Formation of Self-Organized Anodic Oxide Nanotubes and Nanopores

Anodic aluminum oxide (AAO) is a well known hexagonally arranged nanoporous material. Anodization of Ti metal in aqueous fluoride solution produces similar morphology, whereas, anodization of Ti metal in the same solution tends to form nanotubular structures. Anodization of an alloy of these two metals (Ti-35Ta) in aqueous electrolyte solutions yields only nanotubular structures. Researchers from the University of Erlangen-Nuremberg investigating the self-organizing anodization of this alloy using an organic electrolyte solution, found that either nanotubular or nanoporous structures can form depending on the anodization conditions (e.g., water content and applied voltage). The authors report, for a 5 vol % water in NH4F-containing ethylene glycol solution, the expected trend of interpore distance increasing with increasing anodization voltage from 20 V to 40 V to 60 V. However, the pore diameter did not scale with voltage between the 40 V and 60 V conditions. At 20 V applied voltage, a transition from the nanopore structure to the nanotubular structure could be effected by increasing the water content to 10 and 15 vol %. Additional observations were made for a matrix of these anodization conditions. The authors speculate on possible mechanisms controlling the growth of these structures that have application as highly corrosion-resistant and sufficiently light biomedical implant materials.

Oxygen Permeation Properties of Nanocrystalline CeO2 Thin Films

The ability of nanocrystalline oxides to exhibit significant ionic and electronic conductivities has resulted in many studies aimed at exploring their use in electrochemical devices and components such as fuel cells, oxygen permeation membranes, and sensors. One of the key aspects of this ambipolar conductivity is the ability to separate oxygen from air using only the chemical potential gradient of oxygen as the driving force. A research team comprised of collaborators from Savannah River National Laboratory, Tohoku University, Massachusetts Institute of Technology, and the National Institute of Advanced Industrial Science and Technology in Japan recently reported results on the oxygen permeation characteristics of nanocrystalline ceria (CeO2) thin films. They prepared ceria samples by a combination of sol-gel and sputtering techniques, and characterized the films by x-ray diffraction and scanning electron microscopy. Oxygen flux measurements at intermediate temperatures showed a measurable flux (e.g., 0.014 µmol/cm²s at 800°C) that confirmed the mixed ionic and electronic structure. LEDs possessing MQB structures exhibited higher emission intensities and were less sensitive to changes in temperature, suggesting an inhibition of nonradiative carrier recombination and the enhancement of exciton localization effects. The researchers found that decreasing the indium content of the MQB structures lowered the diode “ideality factor” and increased the quantum efficiency. They attributed this observation to a decrease in interfacial carrier density and a lower number of interfacial states existing in the heterojunction, resulting in a reduction of carrier tunneling through the heterojunctions.


NMR Study of Nanoscale Ionic Materials

Nanoscale ionic materials (NIMs)—a new class of materials consisting of oligomeric chains densely grafted via ionic linkages onto an inorganic nanoparticle core—exhibit properties of interest for use in applications being developed to solve energy and water needs. Some useful properties include negligible vapor pressure and fluid-like behavior without the aid of a solvent. Expanding on other characterization studies, a team of researchers from King Abdullah University of Science and Technology and Cornell University performed a nuclear magnetic resonance (NMR) spectroscopy study of NIMs and their temperature performance. The researchers confirmed, using a temperature stability study, the presence of covalent bonding, rather than hydrogen bonding, between the SiO2 nanoparticle and the sulfonate group attached with a silane spacer. In the authors’ set of three materials, the corona consisted of either poly(ethylene glycol) (PEG) (9000 or 2000 Mw) or polystyrene (PS) (6500 Mw). They were able to distinguish the aromatic and aliphatic carbons and determine the relative concentrations. With this experience of using NMR to characterize the composition and structure of NIMs, the authors next plan to conduct diffusion experiments.


Modulating the Luminescence Characteristics of InGaN/GaIn Multiquantum-Barrier Heterosystems

InGaN/GaIn semiconductors efficiently emit light in wavelengths ranging from blue to ultraviolet, enabling light emitting diode (LED) use in full color displays and white LED lighting. However, carrier transport and radiative processes in InGaN structures are not well understood, and epitaxial InGaN heterosystems can feature defects, such as misfit dislocations, that can act as nonradiative recombination centers and decrease emission efficiency. To better understand carrier transport in InGaN/GaIn heterosystems, researchers from Taiwan studied the correlations between the optical properties and electrical characteristics of InGaN/GaIn multiple-quantum well LEDs at various temperatures. They report reduction and modulation of the charge leakage distribution over the light-emitting layer through modification of the multiquantum-barrier (MQB)