Digest of Tech. Papers The 12th Conf. on Solid State Devices, Tokyo

B-2-7 Low-Threshold-Voltage AC Thin-Film Electroluminescent Device

K. OKAMOTO, Y. NASU, M. OKUYAMA and Y. HAMAKAWA

Faculty of Engineering Science, Osaka University, Toyonaka, Osaka

Recently, a series of intensive studies have been in progress to develope a bright thin-film electroluminescent (EL) devices because it has a number of attractive advantages such as low power dissipation, large area flat-panel display having a possibility of multi-coloring and solid state modular. The efforts have been bloomed by the form that a considerably bright thin-film EL panel with orange and green colors have been developed.[1-3] Although high-brightness and long-life have been achieved, several important problems still remain that the operation voltage of 200-300 volts in rms is too high. This high driving voltage makes the use of commercially available IC as a driving circuit difficult and leads high-cost and complexity of the driving circuit. Moreover, the application of such high electric field to the device makes a failure of the device reliability. From these reasons, the developement of a new device which can be operated with reasonably low voltage has been desired sincerely. In this paper, we report a new type of low-voltage-operated ac thin-film EL devices having about three times lower driving voltage as compared with that of conventional EL devices.

Figure 1 shows two types of newly developed device structure. We have succeeded to grow a perovskite type ferroelectric $PbTiO_3$ thin-film on several substrate material such as Indium-Tin-Oxide (ITO), ZnS and Pt by rf-sputtering. This perovskite type thin-film has a dielectric constant of 100-200 which is about one order of magnitude higher than that of the conventional insulating film of 10-15. Therefore, voltage across the dielectric layer can be reduced remarkably under ac voltage excitation. While, another pyrochlore type $PbTiO_3$ thin-film shows low dielectric constant of only 10-30. The $PbTiO_3$ film having the perovskite structure is obtained at high substrate temperature beyond 450°C.[4]

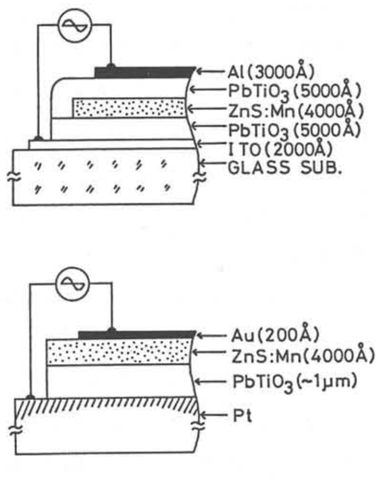

Fig.1 Schematic device construction.

Figure 2 shows typical brightness (B) versus applied voltage (V) characteristics for three layered device shown in Fig.1 (a). As can be seen from the figure, a remarkable emission appears from a threshold voltage of 65 volts, and the brightness increases steeply with increasing applied voltage. Around 70 volts, the brightness saturates to the level of 200-400 fL. A typical brightness obtained at the driving voltage of 85 volts is about 300 fL. This driving voltage for 300 fL brightness is about three times smaller than that of previous EL devices which employed

Y_2O_3 as an insulating layer. In the threshold voltage region, voltages applied across the ZnS:Mn and $PbTiO_3$ layers are shared to be 57 and 8 volts, respectively. Therefore, the driving voltage mainly depends on the film thickness of ZnS:Mn layer rather than that of $PbTiO_3$ layer. Figure 3 shows a maximum brightness and driving voltage required for brightness saturation versus film thickness of the ZnS:Mn layer, which is obtained by the device shown in Fig.1(b). The maximum brightness increases with increasing film thickness of the ZnS:Mn layer and tends to saturate. Also the driving voltage linearly shifts toward higher voltage region with increasing active layer thickness. Almost constant power conversion efficiencies of $3X10^{-3}$(w/w) have been obtained by the device having ZnS:Mn film thickness of above 3000Å.

Figure 4 shows a comparison of ageing characteristics between newly developed M-F-S-M structure and conventional M-I-S-I-M structure. As already reported, the B-V characteristic of M-I-S-I-M structure shows large voltage shift of about 100 volts during initial 160 hrs operation. After this ageing process, device shows no degradation.[1] In contrast to this, the B-V characteristic of the M-F-S-M structure shows extremely low voltage shift of only 10 volts during the same ageing process. These results are more adequate for practical use, because no ageing process is required for using the M-F-S-M structure as an display panels. More informations of the technical data with the results of other ferroelectric material such as PLT are introduced and discussed at the presentation.

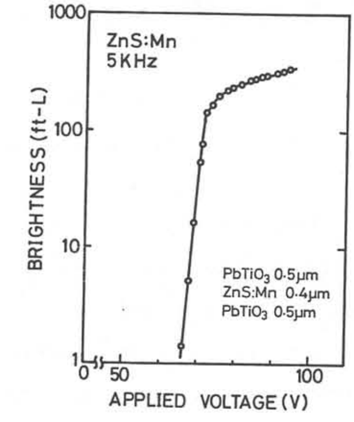

Fig.2 Brightness versus applied voltage characteristics of ITO-$PbTiO_3$-ZnS:Mn-$PbTiO_3$-Al structure.

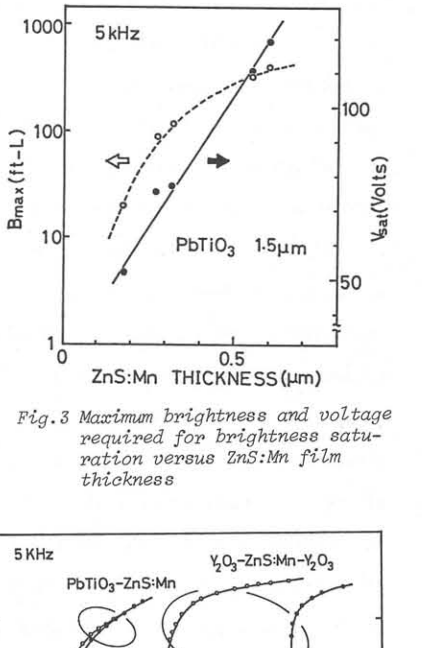

Fig.3 Maximum brightness and voltage required for brightness saturation versus ZnS:Mn film thickness

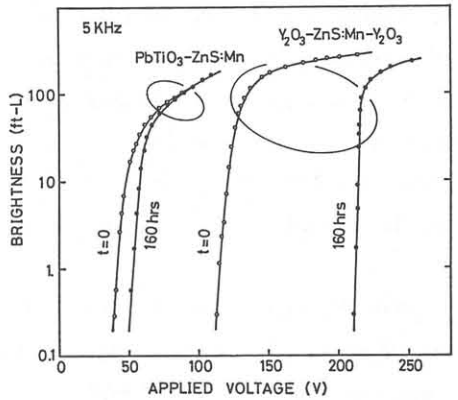

Fig.4 Comparison of ageing characteristics between M-F-S-M *and* M-I-S-I-M *structure.*

REFERENCES

1. T.Inoguchi and S.Mito;*Electroluminescence* (Springer-Verlag, New York, 1977) p.197
2. K.Okamoto and Y.Hamakawa; Appl. Phys. Lett. 35 (1979) 508
3. K.Okamoto and Y.Hamakawa;*Proc. 11th(3rd Int.) Conf. Solid State Devices*, Tokyo, 1979 in press
4. M.Okuyama, Y.Matsui, H.Nakano, T.Nakagawa and Y.Hamakawa; Jpn. J. Appl. Phys. 18 (1979) 1635