TECH HIGHLIGHTS

Copper Electrodeposition in High Aspect Ratio Trenches and Vias

As integrated circuits progress toward features with increasingly smaller linewidths, interconnect technology will have a greater impact on circuit density, performance, and yield. The new chip architectures that are being developed and adopted by the semiconductor industry will incorporate insulator materials with the lowest possible permittivity ("low-k dielectrics") and copper as the conductor material. These advanced chip architectures are expected to improve integrated circuit speed by factors of 5 or more. Among the technologies being evaluated for copper deposition are chemical vapor deposition (CVD), physical vapor deposition (PVD), ionized PVD, and electrodeposition. Researchers at Columbia University in New York City have reported the results of a theoretical study of the electrodeposition of copper into high aspect ratio vias and trenches. The authors modeled electrodeposition methods that have the potential to produce high-quality electrodeposits from plating baths that do not contain large amounts of organic additives. Their results demonstrated that pulse electrodeposition methods, including a "reverse plating" technique whereby copper deposition is modulated with electrodissolution, should result in high-quality electrodeposits (i.e., small voids), provided there is adequate control of key experimental parameters such as deposition/dissolution times, deposition/dissolution current densities, and "off times," during which faradic processes do not occur.

From: *J. Electrochem. Soc.,* **145,** 3070 (1998).

Moisture Instability of Borophosphosilicate Glass

Borophosphopsilicate glass (BPSG) is used as an insulator between the semiconductor device layers and the metal interconnect layers of integrated circuits. Moisture in the premetal dielectric oxide of integrated circuits can affect the electrical behavior of an oxide by enhancing its electrical permittivity and conductivity as well as cause corrosion of metal interconnect wiring. Thomas W. Dyer of Rockwell Semiconductor Systems in Newport Beach, California studied the effects of various thermal treatments on the physical and chemical properties of tetraethoxysilane/ozone BPSG and how these properties relate to the subsequent stability of the films against atmospheric moisture penetration. Dyer used three measures of film stability: P=O bond reduction, water absorption and film expansion. Secondary ion mass spectroscopy (SIMS) was used to determine the extent of moisture penetration and thermal desorption analysis to determine the water desorption from the oxides as a function of temperature. The total amount of moisture after various processing and exposure conditions was quantified by moisture evolution analysis. Film thickness and film stress were also obtained. The films used in this study were deposited by chemical vapor deposition on silicon wafer substrates. Repeated stress and thickness measurements over time showed that the as-deposited films are unstable, while thermal cured films are stable. Although both film shrinkage and film stress correlated well with the three measures of stability for one type of thermal treatment, only shrinkage consistently predicted film stability for all thermal treatments. These results, Dyer suggests, indicate an instability mechanism dependent on the diffusion of atmospheric water into pores of the films where water reacts with a P=O bond to form phosphorous dihydroxide.

From: *J. Electrochem. Soc.,* **145,** 3950 (1998).

New Model for Rate of Chemical Mechanical Polishing

Chemical mechanical polishing (CMP) is a prominent method for the removal of oxide and metal layers on silicon wafers. In CMP, a wafer is pressed onto a rotating pad with polishing slurry flowing between the wafer and the pad. An empirical relation (the Preston equation) has often been used to relate the removal rate by CMP to the product of the polish pressure and the linear speed at the wafer-pad surface. Researchers at Rodel, Inc. in Newark, Delaware and Clarkson University in Potsdam, New York considered surface deformation by abrasive particles to explain the observed removal rate. This team (Zhang and Busnaina) showed that a model based on plastic deformation of the polished material along with the contribution of particle adhesion forces was in better agreement with the experimental data than the Preston equation. In the new model, the removal rate is proportional to the square root of the product of the polish pressure and the linear speed at the wafer-pad surface.

From: *Electrochem. Solid-State Lett.,* **1,** 184 (1998).

Review of Capacity Fade Mechanisms in Li-Ion Batteries

Lithium-ion cells were first commercialized in 1990, and they are becoming increasingly popular for consumer applications such as cellular phones, portable computers, and camcorders. Although the energy density and cycle life of these cells are quite attractive, the problem of capacity fade remains unsolved. P. Arora and R. E. White of the University of South Carolina and M. Doyle of Dupont present a review with 177 references detailing categorized capacity fade and side reaction mechanisms that have been proposed in the literature. They point out that none of the published mathematical models of Li-ion cells explicitly include capacity fade mechanisms which limits their predictive capability. After reviewing the experimental findings and postulated mechanisms, the authors present some recommendations for both theoretical and experimental work that is needed to include these phenomena in future mathematical models.

From: *J. Electrochem. Soc.,* **145,** 3647 (1998).

Free-standing Porous Silicon Films

Porous silicon has received a great deal of attention due to its light emitting properties. Until now, the ability to make direct measurements of absorption, without any influence from the substrate, has been limited to films having a porosity less than 80%. Typically, freestanding films with higher porosities collapse under the capillary forces generated during natural drying. It has previously been shown that high porosity aerogels and attached porous silicon films can be prepared using supercritical drying as the final step. D. Xu and coworkers from Peking University have shown that electrochemical etching-electropolishing and chemical dissolution, followed by supercritical drying, can be used to produce free-standing porous silicon films with porosities greater than 90%. Films with 94% porosity were fabricated and found to have 2.6-nm diameter Si crystallites. The films of varying porosities were characterized by Raman scattering spectroscopy, scanning electron microscopy (SEM), optical transmission measurements, and photoluminescence spectroscopy. The transmission curves showed a blue shift and the refractive index decreased as the porosity increased. These findings are reported to be consistent with the quantum confinement model. However, the photoluminescence peak was not blue-shifted, contrary to the prediction of the quantum confinement model.

From: *Electrochem. Solid-State Lett.,* **1,** 227 (1998).

Tech Highlights were prepared by Mike Kelly and Terry Guilinger of Sandia National Labs, and Duane Johnson and Vicki Edwards of Corning Incorporated.