

Al Current Collectors for Li-Ion Batteries Made via an Oxidation Process in Ionic Liquids

Textured Al current collectors demonstrate improved rate capability in Li cells using LiFePO_4 as the active positive electrode material. Researchers from France found that bulk Al substrates can be oxidized to form a nanoneedle morphology using a bath of 1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide [EMIm]TFSI and AlCl_3 salt. During electrochemical etching, regimes of the cyclic voltammograms are described corresponding to deposition of fresh Al, oxidation of the fresh Al, and cracking of the alumina layer. The electrochemical etching process begins with reduction-oxidation of the Al^{III} species from Al_2Cl_7^- . Cyclic voltammetry between -0.7 and 4.0 V vs. $\text{Al}^{\text{III}}/\text{Al}$ up to 100 cycles results in Al pore diameters of 7 to 10 μm and 740 nm high needles. The researchers used LiFePO_4 , which is less conductive than other cathode materials, to demonstrate the effect of the higher surface area Al substrate as a means to improve electrode kinetics beyond simply forming smaller electroactive particles and coating them with carbon. The differences in performance between cells with the planar and cells with the etched Al substrates could be seen most at rates higher than 1C. While the electrode materials do not fully coat the porous current collector surface, the results still show the enhanced rate capability with the roughened Al current collector.

From: *Electrochem. Solid-State Lett.*, **14**, A6 (2011)

Ionic Liquid-Heteropolyacid: Synthesis, Characterization, and Supercapacitor Study of Films Deposited by Electrophoresis

The incorporation of novel electrode materials into next generation electrochemical capacitors (*i.e.*, supercapacitors) is one of the most rapidly developing areas of contemporary research on these devices. Many of the leading approaches in supercapacitor research employ ruthenium-based compounds, such as RuO_2 , because of their long cycle lifetime and superior specific capacitance. However, given the cost of such materials, scientists are striving for alternate, cost-effective electrode materials. In this vein, scientists from the Katholieke Universiteit Leuven have produced ionic liquid-heteropolyacid hybrid materials to be employed as components in supercapacitors, coupled with aqueous, environmentally friendly electrolytes. The scientists employed alternating current (AC) electrophoretic deposition to cast these prototype materials onto stainless steel substrates. The synthesis of films of Keggin anions $[\text{SiW}_{12}\text{O}_{40}]^{4-}$ and $[\text{PMo}_{12}\text{O}_{40}]^{3-}$ with 1-butyl-2-methylimidazolium cations, $[\text{BMIM}]^+$, yielded new hybrid materials that exhibited specific capacitances of 172 F g^{-1} and 89 F g^{-1} , respectively, which are comparable to that observed with RuO_2 , but at a notably

reduced cost. The faradaic efficiency of the $[\text{BMIM}]_4\text{SiW}_{12}\text{O}_{40}$ material was approximately 89% over 1000+ cycles, a performance also comparable to ruthenium electrodes. Such results motivate more extensive investigation of these materials and this fabrication technique for energy storage device applications.

From: *J. Electrochem. Soc.*, **158**, A14 (2011)

Electrochemical Conversion of Carbon Dioxide to Formate in Alkaline Polymer Electrolyte Membrane Cells

Often termed as artificial photosynthesis, the electrochemical reduction of CO_2 to generate fuels or chemical feedstock is an attractive approach to mitigate the ever increasing levels of atmospheric CO_2 nowadays. The majority of the research in this area has been focused on electrolysis techniques based on solution electrolytes. Taking advantages of their expertise in polymer electrolyte-based fuel cells, a group of researchers from the Jet Propulsion Laboratory of Caltech recently reported the use of the polymer electrolyte cell configuration for continuous production of formate from carbon dioxide. The cell consisted of an alkaline polymer membrane sandwiched between two catalyst-coated electrodes. On the cathode side, formate was produced and hydrogen evolution was suppressed with lead and indium as catalysts. On the anode side, the catalyst was platinum; O_2 was evolved from water electro-oxidation. During short experimental runs, the faradaic efficiency of formate production was as high as 80% but fell to lower levels as the process continued. The efficiency change was found to be caused by mass transport limitations of carbon dioxide. The use of an alkaline membrane-based flow cell was proposed to ensure abundant availability of carbon dioxide to the electrode.

From: *J. Electrochem. Soc.*, **158**, A167 (2011)

A Direct Electrochemical Assay for Colorectal Cancer Detection

Colorectal cancer is the fourth leading cause of cancer-related deaths in the world. The mortality rate from this form of cancer has been dropping for more than 20 years. This is due in part to screening techniques that have facilitated early detection of polyps that can be removed before they develop into cancers, and from biopsy screening techniques that can sensitively distinguish cancerous and healthy tissue. Researchers at Tel Aviv University and the Rabin Medical Center in Israel recently reported the results of a new electrochemical technique for direct biopsy screening of colorectal tissue. The method involves placing a mouse biopsy specimen in an electrochemical cell and performing a chronoamperometric measurement on a gold working electrode poised at +220 mV vs. Ag/AgCl . A precise quantity of a substrate, p-aminophenylphosphate (pAPP), is injected into the cell and reacts

with the alkaline phosphatase (ALP) enzyme that is known to be expressed at very low levels (< 0.0001 unit/mg of protein) from cancerous cells but at much higher levels (> 0.7 unit/mg) from healthy differentiated cells. The reaction of pAPP with ALP produces p-aminophenol, which undergoes electrochemical oxidation and hydrolysis to form quinone. The oxidation current is dramatically higher from healthy mouse tissue compared to that for specimens taken from tumors resulting from injection of cancer cells into a mouse. This technique could potentially be important as a cost-effective clinical tool to benefit people in many areas of the world.

From: *J. Electrochem. Soc.*, **158**, P1 (2011)

Stacked Al-based High-k Dielectrics For the Passivation of SiC Devices

Silicon carbide (SiC) is a promising semiconductor material for use in high power semiconductor devices because it exhibits high thermal conductivity, high electric field breakdown strength, and radiation resistance; however, surface passivation and edge termination methods and materials developed for silicon devices can counteract the desirable properties of silicon carbide. Aluminum nitride (AlN) and aluminum oxide (Al_2O_3) have been reported in the literature to be potential passivating materials for silicon carbide and have superior dielectric properties compared to silicon dioxide (SiO_2). Researchers from Sweden and Finland studied the dielectric properties of stacked, alternating layers of AlN and Al_2O_3 deposited by atomic layer deposition on a thin film of SiO_2 thermally grown on epitaxial SiC. The passivation of SiC was improved by the stacked configuration of Al-based dielectric materials on an interface layer of SiO_2 compared to the single use of any of these three materials directly on SiC. The researchers' measurements revealed that the dielectric properties of the stacked films depended on whether AlN or Al_2O_3 was the first deposited layer on the thin SiO_2 buffer layer; the stack with the Al_2O_3 bottom layer was more stable than the stack with the AlN bottom layer.

From: *J. Electrochem. Soc.*, **158**, H75 (2011)

Tech Highlights was prepared by James Dickerson of Vanderbilt University, Mike Kelly of Sandia National Laboratories, Zenghe Liu of Abbott Diabetes Care, Arnold Stux, Craig Walker of Valence Technology, Inc., and Donald Pile. Each article highlighted here is available free online. Go to the online version of Tech Highlights, in each issue of Interface, and click on the article summary to take you to the full-text version of the article.