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Rare Earth-Activated Multicomponent Oxynitride Thin-Film EL Phosphors

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This paper describes thin-film electroluminescent (TFEL) devices that incorporate newly developed rare earth-activated phosphors whose host material is a multicomponent oxynitride composed of nitride and oxide. As an example, the EL characteristics are described for TFEL devices fabricated using Eu-activated gallium oxynitride-based phosphors that use as host materials multicomponent oxynitrides composed of GaN and an oxide phosphor such as Ga_2O_3 or ZnO. The thin films were prepared by rf magnetron sputtering using a powder target composed of a mixture of nitride phosphor powder and oxide phosphor powder. The thin-film emitting layers, thickness of approximately 1 μm, were deposited at 350°C with an Eu content of 1 at.% with postannealing, if applied, carried out at 800°C in a N_2+H_2 (5%) atmosphere for 30 min. The obtained EL characteristics in TFEL devices with a Eu-activated multicomponent oxynitride thin-film emitting layer were strongly dependent on not only the deposition and postannealing conditions but also the chemical composition. Figure 1 shows the GaN content dependence of luminance (L)-applied voltage (V) characteristics for TFEL devices fabricated using as-deposited $((Ga_2O_3)_{1-X}$-$(GaN)_X)$:Eu thin films prepared with targets composed of various powder mixtures of Ga_2O_3:Eu and GaN:Eu and driven by an ac sinusoidal wave voltage at 1 kHz. It should be noted that all TFEL devices fabricated using an as-deposited $((Ga_2O_3)_{1-X}$-$(GaN)_X)$:Eu thin film prepared with a GaN content in the range from 0 to 100 mol.% exhibited red EL emission; the obtained luminance in these devices showed a tendency to decrease as the GaN content was decreased from 100 to 50 mol.%. Figures 2 and 3 show the GaN content dependencies of the L-V characteristics for TFEL devices fabricated without and with postannealing, respectively, using $((ZnO)_{1-X}$-$(GaN)_X)$:Eu thin films prepared using powder targets with various mixtures of ZnO:Eu and GaN:Eu. The obtained luminance in devices with an as-deposited phosphor thin-film emitting layer exhibited a tendency to decrease as the GaN content was decreased from 100 to 50 mol.%, whereas that in devices fabricated using postannealed phosphor thin films exhibited a tendency to increase over the same decrease in GaN content. In addition, there was an improvement in the rate of increase in luminance relative to the applied voltage for the TFEL devices postannealed at 800°C; there was also a tendency to see greater improvement as the GaN content was increased. The shape of EL emission spectra, consisting of a main peak at a wavelength of 615 nm, from TFEL devices using Eu-activated gallium oxynitride-based phosphors was relatively independent of the GaN content and postannealing temperature.

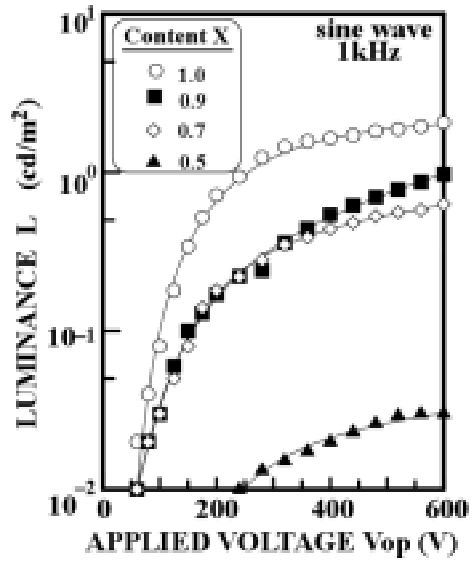

Fig.1 L-V characteristics
(as-deposited $((Ga_2O_3)_{1-X}$-$(GaN)_X)$:Eu)

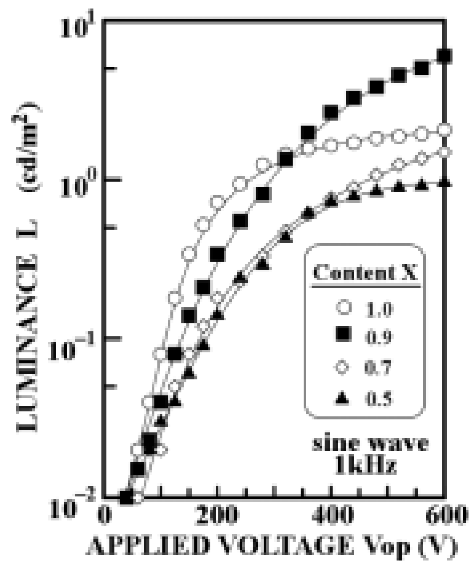

Fig.2 L-V characteristics
(as-deposited $((ZnO)_{1-X}$-$(GaN)_X)$:Eu)

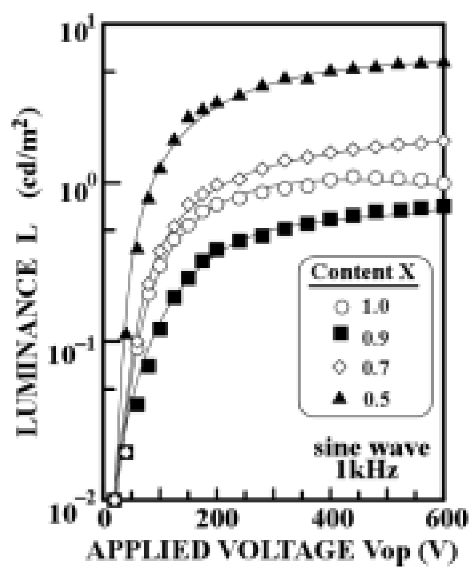

Fig.3 L-V characteristics
(postannealed $((ZnO)_{1-X}$-$(GaN)_X)$:Eu)