TECH HIGHLIGHTS

Electrochemical Reduction of Ethylene Carbonate

Ethylene carbonate (EC) is a widely used solvent in lithium-ion battery electrolytes. It is now generally agreed that the electrochemical reduction of EC plays an important role in the formation of an effective solid electrolyte interface layer on the carbon anode in these batteries. However, neither the composition of this layer nor the reaction pathways involved in its formation have been clearly established. Researchers at the Lawrence Berkeley National Laboratory reported reflectance infrared spectra obtained from a glassy carbon electrode surface after EC/tetrahydrofuran electrolyte reduction. Unlike any other spectrum found in the literature, the new spectrum shows a strong absorption peak at 838 cm^{-1}. This feature was clearly shown not to be from the monoethylcarbonate lithium salt, a frequently proposed product of EC reduction in lithium-ion cells. Ethylene oxide, which has strong absorbance in the same region, is suggested as a possible, but not exclusive, reduction product. The suggested reaction pathway is an electrochemical-chemical sequence, *i.e.*, electrochemical reduction of water to form hydroxide, and hydroxide addition to form ethylene oxide and lithium bicarbonate.

From: Electrochem. and Solid-State Lett., ***4****, A82 (2001)*

Fabrication of Anatase TiO_2 Nanowire Arrays

There has been increasing interest in using ordered porous materials as templates for nanofabrication of electronic, magnetic, optical, and microelectromechanical devices. Template synthesis has been used to prepare nanowire arrays of several materials, including TiO_2, which is widely used as a catalyst support, semiconductor photocatalyst, and in solar cells and sensors. TiO_2 arrays have been synthesized using a sol-gel template method, but the method is complex and sensitive to impurities. Researchers at the Chinese Academy of Sciences have reported the fabrication of highly ordered, single-crystalline anatase TiO_2 nanowire arrays by an electrochemical process. First, nanochannel alumina templates are fabricated by the same two-step method as described in *J. Electrochem. Soc.,* ***148****, B152 (2001),* and a gold electrode is vacuum evaporated onto the porous alumina. The TiO_2 nanowires are prepared by potentiostatic anodic oxidative hydrolysis of acidic aqueous $TiCl_3$ solutions. The sample is annealed at 500°C to obtain 15-nm diameter, single-crystalline anatase TiO_2. The authors speculate that the nanowires nucleate at the center of the alumina pores, and that single-crystal material is formed upon annealing due to the confinement of the $TiOH^{2+}$ particles to the center of the positively charged, small-diameter alumina pores.

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Fabrication of Thin Films with Unique Perforations

Organized arrays of pores have been produced in various materials using a diverse set of techniques. However, the cross-sections of these pore arrays are nearly always circular or rectangular. There are situations where other cross-sections would be more desirable. For example, helical pores have been shown to rotate the polarization of linearly polarized light. Researchers in the Electrical and Computer Engineering Department at the University of Alberta recently showed that thin films could be perforated with helical- and chevron-shaped pores. Harris, Westra, and Brett used a glancing angle deposition and templating technique to fabricate pores with unique geometries. First, template thin films consisting of columns having the negative of the desired pore shape were deposited by glancing angle deposition. Then, the template was filled with a solution of the desired material. The template was removed by chemical etching using a solution specific to the template material. The authors envision uses for these films as particle filters and sieves, gas exchange membranes, microfluidic catalysts, high-density magnetic data storage media, photonic bandgap crystals, and chiral optical devices depending on the materials used to make the films.

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Cobalt and Copper Contamination in Silicon

As silicon microelectronic device features are scaled down below 0.18 µm, alternative materials such as cobalt silicide will be used in gate and source/drain diffusion regions. Further, the copper damascene process has already resulted in the introduction of this metal into integrated circuit fabrication facilities. It is therefore critical to understand the effects of Co and Cu contamination on the electrical properties of front-end processed silicon, and to develop monitoring protocols to measure trace amounts of these metals. Researchers at Bell Laboratories in New Jersey have reported the results of a study of the migration, detection, and gettering of Co and Cu in silicon wafers. The authors intentionally contaminated silicon substrates by ion implantation or dipping in a solution containing the metal ions. Carrier lifetime measurements, SIMS, TXRF, and DLTS were used to analyze metal migration resulting from subsequent heat treatments. Both metals diffused throughout float zone silicon substrates, destroying carrier lifetimes. In contrast, p/p^+ epitaxial wafers gettered the metals so that near-surface carrier lifetimes remained acceptably high. While other device properties indicated no degradation of oxide quality associated with Co or Cu contamination, the authors conclude that careful monitoring of several materials and electrical characteristics will be required to ensure high production yields.

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Efficient Blue Light Emission from Silicon

The rapid development in information technology has generated a tremendous demand for optoelectronic integrated circuit devices. Silicon, the baseline material for microelectronic devices, is not well suited for production of light-emitting devices because of its indirect bandgap of about 1.1 eV. To date, compound semiconductors are most commonly used as discrete optoelectronic devices, and completely Si-based optoelectronic integrated circuits have not been realized. However, a collaboration of researchers from four institutions in Germany has now reported the fabrication of the first all-silicon integrated optocoupler. Their device galvanically separates a light emitter circuit from a photon detector, and transmits information between them via light pulses. The light emitter, based on Ge-implanted SiO_2 layers, exhibits bright blue-violet electroluminescence at record luminescence efficiency levels of 0.5%. The electroluminescence mechanism involves tunnel injection of electrons into the SiO_2 layer, which excite the luminescence centers by impact excitation or field ionization. A radiative T_1-S_0 transition of these centers produces the observed electroluminescence. The authors anticipate numerous applications for this material in sensor, display, and microsystem technologies.

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