

Fabrication of Nanowire Arrays

Nanostructured materials enable the study of new phenomena that only occur on a very small scale, such as quantum size effects, excitons, and electron-electron interactions. Often magnetic structures, such as arrays of nanowires, exhibit magnetic properties superior to those of their bulk counterparts. Previously, arrays of metallic nanowires have been produced by such methods as e-beam lithography and plating into track-etched membranes or into anodized aluminum templates. Researchers at the Naval Research Laboratory, in collaboration with Digital Instruments, have devised and characterized another method based on using "nanochannel glass" (NCG). The NCG is made by a glass redraw process. First, an acid-etchable glass rod is inserted into an inert glass tube, and this structure is drawn at high temperature under vacuum to produce a small-diameter fiber. These fibers are then bundled into a geometric array, and this bundle is redrawn to produce a fused structure having an even smaller cross-sectional area. The process can be repeated to achieve the desired feature sizes. The material is then sliced, polished, acid-etched, and finally filled with metal by electroplating. The authors describe the magnetic properties of arrays of wires ranging from 78 to 800 nm in diameter, although 17-nm diameter wires have been reported in their previous work. The arrays were characterized by a variety of methods, including high-resolution atomic force microscopy and magnetic force microscopy.

From: J. Electrochem. Soc., 145, 247 (1998).

Fullerene Deposition by SEM

A. Weston and V. Muthusubramanian at Southern Illinois University describe a method for producing nanometer-sized two dimensional, i.e. linear, structures of fullerenes. These investigators demonstrate that the width of the structure produced can be precisely and easily controlled, and lines having widths as small as 200 nm and as wide as several microns can be prepared. These structures are deposited directly onto the substrate by oxidation of a nonaqueous solution of the reduced fullerene, that is by oxidation of C_{60n-} to form the insoluble C_{60} at the surface. (The C_{60n-} was prepared by reduction of a slurry of the initial fullerene.) Deposition of the fullerene is done using a scanning electrochemical microscope, which allows control of the dimensional characteristics of the structures produced. Additional work is planned by these investigators to reduce further the size of the structures produced and to improve control of the process.

From: J. Electrochem. Soc., 145, 503 (1998).

Metal Contamination of Si Wafers

Metal deposition onto silicon wafers during wet chemical processing poses a serious reliability problem for integrated circuits. Deposition of noble and transition metals, such as silver and copper, occurs by electrochemical reduction of the metal ion at surface sites, accompanied by electrochemical oxidation of the silicon at other sites. Researchers at the University of Arizona and at Advanced Micro Devices used dc electrochemical polarization techniques and total reflection X-ray fluorescence (TRXRF) to probe the deposition of copper onto silicon in dilute (DHF) and buffered (BHF) hydrofluoric acid solutions. This team showed that increasing the copper content of the solution did not alter the silicon corrosion rate but did increase the amount of copper deposited. They found that less than 1% of the corrosion current was due to copper deposition and attributed the remaining cathodic current to hydrogen

evolution. They also showed that illumination enhanced the corrosion rate of n-Si in DHF and p-Si in DHF and BHF but did not affect the corrosion rate of n-Si in BHF.

From: J. Electrochem. Soc., 145, 241 (1998).

A Computer Simulation of Oxygen Precipitation Behavior in Si

The oxygen content of silicon wafers used in the manufacture of integrated circuits (ICs) must be carefully controlled and understood to ensure optimum performance of ICs fabricated on these substrates. In Czochralski (CZ) grown silicon, oxygen is incorporated during the growth of the crystal from the melt. Oxygen has a beneficial effect because it forms oxide precipitates during thermal processing that then generate defect centers that act as gettering sites which remove heavy metal impurities from the active device region. However, gettering efficiency is highly dependent on the initial interstitial oxygen concentration of the crystal and the subsequent oxide precipitation behavior during thermal processing. Researchers at Shin-Etsu Handotai in Japan have reported results of their computer simulation that predicts oxygen precipitation behavior in CZ-grown silicon during a variety of thermal processes common to complementary metal-oxide-semiconductor (CMOS) processing. Their methodology takes into consideration the experimentally measured thermal history of the substrate during the crystal growth process, which they have determined plays a key role in the oxide precipitation during subsequent CMOS thermal processing steps. Experimentally measured oxygen concentrations and precipitate densities agree very well with values predicted by the simulation, indicating that this method may be a valuable predictive tool for estimating the gettering properties of wafers that are to be subjected to new thermal processing sequences.

From: J. Electrochem. Soc., 144, 4340 (1997).

Phase Transformations of Nickel Hydroxides

The goal of better understanding the fundamental electrochemical nature of nickel hydroxide $[Ni(OH)_2]$ and improving its performance in electrochemical storage devices has interested scientists for years. As part of this effort, researchers at Yonsei University, Korea, studied the phase transformation of electrochemically precipitated α - $Ni(OH)_2$ to its β - phase. Their studies were carried out on thin films in alkaline solution simultaneously using cyclic voltammetry and electrogravimetry with an electrochemical quartz crystal microbalance. The thin films of $Ni(OH)_2$, both pure and doped with co-precipitated cobalt, were formed galvanostatically from nitrate solutions. The results showed that the α - $Ni(OH)_2$ films gained mass during oxidation and then lost this mass during subsequent reduction. In contrast, the β - $Ni(OH)_2$ films showed the opposite electrogravimetric behavior. As α - $Ni(OH)_2$ ages in alkaline solutions, it undergoes a phase transformation to β - $Ni(OH)_2$, with an accompanying decrease in charge capacity. Study of these intermediate phases showed that, although they behaved electrochemically as a single phase, their electrogravimetric behavior was like microscopic mixtures of both the α - and β - phases. The cobalt doped films showed more clearly the existence of these intermediate phases. A model was developed that incorporated the concept of microscopic mixtures of α - and β - $Ni(OH)_2$ phases during the phase transformation that successfully explained their observed electrogravimetric results.

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