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Structure and Optical Properties of CeO_2 Nanoparticles Synthesized by Precipitation

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Cerium dioxide (CeO_2) has special electrical and optical properties, and chemical and thermal stability. It has been used in semiconductor devices and as a luminescent material. In this work, CeO_2 nanoparticles were synthesized by the precipitation method and the product annealed at various temperatures. Thermogravimetric analysis (TGA)/differential scanning calorimetry (DSC) results show that the optimum annealing temperature for fabrication of CeO_2 nanoparticles is greater than 500°C. When the calcination temperature is increased from 550°C to 1050°C, Fourier-transform infrared (FTIR) results show that the water and impurities are almost completely removed, after calcination at 750°C. The x-ray diffraction (XRD) results suggest that the synthesized CeO_2 exhibits a cubic fluorite structure. The crystallite size of the CeO_2 increases from 8 nm to 75 nm when the calcination temperature is increased from 550°C to 1050°C. The absorption spectrum in the ultraviolet (UV) region from 372 nm to 395 nm demonstrates their applicability as UV-filter materials, and the shift of the estimated $E_{g,eff}$ from 3.21 eV to 3.65 eV demonstrates their applicability in photoelectric devices. CeO_2 would be potentially important for applications such as insulator structures, stable capacitor devices, and light-emitting diodes (LEDs).

Key words: CeO_2, optical properties, precipitation method, nanoparticles

INTRODUCTION

Cerium dioxide (CeO_2) is one of the most important rare-earth oxides. It demonstrates high oxygen storage capability, high oxygen ionic conductivity, and strong absorption of ultraviolet radiation.[1,2] In recent years, CeO_2 has been extensively developed and applied in many fields, such as its use for solid-state electrolytes in fuel cells, in abrasives for chemical–mechanical planarization, as an automotive exhaust catalyst, and in gas sensors and ultraviolet (UV)-shielding materials.[3–7] CeO_2 has also been used as a gate oxide in metal–oxide–semiconductor devices,[8,9] as a luminescent material,[10,11] and as a phosphor material including both hosts and activators.[12] However, the performance of CeO_2 in these applications is restricted by the problems of surface area, morphology, and crystalline quality, which are determined by the structure of the material.[13] It is known that nanoscale particles have specific physical and chemical properties, which are significantly different from those of bulk materials. Several methods have been employed for preparation of CeO_2 nanostructures, such as combustion processing, solid-state reaction, mechanical–chemical processing, and solvothermal, sol–gel, hydrothermal, and precipitation techniques.[14–21] These processes each have unique advantages for growth of CeO_2 nanostructures, such as small particle size, high purity, and chemical homogeneity. There are also disadvantages, such as high operating temperatures and pressures, high cost, and damage to the environment. This study uses the precipitation method to synthesize CeO_2 nanostructures, because of its relatively low cost, good

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