3D Nanostructured Materials and Devices

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1. Introduction

Advances in nanofabrication technology have allowed us to create high-level nanostructured materials that were previously unattainable. In particular, new or superphysical properties emerging from well-controlled nanostructures have attracted the attention of many researchers working on advanced materials and next-generation devices. This Special Issue aims to introduce recent studies related to the synthesis/processing of nanostructured materials for diverse applications. Research or review articles published in this Special Issue can be broadly divided into three categories according to their field of focus: (i) fabrication of nanostructured materials, (ii) physical properties of nanostructured materials, and (iii) application of nanostructured materials to devices.

2. Fabrication of Nanostructured Materials

Ahn et al. provide a comprehensive review of advanced process techniques specialized for manufacturing three-dimensional (3D) ordered nanostructures that can be used as novel electrodes for a variety of electrochemical or energy-related devices [1]. This review article focuses on introducing a strategy to realize 3D nanostructured inorganic or organic/inorganic composites by combining an optical 3D nanofabrication technique called proximity-field nanopatterning (PnP) with traditional electroplating. Successful applications of 3D nanostructured materials developed to improve the performance of electrochemical or energy-related devices are also presented.

Lee et al. study the mechanical stability of micro/nanostructured membranes widely used as deposition/etch masks or microfluidic filters [2]. Through theoretical and experimental approaches, they systematically extract and present design rules for improving the mechanical stability of polymer membranes with two-level aperture structures.

3. Physical Properties of Nanostructured Materials

Liu et al. conduct a fundamental study comparing the physical properties of perovskite-type $\text{La}_{0.8}\text{Ca}_{0.2}\text{CrO}_3$ nanopowders prepared by two different synthetic methods [3]. The correlation between the synthesis method and the sintering temperature and electrical/thermal properties of the synthesized material is investigated in depth through various material analysis techniques.

Wen et al. theoretically investigate the extraordinary optical properties resulting from periodic arrays of hoof-shaped subwavelength structures [4]. In particular, the effect of structural parameters and polarization of incident light on enhanced optical transmission (EOT) is systematically analyzed through numerical simulations. Based on this understanding, a concept of a multifunctional optical device operating in the infrared wavelength region is also proposed.

Roh et al. study the electrical and optical properties of transparent conductive films made from RuO_2 nanosheet synthesized by chemical exfoliation [5]. They reveal that the sheet resistance and optical transmittance of the developed transparent conductive film are simultaneously improved by simple UV-ozone treatment.

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4. Application of Nanostructured Materials to Devices

Saber et al. propose heterogeneous composite materials with nanolayered structures that can be applied to energy storage systems [6]. The structure and properties of Ti/Ni-based layered double hydroxides (LDHs) are optimized by controlling the process variables during the synthesis step. The developed LDHs are integrated in three-electrode half-cell assemblies, and their electrochemical performance as supercapacitors are systematically evaluated.

Chae et al. explore a way to improve the thickness uniformity of silver nanowire-embedded polymer films that can be used as flexible transparent electrodes in optoelectronic devices [7]. The correlation between the viscosity of the UV-curable prepolymer, the rotation speed of the spin-coating, and the thickness uniformity of the film is experimentally analyzed. The silver nanowire-embedded polymer film prepared under optimized conditions is successfully integrated into an organic photovoltaic device based on PTB7:PC₇₁BM.

5. Summary and Outlook

This Special Issue focuses on some of the latest research on nanostructured materials that are closely related to advances in material properties and device performance. The introduced studies prove that the fundamental performance of materials and devices can be efficiently improved through the advancement of the technology for synthesizing/processing nanostructures. In the future, nanofabrication technology is expected to develop in the direction of further improving the 3D structuring capability. If process technology related to 3D nanostructured materials is further developed in a direction that meets industrial purposes, it will be possible to provide a clue to break through the performance limits of existing materials and devices that are currently being used.

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