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Optical Properties of the (Y,Gd)BO_3:Eu^{3+} Phosphor Coated with SiO_2 Nano Particles

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In order to improve the luminance of red emission of the (Y,Gd)BO_3:Eu^{3+} phosphors were coated with SiO_2 nano particles. It was revealed that the surface coating of phosphors with SiO_2 leads to an increase in luminance intensity. This seems to be due to the increase of the excitation light which is transmitted into the phosphor, i.e., an effective vacuum ultraviolet absorption of the phosphor via SiO_2 nano particles. The experimental results suggest that the surface coating of phosphors with SiO_2 nano particles is a way to improve the luminance.

Keywords: phosphor; SiO_2 nano particles; surface coating

INTRODUCTION

There have been various intensive efforts to improve the poor characteristics of the luminance and the life time of the phosphors, in particular, the blue $BaMgAl_{10}O_{17}$:Eu^{2+} (BAM) phosphor [1–4]. To avoid phosphor degradation, coating the phosphor surface with MgO has been introduced [5]. For the purpose of both increasing luminance and preventing the degradation of phosphors, several studies regarding surface treatment have been done. ZnO:Zn and Y_2SiO_5:Ce phosphors coated with SiO_2, which have been developed for the vacuum fluorescent display and the field emission display, respectively, are in this scheme [6,7].

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In this work, we investigated the effects of the SiO_2 coating on the optical properties of the (Y,Gd)BO_3:Eu^{3+} phosphor and its application for a gas discharge device such as the flat fluorescent lamp (FFL) for LCD backlights.

EXPERIMENTAL

In this study, the commercial Red (Y,Gd)BO_3:Eu^{3+} phosphor (KASEI OPTONIX, LTD.) was coated with the SiO_2 by a sol-gel method. The SiO_2 coating of the phosphor was simply performed by using colloidal silica (LUDOX-AM-30 Sigma-Aldrich Chemical Co.) as the precursor material [4]. 6 g of (Y,Gd)BO_3:Eu^{3+} phosphor powder was stirred in 400 mL of LUDOX-AM-30 was added to the stirred (Y,Gd)BO_3:Eu^{3+} phosphor suspension and then it was stirred for 140 minutes. After washing for 3 times in ethanol and drying, silica-coated (Y,Gd) BO_3:Eu^{3+} phosphor was obtained. The comparison of material properties between the un-coated and SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphor was done by using scanning electron microscopy [(SEM), HITACHI S-4200], energy dispersive spectroscopy [(EDS), HITACHI S-4200], and photoluminescence spectroscopy [(PL), EG&GPARC 1420 PDA].

In order to compare the electro-optical properties of the coated-(Y,Gd)BO_3:Eu^{3+} phosphor with the un-coated one under the same drive conditions, we fabricated a test panel in which the two types of phosphors were prepared by a screen-printing technology. The screen-printed phosphor films were dried at 350°C for 10 min, and the fired at 450°C for 30 min in order to remove the organic solvents from the phosphors. In the experiment, Xe gas 20 Torr pressure for the surface discharge was included in the test panel. A square driving pulse with a voltage of 450 V, a frequency of 40 kHz and a duty rate of 25% were applied to the test panel. All measurements were performed at the room temperature.

RESULTS AND DISCUSSION

The SEM images of the un-coated and the SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphor are shown in Figure 1. A spherical surface of the pure (Y,Gd)BO_3:Eu^{3+} phosphor can be clearly seen. Nano-sized particles coated on the spherical surface are also seen. Nevertheless, we wonder that the nano particles on the phosphor are SiO_2 particles or not. We tried to make this evident by help of EDS. The EDS image of the un-coated and the SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphors are

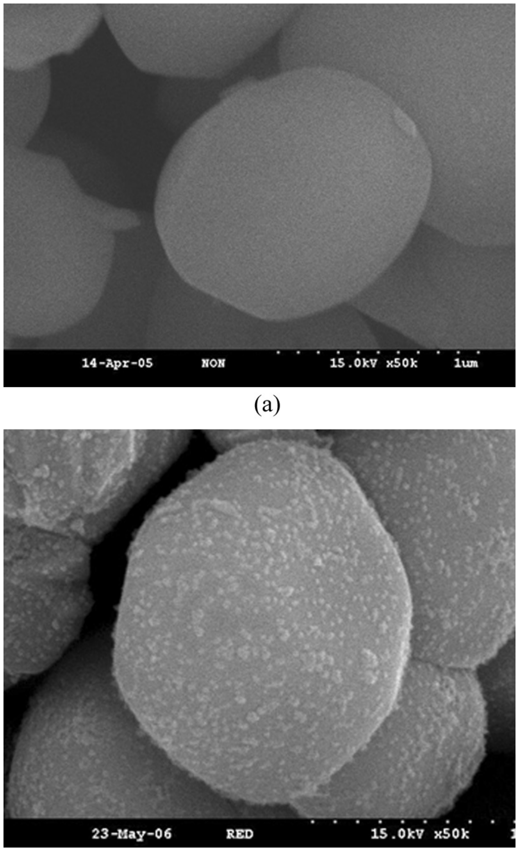
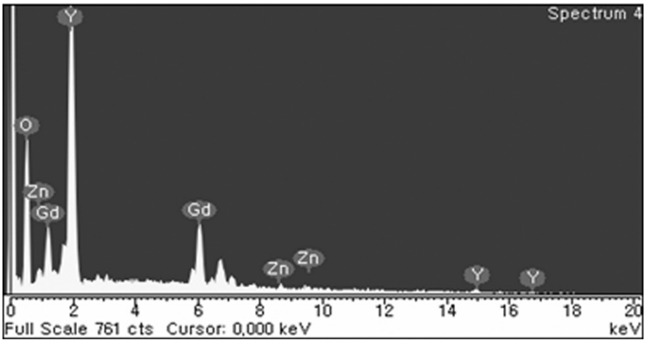


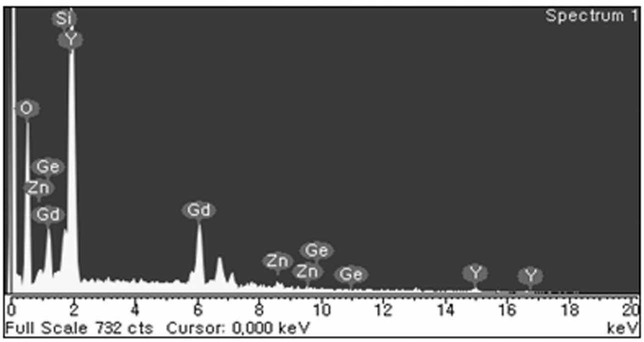
FIGURE 1 SEM images of (Y,Gd)BO_3:Eu^{3+} phosphors (a) un-coated and (b) SiO_2-coated.

compared in Figure 2. We can confirm, from the Si peak appeared at the SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphors, that the particles as seen in Figure 1 are composed of SiO_2.

PL spectra of the SiO_2-coated and un-coated (Y,Gd)BO_3:Eu^{3+} phosphors, excited by ultraviolet (UV) with a wavelength of 254 nm, are shown Figure 3. The PL spectra reveal that both phosphors show sharp red emission with 3 peaks centered at 592 nm, 610 nm, and 625 nm. This is due to the 4f-4f transition of Eu^{3+}. It is of interest that the SiO_2 coating provides an increase in the peak intensity. The reduction of the reflectivity of the excitation UV light from the surface



(a)



(b)

FIGURE 2 EDS image of $(Y,Gd)BO_3:Eu^{3+}$ phosphors (a) un-coated and (b) SiO_2-coated.

of the $(Y,Gd)BO_3:Eu^{3+}$ phosphor due to the SiO_2 coating, may be a reason for this [4].

Figure 4, the luminance of the test panels is plotted as a function of the driving voltages. The luminance values, in both cases, show a tendency to increase with the voltages. We can attribute these results to the production of higher intensity of VUV (147 nm and 174 nm) under higher electric fields. It should be noted that the test panel with the SiO_2-coated $(Y,Gd)BO_3:Eu^{3+}$ phosphor has higher luminance than the panel with the un-coated $(Y,Gd)BO_3:Eu^{3+}$ phosphor. This fact indicates that higher luminance seen in the test panel with the SiO_2-coaed phosphor has a stronger relation with the VUV, which is produced in the gas discharge and is absorbed more effectively into the phosphor via SiO_2 nano particles. In other word, less reflection at interfaces between phosphor and gas, due to

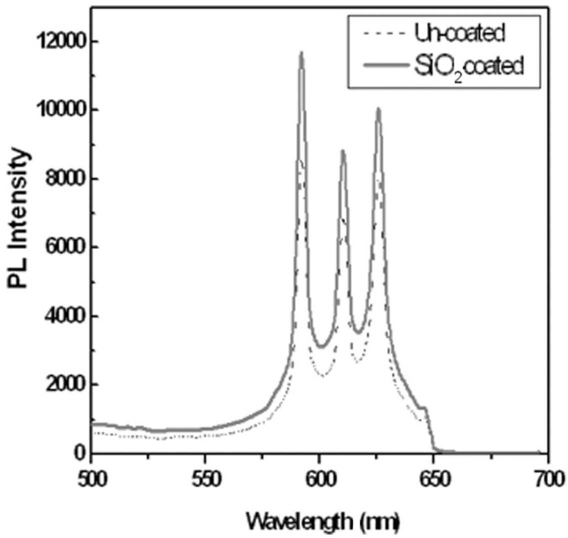


FIGURE 3 PL spectrum of the un-coated and SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphors.

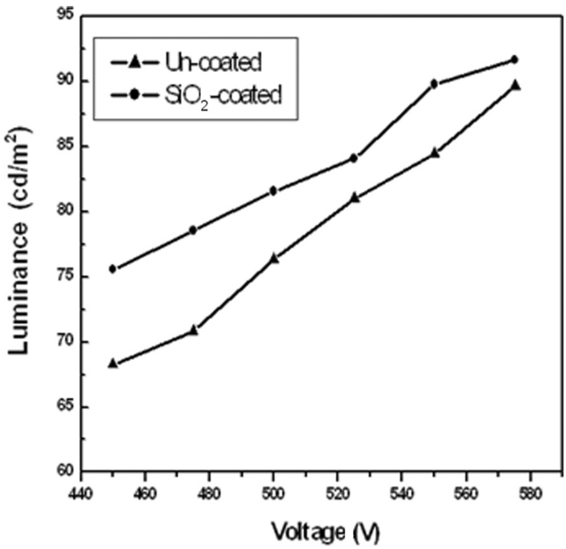


FIGURE 4 Luminance of the un-coated and SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphors as a function of applied voltages in the Xe gas discharge.

the small refractive index difference via SiO_2 nano particles, will be responsible for it.

CONCLUSIONS

In summary, we have coated (Y,Gd)BO_3:Eu^{3+} phosphor with SiO_2 nano particles by a sol-gel method. The electro-optical properties of the un-coated and the SiO_2-coated (Y,Gd)BO_3:Eu^{3+} phosphor were compared. The SiO_2 coating yields an increase in both the PL intensity of the phosphors and in the luminance of gas discharge test panel. The reason for this increase can be explained an increase of the excitation light transmitted into the phosphor, due to the small refractive index difference via SiO_2 nano particles. In other words, the effective VUV absorption of the phosphor via SiO_2 nano particles occurs. It is suggested that the SiO_2-coating on the phosphor surface is a way to improve the luminance.

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