B－4－8 Multi-Coloring of Thin-Film Electroluminescent Device

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Recently, much attention has been paid to doubly insulated ac thin-film electroluminescent(EL) devices for flat panel display because their high brightness and long life have been attained successfully in ZnS:Mn system.[1] However, there still remain two serious problems for extensive application of this ZnS:Mn system; poor color selection and high operation voltage. Especially, the development of multi-coloring has been desired in thin-film EL devices, and the use of various luminescence centers such as donor-acceptor pair type impurities, transition metal ions and rare-earth fluoride molecules has been reported so far.[2-4] Among these luminescence centers, rare-earth fluoride molecules are considered to have great advantage of getting a wide variety of emission color by selecting appropriate molecular centers.

We have conducted a series of systematic experimental studies to develop multi-coloring with high brightness by doping various kinds of rare-earth material into ZnS thin-film EL panel. By optimizing the fabricating conditions such as substrate temperature and film thickness, we have succeeded in developing the EL devices emitting red(SmF_3), yellow(DyF_3), green(TbF_3, ErF_3 and HoF_3) and whitish green(PrF_3), especially for TbF_3, the brightness of more than 600 foot-Lambert(fL) has been obtained under 5 kHz sinusoidal excitation. In this paper, we report the performance of improved thin-film EL devices emitting a variety of colors.

Figure 1 shows the device structure consisting of ITO(Indium-Tin-Oxide)-Y_2O_3-ZnS:LnF_3-Y_2O_3-Al, where Ln denotes a rare-earth element. We have examined the relation between obtained performance and fabrication condition. The results show that the higher substrate temperature and the larger film thickness are effective for obtaining high brightness.

We have fabricated various EL devices doped with PrF_3, NdF_3, SmF_3, EuF_3, TbF_3, DyF_3, HoF_3, ErF_3, TmF_3 and YbF_3. These emissions except for those doped with EuF_3 and YbF_3 are identified to transitions of each rare-earth ion and their spectra are shown in Fig.2. These spectra are almost the same as

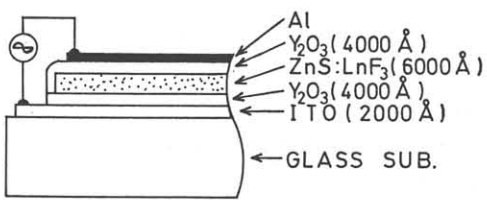

Fig.1 Schematic device construction.

those previously reported[2]. However, for the device doped with HoF_3, the spectrum is different from the previously reported[2], and the obtained emission color is green. This may arise from the difference of the crystal field around the Ho^{3+} ion in the ZnS film.

Figure 3 shows brightness versus applied voltage characteristics of these devices under sinusoidal excitation of 5 kHz. The brightness of more than 100 fL is obtained for many rare-earth centers, particularly bright green mission (TbF_3, 600fL) and red(orange-red) emission(SmF_3, 200fL), have been obtained. These values are about one order of magnitude higher than the previously reported[2]. The efficiency of about 0.05 lm/w is obtained for the devices doped with PrF_3, SmF_3, DyF_3, ErF_3 and HoF_3, and the largest value of 0.4 lm/w is obtained for TbF_3-doped device. From the results of life test we have confirmed that some devices operate more than 4000 hrs with very small degradation of the brightness under 2 kHz pulse voltage excitation.

References

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3) K. Okamoto and Y. Hamakawa; Appl. Phys. Lett. 35 (1979) 508
4) K. Okamoto and Y. Hamakawa; Jpn. J. Appl. Phys. 19 Suppl. 19-1 (1980) 371

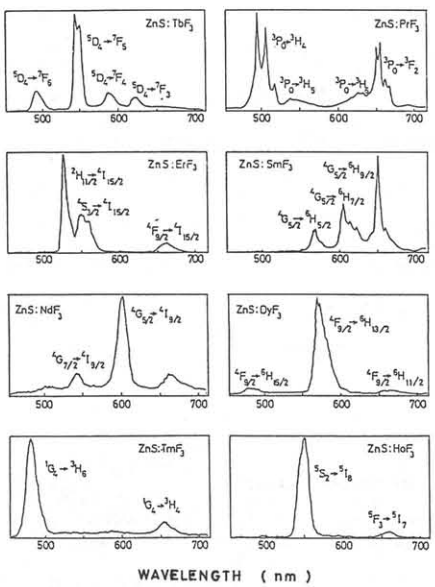

Fig.2 Emission spectra of various rare-earth fluoride doped ZnS thin-film EL devices.

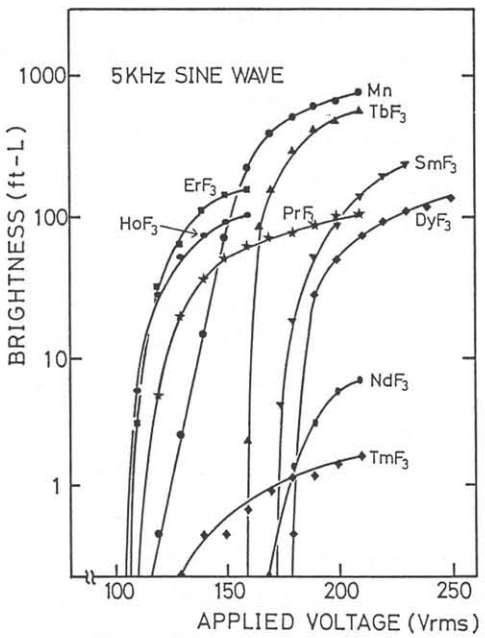

Fig.3 Brightness versus applied voltage characteristics.