INORGANIC/ORGANIC COMPOSITES POWDER EL DEVICE

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Introduction

A powder electroluminescent (EL) device can be fabricated by a printing process and can be used to economically realize field luminescence over a large area by a simple process. Presently, its applications are limited to providing low-intensity backlighting, for example, as a key backlight in cellular phones. In order to realize a lighting system, it is necessary to develop EL panels that exhibit white luminescence.

Organic light-emitting diodes (OLEDs) are considered to be one of the most promising next-generation flat-panel display technologies because of their simple structure and advantages such as self-emission, wide viewing angle, and fast response speed. The dye-dispersion (a guest-host system) method is widely used for obtaining OLEDs with high color purity and high luminance [1]. With regard to an increase in the electroluminescence efficiency of OLEDs, it is well known that the luminosity can be increased by doping Alq3 with coumarin (an organic fluorescent dye).

Thus far, we have manufactured high-luminance inorganic/organic composites powder EL panels [2] as well as a red luminance powder EL device [3]. Thus, we have produced white-light-emitting inorganic/organic composites powder EL devices that consist of three primary color [4]. Furthermore, this implies that it will be possible to display the full spectrum of colors on a display screen.

Experimental

The inorganic/organic composites powder EL device developed in this study has a layered structure. Its structure is fundamentally the same as that of a conventional powder EL device. Only the phosphor layer is different in this device. The device structure is laminated on a transparent, electrically conductive substrate with the following layers in the given order: the phosphor layer co-doped by organic fluorescent dyes, a dielectric layer, and a back electrode.

Two types of organic dyes were used—a green dye for coumarin 6 (C6) and a red dye for 4-(dicyanomethylene) -2-i-propyl-6-(1,1,7,7-tetramethyljulolidyl-9-enyl)-4H-pyran (DCJTB). The devices used in this study were manufactured by using a screen printer that ensured the reproducibility of screen printing. The phosphor layer used in a ZnS system (ZnS_{sys}) comprises granular phosphors with emission spectrum peaks at 450 nm. The phosphors were dispersed in a high-dielectric polymer along with the organic fluorescent dyes and then converted into a paste. Moreover, a dielectric paste containing $BaTiO_3$ as the main component was used as the dielectric layer, while a silver paste with Ag as the main component was used as the back electrode.

Results and Discussion

The frequency dependence of the inorganic/organic composites powder EL device is shown in the emission spectrum in Fig. 1. The emission wavelength of the original ZnS_{sys} phosphor exhibits a peak at 455 nm. When the green organic dyes are mixed in the inorganic phosphors, an electroluminescent spectrum with a peak at 515 nm is obtained, as shown in Fig. 1. When red organic dyes are mixed in the inorganic phosphors, an electroluminescent spectrum with the main peak at approximately 640 nm is obtained, as shown in Fig. 2. These results are for a material in which the organic dye is excited by the fluorescence energy of the inorganic phosphor.

The frequency dependence of the white-light-emitting inorganic/organic composites powder EL device is shown in the emission spectrum in Fig. 3. The emission wavelength of the original ZnS_{sys} phosphor exhibits a peak at 455 nm. When the organic dyes are mixed in the inorganic phosphors, and an electroluminescence emission spectrum with peaks at approximately 440, 510, and 620 nm is obtained. These results are for a material in which the organic dye is excited by the fluorescence energy of the inorganic phosphor. First, the inorganic phosphor emits light. Then, a part of the luminescence energy of the inorganic phosphor excites C6, which emits light. Furthermore, a part of the luminescence energy of C6 excites DCJTB, and it also emits light. As a result, white luminescence by three primary colors is realized.

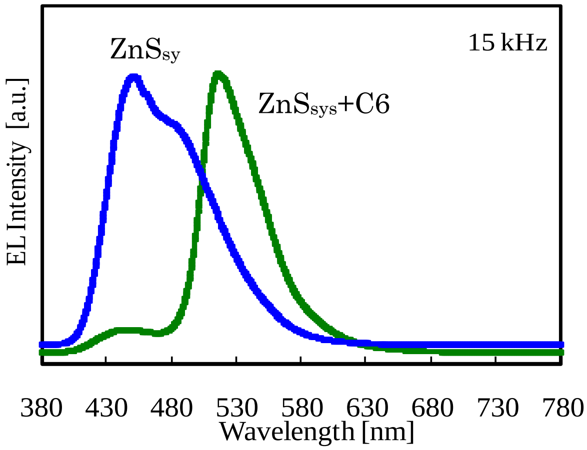

Fig. 1 Frequency dependence of the emission spectrum of green-emitting organic-dye-dispersed powder EL device.

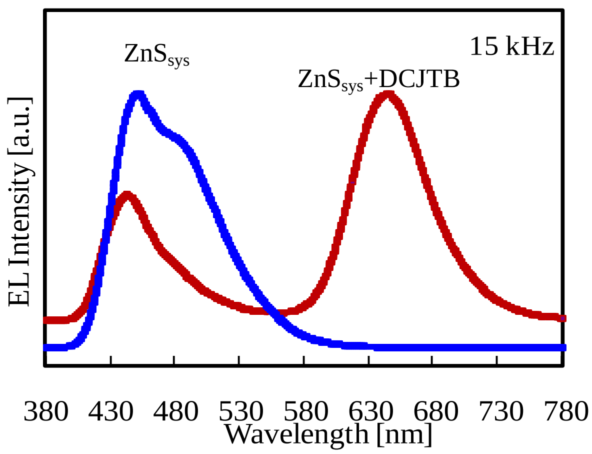

Fig. 2 Frequency dependence of the emission spectrum of red-emitting organic-dye-dispersed powder EL device.

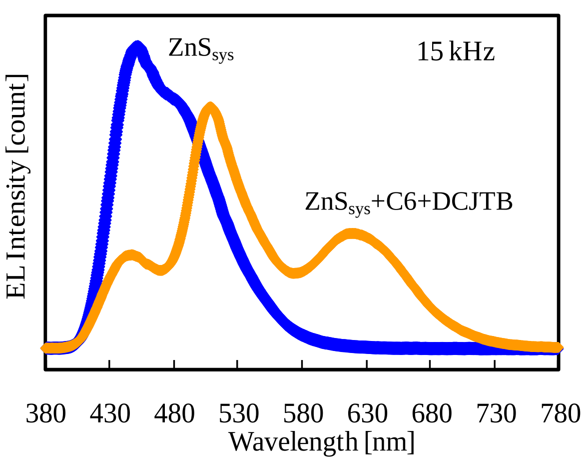

Fig. 3 Frequency dependence of the emission spectrum of white-light-emitting organic-dye-dispersed powder EL device.

The inorganic/organic composites powder EL device emits RGB luminescence without color filters.

We have manufactured a novel white-light-emitting inorganic/organic composites powder EL device with a new structure by doping the organic fluorescent dyes in the phosphor layer. We observed that the inorganic /organic composites powder EL device exhibits white luminescence for the color coordinates $x = 0.32$ and $y = 0.32$ without a color filter. This remarkable increase in the purity of white luminescence is achieved by co-doping the phosphor layer with a green dye (for C6) and a red dye (for DCJTB). The white luminescence of the hybrid EL panel at 300 V is 320 cd/m^2 at 1 kHz. This value is higher than the white luminescence values of present commercial EL devices.

Conclusion

Both a white-light-emitting device and an RGB device are hybrid devices designed by the combination of an inorganic phosphor and an organic dye. The novel inorganic/organic composites powder EL device proposed in this study could be fabricated by a printing process, which could be used to construct luminescence panels of high color purity at low cost.

Acknowledgements

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References

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