Effect of Frit Content in Ag Paste on the Discoloration of Transparent Dielectric in PDP

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Abstract

In PDP, a transparent dielectric is formed on a front glass substrate so as to cover bus electrodes (Ag). During the fabrication process, sometimes, a transparent dielectric reacts with bus (Ag) electrode in the range of 560-600 ℃, and the reaction gives the dielectric its yellow coloration, what is called "yellowing phenomena". In this paper, we investigated the reaction between bus electrode and transparent dielectric covered with different frit content in Ag paste.

1. Introduction

In PDP, it is necessary for the transparent dielectric to maintain discharge, to have a high dielectric strength, and to have good transparency. Such a transparent dielectric is formed by either screen printing or by sheet process using paste state containing glass frit with lead-oxide system. The lead-oxide system of low firing temperature glass has been commonly used for dielectric, barrier ribs and sealing in PDP. The frit used for dielectric has around 60-70wt% of PbO in the composition.

Recently, it is known that lead-oxide adversely affects the health of workers handling the glass powder as well as environmental pollution caused by glass waste [1]. Therefore, many countries are actively studying the development of lead-free glasses compositions [2-4] for transparent dielectric.

One of the most problems is to control the reaction between bus (Ag) electrode and transparent dielectric with lead-oxide glass (Yellowing phenomenon). Yellowing phenomenon is the color change of transparent dielectric through a reaction between Ag electrode and transparent dielectric during firing process as shown in Fig. 1. So far, the cause of occurrence and perfect solution of yellowing phenomenon is unknown. In this paper, our research purpose is to find any relationship between yellowing phenomenon and the glass frit content in Ag paste.

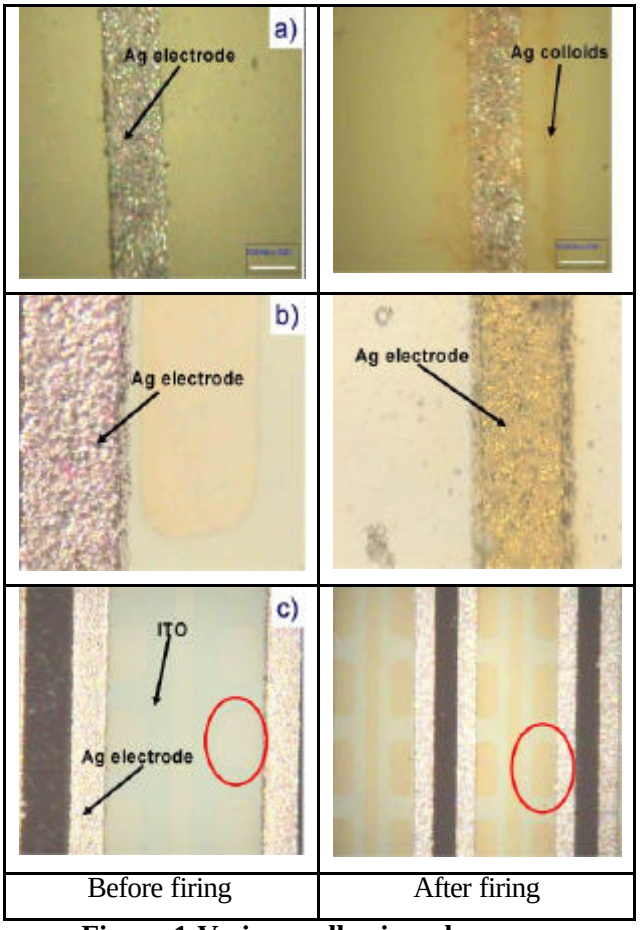

Figure 1 Various yellowing phenomena

2. Experimental Procedure

It was prepared two types samples to observe the effect of firing process on the discoloration of transparent dielectric: Ag electrode without coating and with coating a transparent dielectric. In the Ag paste, frit content (3, 5 and 7wt%) was used for this work. The Ag pastes were fabricated in a laboratory by mixing Ag powders, glass frits and polymers. The laboratory-made and commercially available Ag pastes were coated on glass substrates by a die coater method. Firing was carried out at 580℃ in a box furnace and the heating rate was 5℃/min.

As the first work, without dielectric, surface morphology of Ag electrode after firing was analyzed by a zoom stereo microscopy. On the other hand, as the second type sample, dielectric layer pastes were coated on the Ag electrode and glass substrates by a die coater method, and fired at 580℃ for 30min. And we investigated the color change as a function of thickness of transparent dielectric.

3. Result and discussion

Fig. 2 shows surface morphology of Ag electrode with frit content in Ag paste fired at 580℃.

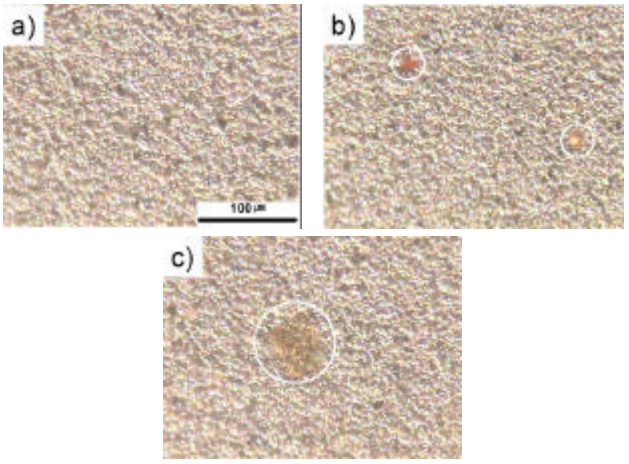

Figure 2 Surface morphology of Ag electrode with frit content in Ag paste (a) 3%, b) 5% and c) 7%

As the frit content in Ag paste increased, the electrode gave yellow color and showed gradually deep yellow color, and the range of the discoloration widened. The result is the same as found in Fig. 3 which shows the surface morphology of transparent dielectric with frit content in Ag paste fired at 580℃. With increasing the frit content in Ag paste, the transparent dielectric gave yellow color and showed gradually deep yellow color.

Table 1 shows chromaticity of transparent dielectric under frit content in Ag paste. The chromaticity was based upon at the ASTM E308-85(Computing the Colors of objects by using the CIE system) and measured. Gradually deep yellow color was found in the dielectric as the b* indicates in Table 1.

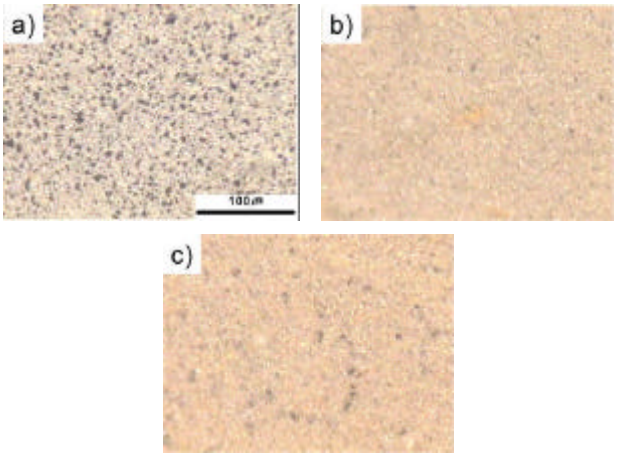

Figure 3 Surface morphology of transparent dielectric with frit content in Ag paste (a) 3%, b) 5%, and c)7%

Table 1 Chromaticity of transparent dielectric with frit content in Ag paste

Content (%)	3	5	7
L*	87	83	84
a*	8	9	9
b*	13	18	25

L* : brightness, a*, b* : color composition factor

We observed the cross section to find a yellowing phenomenon b) type which explained in the introduction (Fig. 4). Transparent dielectric around the Ag electrode showed gradually deep yellow color.

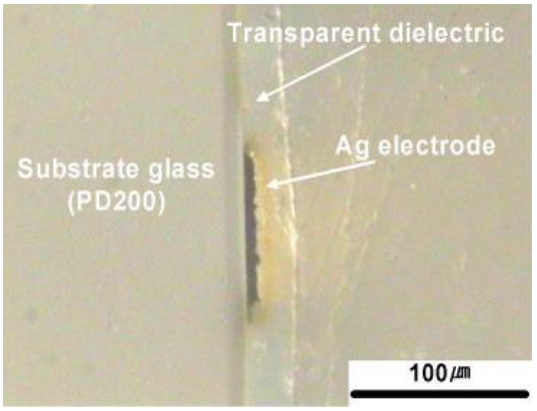

Figure 4 Cross section of transparent dielectric with Ag electrodes

Surface morphology was analyzed with thickness of transparent dielectric to find upside's phenomenon out more explicitly.

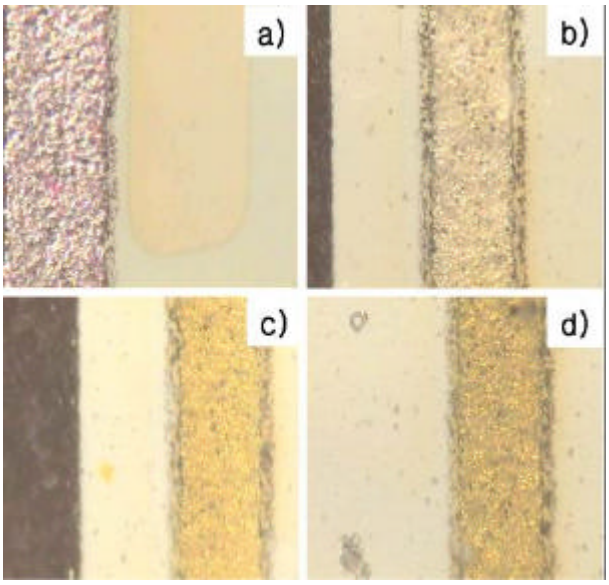

Figure 5 Surface morphology of transparent dielectric with different thickness (a) as received b) 8㎛, c) 20㎛, and d) 28㎛)

With increasing thickness of the dielectric, the transparent dielectric gave yellow color and showed gradually deep yellow color (Fig. 5).

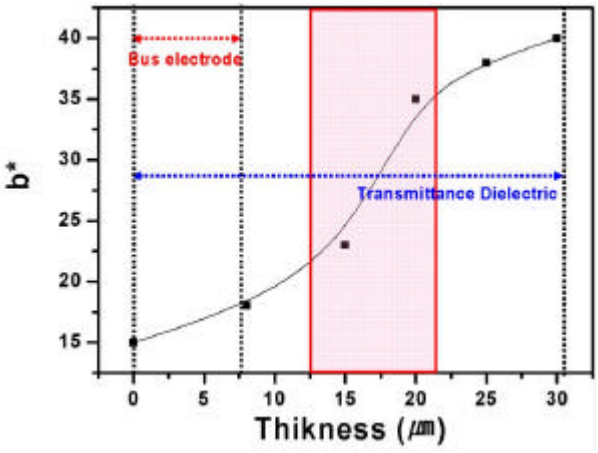

Figure 6 Chromaticity of transparent dielectric as a function of thickness

As shown in Fig. 6, the chromaticity of transparent dielectric, b* increased with increasing thickness of transparent dielectric. The b* suddenly increased in the range of 13~23㎛ of thickness. We can explain the cause of color change of transparent dielectric with the thickness (Fig. 7)

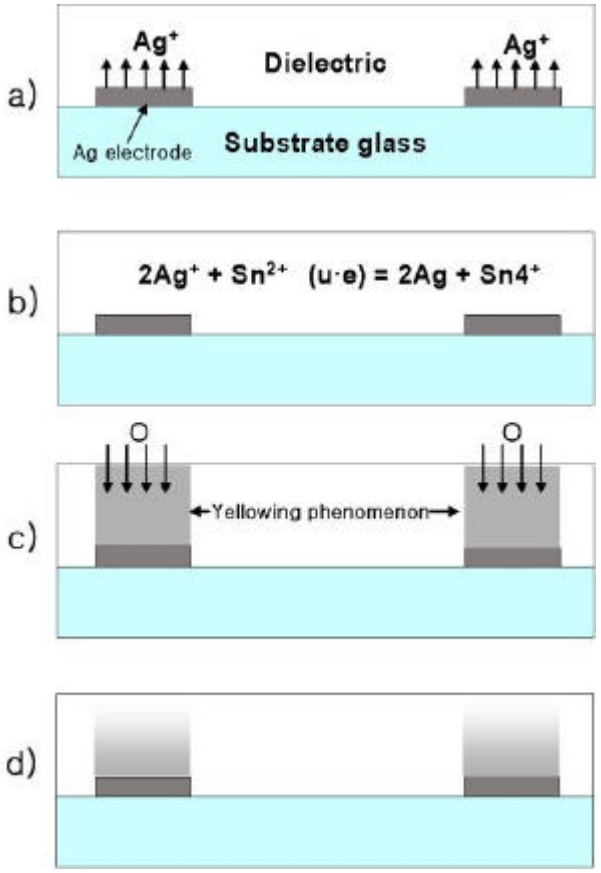

Figure 7 The cause of color change of transparent dielectric

Ag^+ ion is produced as the result of a reaction between Ag metal in Ag electrode and glass composition of dielectric, and diffuses into the transparent dielectric during firing process (Fig. 7a)). Ag colloid is made from the reaction between Ag^+ ion and Sn^{2+} in ITO electrode or unknown element in transparent dielectric (Fig. 7b). During discoloration at the dielectric, Ag colloid is oxidized by oxygen in air outside of the dielectric, so discoloration is restrained (Fig. 7c)). Finally, discoloration happens near the electrode in the dielectric and does not

happen far from the electrode (Fig. 7d)). The result suggests that the oxygen has an influence on the discoloration of dielectric.

4. Conclusion

We investigated the reaction between bus electrode and transparent dielectric covered with different frit content in Ag paste and change to follow to the thickness of transparent dielectric. Increasing frit content in Ag paste was resulted from the transparent dielectric to change yellow color and to become gradually deep yellow color. It seems that the oxygen in air affects the discoloration.

5. References

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