PLD 방법으로 제작한 $ZnGa_2O_4$ 형광체 박막의 발광특성

Luminescence characteristics of $ZnGa_2O_4$ thin film phosphors grown by pulsed laser deposition

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Recently, $ZnGa_2O_4$, one of the most promising luminescence oxide materials has attracted enormous attention for blue emission. It can be used for the applications in vacuum fluorescent display (VFD) and field emission display (FED) as a low-voltage cathodoluminescence phosphor[1]. $ZnGa_2O_4$ is a binary compound oxide consisting of ZnO and Ga_2O_3, crystallizing in the spinel structure with space group of Fd_{3m} and its optical bandgap is about 4.4 eV. In the normal oxide spinel (AB_2O_4) structure, Zn^{2+} ions occupy the tetrahedrally coordinated A-sites, whereas Ga^{3+} ions occupy the B-sites that are octahedrally coordinated. Like other wide bandgap semiconductors, $ZnGa_2O_4$ exhibits a strong blue emission due to transition via a self-activation center under excitation by ultraviolet light[2]. Jeong et al.[3] reported the new self-activated optical center in $ZnGa_2O_4$ related to tetrahedrally coordinated Ga-O groups. Several methods have been used to synthesize polycrystalline $ZnGa_2O_4$ thin film phosphor materials including sputtering[4], sol-gel processing[5] and chemical vapor deposition[6]. In this study, we have investigated the luminescent properties of $ZnGa_2O_4$ films deposited on silicon (Si) substrates by a pulsed laser deposition.

The films were grown by pulsed laser deposition method using an ArF excimer laser with a wavelength of 193 nm. The distance between target and substrate was kept at 35 mm. The laser fluence was approximately 4.0J/㎠ and repetition rate was 5 Hz. $ZnGa_2O_4$ thin film phosphors were deposited at a substrate temperature of 550C with the oxygen pressure 100 mTorr, and subsequently post-annealed at 600 °C and 700 °C. A variety of characterization techniques were employed to study various properties of the $ZnGa_2O_4$ films, including a x-ray diffraction (XRD), atomic force microscope (AFM). The photoluminescence (PL) spectra were measured at room temperature using a luminescence spectrometer broadband incoherent ultraviolet (UV) light excitation source with a dominant wavelength of 232 nm.

Figure 1 exhibits a series of XRD data for ceramic target, as-grown and post-annealed $ZnGa_2O_4$ films deposited under oxygen pressure of 100mTorr. The higher annealing temperature destroys the preferred orientation peak of (222) and results in the transition toward the standard powder diffraction pattern. At 600 °C, a small amount of $ZnGa_2O_4$ was converted to β-Ga_2O_3 due to the vaporization of ZnO. Figure 2 (a) to (c) present the AFM images of the $ZnGa_2O_4$ films deposited at

100 mTorr with different annealing temperatures of 550, 600 and 700 °C, respectively. The variations in morphology are evident for the $ZnGa_2O_4$ films annealed at different temperatures. Figure 3 shows the emission spectra of $ZnGa_2O_4$ films annealed at different temperatures for 30 min. at a deposition oxygen pressure of 100 mTorr, respectively. As proposed by Shea et al.[2], the absorption of the host $ZnGa_2O_4$ arose from the Ga^{3+} ions of Ga-O group, and the excited Ga^{3+} ions are responsible for the UV or blue luminescence. Upon excitation by ultraviolet light (=232 nm), the emission spectra of as-grown film show a broad band extending from 300 to 600 nm peaking at 460 nm, The main peaks of emission spectra shown in Fig. 3 shift from 460 to 370 nm, when the $ZnGa_2O_4$ films were annealed at different temperatures. The annealing at different temperatures may lead to the different dominant emissions.

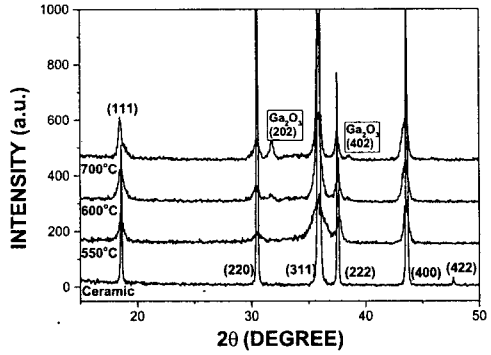

Fig. 1 XRD patterns of $ZnGa_2O_4$ films annealed at different temperatures for 30 min.

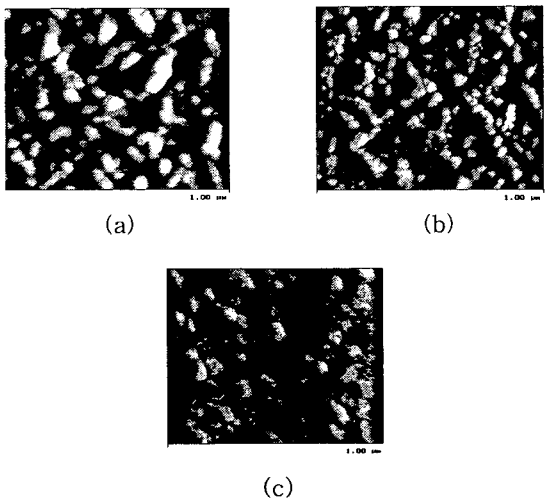

Fig. 2 AFM images of $ZnGa_2O_4$ films annealed at different temperatures (a) as-grown, (b) 600 °C and (c) 700 °C.

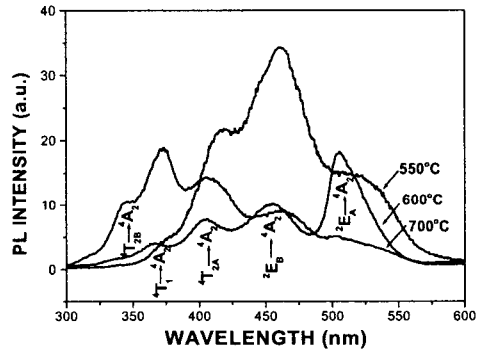

Fig. 3 Room-temperature PL spectra of $ZnGa_2O_4$ films annealed at different temperatures.

References

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