The Study on the Fabrication and Characterization of Dielectric Materials of Front and Back Panel for PDP(Plasma Display Panel)

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Abstract

The glass compositions of $PbO-SiO_2-B_2O_3$ system and $P_2O_5-PbO-ZnO$ system for the transparent dielectric materials for front panel and $P_2O_5-ZnO-BaO$ and $SiO_2-ZnO-B_2O_3$ for the reflective dielectric materials for back panel of PDP(Plasma Display Panel) were investigated. As a transparent dielectric materials for front panel, $PbO-SiO_2-B_2O_3$ glass showed good dielectric properties, high transparency and proper thermal expansion matching to soda-lime glass substrate. And the reflective dielectric materials for back panel were prepared from parent glass of $SiO_2-ZnO-B_2O_3$ system and oxide filler. It was found that these glass-ceramics are useful materials for reflective dielectric layers, as those have a similar thermal expansion to soda-lime glass plate, high reflectance, low sintering temperature.

Introduction

Various glass materials are used in PDP e.g. soda lime glass, dielectric glass materials, sealing glass, glass tube etc.

Transparent dielectric materials for front panel require high transparency, good thermal expansion matching to glass substrate, high breakdown voltage etc. To achieve these characteristics variety of glass compositions were examined. The properties of dielectric material and the fabrication process are investigated. The dielectric constant of transparent dielectric materials is 12~13 and transmittance of 20 ㎛ thick fired film on 2.8 mm thick substrate is 85%.

Of a variety of glass-ceramics, especially high PbO-contained glass ceramics containing more than 40% PbO have been most broadly utilized for past few years in PDP device because of its low working temperature below 580°C for sintering, which is necessary to prevent deformation of glass plate[1]. However, due to a environmental and human health problem as well as deterioration of properties by thermal process, high PbO-contained glass-ceramics are no longer satisfactory for dielectric layer in PDP device. We have extensively studied a promising alternative for non or low PbO-contained glass-ceramic, and consequently obtained new glass-ceramic which is practical to dielectric layer in PDP device, satisfying the requirements for dielectric layer as previously mentioned.

Experimental Procedure

1. Transparent dielectric material for front panel

The raw materials were mixed to get a designed composition. Then this mixture was melted in a platinum crucible at 1200 ℃ for 1 hour with stirring and the melt was quenched in a quenching roller to make flakes. The glass flakes was pulverizes in a ball mill to obtain a glass powder. Transition temperature (Tg) and sag temperature (At) of glass was determined by differential thermal analyzer (DTA) using glass powder and coefficient of thermal expansion (CTE) of bulk glass (5mm× 5mm× 25mm) was measured by dilatometer. The relative dielectric constant was measured by impedance analyzer using 10mm× 10mm× 1mm bulk glass.

The glass powder was mixed with an organic vehicle which consists of ethyl cellulose, butyl carbitol acetate and butyl carbitol to make a glass paste.

The glass paste was coated on a soda lime glass substrate by screen printing method and then dried 130℃. The coated glass substrate was heated at a firing temperature for 50 minutes. Transmittance of fired 20 ㎛ thick film on 2.8mm thick glass substrate was measured by spectrophotometer with integrated sphere.

2. Reflective dielectric material for back panel

Table 1 represents the compositions of the parent glass and oxide filler used in this study. The paste with optimized rheology were printed onto soda-lime glass plate and fired to sinter the glass particles at temperature below softening point of glass plate. Differential thermal analysis (DTA) was conducted on parent glass and mixed powder with nucleating agents, respectively. CTE on sintered samples with a dimension of 2.5mm× 5mm× 2mm were measured in the range 20°C to 600°C utilizing a dilatometer. Optical measurements were made on sintered samples using a spectro-photometer to evaluate reflectance. Samples etched in 10% HF solution were subsequently used in SEM with a view of observing surface morphology and crystal shape within sintered samples.

Table 1. Composition of parent glass and oxide filler

No	d_{50} (㎛)	Composition
M1	2.5	$P_2O_5-PbO-BaO$ glass + TiO_2 filler
M2	2.2	$SiO_2-ZnO-B_2O_3$ glass + TiO_2 filler
M3	2.7	$SiO_2-ZnO-B_2O_3$ glass + TiO_2 filler + BPO_4 filler

Results and Discussion

1. Transparent dielectric material for front panel

Table 2. shows the range of glass composition and properties investigated. The glass composition of $PbO-SiO_2-B_2O_3$ glass is PbO 60~80, SiO_2 8.3~20, B_2O_3 8.3~20, ZnO 0~15, Bi_2O_3 0~10, CeO_2 0~5, SrO 0~5, Na_2O 0~2, K_2O 0~2 and that of $P_2O_5-PbO-ZnO$ glass is PbO 0~50, P_2O_5 30~50, B_2O_3 0~10, ZnO 0~47, BaO 0~16, Al_2O_3 1.9~2, As_2O_3 1.9~2. Table 2. shows the properties of these glasses.

Table 2. The properties of $PbO-SiO_2-B_2O_3$ and $P_2O_5-PbO-ZnO$ glasses

$PbO-SiO_2-B_2O_3$				$P_2O_5-PbO-ZnO$			
Tg	At	α	K	Tg	At	α	K
321	355	64	9.6	389	404	75	7.8
~432	~457	~112	~15.9	~492	~520	~105	~10.4

Among them, considering the matching of CTE, Tg, dielectric constant and transparency, 3 glasses were chosen as the best composition.

The transmittance of transparent dielectric glass varies with the firing temperature and thickness. According to this relation optimum condition for firing can be deduced. Fig.1. shows the variation of transmittance of $PbO-SiO_2-B_2O_3$ with firing temperature and number of coatings. The transmittance increases rapidly to 490 ℃ with firing temperature and decrease slowly over this temperature. And it increases again over 550 ℃, the minimum.

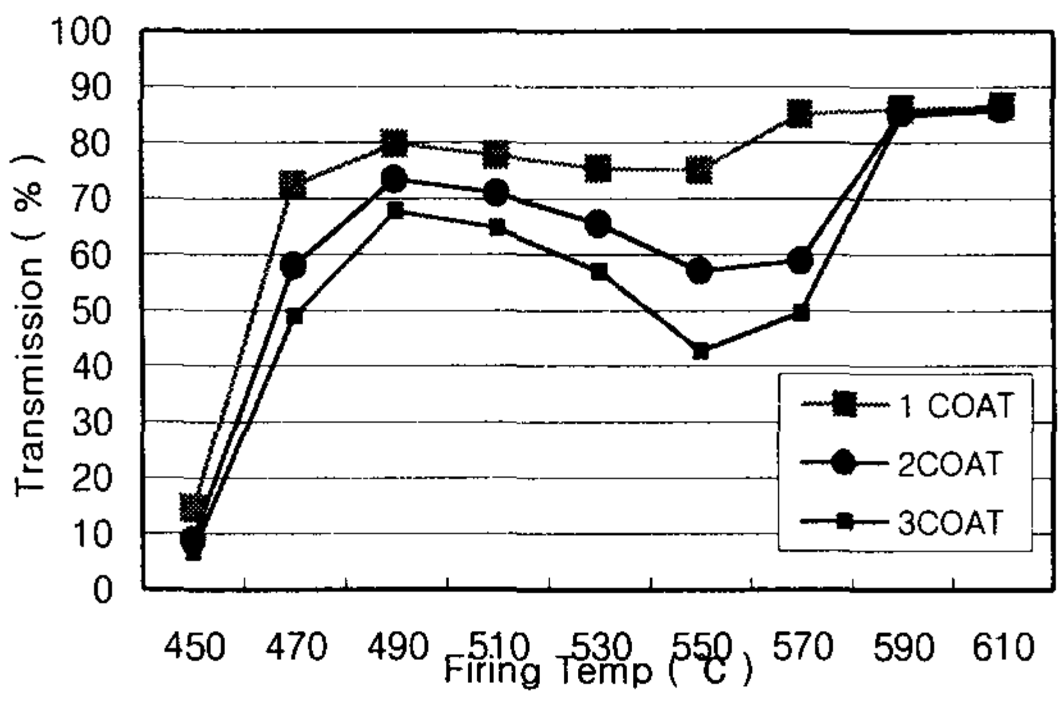

Fig.1. The transmittance of $PbO-SiO_2-B_2O_3$ with firing temperature and number of coatings.

2. Reflective dielectric material for back panel

The $P_2O_5-ZnO-BaO$ system is significantly higher than $SiO_2-ZnO-B_2O_3$ system in dielectric constant, which increased proportionally with increasing TiO_2 content. It is assumed that this result is attributable to increase in portion of newly formed crystal and remnant TiO_2(anatase) crystal in glass matrix [2,3]. In $P_2O_5-ZnO-BaO$ system, the microcrack occurred due to considerable difference of thermal expansion coefficient, approximately $10x10^{-7}$/℃, with soda-lime glass substrate under sintering at 550℃. The $P_2O_5-ZnO-BaO$ system exhibited 5% lower than that of $SiO_2-ZnO-B_2O_3$ system in reflectance in Fig.1, and it can be deduced that this result arose from the difference at reflective index of parent glass. In particular, $P_2O_5-ZnO-BaO$ glass-ceramics showed monotonous increase with increment of TiO_2 filler, whereas $SiO_2-ZnO-B_2O_3$ glass ceramics, irrespective of TiO_2 content, showed no remarkable change. The reason for this phenomena can be speculated from the fact that the fraction and size of crystal phase containing Ti rose proportionally with increase of TiO_2 content in $P_2O_5-ZnO-BaO$ layer but maintained constantly without any remarkable change in $SiO_2-ZnO-B_2O$ layer. In sharp contrast, M3 sample with TiO_2 as 1st filler and BPO_4 as 2nd filler exhibited high reflectance over visible light range because of dense structure and ZnO crystal phase precipitated in glass-ceramic matrix by heat treatment for sintering.

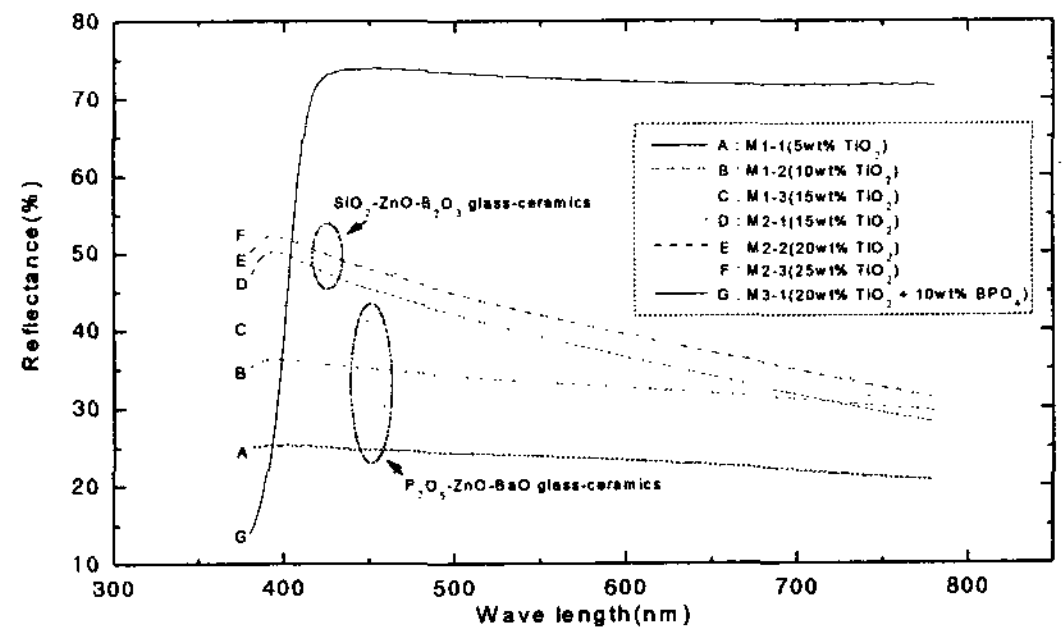

Fig.2 Reflectance of M1,M2 and M3 samples as a function of wavelength

The abnormal growth like nodular shape was observed on dielectric layer of $P_2O_5-ZnO-BaO$ glass-ceramics, while the layer of $SiO_2-ZnO-B_2O$ glass-ceramics layer kept plane surface with no unusual growth. As the results of discharge test on 7.5"-diagonal panel, some of favorable results were obtained in the panel with sample M3 as shown in Table 4.

Table 3. Result of plasma discharging test in 7.5" diagonal PDP panel

No	Brightness (Cd/m^2)	Back-scattering (Cd/m^2)
M3	103	1.4
Reference	80 - 100	4 - 6

Conclusion

We investigated the glass forming ranges of $PbO-B_2O_3-Al_2O_3$ and $P_2O_5-PbO-ZnO$ ternary system. As a result of these investigation, we developed transparent dielectric material and reflective dielectric material for PDP panel.

It was concluded that the glass-ceramics composed of $SiO_2-ZnO-B_2O_3$ glass and oxide filler are potential candidate for reflective dielectric layers in PDP device. In especial, it is notable that the addition of TiO_2(20wt%) and BPO_4(10wt%) as fillers to $SiO_2-ZnO-B_2O_3$ glass played a major role in acquiring lower dielectric layer with good properties in PDP device.

References

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