Secondary Electron Emission Properties with Lead and Lead-Free Dielectric in AC-PDP

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Abstract
The increase of secondary electron-emitting coefficient is effective to reduce the discharge voltage as well as to improve the luminance efficiency of PDP. We investigated the properties of ? with composition and different dielectric constants, and the microstructure of dielectric after ion collision. As a result the dielectric of PbO system showed higher ? compared with Pb-free system. However, there was no difference in ? when the MgO protective layer was covered.

1. Introduction
Low luminous efficiency is one of the major problems in the PDP. It is well known that the luminous efficiency of PDP is influenced by four steps: VUV (vacuum ultra violet) emission, VUV transport to phosphor, visible light conversion and visible light outputs. Many research institutes have studied new structure of barrier rib, driving waveform, and gas composition to accomplish higher luminous efficiency [1]. As a point of view discharge voltage, a previous study indicates that the discharge voltage in PDP cells decreases significantly with increasing ion-induced secondary electron emission [2]. Therefore, a high ion-induced secondary electron emission coefficient ? of the MgO protective layer plays an important role in lowering the discharge voltage in AC-PDP.

The role of dielectric is to work as a protecting layer of electrodes as well as a memory function by forming region wall charge state in PDP. Transparent dielectric has been considered to have only high optical transmittance as a key characteristic with neglecting diverse dielectric constants, shapes (patterns), secondary electron emission coefficient of dielectric and MgO layer. A thin insulating film (MgO), deposited on the top of the dielectric to protect from erosion by plasma ion bombardment, has high secondary electron emission coefficient. New materials of transparent dielectric, phosphors and protecting layer would be effective to increase the luminous efficiency [3]. However, little information on the effect of dielectric on the luminous efficiency is reported.

In this work, our purpose is to reveal the ? values (1) when only a dielectric (PbO and Pb-free system) deposited and (2) MgO protect layer on the dielectric (PbO and Pb-free system) and the change of microstructure (dielectric and MgO) with ion collision.

2. Experimental procedure
The 3 types (PbO, Bi_2O_3 and B_2O_3) glass compositions were designed for transparent dielectric in PDP. Glass transition temperature (Tg) was measured by an differential thermal analysis (DTA-TA 1600, USA). The softening point and 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. The glass powder was mixed with a-teripinol 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 an electric furnace to form a thin glass film.

Figure 1 shows a schematic diagram of the ?-FIB (? focused ion beam) system for direct measurement of the secondary electron emission from the dielectric and MgO layer was deposition on the dielectric layer about 5000Å. The secondary electrons were collected at the electron collector.

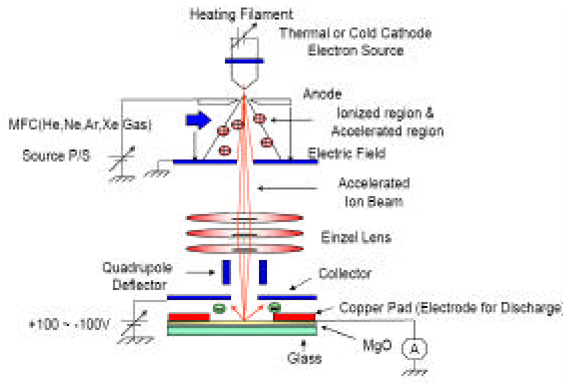

Fig. 1 Schematic diagram of the ?FIB system for measurement of the secondary electron-emission coefficient.

The background vacuum pressure of the ?-FIB before injection gas was maintained at 5.3 x 10^{-5} Torr. However, the pressure was kept at 1 x 10^{-4} Torr during ion-beam formation by the feeding gas. The anode is positively biased and can be adjusted from +80V to +200V for ion acceleration in the Ne+ neutral gas environment. The secondary electron emission coefficient ? was calculted by ? = I_e/I_i at any given collector sweeping voltage, where $I_e = I_t - I_i$ (It: total probe current, Ii: initial current) [4]

3. Results and discussion

Thermal and electric properties of each dielectric are summarized in Table 1. The results of physical properties of Pb-free system were similar to Pb-base glass system.

Table. 1 Properties of dielectric

Dielectric Comp.	Tg(℃)	Ts(℃)	CTE X10^{-7}/K	Dielectric constant
PbO-B_2O_3-SiO_2	462	568	78	12
Bi_2O_3-B_2O_3-BaO	458	564	74	10~12
B_2O_3-ZnO-BaO	480	583	77	8

Figure 2 shows the secondary electron emission coefficient ? with 3 different dielectrics without coating MgO. The PbO system was found to have the highest ? ranging from 0.033 up to 0.050 compared with other systems. It is not clear why the ? of PbO system is higher than Pb-free dielectrics. Without suggesting any data on the interface between dielectric and MgO film, it is supposed that sputtering resistance, surface condition, work function, and dielectric constant are involved in the phenomenon.

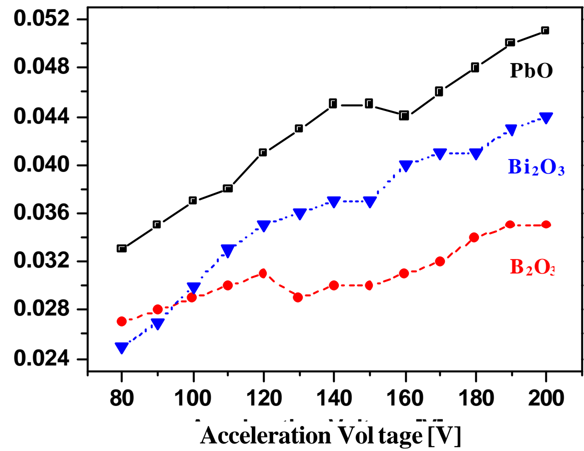

Fig. 2 Secondary electron emission coefficient ? of the dielectric s.

In the case of MgO layer coated, the dielectrics showed the result of similar ? values irrespective of dielectric composition. In the range of low voltage (<120V), however, the value of B_2O_3 system was smaller than that of other systems. The coefficient ? usually increases with increasing value of the accelerating voltage for Ne^+ ions.

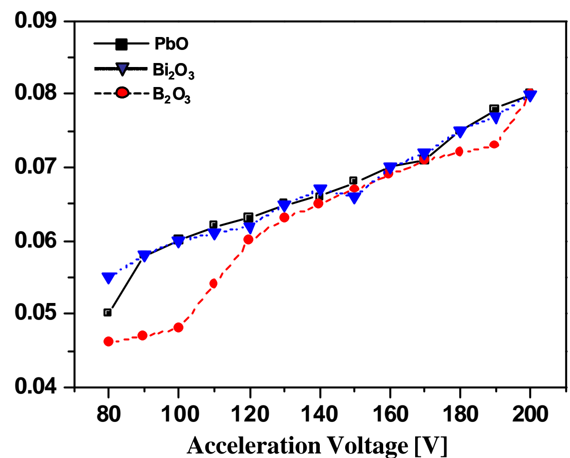

Fig. 3 Secondary electron emission coefficient ? of the dielectric with MgO layer for 3 dielectric system.

The morphology of dielectric surface after collision with ion beams, which was focused at collector about 100㎛ in the rage of acceleration voltage 80V~200V, are given in Fig. 5. As expected, PbO and Bi_2O_3 system coated with only dielectric showed very damage surface compared with the other samples with coated MgO protective layer (Fig. 5a and b). Whereas, MgO protective layer having a high sputtering resistance was found to be a small area of damage. For the comparison of physical structure of dielectric, two dielectrics (PbO and PbO-free) without coating with MgO film were exposed to ion beams: PbO system is larger width of the damage than Bi_2O_3 system but, reverse result for the depth. Also, it was observed that the PbO system had larger size of the residue in the damage area compared to that of Bi_2O_3 system. We need further research works for this result.

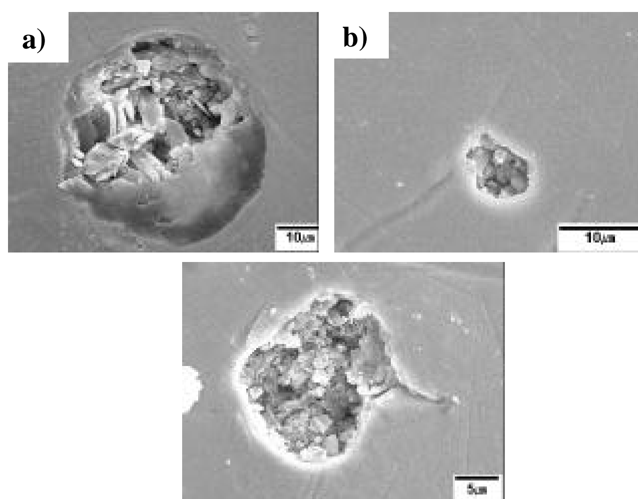

Fig. 4 SEM micrographs a) PbO dielectric and b)PbO dielectric with MgO layer, and c) Bi_2O_3 dielectric after ion collision for 2h.

The effect of different dielectric constant on the ? was investigated. The ? value for the Bi_2O_3 composition with only dielectric and with MgO protective layer are presented in Fig 4. It was not detected to find any difference in the ? value when materials with different dielectric constant were compared.

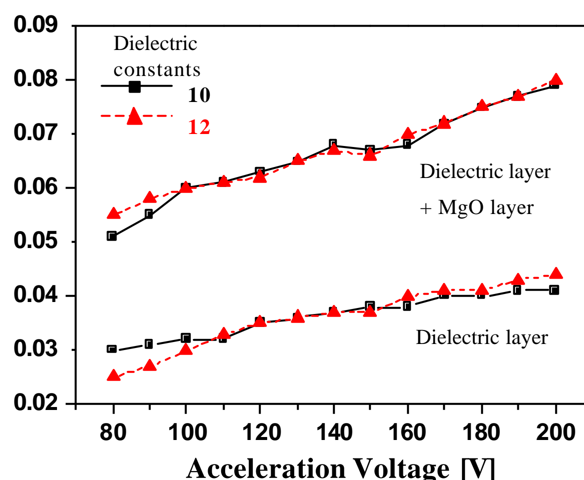

Fig. 5 Secondary electron emission coefficient ? of the Bi_2O_3 system with different dielectric constant coated with MgO layer.

4. Conclusion

For lower discharge voltage in PDP, we compared ? for different dielectric, Pb and Pb-free compositions. When only a dielectric was deposited, PbO system showed higher ? compared with Pb-free dielectric, Bi_2O_3 and B_2O_3 systems. However, there was no significantly difference in ? between PbO and PbO free systems when MgO protective layer was covered. The effect of dielectric constant on the ? was not found at all. Further research on the interface between dielectric and MgO is required.

5. Acknowledgements

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6. References

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