

### A Novel CO-Tolerant Anode for Proton Exchange Membrane Fuel Cells

Typically Pt is alloyed with metals such as Ru, Sn, or Mo to provide more CO-tolerant, high-performance anodes for proton exchange membrane fuel cells. Researchers at the University of South Carolina, Plug Power, Inc., and the State University of New York at Albany recently reported a non-alloy anode configuration using Pt and Ru. In their work, a layer of carbon-supported Ru was placed between the Pt catalyst and the anode flow field to form a filter. In the presence of a small amount of oxygen in the fuel stream, the slow H<sub>2</sub> oxidation kinetics of Ru in this filter becomes an advantage compared to Pt and Pt:Ru alloy anodes because a greater percentage of O<sub>2</sub> is available to oxidize adsorbed CO to CO<sub>2</sub>. With an anode feed of H<sub>2</sub> containing 2% O<sub>2</sub> and up to 100 ppm CO, the Pt + Ru filter anode performed better at 70°C than the Pt:Ru alloy. The oxygen in the anode feed stream was found to form a hydroxyl species within the filter. The reaction of these hydroxyl groups with adsorbed CO was the primary pathway for CO oxidation within the filter. Due to concomitant proton formation, the Ru filter must be placed in front of and adjacent to the Pt anode and must contain Nafion in order to provide the ionic pathways for proton conduction.

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### Glass Capillaries as a Tool in Nanoelectrochemical Deposition

Electrodeposition of sub- $\mu\text{m}$  metal structures has been achieved using *in situ* scanning tunneling microscopy and through the use of the scanning electrochemical microscope. In both of these techniques, the whole substrate must be submerged into the electrolyte. Researchers at the Institute for Materials Chemistry and Corrosion in Switzerland recently demonstrated that metals could be locally electrodeposited, without submerging the substrate, using electrolyte-filled nanocapillaries. Staemmler, Suter, and Böhni used a glass nanocapillary filled with a dilute, acidic solution of copper sulfate to electrodeposit copper dots onto a gold substrate. The precise alignment of the 400-nm-diameter nanocapillary tip to the gold working electrode was accomplished with a laser-based shear force feedback system. A platinum wire was used as a counter electrode and a saturated calomel electrode was connected to the capillary via an electrolyte bridge. The authors point out that this new nanoelectrochemical tool can also be used to map local surface potentials of heterogeneous metals and alloys.

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### Concentration Polarization of a Polymer Electrolyte

The poor ionic transport properties of poly(ethylene oxide)-type solid polymer electrolytes used in lithium batteries at moderate temperatures can cause concentration polarization and limit battery performance. Despite more than two decades of research, a complete understanding of these transport properties has not been achieved. Researchers from the Royal Institute of Technology and Chalmers University of Technology in Sweden have reported the results of a theoretical and experimental investigation of transport properties of an electrolyte consisting of lithium bis(trifluoromethanesulfone)imide salt in a 75/25 copolymer of ethylene oxide/propylene oxide. The salt concentration was measured *in situ* by confocal Raman spectroscopy during galvanostatic polarization and relaxation experiments. The authors compared experimental measurements of the salt concentration at distances of 0, 20, and 40  $\mu\text{m}$  from the lithium working electrode to results obtained from a transport model based on con-

centrated electrolyte theory. The excellent agreement between experimental and theoretical results allowed the authors to determine the salt diffusion coefficient and the cationic transport number.

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### Filiform Corrosion on Coated Aluminum Alloys

Filiform corrosion is an atmospheric corrosion process that occurs on coated surfaces of aluminum, steel, magnesium, and other metals. The exact mechanism of filiform corrosion is not completely understood, but it is generally believed that in the case of coated aluminum it is a special type of anodic undermining. Researchers at the Swedish Corrosion Institute used Fourier transform infrared microspectroscopy and scanning Kelvin probe microanalysis to study filiform corrosion on AA6016 alloy samples that had been covered with an epoxy-based, electrodeposited coating. They identified the formation of thin, thread-like filaments beneath the coatings. The filament head was filled with a partially hydrolyzed aluminum chloride solution containing monomeric and polymeric cations of aluminum that are highly soluble and hygroscopic. The Volta potential of the head was found to be approximately 400 mV lower than that of the filament tail. Aluminum ions produced by anodic reactions in the front of the head are hydrolyzed by hydroxyl ions generated by oxygen reduction, a cathodic process that occurs at the back of the head and at the tail. Complete neutralization of the aluminum chloride solution in the back of the head and in the tail leads to the formation of an aluminum hydroxide gel. During this precipitation process, carbonate ions are also incorporated in the gel.

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### Chemical Mechanical Polishing of Gallium Nitride

Gallium nitride has emerged as a promising semiconductor material for short-wavelength optoelectronic emitters as well as high power microwave and RF electronic devices. A key issue for these applications is the availability of high quality GaN. Currently, most GaN devices are produced by heteroepitaxial techniques on substrates such as sapphire or silicon carbide. Although high quality GaN wafers are not readily available, they are generally considered to be essential as homoepitaxial growth substrates for the next generation of GaN devices. In either case, many devices are intolerant to intrinsic surface defects such as hillocks and pits or process-induced defects such as polishing scratches. Scientists at the University of California (Santa Barbara) have reported the results of a study of the chemical mechanical polishing of GaN with alkaline colloidal silica solutions. They studied GaN samples produced by hydride vapor phase epitaxy (HVPE), metallorganic vapor phase epitaxy (MOVPE), and molecular beam epitaxy (MBE). GaN removal rates at room temperature varied from 0.4 to 1.1  $\mu\text{m}/\text{hour}$ , resulting in a root mean square surface roughness as low as 0.4 nm. The authors report that polishing occurs very efficiently on N-terminated surfaces of the crystal but that Ga-terminated surfaces exhibit no polishing action.

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