Thin film thermometer application of long afterglow $SrAl_2O_4$:Eu,Dy phosphors

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Long afterglow phosphorescent $SrAl_2O_4$ phosphors co-doped with Eu and Dy have attracted interest in an optical thermometer as sensor head materials (1). The thin film fabrication of the long afterglow phosphorescent $SrAl_2O_4$ phosphors enables the temperature mapping of an objective with a temperature distribution. In this case, two dimensional temperature sensing is achieved by the scanning of the excitation light and the monitoring the phosphorescent characteristics depending dramatically on temperature. In this paper, the long afterglow phosphor films are fabricated by laser ablation, and the possibility of these films as the thermometer materials is discussed.

The powder with a prescribed amount of $Sr_{0.9}Al_2O_4$:$Eu_{0.05}$,$Dy_{0.05}$ is pressed to a pellet and is used for an ablation bulk target. A Q-switched YAG laser (wavelength of 266 nm) is used to ablate the bulk target. $SrAl_2O_4$:Eu,Dy films of about 200 nm thick were formed on a Si (100) substrate in a H_2 atmosphere of $1x10^{-3}$ Torr at room temperature. After deposition, the thin films were annealed at 900 °C for 2 hours in 5%H_2+Ar atmosphere. The crystalline structure was investigated by an x-ray diffraction measurement, resulting in the typical $SrAl_2O_4$ crystal structure. Photoluminescence (PL) measurement was carried out using He-Cd laser (325nm). Intense and broad PL is observed near 520 nm. The PL intensity increases with increasing annealing time, indicating the optical activation of Eu^{2+} ions due to the reductive atmosphere.

In order to investigate the afterglow characteristics, the decay of the PL intensity was measured. After He-Cd laser excitation is turned off, the PL intensity decays with multi-exponential and is observed even at 20 min later. The PL spectrum shape and PL peak position, however, hardly change during the afterglow. The appearance of the afterglow characteristics is due to the thermal activation of holes that are trapped in the hole-trap levels created by the Dy doped into the films (2). On the basis of the result of the thermally stimulated luminescence measurement, the hole-trap level is estimated to be 0.54 eV of which value is in good agreement with that of the $SrAl_2O_4$:Eu,Dy bulk phosphor. The afterglow intensity of the thin films is weaker by about four orders of magnitude than that of the $SrAl_2O_4$:Eu,Dy bulk phosphor. The difference of this intensity is simply considered to be due to the sample thickness. In the time domain of ms order, the temperature dependence of the time response of the PL from the films has been examined under pulse excitation using Q-switched YAG laser (355 nm). With decreasing temperature from RT to 9K, the PL decay characteristics changes from triple exponential (decay times of 4 ms, 40 ms and 900 ms) to single exponential (2 ms), and also the intensity after 200 ms decreases monotonously to one order of magnitude.

In conclusion, it can be considered in afterglow $SrAl_2O_4$:Eu,Dy thin films that the PL decay and the PL intensity that are sensitive to the temperature change has an advantage of the application for the thin film thermometer as a two dimensional sensor materials.

References

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