Chemical Engineering Journal 215–216 (2013) 151–156

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

Structure and optical properties of Bi_2S_3 and Bi_2O_3 nanostructures synthesized via thermal evaporation and thermal oxidation routes

Hyunsu Kim [a], Changhyun Jin [a], Sunghoon Park [a], Wan In Lee [b], In-Joo Chin [c], Chongmu Lee [a,*]

[a] Department of Materials Science and Engineering, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon 402-751, Republic of Korea
[b] Department of Chemistry, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon 402-751, Republic of Korea
[c] Department of Polymer Science and Engineering, Inha University, 253 Yonghyun-dong, Nam-gu, Incheon 402-751, Republic of Korea

HIGHLIGHTS

- ▶ Bi_2S_3 nanorods were synthesized by thermal evaporation.
- ▶ Bi_2O_3 nanostructures were synthesized by thermal oxidation of the Bi_2S_3 nanorods.
- ▶ The structural evolution of the two nanomaterials was examined.
- ▶ The luminescence properties of the two nanomaterials were examined.
- ▶ The origins of the emissions are also discussed.

ARTICLE INFO

Article history:
Received 18 August 2012
Received in revised form 4 October 2012
Accepted 16 October 2012
Available online 10 November 2012

Keywords:
Bi_2S_3 nanorods
Bi_2O_3 nanostructures
Thermal evaporation
Thermal oxidation
Photoluminescence

ABSTRACT

Bi_2S_3 nanorods with diameters of a few tens of nanometers and lengths of a few to a few tens of micrometers were synthesized by thermal evaporation. Subsequently, Bi_2O_3 nanostructures were synthesized by thermal oxidation of the Bi_2S_3 nanorods. The structural evolution of the two nanomaterials and their luminescence properties were examined by scanning electron microscopy, transmission electron microscopy, X-ray diffraction, energy-dispersive X-ray spectrometry, and photoluminescence (PL) spectroscopy. The PL measurements revealed the as-synthesized Bi_2S_3 nanorods to have an emission band centered at ~595 nm. The Bi_2O_3 nanorods synthesized by the thermal oxidation of Bi_2S_3 nanorods for 1 h showed an emission band centered at ~440 nm, which is in the bluish violet region. In contrast, the Bi_2O_3 nanostructures synthesized by thermal oxidation of Bi_2S_3 nanorods for 2 or 3 h showed an emission band centered at ~505 nm, in the bluish green region, and a shoulder at ~380 nm. The origins of the emissions are also discussed.

1. Introduction

Bismuth sulfide (Bi_2S_3) is a semiconducting material with a direct bandgap in the range 1.3–1.7 eV with many potential applications including photovoltaics [1], thermoelectrics [2], X-ray computed tomography [3], and electrochemical hydrogen storage[4,5]. Over the past decade, many studies on one-dimensional (1D) Bi_2S_3 nanostructures have been reported. A range of 1D Bi_2S_3 nanostructures such as nanorods [6–10], nanowires [11–13], nanoribbons [14,15], nanocables [16,17], and nanotubes [18,19] have been synthesized using various methods: Ye et al. synthesized Bi_2S_3 nanotubes using an evaporation technique [20]; Liu et al. synthesized Bi_2S_3 nanowires using a simple inorganic-surfactant-assisted solvothermal process [21]; Flower-like shapes, snow flake-like structures, and nanowires have been synthesized via a biomolecule-assisted route [4,22]; Zhang et al. adopted a thioglycolic acid-assisted hydrothermal technique for the synthesis of flower-like Bi_2S_3 nanostructures [23]; 1D Bi_2S_3 nanostructures were also synthesized using an anodic alumina membrane template [18].

On the other hand, bismuth oxide (Bi_2O_3) has been the focus of scientific research owing to its unique chemical and physical properties such as high-energy bandgap (2.85 and 2.58 eV for monoclinic and tetragonal Bi_2O_3 phases, respectively), high refractive index, high dielectric permittivity, and excellent photoconductivity [18,24,25]. These versatile properties make Bi_2O_3 an attractive candidate material for optical coatings, microelectronics, ceramic glasses, and gas sensors [26–30]. They are also used in the soft oxidation of hydrocarbons and are good electrolyte materials for applications such as solid oxide fuel cells [31,32]. 1D nanostructures of Bi_2O_3 have been synthesized using a range of techniques

* Corresponding author. Tel.: +82 32 860 7536; fax: +82 32 862 5546.
E-mail address: cmlee@inha.ac.kr (C. Lee).

1385-8947/$ - see front matter
http://dx.doi.org/10.1016/j.cej.2012.10.102