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ScienceDirect
Physica B 403 (2008) 619–623
PHYSICA B
www.elsevier.com/locate/physb

Emission analysis of Eu^{3+}:$MgLaLiSi_2O_7$ powder phosphor

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Received 16 May 2007; received in revised form 31 August 2007; accepted 6 September 2007

Abstract

Newly synthesized reference $MgLaLiSi_2O_7$ and red luminescent Eu^{3+}:$MgLaLiSi_2O_7$ powder phosphors have been successfully developed by a solid-state reaction method to analyze their emission and structural properties from the measurement of their XRD, SEM, FTIR and PL spectra. Emission spectra of Eu^{3+} powder phosphors have shown strong red emissions at 613 nm ($^5D_0 \rightarrow {}^7F_2$). These phosphors have also shown bright red emissions under a UV source. Based on the red emission performance, the Eu^{3+} concentration has been optimized to be at 0.3 mol%.

PACS: 71.20.Ps; 78.55.Hx

Keywords: $MgLaLiSi_2O_7$; Solid-state reaction; PL spectra

1. Introduction

In recent times, luminescent phosphors have gained abundant interest in their production for their potential applications in the development of different luminescent display systems [1–6]. Phosphors, based on particularly silicates, aluminates, germinates and other related oxides are of more interest nowadays. Among these phosphors, silicates are most efficient due to water resistance, stable crystal structure over the other oxide-based phosphors [7–11]. In our present work, we have synthesized the novel phosphor material based on magnesium lanthanum lithium silicate ($MgLaLiSi_2O_7$) (abbreviated as an MLLS phosphor) developed by means of a solid-state reaction method and it belongs to an orthorhombic structure. Here, our interest is to examine the emission efficiency of a rare earth ion namely Eu^{3+} doped in this MLLS host matrix. Further, La^{3+} ion in the host matrix provides compatibility for the dopant Eu^{3+} ion, due to possessing nearly the same ionic radii values for substitution [12]. In this paper, we report on the structural and luminescence spectral results of both undoped (MLLS) and doped (Eu^{3+}:MLLS) phosphors from the measurement of their X-ray diffraction (XRD), scaning electron microscope (SEM) and emission spectra.

2. Experimental

Powder phosphor samples of undoped (host) $MgLaLiSi_2O_7$ (MLLS) and red luminescent $MgLa_{(1-x)}Eu_xLiSi_2O_7$ (Eu^{3+}:MLLS) ($x = 0.05$, 0.1, 0.3, 0.5) were prepared by using a conventional solid-state reaction method by taking stoichometric amounts of high-purity (99.99%) grade MgO (S.d.fine Chem. Pvt. Ltd.), La_2O_3 (Sigma-Aldrich), Li_2CO_3 (S.d.fine Chem. Pvt. Ltd.), SiO_2 (S.d.fine Chem. Pvt. Ltd.) and Eu_2O_3 (Sigma-Aldrich) chemicals. A small amount of acetone was added in order to ensure homogeneity in the materials synthesized. The starting materials were mixed homogeneously by an agate mortar for 2 h. The chemical mix was then transformed into silica crucibles suitably and then sintered this chemical mix for 4 h in a muffle furnace at 1100 °C.

XRD patterns of MLLS and Eu^{3+}:MLLS were recorded on a Seifert-3000 X-ray diffractometer with Cu $K_\alpha =$ 1.5406 Å, which was operated at 40 KV voltage and 50 mA anode current. Data were collected in the 2θ values from 10° to 80° in each case at the rate of $0.05° s^{-1}$.

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0921-4526/$ - see front matter
doi:10.1016/j.physb.2007.09.073

The morphology and size of the 0.3% Eu^{3+}:MLLS sintered particles were examined by means of SEM model Philips XL30 ESEM. Gold coating was sprayed on the sample surfaces by using JEOL fine coat ion sputter *FC-1100* unit for avoiding possible charging of specimens before SEM observation was made each time. The FTIR spectra of MLLS and Eu^{3+}:MLLS were recorded on a Thermo Nicolet-5700 spectrophotometer by using a KBr pellet technique in the wavenumber range from 4000 to 400 cm^{-1}. The photoluminescence (PL) spectra of MLLS and Eu^{3+}:MLLS phosphor were recorded on a YVON Fluorolog-3 Fluorimeter with a Xe-arc lamp of power 450 W as an excitation source for a steady-state emission spectrum measurement on this system and the lifetime of the bright and prominent red emission was measured with a phosphorimeter attachment to the main system which is a computer controlled with a Xe-flash lamp (25 W power). All the above measurements were carried out at room temperature.

Fig. 1. Red luminescent (0.3 mol%) Eu^{3+}:MLLS phosphor under a UV source.

3. Results and discussion

Eu^{3+} (0.3 mol%):MLLS phosphor has shown bright red emission from its surface under a UV-source as shown in Fig. 1. XRD profiles of the host matrix and Eu^{3+}:MLLS phosphors are shown in Fig. 2 which confirm their orthorhombic structures. Even after the substitution of La^{3+} ion by Eu^{3+} ion, the matrix crystalline structure does not get affected. However, with an increase of Eu^{3+} content in the host matrix, the intensities of the XRD peaks have significantly been reduced, as we see it in Fig. 2. Values of unit cells (*a*, *b*, and *c*) concerning these phosphors have been computed and the results are presented in Table 1. From Fig. 2, we notice that all the diffraction peaks are found to be slightly shifted towards higher angle side with an increase of Eu^{3+} concentration in the host matrix.

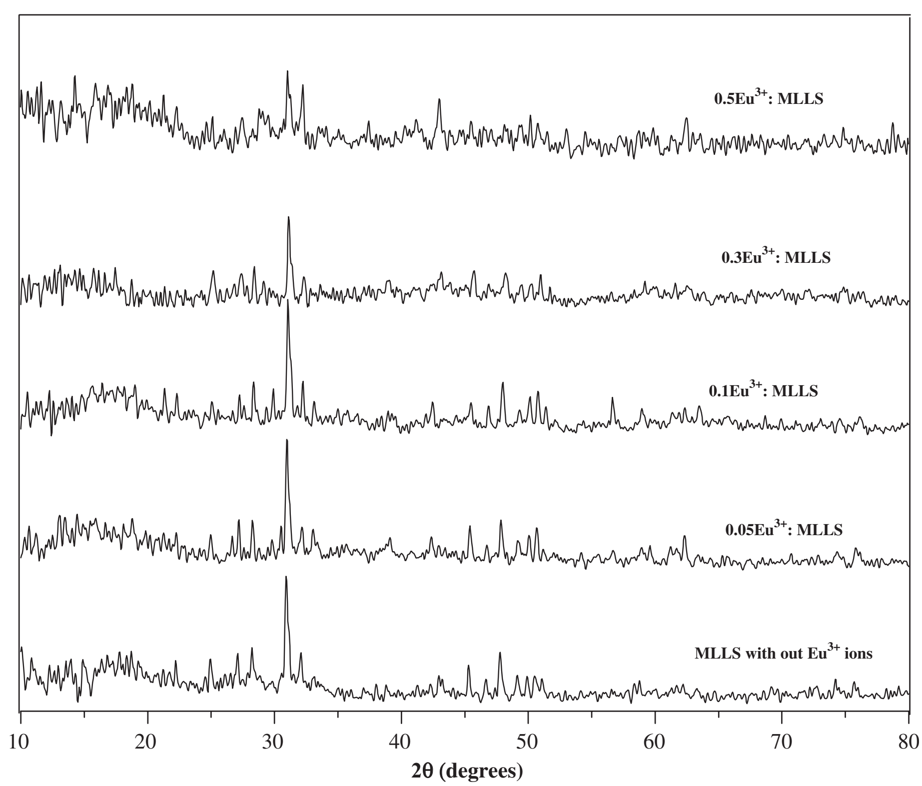

Fig. 2. XRD patterns of the host MLLS and Eu^{3+}:MLLS phosphors.