TECH HIGHLIGHTS

Interface *would like to extend a sincere thank you to Vicki Edwards, who has been the Contributing Editor for Tech Highlights since its debut in the Winter 1993 issue. Vicki has been one of those rare editors who always submitted her contributions on time! She will continue to contribute highlights and this feature will continue under the leadership of Mike Kelly.*

Electrochemical Storage of Hydrogen in Nanotubes

For the next generation of hydrogen/air fuel cells or hydrogen combustion engines, safe hydrogen storage will be critical. The use of liquified hydrogen is hazardous and consumes considerable energy. Storage of hydrogen in metal hydrides has been investigated but has generally been rejected because of the low energy density. Recent research has focused on light-metal hydrides such as storage in carbon nanotubes. Researchers in the Department of Physics at the University of Freiburg in Switzerland recently demonstrated that hydrogen can be reversibly stored in carbon nanotubes through an electrochemical absorption/desorption mechanism. Nutzenadel, Zuttel, Chartouni, and Schlapbach found unexpectedly high hydrogen absorption in these samples. The absorption was much higher than for any other form of carbon. Further, only a slight loss in hydrogen storage capacity was observed after many charge/discharge cycles. More work is in progress to fully characterize the unexpectedly high absorption.

*From: Electrochemical and Solid-State Letters, **2(1)**, 30 (1999).*

Electrochemical Nanostructuring of Silicon

Metal nanostructures on silicon will be needed for the next generation of devices, such as room temperature, single-electron quantum confinement devices. However, current lithographic techniques are limited by the excitation source wavelength. Even the most advanced techniques, electron- or molecular-beam lithography, cannot provide lateral resolution better than the low tens of nanometers. Scanning probe techniques offer the ability to write nanometer-sized features, and electrochemical deposition allows such features to be deposited in-situ, without damaging the substrate. Potzchke and coworkers at the University of Karlsruhe in Germany have demonstrated and studied the electrochemical deposition of lead clusters on n-Si(111). They classify the available probe-based nanostructuring methods into probe-induced, field-induced, and defect-induced techniques. They have developed the appropriate tip polarization routines for both field-induced and combined tip-induced and field-induced methods. In the combined method, lead is pre-deposited on the probe tip and subsequently dissolved locally, enriching the metal ion concentration in the region of the tunneling gap. Also, the field induced by the probe locally changes the normal semiconductor depletion layer into an accumulation layer, which allows the metal ions to be reduced to the metal, but only in the region below the tip. The next step is to fabricate defined structures that will enable electrocatalysis studies and the construction of electronic nanodevices.

*From: J. Electrochem. Soc., **146,** 1412 (1999).*

Electrochemical Atomic Layer Epitaxy of CdTe Films

Villegas and Napolitano at the University of New Mexico have recently described their efforts aimed at optimization of methodologies for atomic layer epitaxial growth by electrochemical means. The researchers describe the development of prototype hardware for computer-controlled, continuous flow deposition of expitaxial layers. The method relies on the alternating and sequential underpotential deposition of cadmium and telluride in order to generate an epitaxial layer of CdTe. One of the main objectives of this activity is to begin to address the issues that will be faced for development of a practical, viable, electrochemical atomic layer epitaxial deposition system. The resultant films prepared using the prototype hardware are relatively uniform and stoichiometric. The film morphology follows that of the underlying substrate and ordered domains on the 10-100 nanometer size range are obtained. The authors clearly recognize that further improvements will be necessary to achieve commercialization.

*From: J. Electrochem. Soc., **146,** 117 (1999).*

Characterization of TEOS/Ozone Reaction Products

Chemical vapor deposition of tetraethylorthosilicate (TEOS) in the presence of ozone is a mature technology for the fabrication of integrated circuits. Among the reasons for its widespread application in quarter-micron device fabrication is the excellent step coverage that can be obtained. Little is known, however, about the mechanisms leading to ozone-induced TEOS decomposition. Such information could lead to improved tool designs and more efficient hazardous waste abatement schemes. Researchers at ATMI-EcoSys Corporation in Connecticut and Watkins-Johnson Company in California have reported the results of a Fourier transform infrared (FTIR) spectrocopic study of an on-line determination of the products of the atmospheric pressure reaction of TEOS and ozone. The principal products of the reaction are carbon monoxide, carbon dioxide, water, formic acid, and acetic acid. Unreacted TEOS and ozone were detected in some experiments as well. The composition of the product mixture, as well as the concentrations of the individual components in the mixture, were primarily determined by the reaction temperature and the initial ozone/TEOS molar concentration ratio. Reaction conditions that lead to complete depletion of the TEOS reactant, and those that lead to the absence of formic and acetic acid products, are described.

*From: J. Electrochem. Soc., **146,** 276 (1999).*

Plasmon Resonance Spectra of Gold Nanoparticles

It is well known that surface reactions on colloidal metal particles can dramatically affect their optical properties. Recently, it has been reported in the literature that optical properties of metal particles can be electrochemically altered as well. Ali and Foss of Georgetown University in Washington, D.C., have reported the results of plasma resonance spectroscopy experiments on nanoscopic gold particles adsorbed on optially transparent tin oxide electrodes. They examined these particles in contact with several electrolytes which show differing adsorption characteristics on gold as a function of applied potential. In all cases, the spectral bands decrease in intensity and shift to longer wavelengths as the applied potential is made more anodic. The authorís simulations using a Rayleigh limit coated-sphere scattering theory suggest that these effects are not explained by free electron depletion and consequent reduction in the metal plasma frequency. They conclude that these potential-induced spectral effects are due to reductions in the electron mean free lifetime resulting from anodic polarization and specific anion adsorption effects.

*From: J. Electrochem. Soc., **146,** 628 (1999).*

Tech Highlights was prepared by Mike Kelly, Terry Guilinger, and David Ingersoll of Sandia National Labs and Vicki Edwards of Corning Incorporated.