Luminescent Properties of Mn^{2+} co-doped $Ca_8Mg_1(SiO_4)_4Cl_2:Eu^{2+}$ phosphor and Application in white LEDs

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Abstract

The manganese co-doped $Ca_8Mg_1(SiO_4)_4Cl_2:Eu^{2+},Mn^{2+}$ phosphor was synthesized by solid-state reaction and its photoluminescence characteristics were investigated. The synthesized phosphor show two emission spectrums: green band of 512nm and yellow band of 550nm. White light-emitting diodes (LEDs) were fabricated through combination of a 405nm-emitting InGaN chip and a synthesis phosphor in a single package. Under 20mA current, its CIE chromaticity coordinates are x=0.40 and y=0.45 and a color temperature of 4053K.

1. Objectives and Background

The LED (Light Emitting Diode) has very attractive applications in back-light for liquid crystal displays and incandescent lamps due to its long life time, compactness and high-energy efficiency.[1-3] Especially, the efficiency of white LED lighting has already exceeded that of the incandescent lamps and now is competitive with fluorescent lamp.[4] White emitting single chip luminescence conversion LEDs, based on blue LED chips coated with a yellow emitting phosphor (YAG:Ce), were first reported in 1997.

2. Results

$Ca_8Mg_1(SiO_4)_4Cl_2:Eu^{2+}Mn^{2+}$ phosphor were synthesized through a solid-state reaction method. The starting materials were CaO, CaCl2, MgO, SiO2, Eu2O3 and MnO with purity of 99.9%.

The resulting powder samples were characterized by using a Rigaku (D/MAX-2200V) X-ray diffraction (XRD) system with Cu Kα radiation (Ni filter). Photoluminescence characteristics of the synthesized phosphor at room temperature were measured by a spectrometer equipped with Xe-lamp, PMT, and monochrometers. White LEDs were manufactured by synthesized phosphor with epoxy on InGaN-based blue chips with 405nm emission wavelength. The luminescent properties of the LEDs wee investigated in a spectrascan

PR650 with a 50cm single-grating monochrometer under a forward bias of 20mA.

The emission spectra (λ_{ex}=450nm) of phosphor $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+} are show in Fig. 1. When the Mn^{2+} ion do not exist, the emission spectra show broadband characteristics with a low intensity emission at 512 nm. However, with a gradual addition of Mn^{2+} ions, the emission peak appeared at 550 nm with an increase of emission peak intensity. The 512 nm emission band is attributed to $4f^6$-$5d^1$ transition of Eu^{2+} ion substituted by Ca^{2+} site. The 550 nm emission band occurred ^4T-^6A transition of Mn^{2+} ion substituted by Ca^{2+} site.

The excitation spectra of the Mn^{2+} co-doped $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+} phosphor powder prepared from a solid-state reaction are shown in Fig. 2. The Mn^{2+} co-doped $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+} phosphor showed a broad excitation wavelength ranging from 300 to 500 nm. Thus, $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+} could be applied as green phosphor for a LED having an emission wavelength of ranging 300 to 500 nm. Besides $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+} could be applied UV LED having an emission wavelength.

3. Impact

The phosphor samples with Mn^{2+} co-doped $Ca_8Mg_1(SiO_4)_4Cl_2$:Eu^{2+} were prepared using the solid-state method. The optimum conditions of the phosphors at various concentration of the Eu^{2+} and Mn^{2+}, flow of the gas, and the reaction temperature were determined.

4. References

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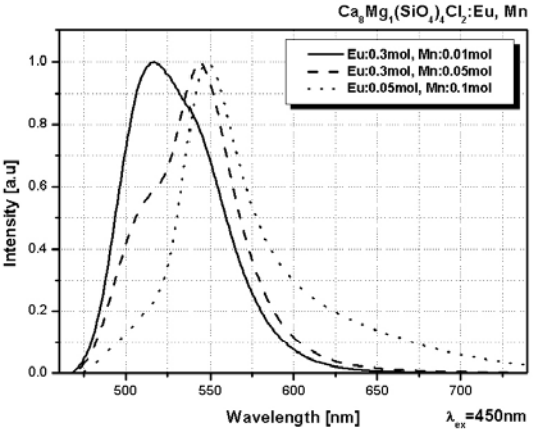

Fig. 1 Emission spectra of $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+}

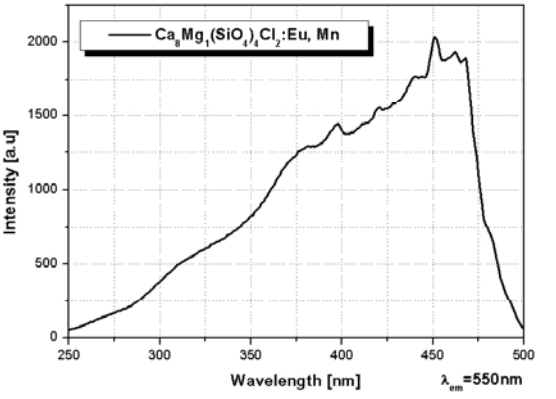

Fig. 2 Excitation spectra of $Ca_8Mg_1(SiO_4)_4Cl_2$: Eu^{2+}, Mn^{2+}