B—2—5 High-Brightness Green-Light Emitting Thin-Film Electroluminescent Device

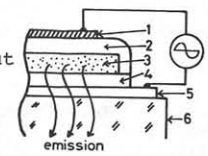
K. Okamoto and Y. Hamakawa

Faculty of Engineering Science, Osaka University, Toyonaka, Osaka, Japan

A great deal of efforts has long been paid on the developements of thin-film Electroluminescent (EL) devices for the flat-type display panel. In the various approaches, doubly insulated ZnS:Mn thin-film is a promised EL device. Although a considerable amount of potential needs have been gathered on the multi-coloring of thin-film EL devices, emission color having a practically acceptable level brightness is only orange which is attained by ZnS:Mn system.[1] To break through this barrier, many kinds of luminescence centers, for example Donor-Acceptor pair type impurities, transition metal ions and rare-earth fluoride molecules have been investigated. Among these luminescence centers, rare-earth fluoride molecules have at least two advantages in view of practical application. The first is their high efficiency due to the large ionization cross section of molecular centers. The second one is their capability on a wide variation of the emission color by selecting appropriate molecular centers. However, practically available level performances of this kind of EL device have not been obtained.

We have conducted systematic investigations to improve the performances of a rare-earth doped ZnS thin-film EL device, and succeeded to realize practically available level performances with ZnS:TbF_3 thin-film EL device having a construction of In_2O_3-Y_2O_3-ZnS:TbF_3-Y_2O_3-Al. In this paper, we describe a series of technical data on the performances of newly developed thin-film EL device which emits strong green light stably. A schematic device structure is shown in Fig.1. The Y_2O_3 layer employed in this device has a semiconductive property which is prepared by a conventional electron beam evaporation at certain substrate temperature and subsequent heat treatment.

Figure 2 shows the brightness versus applied voltage characteristic of the device under sinusoidal voltage excitation of 5 KHz. As can be seen from the figure, the brightness gradually saturates at about 200 V to around 200 fL. This brightness obtained here in green color is believed to be the highest one while the brightness previously reported[2] is a level of 50 fL as shown by the hatched band in Fig.2. A typical power efficiency is estimated to be 2×10^{-4}. Observed emission decay time of 1∿2 ms is considerably long as compared with already reported data of 220 μs.[3] Since the brightness is time-averaged value of emission, this long



1. Al electrode
2. Y_2O_3 (4000A)
3. ZnS:TbF_3 (5000A)
4. Y_2O_3 (4000A)
5. In_2O_3 (2000A)
6. GLASS SUB.

Fig.1 Device structure

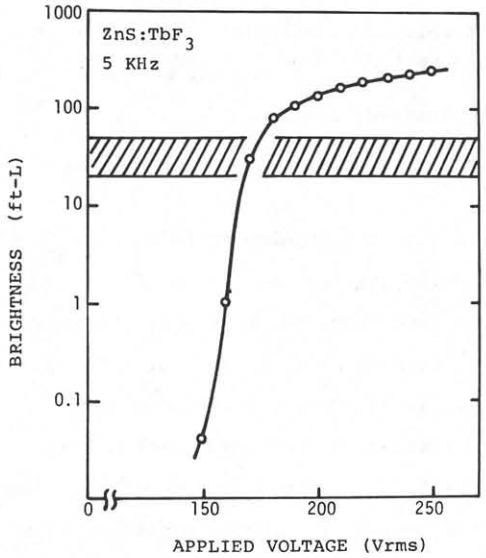


Fig.2 B-V characteristic under sinusoidal voltage excitation. Hatched band shows previously reported level.

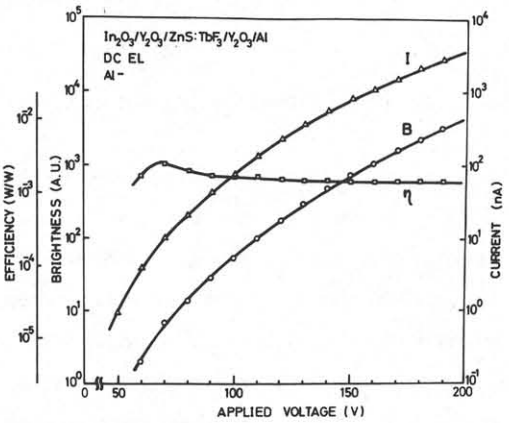


Fig.3 Brightness, current and efficiency versus applied voltage characteristics under dc voltage excitation.

decay time might contribute to higher values in brightness. In addition, dc EL component having the brightness of 10 fL is also observed under the operating condition with 50 μA current level. Figure 3 shows brightness, current and efficiency versus applied voltage characteristic under dc voltage excitation. The brightness increases linearly with current flowing through the device. A typical power efficiency of this dc EL component is around $1.0X10^{-3}$. This value is about one order of magnitude higher than that under ac voltage excitation. Electrons which contribute the dc EL component of emission is injected from the semiconductive Y_2O_3 layer to the ZnS active layer. This fact implies that the semiconductive Y_2O_3 layer may act as an efficient electron injector to the ZnS layer and also act as a current limiter which protects ZnS active layer from thermal runaway.[4] Although we have not concentrated our attention to the passivation and other packaging technology, no special change in the device performances are observed during the continuous operation of more than 100 hrs after an initial forming process which also takes about 100 hrs. More informations of the technical data on the developed thin-film EL device and possible model of carrier injection from the semiconductive Y_2O_3 to the ZnS are introduced and discussed at the presentation.

REFERENCES

1) T. Inoguchi and S. Mito, in Electroluminescence, (Spring-Verlag, New York, 1977), p.197.
2) E. W. Chase, R. T. Hepplewhite, D. C. Krupka and D. Kahng, J. Appl. Phys. 40, 2512 (1969)
3) Y. S. Chen, M. V. Depaolis, Jr., and D. Kahng, Proc. IEEE 58, 184 (1970)
4) K. Okamoto, S. Tanaka, H. Kobayashi and H. Sasakura, IEEE Trans. Electron Devices ED-25, 1170 (1978)