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Structural and phase dependent thermo and photoluminescent properties of $Dy(OH)_3$ and Dy_2O_3 nanorods

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ABSTRACT

Hexagonal $Dy(OH)_3$ and cubic Dy_2O_3 nanorods were prepared by hydrothermal method. $Dy(OH)_3$ nanorods was directly obtained at 180 °C for 20 h after hydrothermal treatment whereas subsequently heat treatment at 750 °C for 2 h gives pure cubic Dy_2O_3. SEM micrographs reveal that needle shaped rods with different sizes were observed in both the phases. TEM results also confirm this. The TL response of hexagonal $Dy(OH)_3$ and cubic Dy_2O_3 nanorods have been analyzed for γ-irradiation over a wide range of exposures (1–5 kGy). TL glow peak intensity increases with γ dose in both the phases. The activation energy (E), order of kinetics (b), and frequency factor (s) for both the phases have been determined using Chen's peak shape method. The simple glow curve shape, structure and linear response to γ-irradiation over a large span of exposures makes the cubic Dy_2O_3 as a useful dosimetric material to estimate high exposures of γ-rays.

1. Introduction

Inorganic luminescent nanomaterials have stimulated great interest because the morphology and size of materials have great effect on their physical and chemical properties as well as for their application in optoelectronic devices [1–4]. Most of these properties strongly depend on the compositions and structures, which are sensitive to the bonding of rare earth atoms or ions. Among all the nanomaterials, rare earth oxides have been widely used in the field of high performance luminescent devices and other functional materials based on their electronic, optical characteristics arising from 4f electrons [5]. Lanthanide oxide (Ln_2O_3) compounds have been synthesized with different methods such as hydrothermal or solvothermal [6,7], sol–gel [8,9], combustion [10], chemical oxidation method [11] and other methods.

Among lanthanide oxide compounds, Dy_2O_3 is highly insoluble and thermally stable, suitable for glass, optical and ceramic applications [12]. It can also be used in laser based devices, magneto-optical recording materials with a large magnetostriction, and measurement of neutron energy-spectrum, nuclear reaction control rods, neutron absorbents, glass additives and rare earth permanent magnet materials [13]. It is know that a high concentration of surface atoms and defects at multiple nano grain boundaries may be regarded as one of the fundamental properties of nanophosphors. They create surface charge carrier trapping center, which are analogous to bulk centers, but have a different energy depth. Thermoluminescence (TL) is a highly sensitive technique for the detection of surface/deeper/defects traps in insulator of semiconductor materials which is heated after being irradiated with ionizing radiations such as X-ray, γ-ray, β-ray or heavy ions [14–16]. The irradiated solid sample emits thermally stimulated luminescence in the form of glow peaks.

Recently, luminescent nanomaterials have showed potential application in dosimetry of ionizing radiations for the measurement of high doses using TL technique, where the conventional microcrystalline phosphors saturate [17]. This saturation occurs due to the ionized zones overlapping each other in the bulk material at higher doses. However, with the use of macro particles, this problem overcomes to a major extent. The luminescence yield may be expected to increase at higher doses since in a phosphor electron–hole pairs are formed inside the nanoparticles and are

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