Development of Transparent Dielectric Paste for PDP

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Abstract

Plasma display panel is a potential candidate for HDTV, due to the fact that the expansion of screen size is much easier using thick film technology. In this study, transparent dielectric materials using lead borosilicate glasses is developed, which satisfy the requirements of dielectrics for PDP. Paste is made of this glass composition. The paste has thixotropic behavior suitable for screen printing. The paste shows more thixotropic behavior as the particle size decrease. After firing, cross sectional area was analyzed by SEM. The void of fired thick film was removed using bimodal particle system. The dielectric showed good adhesion characteristics.

I. Introduction

Plasma display technology is an attractive method for fabricating large area HDTV(40 to 60 inch screen). Thick film paste is used for fabricating plasma display panel. Thick film technology is cheaper and easier to expand the size of panel compared to thin film technology. The plasma display construction consists of address, sustain electrodes which are formed onto the rear and front substrates of glass. The electrodes are insulated using a dielectrics to protect electrodes and improve performance[1]. Electrons collide with the dielectric surface in the electric field. It creates the wall charge. Memory function is attained by this wall charge effect[2]. Barrier ribs are utilized to form individual pixels.

In this study, transparent dielectrics materials were developed. The dielectrics used in this experiment is lead borosilicate glass. The demands for dielectric glass are as follows. Dielectric constant must be 10-14, optical transmittance must be higher than 80% in visible range, the coefficient of thermal expansion must match to that of the glass panel to prevent cracking and thermal stresses. The softening point must be 50-100℃ lower than the firing temperature(530-600℃).[3] Paste, which consists of dispersed functional phase in organic vehicles, was made of this glass composition. The transmittance of fired thick film was measured. The microstructure of fired thick film was controlled by the different particle size functional phase systems in the paste.

II. Experimental Procedures

The glasses were fabricated by quenching method. The melting conditions were 1050℃, 1 hours. The dielectric glass composition in this experiments is summarized in Table I. The glassification was confirmed by powder x-ray diffraction. All glasses were annealed at 480℃ 30minutes for thermal analysis. The transition point, softening point, linear coefficient of thermal expansion were measured using the dillatomter(Netzch dillatometer 402), heating rate was 10℃/min. The dielectric constant of polished samples was measured by RF impedance/material analyzer(Hewlett Packard 4291A) at 1 MHz.

The PD70 glass is suitable for dielectrics of PDP among these glasses. So the paste is made from PD70 glasses. Quenched PD70 glass was comminuted in an agate mortar. After filteration with 60 mesh sieve, the powder was pulverized in an attrition mill. Different mean particle size, 5.14㎛, 1.43㎛. powder was obtained with different milling time. Three pastes were made from that glasses. The first consists of 5.14㎛ glass powder. The second consists of 1.43㎛ glass powder. The third consists of the mixed powder of previous two. The solid content is all the same. Organic vehicles consists of a solvent binder plastisizer. Buthyl carbitol acetate, buthyl carbitol mixed solvent was used. This mixed solvent which slows the evaporation rate prevent the viscosity degradation after long time duration, and dissolves the binder well[4]. Binder used is ethyl cellulose n-type. Plastisizer is dibuthyl phthalate considering the compatibility with binder. The organic vehicles and glass powder were premixed in a stirrer. Wetting occurred in this premixing procedure. Paste was mixed in a 3 roll mill after premixing. Three roll mill consists of feed roll, center roll, apron roll. Each roll has a different rotation speed. paste was forced on to a high shear stress, agglomerates were separated, and air was removed[4]. Paste viscosity was measured using a rheometer(Haake, RV20 Plate type).

Paste was screen printed onto the soda lime glass substrate. Mask frame was 200 mesh stainless steel. Printed substrate was dried at 130℃ 20 minutes. Firing temperature was from 540℃to 600℃. Fractured surface was analyzed by SEM. The transmittance of fired thick film was measured by UV/VISIBLE spectrophotometer(Hitachi U-3410).

III. Results and Discussion

The dillatometer analysis results are given in table II. Transition point(Tg) and softening point increased, while the coefficient of thermal expansion(CTE) decreases as sample's number increases(SiO_2 weight increases, B_2O_3 decreases) at the range from PD10 to PD40. The softening point decreases as the contents of PbO increases. PD70 glasses are suitable for dielectrics in PDP considering the softening point and the CTE. Table III shows the dielectric constant of glasses. Dielectric constant increase with the amount of lead oxide. Fig 1. shows paste viscosity with the different particle size. All paste have thixotropic behavior and the paste viscosity shows more thixotropic behaviors as particle size decrease. Fig 2. shows the optical transmittance of fired thick film ,bulk glass and soda lime silicate. The optical transmittance of fired thick film increases with the temperature. And the optical transmittance of thick film fired at 580℃ is higher than 80%. The more transmittance, the better brightness in PDP. However considering the thermal compaction of glass substrate, The recommended firing temperature of PD70 glass paste is 580℃. The transmittance in ultra violet range is poor. Plasma display panel use ultra violet to excite the phosphor in operation. So UV light must be shut out. This thick film has preferable properties in UV range.

Fig 3. shows the cross-section of thick fired at 560℃. The fired thick films using the paste containing 5.14 ㎛ mean particle size powder and 1.43 ㎛ mean particle size powder shows voids. However, the thick film using the paste containing mixture powders has no void, and show good adhesion characteristics. So Using the bimodal system in paste is effective method to remove the void.

Acknowledgements

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References

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Table I. Transparent dielectric glasses system for PDP. (wt%)

	PD10	PD20	PD30	PD40	PD50	PD60	PD70
SiO_2	7.48	9.98	12.52	15.2	7.09	5.29	5.49
B_2O_3	33.45	30.64	27.85	25.12	31.66	28.21	26.52
PbO	49.93	50.04	50.21	50.57	53.86	52.90	57.62
Al_2O_3	9.14	9.34	9.42	9.19	7.39	13.6	10.37

Table II. Thermal properties of glasses CTE * 10^{-7}/℃

Samples	T_g	Softening Point	CTE(100-350℃)
PD10	476℃	510℃	81.720
PD20	469℃	512℃	75.455
PD30	484℃	518℃	46.773
PD40	490℃	530℃	38.687
PD50	471℃	503℃	82.225
PD60	480℃	510℃	73.801
PD70	472℃	497℃	60.222

Table III. Dielectric constant of glasses.

	PD10	PD20	PD30	PD40	PD50	PD60	PD70
Dielectric Constant	10.08	9.96	9.92	9.82	11.39	11.21	12.35

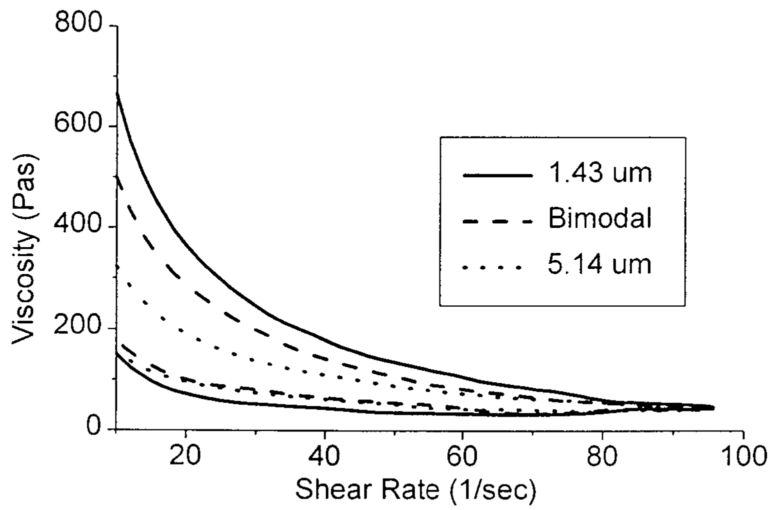


Fig 1. The change of paste viscosity with different particle size.

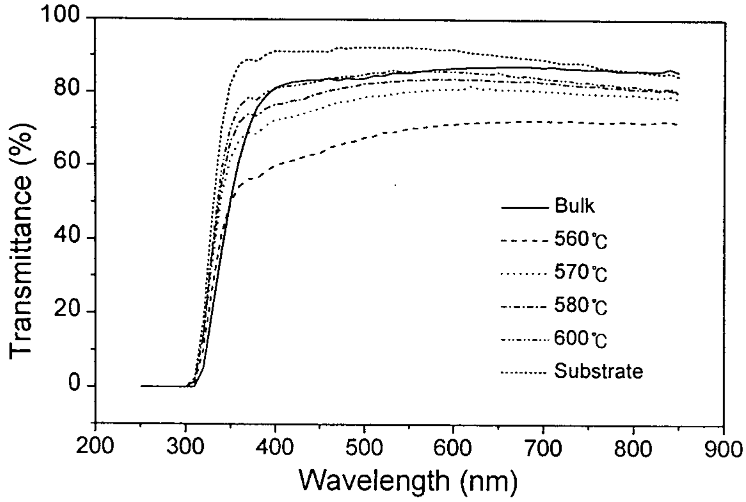
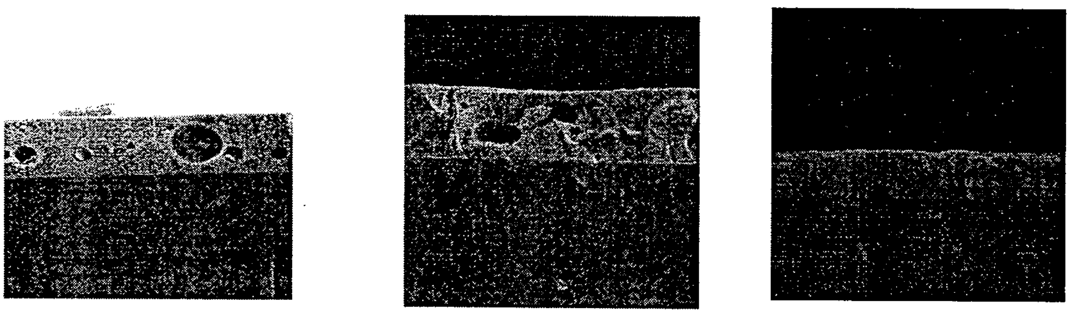


Fig 2. The optical transmittance of bulk glass, substrate & fired thick films.



5.14 um paste   1.43 um paste   Bimodal paste

Fig 3. Cross section of fired thick film at 560℃ 10 min.