Effect of Additives on Transmittance of Tick Film Prints in PDP

Jae Sam Jun, Myung Ryoung Cha, Yu Jin Kim and Hyung Sun Kim
Dept. of Materials Science & Metal. Eng. Sunchon National Uni., Sunchon 540-742, Korea

Abstract

Glass frits for dielectric layers are mostly used for screen printing process. Several additives have already been known to be well matched with lead-oxide glasses system. The use of lead oxide, however, creates environmental problems, so many recent studies on lead-free glasses compositions have been carried out. A study of the suitability between additives and lead-free glass system is needed. In this study, we have used a screen-printing method to make thick films of lead-oxide glass and lead-free glass using different additives, and analyzed and compared the transmittance of the thick films.

1. Introduction

Many companies which make plasma display panels (PDP) have been demonstrating PDPs with high image quality and performance. As plasma displays are recognized as being promising for large area, hang-on-the-wall TVs and computer monitors, the market potential for plasma displays is growing rapidly [1-3].

In a PDP, a dielectric layer is formed on a front glass substrate so as to cover the display electrodes. It is necessary for the dielectric layer to maintain discharge, to have a high dielectric strength, and to have good transparency. Such a dielectric layer is formed by screen printing repeatedly about three or four times.

The lead-oxide glass system of low-temperature firing glass has been commonly used in household appliances. Lead-oxide glass system has been investigated for sealing of electronic industry and transparent dielectric and barrier rip in PDP. However, glass containing lead-oxide has problems in that lead-oxide adversely affects the health of workers handling the glass powder as well as environmental pollution caused by glass waste [4]. Therefore, various countries are actively studying the development of lead-free glasses compositions suitable for transparent dielectric layers.

Glass frits for dielectric layers are mostly used in a paste condition. Several additives are already known to be well matched with a lead-oxide glass system. The use of lead oxide, however, creates environmental problems, so a study of the suitability between the additives and the lead-free glass system is needed.

In this paper, we have used a screen-printing method to make thick films of lead-oxide glass and lead-free glasses (bismuth glass system, boric-zinc glass system) using different additives, and analyzed and compared the properties (transmittance and surface morphology) of the thick films.

Table 1 The composition of glass paste (Y : added , N : no added)

Samples	Glasses (major components)	Binder (Hydroxypropyl cellulose, Aldrich)	Solvent (3-Methoxy-3-methyl - 1-butanol, Aldrich)	Dispersant (Disperbyk-180, BYK-Chemie, Germany)	Leveling Additive (Byk-354, BYK-Chemie, Germany)
P1	PbO	Y	Y	Y	Y
B1	Bi_2O_3	Y	Y	Y	Y
Z1	B_2O_3-ZnO	Y	Y	Y	Y
P2	PbO	Y	Y	N	N
B2	Bi_2O_3	Y	Y	N	N
Z2	B_2O_3-ZnO	Y	Y	N	N

2. Experimental Procedure

For glass preparation of the matrix, all compositions used are chemically pure reagents. A batch of each composition, consisting of high purity raw materials was well mixed with a mortar and pestle. The batches were melted in an alumina crucible at 1100℃ for 1~2h. Each glass melt was quickly poured and quenched on a ribbon-roll and then the glass was ground to a frit (d_{50}=1~2㎛). The glass frits (bismuth glass system, boric-zinc glass system and lead-oxide glass system) and several additives were mixed by 3-roll mill for 1~2h (Table 1). Glass paste were coated on glass substrates (PD200) by a screen printing method and sintered at 580℃ for 30min. Figure 1 shows the firing stages used.

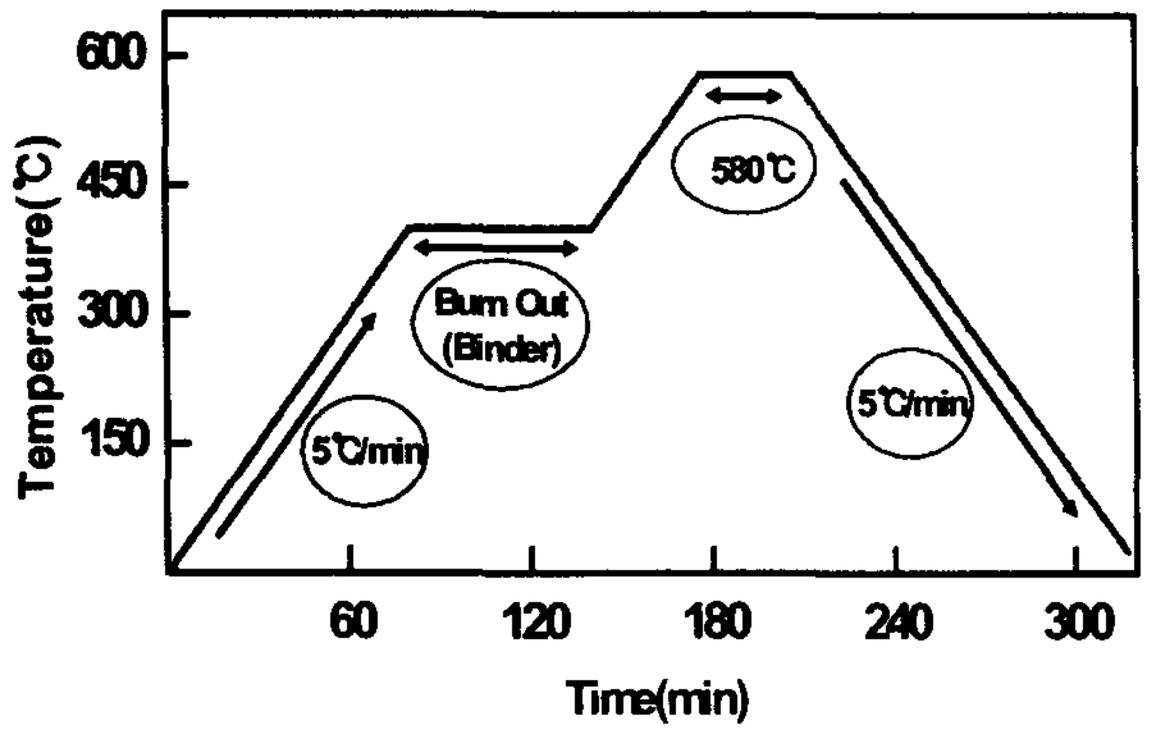

Fig. 1 Stages of firing process on thick films

The glass transition temperature (Tg) and crystallization peak were determined using a differential thermal analyzer (DTA-TA 1600, USA). Glass fiber of 0.5~0.75cm in diameter and 23.5㎝ in length was made for the Littleton softening point (Ts). For the optical measurements, UV-visible spectroscopy was used.

3. Results and discussion

The thermal properties of the glass powder are shown in Table 2. The glass transition temperature, and the Littleton softening point were detected at 440~510℃, and 535~600℃, respectively. The thermal properties indicate excellent qualification for low firing temperature.

Figure 2 shows surface morphology of thick films fired at 580℃.

Table 2 Thermal analysis of glass frits.

Glasses	Tg(℃)	Ts(℃)
PbO glass	440	536
Bi_2O_3 glass	456	541
B_2O_3-ZnO glass	510	600

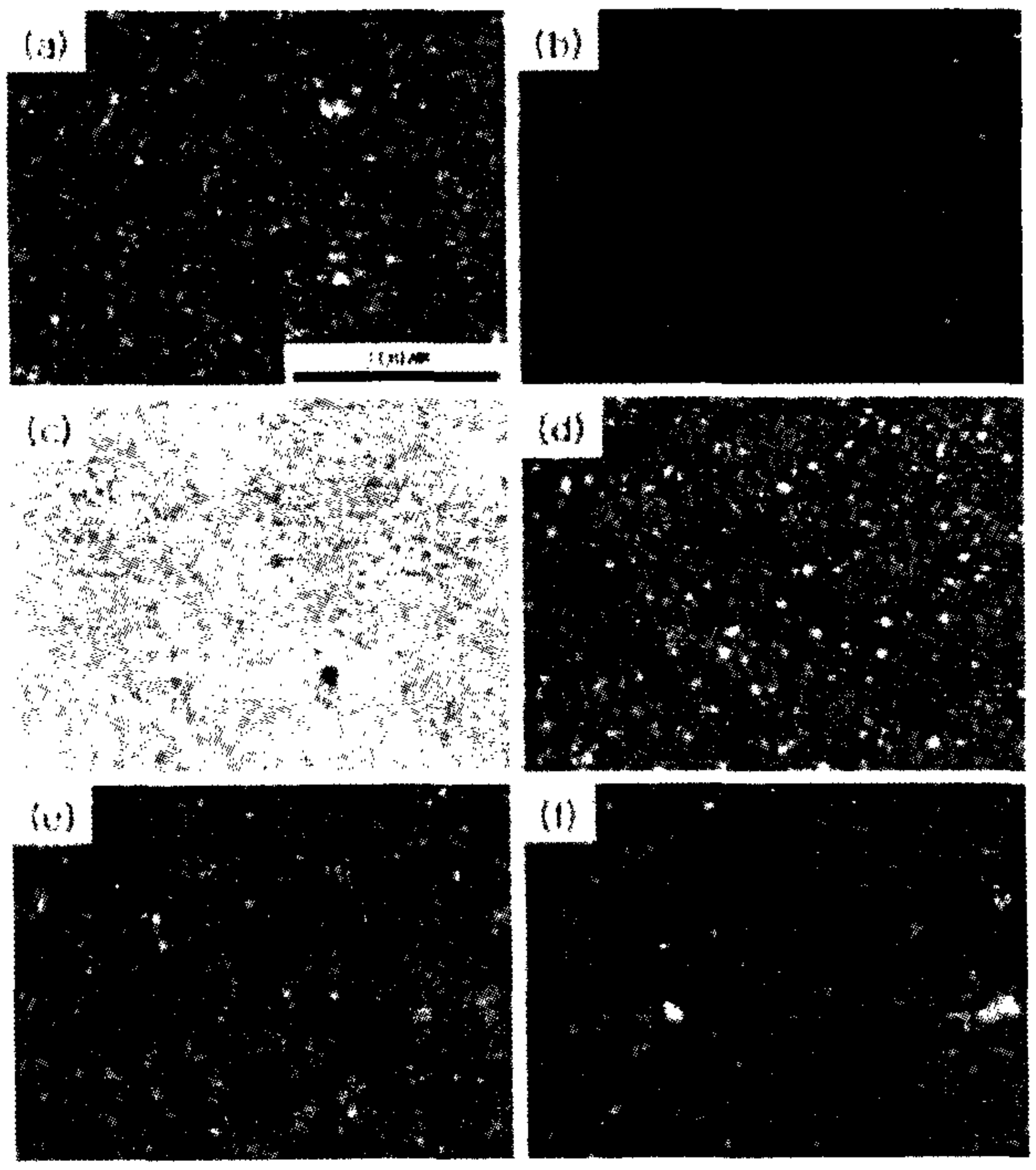

Fig. 2 Surface morphology of thick films fired at 580℃. (a) P1, (b) P2, (c) B1, (d) B2, (e) Z1 and (f) Z2

There are many pores in the thick films at all conditions, however, the thick films used additives (P1, B1, Z1) have much more pores than the thick films (P2, B2, Z2) that does not contain additives(dispersant, levelling additive). Also, the number of pores in bismuth glass is extremely increased when it contains several additives compared to the other glass compositions. It seems that the composition of bismuth glass would be reacted with additives, considering that the frequency of occurring pore is the highest in Fig. 2.

Table 3 Distribution of pores in thick films of 260㎛×195㎛ (in Fig. 2)

Samples	No. of pores	Volume fraction (%)
P1	2756	10
P2	247	1
B1	3579	75
B2	3465	15
Z1	3026	12
Z2	2955	9

Table 3 shows the distribution of pores in the thick films. Although B1 and B2 have similar number of pores, its volume fraction of pores show a certain difference. As shown in Fig. 3, the distribution of pore size in B1 indicates bigger pores in the range of >8㎛ than in B2.

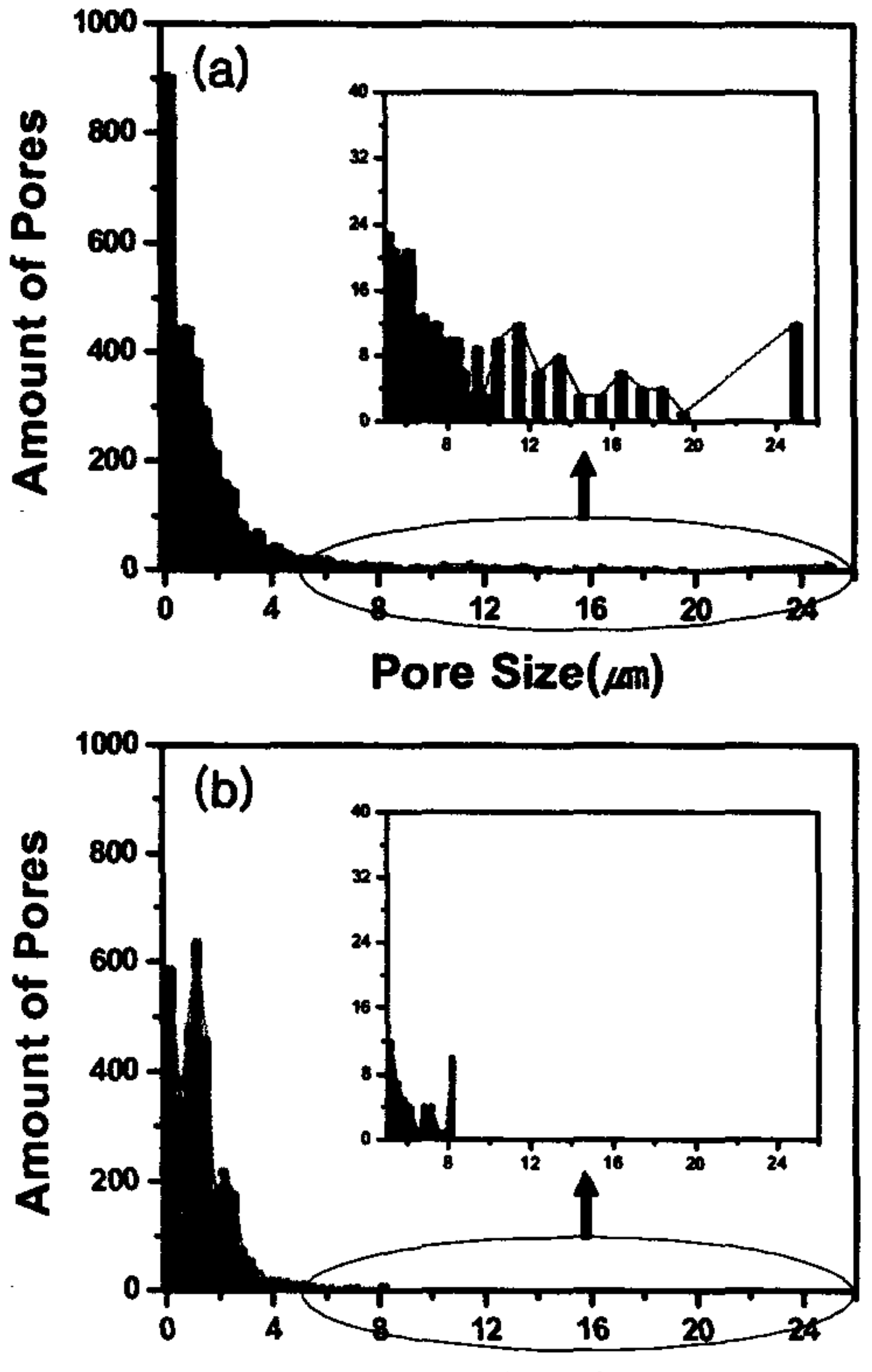

Fig. 3 Distribution of pore size B1 and (b) B2

The thick films that does not contain additives shows much more high transmittance than the thick films used additives as suggested in Fig. 4. Also, the transmittance of bismuth glass is extremely reduced when it contains several additives compared to the thick films that does not contain additives.

Regarding the reaction mechanism between additives and frits, further research should be carried out based on the current work.

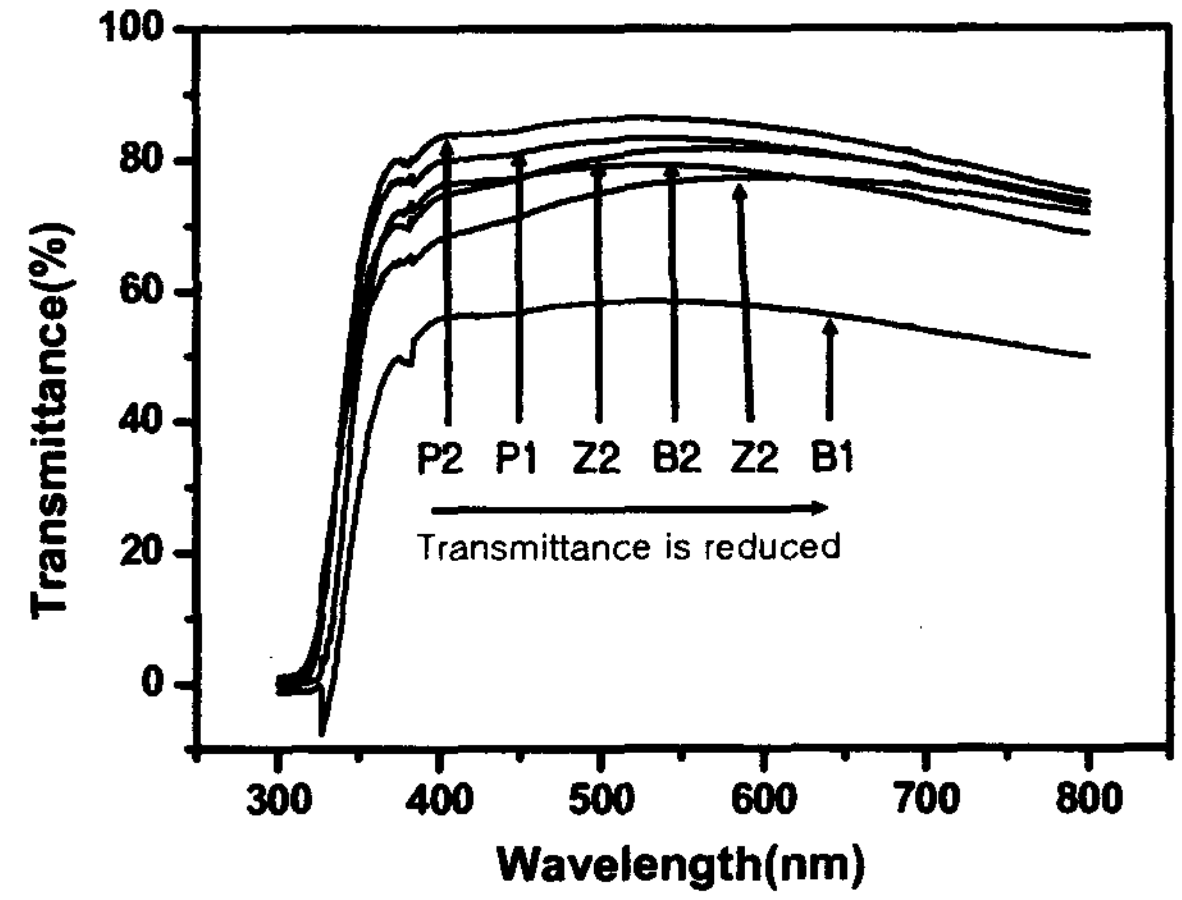

Fig. 4 Transmittance of thick films

4. Conclusion

We have used a screen-printing method to make thick films of lead-oxide glass and lead-free glass using different additives, and analyzed and compared the properties of the thick films. The transmittance and distribution rate of pores of lead-oxide glass system and boric-zinc glass system were slightly influenced by additives, but bismuth glass system was strongly influenced. The transmittance was extremely reduced and the number of pores was significantly increased. The additives used for lead-oxide glass were also suitable for boric-zinc glass powder, but not for bismuth glass.

5. Acknowledgement

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6. References

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