# The Effect of Oxygen Flow Rates on the Electrical Resistivity of MgO Thin Films in AC-PDPs

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## Abstract

*Magnesium oxide thin films were deposited with different thickness and oxygen flow rates for investigating the effects of the electrical resistivity of MgO thin films in AC-PDPs. The surface roughness was characterized by AFM. It reveals that higher oxygen flow rate generates higher electrical resistivity of MgO thin films.*

## 1. Introduction

Magnesium oxide (MgO) thin film, which is used as the protective layer in plasma display panel, is generating the secondary electrons that make the γ process to sustain the discharge. The MgO film shows the highest secondary electron emissions coefficient (γ) among the many candidates for the protective materials such as $CeO_2$, and $La_2O_3$ [1~2]. Moreover, the reduced discharge voltage results in a low cost for the PDP [3].

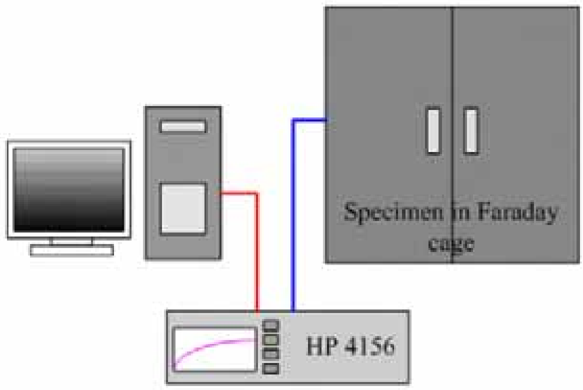
PDP is using the electrical properties of MgO thin films for the ignition and sustaining the plasma in the cells. In order to light up the cell of PDP, it needs to make the secondary electrons between ions and the surface of MgO thin film by the electric field. As a result, the electrical properties of MgO thin films must be the possible factor to influence the performance of PDP. The operation mechanism of AC-PDP is based on the gas discharge phenomenon that occurs around the protective layer that covers the dielectric layer [4]. Recently, the MgO thin films are fabricated by electron beam evaporation, because of high deposition rate. In this study, we measured the electrical resistivity of MgO thin films and the surface morphology and roughness was also characterized by AFM.

| No. | Oxygen (sccm) | Designed Thickness (Å) | Real Thickness (Å) |
|---|---|---|---|
| 1 | 40 | 5000 | 5482 |
| 2 | 10 | 5000 | 5071 |
| 3 | 40 | 7500 | 7504 |
| 4 | 10 | 7500 | 7314 |
| 5 | 40 | 10000 | 10305 |
| 6 | 10 | 10000 | 9789 |

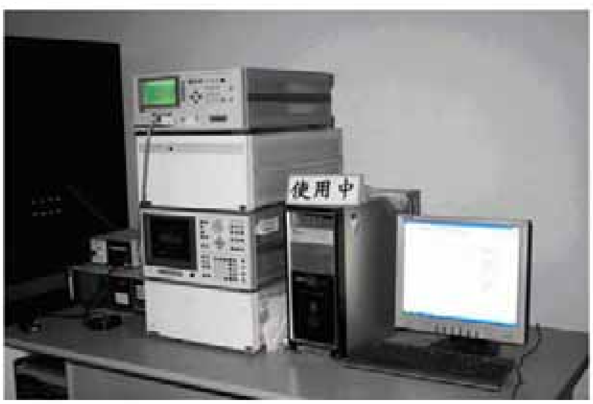
**Table 1. The deposition condition of the MgO specimens.**

## 2. Experiments

The MgO thin films were also deposited by electron-beam evaporator and the slide glass was selected as a substrate. The MgO thin films were deposited in an oxygen environment, which are the 10 sccm and 40 sccm, on the heated substrate at 220°C. The thickness of MgO was selected at 5000 Å, 7500 Å and 10000 Å by operating electron beam current 502 mA, 535 mA and 595 mA. The working pressure for MgO thin films was 2.1 x $10^{-4}$ Torr during the deposition. The deposition condition of the MgO thin films is listed in Table 1. Furthermore, the electrical properties measuring system consists of High Precision I-V Measurement Instrument, Faraday cage, Heater, and Optical Microscope. The schematic diagram of the electrical properties measuring system is shown in the figure 1. (a) and (b) shows the photograph of the measuring system. The surface morphology and roughness of MgO thin films was investigated by AFM.




(a)




(b)

**Figure 1. (a) The schematic diagram of the electrical properties measurement system and (b) the photograph of the electrical properties measurement system.**

## 3. Results

According to the electrical resistivity of MgO thin films in our experiment, the electrical resistivity significantly decreased as a function of temperature. Figure 2 shows the electrical resistivity for the 10000 Å thickness of MgO thin film under 10 sccm and 40 sccm oxygen flow rates. The resistivity of MgO thin films decreased rapidly from 25°C to 75°C and showed a stable decreasing tendency after 75°C. The electrical resistivity of MgO thin films with 10 and 40 sccm oxygen flow rate at room temperature was $2.59 \times 10^{12}$ Ω-cm and $3.23 \times 10^{12}$ Ω-cm, respectively. It shows that the electrical resistivity of MgO thin films is higher when the 40 sccm oxygen flow rate is introduced.

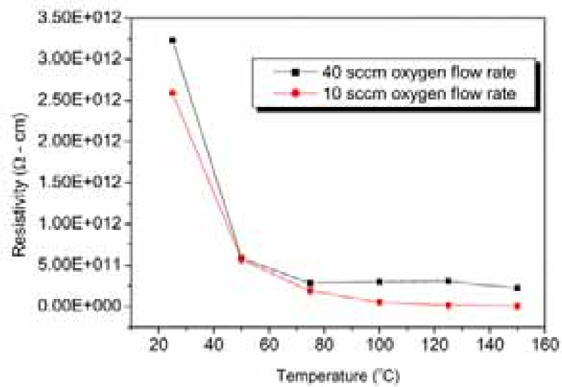
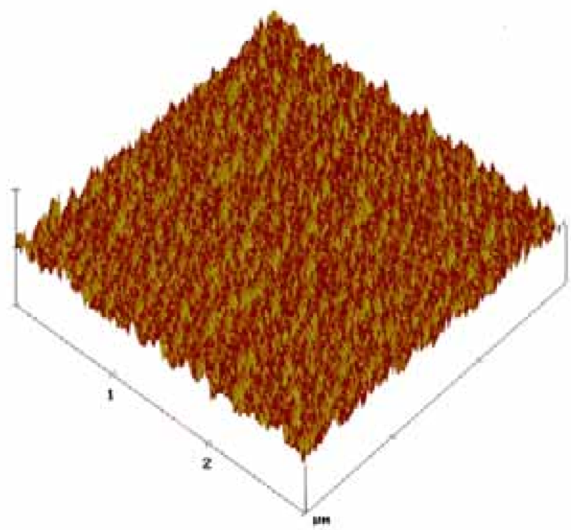


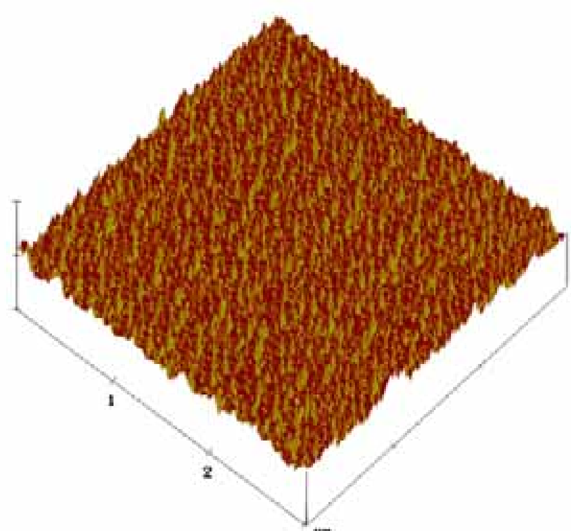

**Figure 2. The electrical resistivity of MgO thin films with 10 sccm and 40 sccm oxygen flow rate (10000Å thickness).**

The oxygen gas is used in the vacuum chamber when depositing MgO thin films by using electron beam evaporation. The function of oxygen is like the particle formation, such as atoms and ions when they are heated during evaporation. The formed MgO was reacted by the oxygen as the evaporated particles move to the substrate to collide with MgO and give rise to the recrystallized phenomena in the vacuum chamber. As a result, the crystallinity of MgO thin films is changed during the deposition. Furthermore, oxygen helps to decrease the number of excess Mg carriers, through the recombination of Mg and O, which may also contribute to the high resistivity of MgO thin films. Consequently, the higher oxygen flow rate provides higher electrical resistivity of MgO thin films which are obtained in our result.

The surface morphology of MgO thin films is also affecting the electrical properties of MgO thin film. Furthermore, if the film becomes rough, it tends to initiate cracking in the film. Then, the lifetime of PDP will be reduced by the cracks, because the dielectric layers are not strong enough for the ion bombardments to protect during long time operation. As a result, the surface roughness of MgO thin films was investigated by using AFM.



(a)



(b)

**Figure 3. (a) The surface morphology of MgO thin films with 10 sccm oxygen flow rate and (b) the surface morphology of MgO thin films with 40 sccm oxygen flow rate (10000Å thickness).**

Figure 3. (a) shows the surface morphology of MgO thin films with 10000 Å under 10 sccm oxygen flow rate and figure 3. (b) indicates the surface morphology of MgO thin films with the 10000 Å under 40 sccm oxygen flow rate. The surface roughness (RMS) of MgO thin films under 10 sccm oxygen flow rate is 2.93 nm and the other one under 40 sccm oxygen flow rate is 2.727 nm. It has been reported that the roughness decreases as the oxygen inflow rate increases because it can be attributed to the change of grain size in films. While depositing MgO thin films, the films with higher oxygen flow rate are uniform and are able to generate stable electrical properties. The increase of electrical resistivity in MgO thin films arises from the smooth surface by comparing the AFM measurement.

## 4. Conclusion

The electrical resistivity of MgO thin film with 10 sccm and 40 sccm oxygen flow rates was investigated. The higher oxygen flow rate to the evaporated MgO thin films generates higher electrical resistivity. It might be the increased recombination of Mg and O, which contributes to the high resistivity of MgO thin films. The surface roughness of MgO thin film decreased with increasing oxygen flow rate on account of the change of grain size in MgO thin films.

## 5. Acknowledgements

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## References

[1] Toshinori Urade, Toshiaki Iemori, Mitsuoki Osawa, and Norihiko Nakayama, IEEE Trans on Electron Devices, Vol.23, No. 3 (1976)

[2] Heiju Uchike, Kenji Miura, Norihiko Nakayama, Tsutae Shinoda, and Yoshifumi Fukushima, IEEE Trans on Electron Devices, Vol. 23, No. 11 (1976)

[3] Chung-Hoo Park, Young-Kee Kim, Byeong-Eon Park, Woo-Geun Lee, and Jung-Soo Cho,

Materials Science and Engineering B60, pp. 149-155 (1999)

[4] Rakhwan Kim, Younghyun Kim, and Jong-Wan Park, Thin Solid Films 376, pp. 183-187 (2000)