TECH HIGHLIGHTS

Detection of Metallic Contaminants on Silicon Surfaces

Contamination of semiconductor silicon by trace metal impurities degrades the performance of integrated circuit devices and reduces the production yield of these devices during their fabrication. The deposition of both copper and gold from hydrofluoric acid (HF) solutions is thermodynamically favored and presents several significant technical challenges, including minimization of the contamination resulting from these reactions, measurements of the effects of these metals on key electrical properties of the silicon substrates, and in situ monitoring of metal ion contamination in liquid processing tools. Researchers at MIT and Digital Equipment Corporation in Massachusetts have reported the development of a radio-frequency photoconductance decay (RFPCD) method for in situ measurements of the minority carrier lifetime of silicon substrates immersed in aqueous HF. The method is quite sensitive, being capable of detecting the effects of very low contaminant concentrations (down to 10 ppb) on surface minority carrier lifetimes. In addition, since surface carrier lifetimes were shown to be directly related to the solution concentrations of the metal ions, the RFPCD method also offers the possibility of a non-invasive monitor for contaminants in HF processing baths. Finally, the authors make important conclusions regarding the mechanistic pathways of copper and gold deposition processes and present quantitative thermodynamic and kinetic information for these reactions.

*From: J. Electrochem. Soc., **145**, 2602 (1998).*

Macropore Formation in Silicon

Macropore formation (pores in the micron-size diameter range) in silicon could lead to new texturizing techniques for silicon solar cells. Researchers at the Laboratoire de Physique des Solides de Bellevue in Meudon, France, used non-aqueous, fluoride-containing electrolytes such as acetonitrile (MeCN) and dimethylformamide (DMF) to form macroporous layers on p-type silicon of (100) and (111) crystal orientation. The team of Ponomarev and Levy-Clement observed that macropore growth is limited to wafers with resistivities greater than a threshold value of 10 ohm-cm for MeCN and 1 ohm-cm for DMF and that growth was always perpendicular to the surface for both crystal orientations. Macropore formation was attributed to the effective collection of holes at the tips of growing macropores. Macropore structures could also find use as membranes and templates for localized photoelectrochemical metal deposition.

*From: Electrochem. and Solid-State Lett., **1**, 42 (1998).*

Characterization of High-Surface Area Electrocatalysts

Platinum is used on high surface area substrates in fuel cells as an electrocatalyst in both the anodic oxidation of hydrogen and the cathodic reduction of oxygen. Mass-transport resistances and/or incomplete wetting of the electrode structure, however, hamper the evaluation of the electrocatalytic activity of these catalysts. Rotating disk electrode (RDE) measurements were used to address these problems. The method involves the deposition of a relatively thick (1-6 µm) Nafion film onto a glassy carbon RDE. In order to determine the electrode kinetics from the experimental data, extensive mathematical modeling is required. Scientists from the Universität Ulm and the Daimler-Benz research center in Ulm, Germany, describe a modification and improvement of this RDE method that allowed for the characterization of the catalysts by carbon monoxide stripping voltammetry and the determination of electrocatalytic activity under conditions of negligible film resistance. The researchers used standard and CO stripping voltammetry to study the mass transport resistances through Nafion films of various thicknesses. Their results indicate that these RDE measurements can be made on high surface area electrocatalysts without interference from film diffusion if the Nafion film used to attach the catalyst particles to the RDE has a thickness of less than 0.5 µm. This enables direct measurements of kinetics without the use of mathematical modeling.

*From: J. Electrochem. Soc., **145**, 2354 (1998).*

Solar-to-Chemical Energy Conversion

Separation of electron-hole pairs in semiconductors is important for efficient solar-to-chemical energy conversion schemes. Nakato and coworkers at Osaka University achieved efficient electron-hole pair separation by creation of an electrical potential gradient in the semiconductor, in this case n-type silicon having dispersed platinum on the surface. Asymmetry in the band energies at the front and rear surfaces of the n-type silicon is achieved by immersion of each surface into a different solution. For this case the front side of the semiconductor was immersed in an aqueous solution of HI/I_2 and the back side was immersed in an aqueous solution of HBr. Modulation of the semiconductor surface band energy occurs due to the interaction of the surface species with those found in the aqueous solution in which it is immersed, with the most important interaction being identified as the silicon-iodine termination bonds that form. Upon irradiation of the semiconductor, H_2 and I_2 are generated; the efficiency of the process is reported to be 3.4%. Besides semiconductor chips or particles, the researchers mention that this scheme has widespread utility to other systems, such as organic thin films, membranes, and nano-sized and supra-molecules.

*From: Electrochem. and Solid-State Lett., **1**, 71 (1998).*

Air Gaps for Electrical Interconnections

As transistors continue to shrink, the need for a material with low dielectric constant becomes more critical. In-plane, intralevel capacitance has been been shown to be the major contributor to the RC delay in sub-0.5 µm interconnections. Researchers at the Georgia Institute of Technology and BF Goodrich (Kohl, et al.) have developed a method for using air as the intralevel insulating dielectric. A sacrificial, thermally decomposed polymer was used to define the air gaps between metal lines. An overcoated interlevel dielectric layer, such as PECVD silica, is deposited on top of the metal-polymer structure, and the polymer is then decomposed to form the air gap. The authors show that polynorbornene can be decomposed, leaving only a thin layer of residual material. The remaining decomposition products diffuse out through the overcoated dielectric. Simulation shows that the effective dielectric constant of silicon dioxide (ε=4.2) can be lowered to 2.4-2.8.

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