TECH HIGHLIGHTS

Integration of Electrochemistry and Biotechnology

Bartlett, Pletcher, and Zeng of the University of Southampton describe initial experiments aimed at addressing issues related to the practicality of enzyme modified electrodes. The authors point out that the economics of enzyme modified electrode systems is key to their ultimate commercial use. Toward this end, they describe methods for increasing the effective current density and stability of the system, both issues related to increased "space/time/yield" of enzyme modified electrodes. The enzyme used in this work is horseradish peroxidase, and the reaction considered is the reduction of hydrogen peroxide to water. A high-surface-area polyanaline film is grown onto a carbon electrode substrate, and the enzyme is immobilized onto this substrate. In this way, the effective limiting current density can be increased by at least an order of magnitude. By using a high-surface-area carbon electrode substrate for deposition of the initial electroactive polymer, the effective current density can be further increased. They also show that by cross linking the enzyme, the overall stability and activity of the enzyme can be significantly improved. Methods for preparing the films and attaching the enzyme to the films are described.

*From: J. Electrochem. Soc., **144**, 3705 (1997)*

Quantum Chemical Analysis to Predict Battery Performance

The first principles of quantum chemistry, based on a solution of the Schrödinger equation, have been long used to predict the physical and chemical properties of various compounds. Recently, a group of Swiss and Austrian scientists have used this technique to determine the theoretical performance of two lithium ion couples, LiC_6/MoO_2 and LiC_6/NiO_2. Crystallographic data and chemical composition, both before and after discharge, were used in the analysis to determine the average voltage, energy density (Wh/L) and specific energy (Wh/kg) for each couple. The calculations were first done at zero temperature and then, for the LiC_6/NiO_2 couple, the temperature dependence was determined for each of the three performance criteria. The effect of temperature on the calculated values of the performance criteria was found to be minor. For each lithium ion couple, the theoretical performance results were compared to those experimentally obtained. In every case, the theoretically obtained values were higher than the experimental data, and in some cases much higher. In general, the results were very encouraging due to their consistency and agreement with experimentally observed trends. Although refinements to future calculations may yield more accurate results, the usefulness of this theoretical technique could be realized now as a powerful aid in directing future experimental work.

*From: J. Electrochem. Soc., **144**, 3877 (1997)*

Poly-Si Thin Film Transistors

Thin film poly-silicon transistors are used in electrically erasable programmable read-only memories (EEPROMs) and active matrix liquid crystal displays (AMLCDs). Lee and coworkers at the Korean Institute of Science and Technology and Samsung Electronics describe a process for depositing a thin gate oxide for poly-Si thin film transistors (TFTs). Various methods have been previously proposed to grow the transistor dielectric layer. One method is thermal oxidation, which is not suitable due to the resulting rough poly-Si/SiO_2 interface. Another method is to use an electron cyclotron resonance (ECR) oxygen plasma, which gives a smoother interface and passivates the dangling bonds. In separate studies, nitrogen has been shown to have the benefit of passivating defects at the grain boundaries. Here, the authors combine these advantages by using an ECR N_2O plasma to grow the oxide. Using SIMS (secondary ion mass spectroscopy), XPS (x-ray photoelectron spectroscopy), and AFM (atomic force microscope) characterization of the interface, along with electrical measurements of MOS (metal-oxide-semiconductor) capacitors and TFTs, they demonstrated the advantages of their method and suggested some mechanisms. The improvement in surface quality is postulated to be due to lower oxidation temperature and to the formation of a nitrogen-rich diffusion barrier layer that is believed to segregate to the grain boundaries. The nitrogen-rich layer at the poly-Si/SiO_2 interface also results in somewhat self-limited growth, making it easier to control the oxide thickness.

*From: J. Electrochem. Soc., **144**, 3283 (1997)*

Low Temperature Crystallization of Amorphous-Si Thin Films

Sohn and colleagues from the Korea Advanced Institute of Science and Technology, have demonstrated a method for crystallizing Si from amorphous Si (a-Si). Solid-phase crystallization (SPC) of a-Si has been shown to give high quality poly-Si, but to use an inexpensive glass substrate, the process temperature should be below 600°C. The authors propose using a liquid solution spun onto the wafer to deposit copper onto the a-Si. Upon annealing at 530°C, about 99% of the copper evaporates, but the remainder forms clusters that serve as nucleation sites for the fractal growth of Si crystals. The metal deposition occurs by an electroless mechanism, in which copper deposition and silicon dissolution occur simultaneously. A standard solution of 1000 ppm $CuCl_2$ dissolved in 1 N HCl was used. The copper concentration was varied by diluting this solution with deionized water. In most cases, the concentration dependence of the Si crystallinity was as expected, but it was found that more copper was deposited from the 10-ppm solution than from the 100-ppm solution. This finding was explained by the higher pH of the 10-ppm solution; thus the silicon dissolution and copper deposition were enhanced. Device data were not presented.

*From: J. Electrochem. Soc., **144**, 3592 (1997)*

Detection of Localized Corrosion

Alodan and Smyrl, from the University of Minnesota, have used fluorescence microscopy to monitor, in situ, the localized attack on aluminum alloy 2024 in 0.1 M KCl. The relatively new technique, confocal laser scanning microscopy, boasts a lateral resolution of 0.5µm and a vertical resolution of 0.1-0.2µm. By choosing an appropriate dye, chemical changes, such as pH changes can be monitored in situ. The authors used this technique to study the corrosion of Al 2024 containing various types of inclusions. Various ex-situ techniques were used to verify the conclusions. Depending on whether the inclusion acted as an anodic or a cathodic site, the dye was distributed either in a ring pattern around the inclusion or uniformly across the inclusion. The ring pattern results when the inclusion behaves as a cathodic site, which promotes dissolution of the surrounding matrix to form a groove around the periphery. The dye is then trapped in the resulting corrosion film. On the other hand, when the inclusion acts as an anodic site, the corrosion products form on the surface of the inclusion, and the fluorescence pattern is uniform.

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Tech Highlights were prepared by David Ingersoll, Greg MacLean, and Vicki Edwards.