

Formation of Self-Organized Anodic Oxide Nanotubes and Nanopores

Anodic aluminum oxide (AAO) is a well known hexagonally arranged nanoporous material. Anodization of Ta 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 NH_4F -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.

From: *J. Electrochem. Soc.*, **157**, C409 (2010)

Oxygen Permeation Properties of Nanocrystalline CeO_2 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 (CeO_2) 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., $0.014 \mu\text{mol}/\text{cm}^2\text{s}$ at 800°C) that confirmed the mixed ionic and electronic

conductivities of nanocrystalline ceria and demonstrated the feasibility of using this material as an oxygen separation membrane. The authors also determined the relationship between oxygen flux and nanocrystalline grain size, thereby illustrating the possibility of using controllable materials properties in the design of oxygen separation membranes.

From: *J. Electrochem. Soc.*, **157**, B1852 (2010)

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 SiO_2 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.

From: *Electrochem. Solid-State Lett.*, **13**, K87 (2010)

Modulating the Luminescence Characteristics of InGaN/GaN Multiple-Quantum-Barrier Heterosystems

InGaN/GaN 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/GaN heterosystems, researchers from Taiwan studied the correlations between the optical properties and electrical characteristics of InGaN/GaN 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 multiple-quantum-barrier (MQB)

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.

From: *J. Electrochem. Soc.*, **157**, H1095 (2010)

Aminated Perfluorosulfonic Acid Ionomers to Improve the Triple Phase Boundary Region in Anion-Exchange Membrane Fuel Cells

Along with the widespread development of proton exchange membrane fuel cells, anion-exchange membrane fuel cells (AEMFCs) have recently gained renewed attention due to their advantages of faster oxygen reduction kinetics under alkaline conditions, and thus facilitating the use of less expensive, non-noble metal catalysts. The main obstacle in developing a viable AEMFC is the anion-exchange membrane (AEM). A group of researchers from Japan recently reported a new approach to make the AEM from the well known Nafion. The authors derivatized the perfluorosulfonic acid ionomer with molecules containing multiple amino groups. One of the amines was used to react with the sulfonic acid group and the resulting strong coulombic attraction immobilized the whole molecule to the polymer framework. The rest of the amine groups were used to form anion exchange sites. A membrane electrode assembly was fabricated using such aminated Nafion ionomers and catalyst layers. Electrochemical oxygen reduction was performed to evaluate the triple phase boundary regions in the catalyst layers. The results indicated better performance as the number of amino groups in the derivatization molecules increased.

From: *J. Electrochem. Soc.*, **157**, A1153 (2010)

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