Superlattices and Microstructures 78 (2015) 116–124

Contents lists available at ScienceDirect

Superlattices and Microstructures

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

High temperature solid state synthesis and photoluminescence behavior of Eu^{3+} doped $GdAlO_3$ nanophosphor

Kanchan Upadhyay [a], Raunak Kumar Tamrakar [b,*], Vikas Dubey [c]

[a] Department of Chemistry, Shri Shankaracharya School, Hudco, C.G., India
[b] Department of Applied Physics, Bhilai Institute of Technology (Seth Balkrishan Memorial), Near Bhilai House, Durg, C.G. 491001, India
[c] Department of Applied Physics, Bhilai Institute of Technology (Seth Balkrishan Memorial), Raipur, India

ARTICLE INFO

Article history:
Received 7 November 2014
Accepted 26 November 2014
Available online 4 December 2014

Keywords:
$GdAlO_3:Eu^{3+}$
XRD
TEM
Solid state synthesis
Photoluminescence
CIE
Phosphor

ABSTRACT

Gadolinium monoaluminate is successfully synthesized by the high solid state reaction method. The method is suitable for large scale production. The high temperature synthesis techniques have some advantages to enhance the efficiency of luminescence. Samples were prepared with variable concentration of europium (0.5–6 mol%) all the prepared sample were characterized by X-ray diffraction technique (XRD) and transmission electron microscopic (TEM) technique. The particle size was evaluated by Scherer's formula and found around 55.16 nm and having orthorhombic phase. The surface morphology of prepared phosphor was determined by TEM and it shows good connectivity with grain and formation of nano sized crystal. The photoluminescence with variable concentration of europium shows very good excitation and emission spectra. The excitation spectra monitored at 612 nm excitation and excitation found with broad peaks at 266 nm with shoulder peak at 274 nm. The emission spectra monitored at 266 nm and it shows all peaks in visible region (583, 594, 599, 613 and 630 nm) with intense peak at 613 nm (red emission). The intensity of PL spectra increases with increasing the concentration of europium, up to 5 mol% after this concentration intensity decreases due to concentration quenching occurs. The spectrophotometric determination was determined by Commission Internationale de I'Eclairage (CIE) technique.

* Corresponding author. Tel.: +91 9827850113.
E-mail addresses: raunak.ruby@gmail.com, raunak.physics@gmail.com (R.K. Tamrakar).

http://dx.doi.org/10.1016/j.spmi.2014.11.030
0749-6036/

1. Introduction

During the last few decades, rare-earth-activated phosphors have led to a revolution in lighting industry. Now in the present day high efficient phosphor with higher lifetime as well as eco friendly qualities are basic requirement for environment. Therefore mercury free phosphors with high efficacy under excitation with ultraviolet radiation and excellent physical and chemical stability were foremost requirements for good lamp phosphors with better future environment [1]. Gadolinium based materials are having remarkable application in different fields of the biological, medical and optical applications [2–6]. $GdAlO_3$ is an ortho-aluminate crystal. It is a hard crystal of high density, which shows fast luminescence behavior under excitations [7]. The rare-earth aluminates RAlO3 are a potential class of host material for rare earth ions to give light emission [8–11].

It is well known that rare-earth-ion-doped, activated phosphors have attracted considerable research interest due to their excellent luminescent properties. Because the 4f electrons of rare-earth ions are shielded by outer $5s^2$ and $5p^6$ electrons, the intra 4f–4f emission spectra of rare-earth ions are characterized by narrow lines with high color purity [12,13]. Due to, the remarkable narrow-band emission properties of Eu^{3+}, Tb^{3+}, Dy^{3+} and Tm^{3+} ions have been utilized to the maximum extent in the development of efficient phosphors for lamps, plasma display panels and also for light-emitting diodes [14]. All of these, it is well known that Eu^{3+} is an excellent candidate to produce red color LED's. Eu^{3+} must be doped into a lattice to emit luminescence upon excitation. Eu^{3+}-doped phosphor are very interesting materials for luminescence applications due to its red emission [15–20].

In the present work, $GdAlO_3$:Eu^{3+}-doped phosphors were prepared via a solid-state-reaction method to examine the potential for their utility as luminescence phosphors with different color emission at each exciting wavelength.

2. Experimental methods

2.1. Synthesis of Eu^{3+} doped $GdAlO_3$ phosphors

The Eu^{3+} doped $GdAlO_3$ phosphors with different concentration of doping (0.5, 1, 2, 3, 4, 5 and 6 mol%) were prepared via high temperature modified solid state reaction method. Gadolinium nitrate [$Gd(NO_3)_3$], aluminum nitrate [$Al(NO_3)_3$], europium nitrite [$Eu(NO_3)_3$], purchased from Sigma–Aldrich and boric acid used as flux were taken as starting raw materials in stoichiometric amount. After being ground thoroughly by using an agate, mortar-pestle by dry grinding for near about 45 min, to ensure the best homogeneity and reactivity, powder was put in alumina crucible, and heated in a muffle furnace at 1000 °C for 2 h [4].

2.2. Instrumentation details

The samples were characterized at the Inter University Consortium (IUC) Indore for X-ray diffraction. X-ray diffraction was used for phase identification and crystallite size calculation. XRD data were collected over the range 20–70° at room temperature. The XRD measurements were carried out using a Bruker D8 Advance X-ray diffractometer. The X-rays were produced using a sealed tube, and the wavelength of the X-ray was 0.154 nm (Cu K-α). The X-rays were detected using a fast counting detector based on silicon strip technology (Bruker Lynx Eye detector). Molecular structure was determined by FTIR analysis done by Nicolet Instruments Corporation USA MAGNA-550. The surface morphology of the prepared phosphor was determined by field emission scanning electron microscopy (FESEM) JSM-7600F. Particle diameter and surface morphology of prepared phosphor determined by Transmission Electron Microscopy (TEM) using Philips CM-200. The excitation and emission spectra were recorded using RF5301 spectrophotofluorometer.