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Original Research Paper

Nanocrystalline copper doped zinc oxide produced from copper doped zinc hydroxide nitrate as a layered precursor

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ABSTRACT

Undoped and copper doped nanostructured zinc oxides were synthesized by using a series of synthetic layered material, undoped and copper doped zinc hydroxide nitrates at various molar percentages of copper (2–10) within the layers as precursors. The layered materials were heat-treated at 500 °C to produce zinc oxide nanostructures with crystallite sizes in the range of 23–35 nm. Optical studies of the nanostructured copper doped zinc oxides showed the decrease in band gap with increasing content of the doping agent, copper.

1. Introduction

Zinc oxide as an important metal oxide has been extensively studied. Since it has been used in various products such as solar cells, sensors, photocatalysts and different electrical devices due to its semi-conductive property with a wide band gap, 3.37 ev [1–6]. Furthermore, antibacterial property has also been observed for the material [7]. Moreover, zinc oxide with the excellent properties is rather cheap compared to other electrical ceramic oxides such as ITO with high costs of indium and tin. Zinc oxide has been doped with other elements to enhance or modify its properties. For instance, for higher photo catalytic efficiency, ZnO should absorb both visible and UV lights, while the bare ZnO only absorbs the latter. Aluminum doped zinc oxide shows improved solar cell characteristics [8]. Other optical, electrical and catalytic properties of the material can be tailor-made by introducing the relevant doping agents [9–12]. Manganese doped zinc oxide shows the enhanced antibacterial activity in comparison with that of the undoped ZnO [7]. Many methods have been used to produce doped zinc oxide materials such as, sol–gel, co-precipitation, chemical vapor deposition, magnetron sputtering and thermal decomposition route, etc. But, doped zinc layered materials have not been used as a precursors to produce doped zinc oxide in our knowledge. These layered materials are produced very simply. The chemicals used in the synthesis are cheap and they are not poisonous. The method can be used to produce the large scale nanostructure products with no expensive instruments.

Zinc hydroxide nitrate is an anionic layered material with brucite-like structure, in which layers are formed in the monoclinic lattice with its composition – $Zn_5(OH)_8(NO_3)_2{\cdot}2H_2O$ (Card 24-1460) [13,14]. Thermal decomposition of zinc hydroxide nitrate at moderate temperatures produces nanocrystalline zinc oxide [13]. Therefore, by introducing copper ions within the layers of zinc hydroxide nitrate and collapsing the doped layered material, nanocrystalline copper doped zinc oxide can be obtained.

This paper reports the results obtained in the synthesis and characterization of the undoped and copper doped zinc hydroxide nitrate material, thermal decomposition of the as-prepared materials and characterization of the resulting nanostructured materials, undoped and copper doped zinc oxide. Results from powder X-ray diffraction (PXRD), fourier transform infrared (FTIR), scanning electron microscopy (SEM) and also optical measurement studies are discussed.

2. Experimental

All chemicals were used as received and all solutions were prepared using distilled de-ionized water. Zinc hydroxide nitrate (ZHN) and copper doped zinc hydroxide nitrates (CZHNs) were prepared according to our previous works [13,14], by the precipitation method of aqueous solutions of $Zn(NO_3)_2$ and $Cu(NO_3)_2$.

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