Effect of ZnS Buffer Layer on Inorganic EL Device

Duck Gon Kim[1], Lee Soon Park[2,4,5] , Tae Il Kum[2]
Sang Mok Lee[3], Sang Ho Sohn[3], Sang Kooun Jung[5]

[1]Department of Sensor & Display Engineering, Kyungpook National University, Taegu, 702-701, Korea
[2]Department of Polymer Science, Kyungpook National University, Taegu, 702-701, Korea
[3]Department of Physics, Kyungpook National University, Taegu, 702-701, Korea
[4]Advanced Display Manufacturing Research Center, Kyungpook National University, Daegu 702-701, Korea
[5]Mobile Display Research Center, Kyungpook National University, Daegu 702-701, Korea

Phone: 82-53-950-5627 , E-mail: lspark@knu.ac.kr

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Abstract

Significant process in the performance and commercialization of full-color thin-film electroluminescent(EL) displays has been achieved. This is due to the remarkable progress made in the performance of exiting EL phosphors, development of new phosphor materials, and design of new EL phosphor structures. In this paper, we fabricated thin-film EL devices with ZnS buffer and $BaTiO_3$ electric layer with on top and bottom of phosphor layer. The effect of ZnS and $BaTiO_3$ layer on the luminance of EL device were studied.

1. Introduction

Zinc sulfide is a widely used phosphor host material which can be efficiently doped with the various transition metals. Mn-doped ZnS phosphor has a relatively broad emission band with the peak maximum at ca. 585nm with for Mn concentration in the range of 0.5-1wt%.

Usually EL phosphors are operated most efficiently at high electric field near their electrical breakdown voltage. Therefore, AC EL devices have been developed utilizing a thin dielectric layer for the inorganic electroluminescent display. This method can provide the high electric field needed for the thin film EL phosphor without reaching electrical breakdown voltage.

Proper selection of thin dielectric layer must satisfy several criteria. First, the dielectric permittivity(εr) and breakdown field(εbr) must be sufficiently high to efficiently and reliably allow the applied voltage to the phosphor layer. This first requirement is satisfied by selecting dielectrics which can provide a charge capacity equal to or greater than that of common phosphors, that is, dielectric thin film with capacitance ~10 nF/cm2, εbr ~ 1MV/cm, εr ~ 8-12. Generally, the permittivity and breakdown field of dielectric materials do not increase together thus leading to candidate dielectrics having properties ranging from εbr ~ 4-8 MV/cm and εr ~ 4-10's, to εbr ~ 0.1 MV/cm and εr ~ 100'-1000's.[3]

Two additional requirements for efficient in-organic thin film EL device include ; (a) proper

interfacial sheet charge properties with the phosphor and (b) nonpropagating , self-healing breakdown mode.

In this study, we fabricated the thin film EL devices with structural variations in the phosphor, buffer(ZnS) and dielectric(BaTiO3) layers. The device structure and their electro-optical property were examined.

2. Experimental

2.1 Materials

The ZnS:Mn phosphor powder was palletized in the mold with 150~200Kg/cm^2 press. The pellet was fired in the electric furnace first 110℃ under the Ar atmosphere and then at 800℃ for 2hr. The ZnS buffer layer and $BaTiO_3$ dielectric later pellets were also palletized under similar condition. The composition of the phosphor materials are shown in Figure 1.

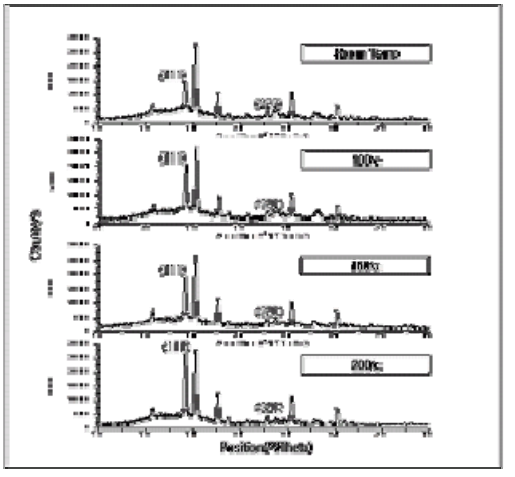
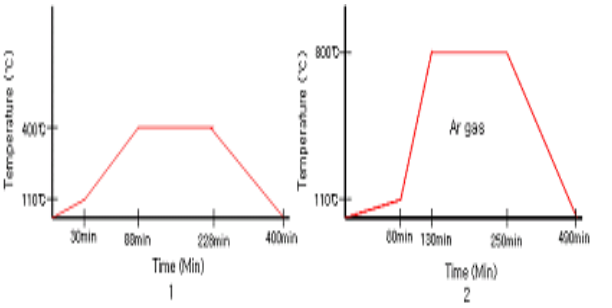


Figure 1. XRD analysis of ZnS:Mn phosphor films

The sintering temperature profiles of $BaTiO_3$, ZnS and ZnS:Mn pellets are shown Fig. 2



(a)$BaTiO_3$ (b) ZnS, ZnS:Mn

Fig. 2

Fig. 2 Sintering temperature profiles of BaTiO3, ZnS and ZnS:Mn pellet

3. Results and discussion

3.1 Fabrication of Inorganic EL Devices and Property

The structure of inorganic thin film EL devices fabricated are shown in Fig 3.

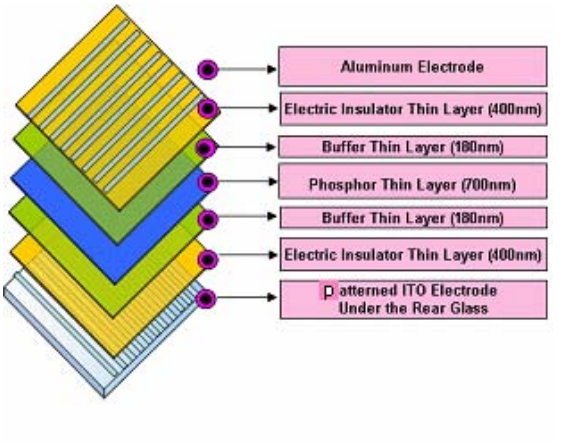


Fig. 3 Device structure of inorganic EL.

First $BaTiO_3$ dielectric layer(320nm) was deposited on the patterned ITO glass substrate with e-beam evaporator and then ZnS buffer layer(180nm) was deposited. The structure of E-Beam evaporator system is shown in Fig.4. ZnS:Mn phosphor layer was also formed by using electron-beam evaporator. The thickness of ZnS:Mn phosphor layer was 380-420nm while depositing the substrate was maintained at 200℃

Fig. 5 shows the luminance vs. voltage profile of EL device with and without dielectric layer. As shown in Fig. 5 and Table 1, the EL device with $BaTiO_3$ dielectric layers both on the top and bottom of phosphor layer exhibited highest luminance.

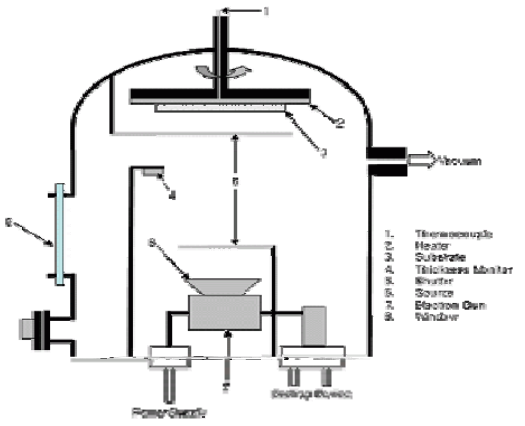


Fig. 4 Schematic diagram of an electron-beam evaporation.

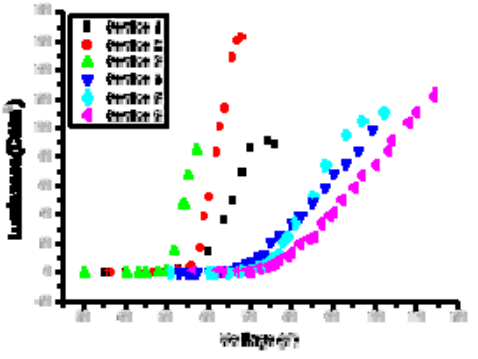


Fig. 5 The luminance vs. voltage profile of EL devices

Table 1. Structure of Thin-film EL Devices

Device No.	EL Device Structure
Device 1	ITO/BaTiO3(4000 Å)/ZnS:Mn(7000 Å) /BaTiO3(4000 Å)/Al(2000 Å)
Device 2	ITO/BaTiO3(4000 Å)/ZnS:Mn(7000 Å) /BaTiO3(4000 Å)/Al(2000 Å) ZnS:Mn (250℃, 60min annealing)
Device 3	ITO/BaTiO3(4000 Å)/ZnS:Mn(7000 Å) /BaTiO3(4000 Å)/Al(2000 Å) ZnS:Mn (450℃, 30min annealing)
Device 4	ITO/BaTiO3(4000 Å)/ZnS(1800 Å) /ZnS:Mn(7000 Å)/BaTiO3(4000 Å)/Al(2000 Å)
Device 5	ITO/BaTiO3(4000 Å)/ZnS:Mn(7000 Å) /ZnS(1800 Å)/BaTiO3(4000 Å)/Al(2000 Å)
Device 6	ITO/BaTiO3(4000 Å)/ZnS(1800 Å) /ZnS:Mn(7000 Å)/ZnS(1800 Å)/BaTiO3(4000 Å) /Al(2000 Å)

4. Summary

The thin film inorganic EL devices were fabricated in which, ZnS:Mn phosphor layer was encapsulated between the ZnS buffer and $BaTiO_3$ dielectric double layer. The EL device with ZnS buffer layers on the both top and bottom of phosphor layer exhibited highest luminance.

5. References

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