optical properties of a material are dependent on the interaction of light with its surface. Researchers from National Taiwan University, National Chung Cheng University, and National Taiwan Normal University have investigated the reflectance of light at anodic aluminum oxide (AAO) having metal deposited within the pores. While many researchers have employed porous alumina as templates for creating nanowires and other nanostructures, the authors sought to study the resulting interference between incident and reflected light caused by different thicknesses of the oxide layer and the metal nanowires layer. They used anodization current densities in the range of 20-100 A/m² to form the pores, followed by ac electrodeposition for 30 s to grow nickel nanowires. Reflectance data show two different spectra at the two viewing angles of 15° and 55°. Optical photos reveal to the naked eye these changes (purple and maroon, respectively, for one anodization level, and yellow to green for another anodization). A series of varied anodization and electrodeposition conditions (current density, voltage, times) led to a demonstration of tuning the visible color of the aluminum oxide film structures at a given observation angle. The authors suggest that depending on the deposited metal other properties could be imparted to the surface (such as antibacterial in the case of silver).

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Electrochemical Behavior of AISI 304SS with Particulate Silica Coating in 0.1 M NaCl

The corrosion behavior of metals can be impacted by surface contaminant layers if the access of reactants is restricted or the local environment is altered. However, very few techniques have been developed that enable tight control over surface contaminant parameters. Tada and Frankel at The Ohio State University investigated the potential use of deposited silica layers as a means of achieving a reproducible and controllable analogue for surface coverage by a chemically inert contaminant. Using electrophoretic deposition, a monodisperse (approximately 350 nm diameter) layer of silica particles was deposited on 316SS. The layer thickness was proportional to deposition time and a maximum thickness of about 80 μm was achieved before the layer peeled off from the substrate. The authors investigated the effects of the

silica layer thickness on open circuit potential, anodic and cathodic kinetics, and impedance characteristics. The primary effect of increasing layer thickness is a reduction in cathodic current density due to an increase in the diffusion path length for oxygen. Also of significance is the observation that the layer had little effect on other measured parameters. The authors did note, however, that the influence of such a layer is likely a strong function of the electrolyte used to conduct the study.

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Development of CuInGaSe_2 Layers for Applications in Thin-Film Solar Cells

Copper indium gallium diselenide, CuInGaSe_2 or CIGS, has been explored extensively over the past decade for applications in low-cost, high-efficiency solar cells. The results to date for multilayer thin-film devices based on CIGS (typically, a glass/Mo/CIGS/CdS/i-ZnO/ZnO:Al/metal grid structure) have been impressive, with 19.5% efficiencies for laboratory scale devices and 13% efficiencies for industrial scale solar modules being reported. However, further progress and development of CIGS-based solar cells will benefit from an improved understanding of the solid-state principles of these structures. As part of an ongoing program addressing these issues, researchers at Sheffield Hallam University in the United Kingdom recently reported initial results on n-n-i-p type glass/TCO/n-CdS/n-CIGS/i-CIGS/p-CIGS/metal solar cell structures (where TCO is a transparent conductive oxide). They grew CIGS layers by electrodeposition and used a photoelectrochemical cell experiment to determine the conduction type of the deposited layers. They also used x-ray fluorescence, optical absorption, x-ray diffraction, atomic force microscopy, and electrical measurements (I-V and C-V) to characterize individual material layers and the solar cell structures. The bandgap of these layers can be varied between 1.1 and 2.2 eV by changing the electrodeposition voltage, and these changes are correlated with changes in stoichiometry. Although I-V and C-V characteristics of preliminary multilayer thin-film solar cells exhibit excellent electrical properties, identification and elimination of defects in the CIGS device structure will be required to meet performance standards necessary for more widespread adoption of this technology. ■

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