Low-dimensional Nanomaterials: Synthesis and Application of Zero- and One-dimensional Nanomaterials

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Since the Nanomaterials Committee of the Electronic, Magnetic & Photonic Materials Division of TMS organized its first Nanomaterials Symposium at the TMS 2005 Annual Meeting, we have observed tremendous growth in the number of papers as well as the diversity in topics and participating academic disciplines. At the 2009 Nanomaterials Symposium, 115 papers were presented covering a broad spectrum of nanomaterials research. For this issue of *JOM*, the Nanomaterials Committee decided upon the theme “Low-dimensional Nanomaterials” to be consistent with all the sessions we enjoyed in the 2009 symposium. Presented here are four excellent papers describing synthesis/fabrication of zero- and one-dimensional nanomaterials as well as their applications to the areas of biomedical science/technology, electronic, optical, and magnetic devices, chemical/biological sensors, and energy harvesting.

Semiconductor nanowires are fascinating one-dimensional nanostructures, with potential applications to electronic and optical devices, thermoelectric devices, molecular-level sensing, energy storage, and solar energy harvesting. The first paper, “Silicon and Germanium Nanowires: Growth, Properties, and Integration” by S.T. Picraux, S.A. Dayeh, P. Manandhar, D.E. Perea, and S.G. Choi, presents an overview of the growth of semiconductor nanowires and their applications. The article describes the principle of the vapor-liquid-solid technique to grow pristine single-crystalline nanowires and its recent ad-

vancements including heterostructure formation, doping, and surface functionalization. An integration technique is presented in which nanowires are vertically grown in well-ordered patterns and are contacted with external electrodes at their top and bottom ends, an important step toward implementing nanowires for practical use.

Next, “Fabrications and Applications of Metal-Oxide Nanotubes” by M. Lee, T. Kim, C. Bae, H. Shin, and J. Kim presents an overview of various fabrication methods of metal-oxide nanotubes and many experimental studies for their applications. Three major fabrication approaches are described: atomic layer deposition (ALD), sol-gel process, and electrochemical synthesis. The ALD method, in particular, draws special attention due to its capability of producing uniform nanotube walls with accurate thickness control. Applications of metal-oxide nanotubes are described, including gas sensors, selective detection of protein molecules, air and water purification utilizing enhanced photocatalytic activities on the nanotubes, and solar energy harvesting.

The third paper, “TiO₂ Nanotube Structures for Enhanced Cell and Biological Functionality” by K.S. Brammer, S. Oh, C.J. Cobb, and S. Jin, presents fabrication of vertically aligned TiO₂ nanotubes and their applications to the biomedical area. The article describes the importance of the physical morphology of nanotubes on cell growth and functioning in the context of orthopedic/dental implantation and stem cell studies. The authors demonstrate that the vertically aligned TiO₂ nanotubes formed on the implant surface enhance the adhesion and mineralization of osteoblasts (bone cells),

thereby significantly accelerating bone healing and mechanical interlocking. They also demonstrate that stem cell differentiations can be controlled by their physical dimensions, affecting cell adhesion, morphology, and proliferation. The fact that the physical structure of nanomaterials can influence cell functioning opens up potential for biomedical applications of nanoscale materials.

Finally, “Ferromagnetic Nanoparticles: Synthesis, Processing, and Characterization” by J.P. Liu focuses on magnetic properties of nanoparticles, presenting novel techniques to synthesize single-domain ferromagnetic nanoparticles and characterization of their important magnetic properties. Ferromagnetic nanoparticles having single magnetic domains with diameters of ~10 nm or below have tremendous technical merit for applications such as ultra-high density magnetic recording, high performance permanent magnets, and biomedical technologies. Their new approaches, “salt-matrix annealing” and “surfactant-assisted milling,” have enabled the synthesis of such ferromagnetic nanoparticles, producing high magnetic coercivities at room temperature. These techniques have potential for large-scale production and also provide an experimental platform for studies of nanoscale magnetic materials.

The articles presented in this issue of *JOM* are a snapshot of many excellent contributions made to the Nanomaterials Symposium of TMS 2009.

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