TECH HIGHLIGHTS

A Miniature Membrane-less Biofuel Cell

Since bioelectrochemical sensors and their circuits have been miniaturized to sub-millimeter dimensions, the largest component of autonomous electrochemical sensing systems for *in vivo* applications is now the power source. Practical limits on the size of manufacturable batteries are established by the dimensions of their cases, membranes, and seals. Biofuel cells have been studied extensively but most of them require membranes to separate the anode and cathode. The few membrane-less fuel cells utilizing glucose and oxygen reactions at the anode and cathode, respectively, suffer from either low power density or biocatalyst inhibition under physiological conditions. In a recent report, Adam Heller and coworkers at the University of Texas at Austin described a miniature biofuel cell without these drawbacks. The enabling chemical components of the cell are electrocatalytic enzyme films comprising cross-linked redox enzymes and redox hydrogels whose reaction centers are "wired" to two 7-μm diameter, 2-cm long carbon fiber electrodes. By oxidizing glucose and reducing oxygen at the two electrodes, the membrane-less cell operated in a pH 7.4 phosphate-buffered saline (PBS) solution at a power density of 50 $\mu W/cm^2$ and a cell potential of 0.5 V. Continuing work in the authors' lab is aimed at improving the kinetics of glucose oxidation to increase the power density of the cell.

From: J. Electrochem. Soc., ***150****, A209 (2003)*

Control of Organic Contamination on Silicon Wafers

Certain surface contaminants on silicon wafers used in microelectronics manufacturing are introduced from storage and shipping environments such as cleanroom air and wafer containers, boxes, and cassettes. The most common approach to dealing with this contamination, which is primarily organic in nature, is by a surface cleaning procedure using a sequence of wet cleaning steps. For over 25 years, one of the common approaches has included treatment with an aqueous mixture of hydrogen peroxide and ammonium hydroxide. However, a simpler approach that does not require the time, facilities, and chemical resources of wet cleaning operations would be very attractive for some applications. Researchers at The Pennsylvania State University and at QC Solutions, Inc. have developed a rapid optical surface treatment (ROST) that is very effective at removal of contaminants introduced during shipment or short-term storage. The wafer surface is illuminated by a 600 W halogen lamp in ambient air and decontamination occurs by thermally driven oxidation, among other mechanisms. Although ROST was not as effective as wet cleaning in removing contamination from wafers stored for prolonged durations in frequently opened boxes, the authors demonstrated that ROST is effective as a cleaning step prior to gate oxidation.

From: J. Electrochem. Soc., ***150****, G39 (2003)*

Drug Delivery from Thin Metal Films

Methods for affecting the time-release delivery of pharmaceuticals from devices implanted in humans are of wide general interest. Currently, polymer-based coating technologies are used to slowly release pharmaceuticals, but there are limitations regarding the type of drug that can be delivered, the rate of delivery, and the biocompatibility of the polymers. Gertner and Schlesinger from the University of California in San Francisco, the University of Windsor, and Nanomedical Technologies have reported the first ever use of electrochemical deposition to create thin metal films that contain and release a range of pharmaceuticals over long periods *in vitro*. The investigators demonstrated that formation of an electroless Ni-P film in the presence of a pharmaceutical agent results in incorporation of the drug into the film. When this thin metal composite film is placed in contact with an aqueous salt solution, the drug is slowly released over a period of weeks, the duration of the experimental data presented. The authors state that the time frame, in principle, may be controlled via film thickness and/or a suitable topcoat.

From: Electrochem. Solid-State Lett., ***6****, J4, (2003)*

Phosphor Coatings for GaN Light Emitting Diodes

Light emitting diodes (LEDs) are widely used because of their high intensity, low power consumption, excellent reliability, and long life. Current applications include flat-panel computer displays, fiber optic data transmission, optoelectronic circuitry, and indicator lights on consumer, industrial, and scientific equipment. Further, by approximately 2030, LEDs are projected to dominate all forms of lighting applications with anticipated savings of up to 70% of the electricity that is used for lighting today. Researchers at the Kwangju Institute of Science and Technology in Korea obtained white light by mixing blue light from a GaN LED and yellow light from the fluorescence of a cerium-doped yttrium aluminum garnet (YAG) phosphor. They deposited phosphor coatings on GaN devices and indium tin oxide (ITO) windows (which were subsequently integrated with GaN LEDs), by slurry, settling, and electrophoretic deposition methods. Electrophoresis was superior in controlling the uniformity, thickness, and packing density of deposited phosphor coatings, but electrophoretic coatings did not adhere well to the ITO substrate unless a UV-curable polyvinyl alcohol / ammonium dichromate mixture was spray coated over the phosphor film. Good spectral output between 400-700 nm was realized via integration of GaN LEDs and YAG-based phosphors.

From: J. Electrochem. Soc., ***150****, H47 (2003)*

Planarization of Copper Films by Electropolishing

Integration of copper and low-k materials in multi-level interconnect schemes is crucial to fabrication of new integrated circuit architectures. In order to successfully implement these materials in the copper damascene process, effective planarization methods are required. While a great deal of research has focused on chemical mechanical polishing (CMP), electropolishing as a possible approach to copper planarization has received very little attention. Padhi, Yahalom, Gandikota, and Dixit at Applied Materials Incorporated in California recently reported the results of their investigation into electropolishing of thin copper films. They used wafers with trench widths from 0.2-5 μm as substrates for electrodeposition of 1-8 μm thick copper films from an electrolyte containing copper sulfate, copper chloride, sulfuric acid, and multiple organic additives. They determined that efficient polishing of these films can be accomplished under galvanostatic conditions in concentrated phosphoric acid. The existence of a resistive anode/electrolyte boundary layer is essential for electropolishing, and anodic transient studies indicated that the formation mechanism for this layer is determined by the diffusive transport of an acceptor species to the anode/electrolyte interface. With optimal process parameters, the local topography of their test wafers was reduced from 550 nm to 200 nm while global non-uniformity (after polishing) across the 200-mm-diameter wafer was only 1.3%.

From: J. Electrochem. Soc., ***150****, G10 (2003)*

Tech Highlights was prepared by Zenghe Liu of TheraSense, Inc., and David Ingersoll and Mike Kelly of Sandia National Laboratories.