Change of Transmittance by Frit Size in Transparent Dielectric of PDP

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Abstract

For the improvements in high transmittance, one of the most important factors of transparent dielectric is pore contents and pore size. This study have investigated the effect of frit size on the transmittance of zinc-boric system with a Pb-free composition. A mixed glass paste was used for thick films, which were made by screen printing methods on a glass substrate (PD200). These dielectric layers were measured for surface roughness, pores content and transmittance. The results show that increase of pore size and content have detrimental effects on the transmittance of films compared to those found in the PbO system.

1. Introduction

In the manufacturing of plasma display panel (PDP), a transparent dielectric layer is formed on bus electrode of PDP. For the development of a reasonable dielectric layer for a PDP, several properties are required: high transmittance (above 80% after firing), a low firing temperature of about 550~580℃[3].

For the improvements in luminance efficiency, contrast ratio and image quality of PDP, high transmittance is one of the most important factors of transparent dielectric. Transmittance is under the influence of pore contents, pore size and frit size. If pores remained on the fired thick film, transmittance and voltage endurance will be decreased. For a transparent dielectric in PDPs, care must be taken to use a glass composition not crystallized during glass sintering (normally 550~600℃).

In this work, we have investigated the effect of frit size on the transmittance of the $ZnO-B_2O_3-BaO$ system for transparent dielectric layer in PDP.

2. Experimental procedure

All compositions were prepared from chemically pure reagents, $BaCO_3$(99%), H_3BO_3 (99%), ZnO (99%) , SiO_2 (98%) and $CaCO_3$ (99%): In all cases the weighed mixtures (the glass compositions: $41ZnO-26B_2O_3-10SiO_2-22RO+RF$ (in mol%)) were melted in an uncovered platinum crucible at 1250℃ for 1h and then quenched on a ribbon-roll. After cooling, each of samples was prepared by the following steps.

The properties of some glass compositions were measured in both solid(bulk) and powdered (frit) forms. These samples were either annealed as solid samples at 470~490℃. Glass transition temperature (Tg) was measured by differential Thermal analysis (DTA-TA 1600, USA) and softening point was measured. The CTE of the glasses were measured using a vertical type of thermal mechanical analyzer (Rhometric, UK, TMA) with a heating rate of 5℃/min. Also, the molten glass was crushed, which glass powder were mixed by planetary mono mill (FRITSCH, pulverisette 6) for 3~5h and then dried. We obtained frit size of two type d_{50} (2.3um and 4.5um).

The glass powder was mixed with α-terpineol solution and ethyl cellulose and kneaded by use of three-roll mill to form a paste was, in turn, applied by the screen printing method to obtain a fired layer of 30um thickness on to a high-strain point glass plate (PD200). Then, the coating layer was fired at 580 ℃ for 30min in a electric furnace to form a thin glass film. The transmittance was measured for the wavelength of 550nm by use of an UV-visible spectrometer. The morphology of the coating layer formed was observed.

Table 1. Thermal properties of $41ZnO-26B_2O_3-10SiO_2-22RO+RF$ system

Tg (℃)	480
Ts (℃)	585
CTE(10^{-7}/K)	76

3. Results and discussion

The thermal properties (Tg, Ts and CTE) of ZnO-

B_2O_3-BaO glass system were investigated to be available for the dielectric in PDP as shown in Table 1.

Figure 1 shows the distribution of particle size after milling for 3~5h. The mean particle size(d_{50}) of frits was determined to be 2.3㎛(SP1) and 4.5㎛(SP2). In spite of fine powder, they contain coarse particle size, over 10㎛ also. SP2 type includes relatively larger size in the range of 20 to 40 ㎛ compared to SP1.

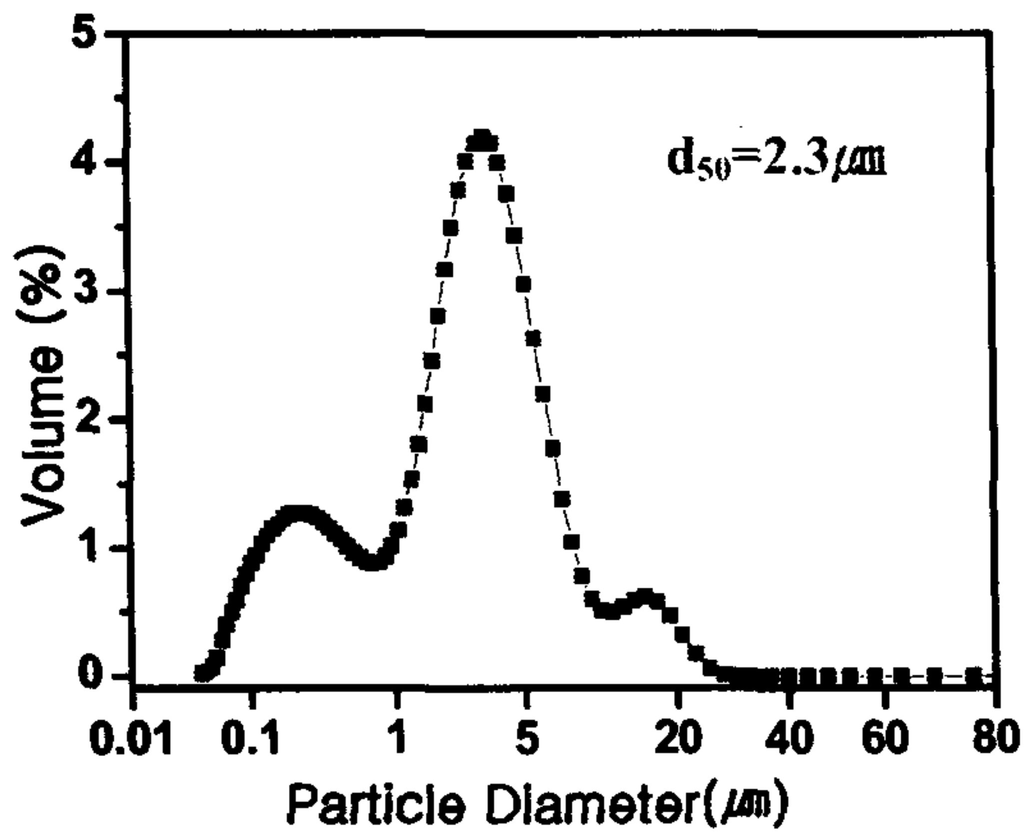

Fig. 1-1 Particle size distribution of SP1

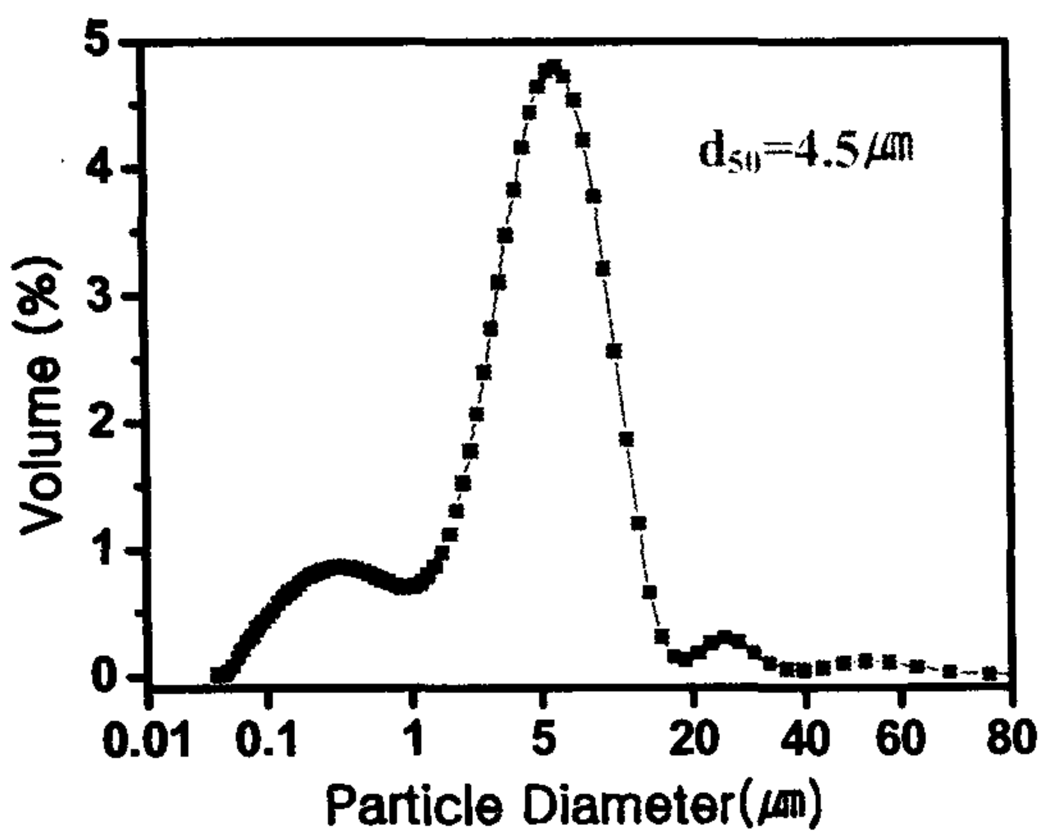

Fig. 1-2 Particle size distribution of SP2

Figure 2 shows a fired surface after coating a thick film by a screen printing. It is shown that pore contents and size increased with increasing particle size. The optimum firing temperature suggested good surface properties at 580(℃) for 30min and then the fired layer had a thickness of 30㎛.

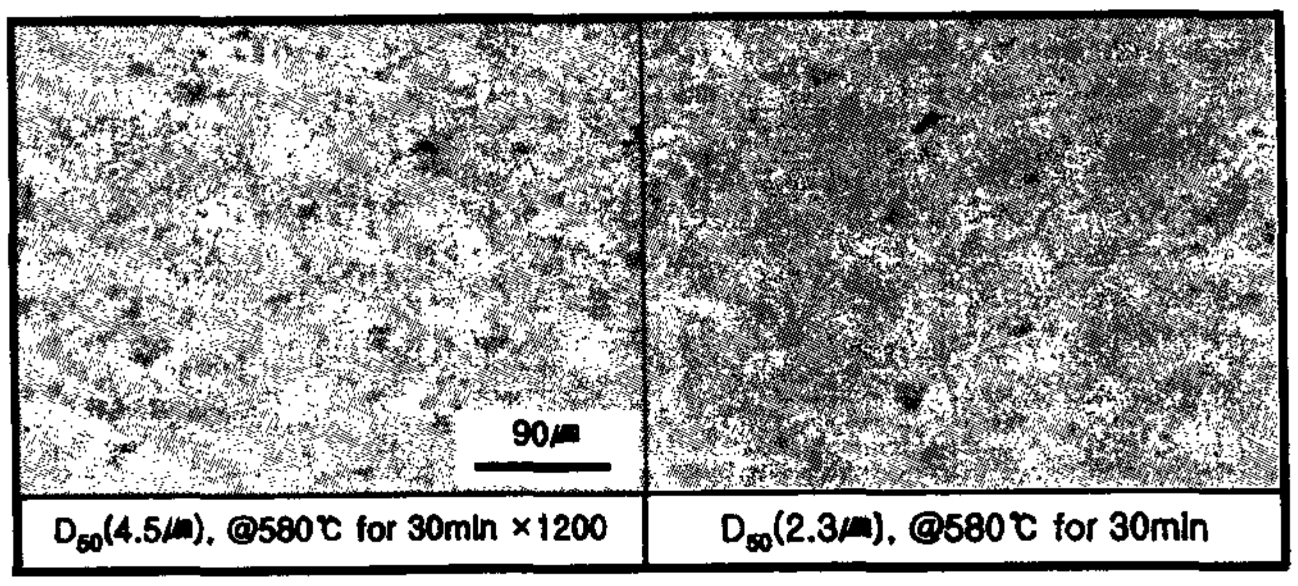

Fig. 2 Surface morphology of thick film

Fig. 3-1 shows smaller pore contents and smaller size compared with Fig. 3-2, which means that large pores are produced with increasing frit size. On the other hand, SP1 sample is high transmittance than SP2 sample as shown in Fig. 4. The Pore contents were increase as coarse particle size (SP2). The result suggests that transmittance of thick films is affected by frit size

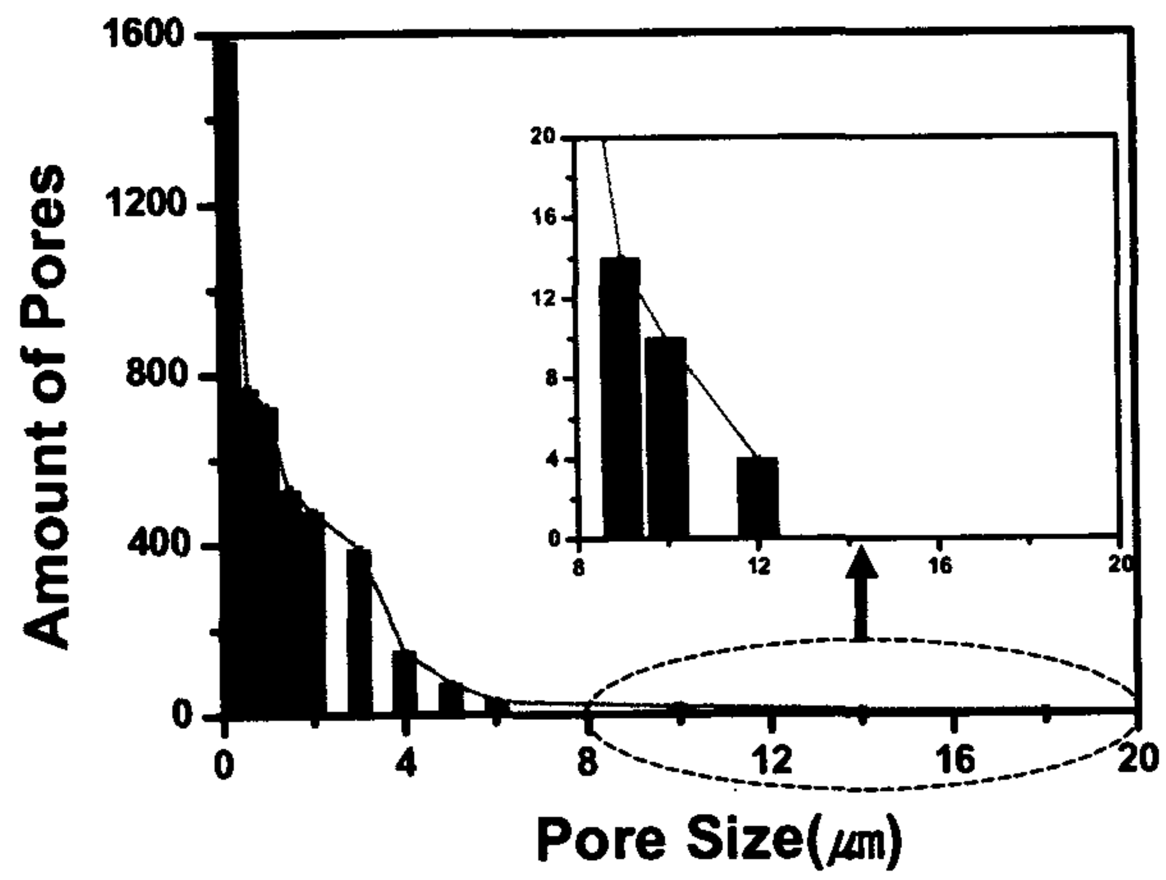

Fig. 3-1 Pore size distribution of SP1

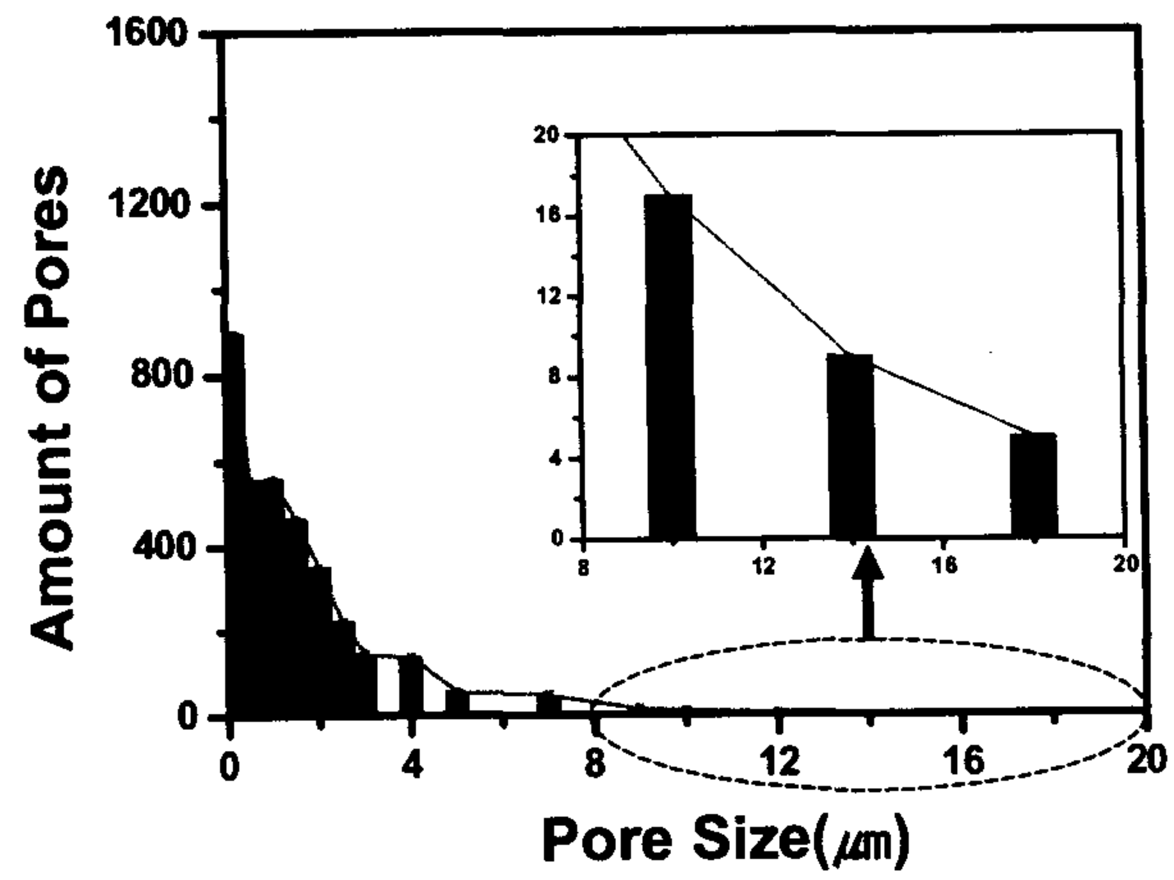

Fig. 3-2 Pore size distribution of SP2

Figure 4 represents that SP1 sample is high transmittance than SP2 sample. The result suggests that transmittance of thick films is affected by frit size.

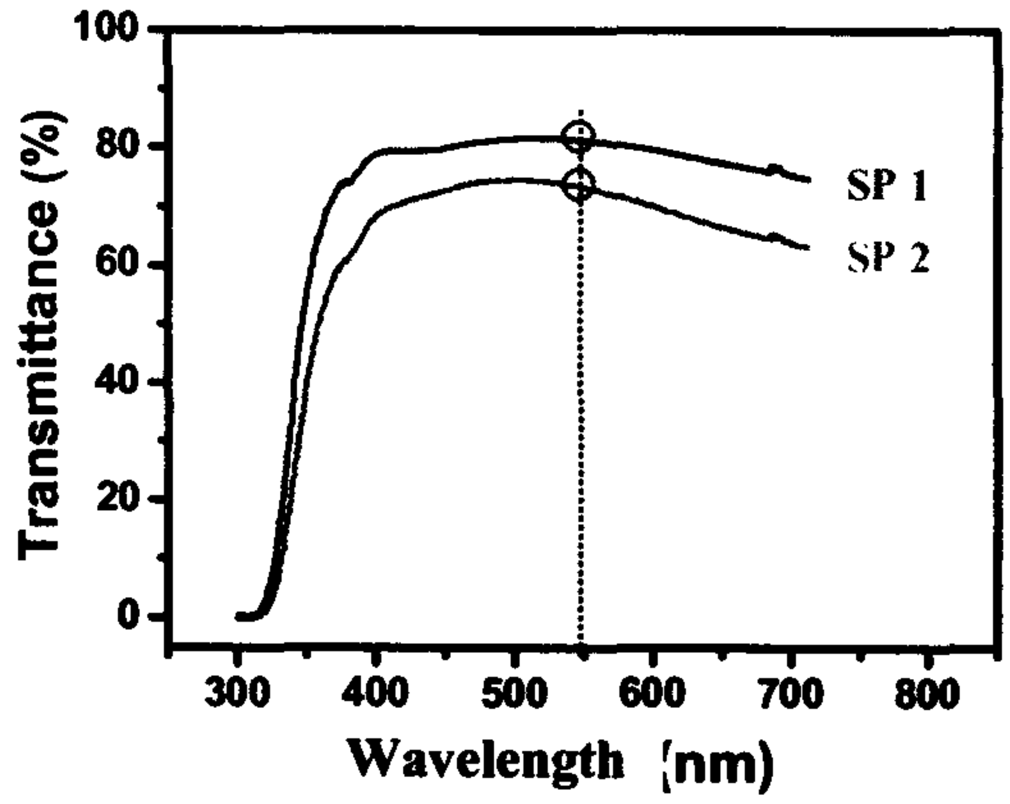

Fig. 4 Transmittance of thick films

Glass sintering rate depends on the packing structures, shapes of powder, green density, coordination number as well as particle size, viscosity and surface tension. In fact, the growth of pores occurred through gathering and grew up micro pores in the final stage of glass sintering process (Fig. 5). In this work, considering others factors are constant except the particle size during firing stage, the inherent pores, gaps between glass particles play an important role for transmittance of thick films.

For the high transmittance, the particle size(d_{50}) of the powders should be as small as possible in the case of the reductive of pore contents and size, to lower the sintering temperature. Also, during the firing process a large amount of shrinkage (up to 30%) will take place as the organic binders are burned out. At this time, if the thick film remained carbon oxide gas it may cause pinholes or bubbling in thick films during firing [2].

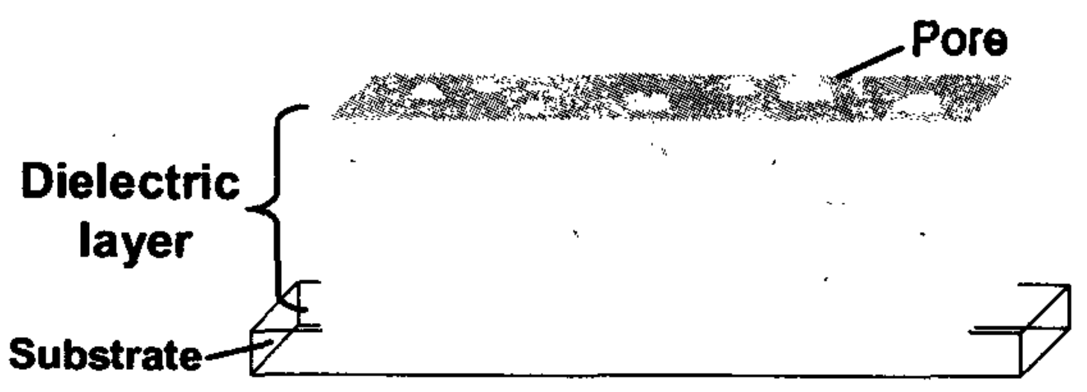

Fig. 5 Shape and location of pores in a thick film during firing stage

Fig. 6 shows the schematic modeling (b) for the relation of surface roughness and pore size on the surface of fired thick films based on the results of the α-step (a). There is an assumption of schematic modeling that the surface roughness would be designed with remain of pores on the surface of fired thick films. Therefore, it suggests that increasing pore size on the surface of fired thick films could cause a rough surface. Based on the schematic modeling, the SP2 has much more pores, which are small pore on surface of fired thick films, than the SP1.

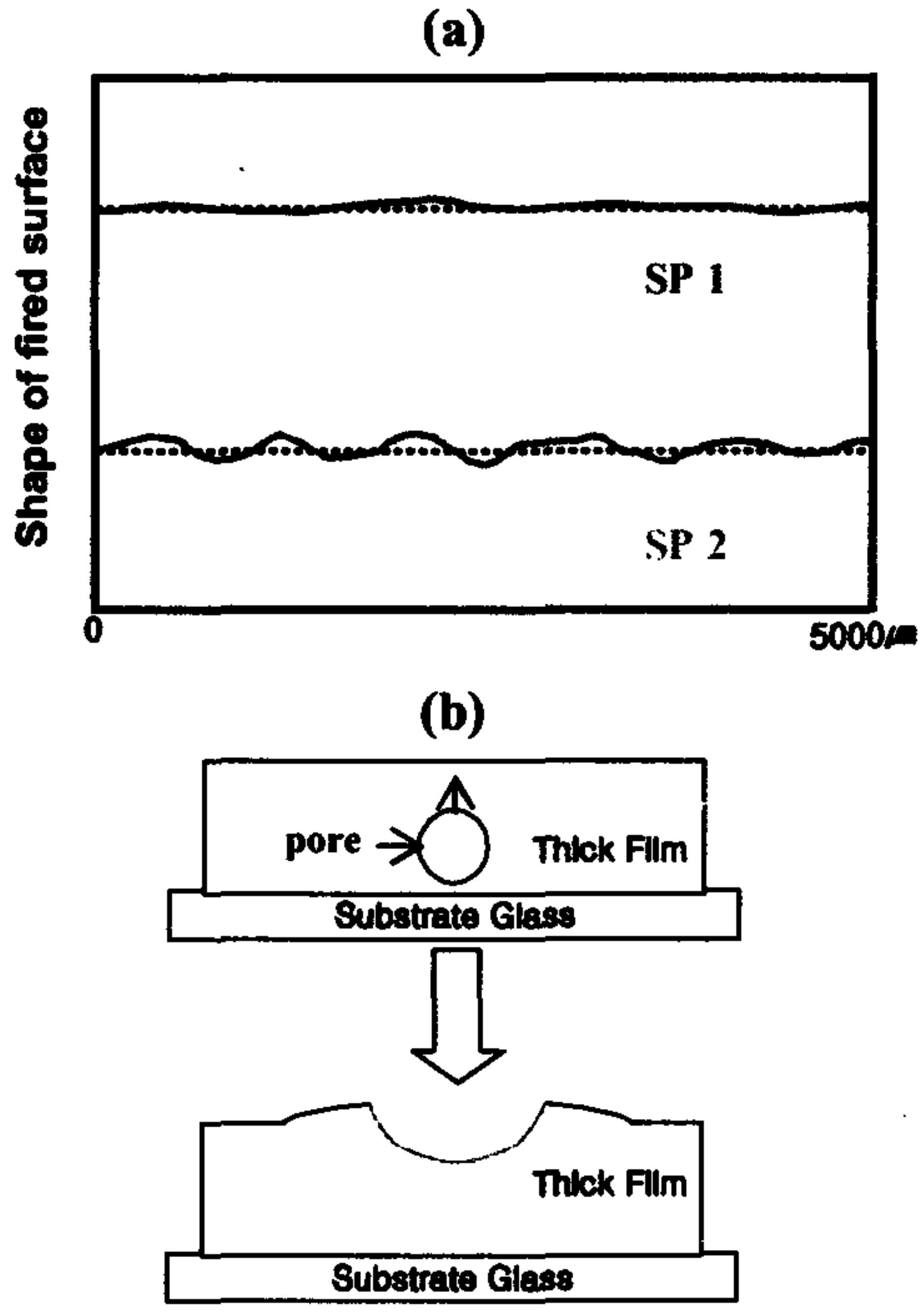

Fig. 6 (a) Surface morphology from α-step (b) a schematic diagram showing how to produce a rough surface with pores

4. Conclusion

Low firing glasses based on $ZnO\text{-}BaO\text{-}B_2O_3$ system would be replaced to Pb-based glass currently used for commercial low-firing dielectric layers. In this study, these glasses system were investigated with the glass transformation temperature (Tg<480℃), thermal expansion coefficient (76×10^{-7}/k), pore behaviors and transmittance (>70%) with different frit size. Therefore, these are indicated that high transmittance of fired thick films is considerable with frit size which could reduce the pore size.

5. Acknowledgements

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6. References

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