JOM, Vol. 66, No. 1, 2014
DOI: 10.1007/s11837-013-0826-6

Characterization of Nanomaterials

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Nanomaterials have attracted attention because of their unique physical, chemical, and mechanical properties that differ from those of bulk solids and molecules. Nanomaterials exhibit distinct size-dependent properties in the 1–100 nm range where quantum phenomena are involved. That is, when the particle radius approaches the asymptotic exciton Bohr radius, the influence of quantum confinement becomes apparent. The very large surface area of nanomaterials is one of the reasons for their novel properties and the high surface-to-volume ratio results in high significant effects of surface properties on their structure. Intensive research is being done for the use of nanomaterials in many applications such as energy storage, energy conversion, solar cells, pharmaceuticals, life science applications, optoelectronics, sensing and actuation nanosystems, catalysis, and composite materials.

The techniques that can be used to characterize nanomaterials include electron microscopy, scanning probe microscopies especially, atomic force microscopy, x-ray diffraction, neutron diffraction, x-ray scattering, x-ray fluorescence spectrometry, acoustic wave technique, contact angle measurements, and various spectroscopies. The following articles describe the production and characterization of different types of nanomaterials, where the morphological, structural, and mechanical properties are determined and discussed.

In the article, “Boron-Doped Strontium-Stabilized Bismuth Cobalt Oxide Thermoelectric Nanocrystalline Ceramic Powders Synthesized via Electrospinning” by S. Koçyiğit et al. both boron-undoped and boron-doped thermoelectric strontium-stabilized bismuth cobalt oxide nanocrystalline ceramics are produced by an electrospinning technique. The powders are characterized by using x-ray diffraction, scanning electron microscopy, and physical properties measurement system techniques. The structural and thermoelectric properties of the produced powders are evaluated and the effects of boron doping on the thermoelectric capacity of materials are also determined.

In the next article, “Single- and Two-Layer Coatings of Metal Blends onto Carbon Steel: Mechanical, Wear, and Friction Characterizations” by B.S. Yilbas et al., single- and two-layer coatings of metal blends onto carbon steel are produced using a high-velocity oxyfuel (HVOF) deposition gun. The wear and friction resistance of super alloy powder coatings are investigated. The surface mechanical properties and the nanomechanical properties of single- and two-layer coatings are measured using the nanoindentation technique. The residual stresses formed on the surface of the coatings are measured using the x-ray diffraction technique. They found that the mechanical properties, friction, and wear resistance of the two-layer coating are similar to that of the single-layer coating.

The synthesis and characterization of new and novel nanomaterials with well-controlled structures, crystalline phases, shapes, sizes, and porosities are very important for breakthroughs in several technologies. The challenge for the so-called nanotechnologies is to achieve perfect control of nanoscale-related properties. This obviously requires correlating the parameters of the synthesis process with the resulting nanostructure. In the article, “Tuning the Properties of Nanocrystalline CdS Thin Films” by S.J. Ikhmayies, a review of the experimental methods for tuning the properties of nanocrystalline CdS thin films is performed. Nanocrystalline cadmium sulfide (CdS) thin films are of potential use in the technology of CdS/CdTe solar cells, photonics, detectors, and computing devices.

Nanomaterials can be used to improve or change the properties of some products, alloys, and composites. In the work, “Effects of Al_2O_3 Nanopowders on the Wear Behavior of NiTi Shape Memory Alloys” by Y. Şahin and K.E. Öksüz, the authors prepared TiNi shape memory alloy and its compos-

Shadia J. Ikhmayies is the guest editor for the Materials Characterization Committee of the TMS Extraction & Processing Division, and coordinator of the topic Characterization of Nanomaterials in this issue.

(Published online December 10, 2013)

ite using nanosized δ-Al_2O_3 particles by the powder metallurgy (PM) method. They investigated some mechanical properties like hardness, wear and corrosion behavior and found that the lower wear rate is obtained for the nano Al_2O_3 reinforced Ti alloy composite due to increased hardness. In the article, "Carbon Nanofiber-Reinforced Syntactic Foams: Compressive Properties and Strain Rate Sensitivity" by R.L. Poveda and N. Gupta, the possibility of reinforcing syntactic foams with carbon nanofibers (CNFs) is explored. The authors focused their study on the high-strain-rate (HSR) compressive behavior of CNF reinforced syntactic foams. In the work, "A Study of the Origin of Weak Ferromagnetism in $Zn_{1-x}Co_xO$" by Sh. U. Yuldashev et al., the origin of weak ferromagnetism in the $Zn_{0.97}Co_{0.03}O$ thin films is investigated using the temperature dependence of the thermal diffusivity and the magnetization. They ascribed the weak ferromagnetism in the $Zn_{0.97}Co_{0.03}O$ to the uncompensated magnetic moment at the surface of CoO nanoclusters. In the article, "Characterization of Silicon Nanoparticles Formed from a Fluidized Bed Reactor and Their Incorporation onto Metal-Coated Carbon Fibers" by M.B. Zbib et al., they worked to enhance light trapping and hence improved the photocurrent of silicon solar cells. They embedded amorphous and crystalline Si nanopowders in nickel-coated carbon fibers. The morphology of the Si particles and their interactions with the coatings is characterized by scanning and transmission electron microscopy techniques.

Surface treatments can be used to produce nanotextured surfaces of unique physical properties. In the article, "Laser Treatment of Sintered Silicon Carbide Surface for Enhanced Hydrophobicity" by B.S. Yilbas and B. Bhushan, sintered silicon carbide (SiC) surfaces are textured by laser treatment to enhance the surface hydrophobicity. Optical and scanning electron microscopy, energy dispersive spectroscopy, and x-ray diffraction are used to evaluate the morphological and metallurgical changes of the treated surfaces. It is found that the laser-treated surfaces consist of fine grooves and pillars with spacing that varies from tens of nanometers to hundreds of nanometers. The resulting surface roughness enhanced the surface hydrophobicity.