Structural and discharge characteristics of MgO films prepared by Arc Ion Plating (AIP) method

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Abstract

MgO thin films were deposited on glass and (100) Si substrates by an Arc Ion Plating (AIP) equipment using a magnesium metal target at various oxygen gas flow. In this work, we investigated the relationship between the structural properties and the discharge characteristics of MgO coating layers. X-ray diffraction and AFM have been used to study behaviors of the structure and surface morphology. The optical transmittance and the ion induced secondary electron emission coefficient of the MgO films have been also measured. The resistivity of the deposited MgO films was gradually increased from 0.17 G ohm/□ to 0.35 G ohm/□ with the oxygen gas flow. The growth rate of the MgO coating layer was decreased with increasing the oxygen gas flow, while the optical transmittance was improved.

1. Introduction

MgO films have been suggested as a protective layer for alternating current plasma display panels (AC PDP) [1,2], which play significant roles in preventing the failure of the dielectric layer from sputtering by ions, in lowering the firing and sustain voltages due to a higher secondary electron emission coefficient (γ) [3,4], and in allowing higher optical transmittance.

While the MgO protective layers prepared generally by e-beam deposition and reactive magnetron sputtering methods showed the suitable properties for the application of AC PDP, there are still some problems in those deposition methods, i.e. rather high sputtering rates and lower growth rate, respectively, to be utilized for AC PDP. Thus, a promoted deposition method such as an arc ion plating method, which shows higher deposition rates and high qualities of the MgO films due to lots of ionized particles and high ion energy, should be introduced to solve the problems.

In this work, MgO thin films were deposited on glass and (100) Si substrates by an Arc Ion Plating (AIP) equipment using a magnesium metal target at various oxygen gas flow. We have investigated the properties and characteristics of MgO protective coating layers with respect to the flow rates of the oxygen gas, such as deposition rates, optical transmittance, secondary electron emission and so on.

2. Experimental

The deposition of MgO films was deposited on the silicon wafers and glass substrates using an arc cathode vacuum technique. An 80 mm diameter magnesium metal of 99.99 % purity was used as the cathode target. The chamber was evacuated up to less than 7 x 10^{-6} Torr before deposition. MgO protective coatings were prepared with various oxygen gas flow rates ranged from 15 sccm to 40 sccm to investigate the effect on the structural and optical properties.

The x-ray diffraction patterns and AFM images were utilized to investigate the structural properties of the MgO films. The optical transmittance and the ion induced secondary electron emission coefficient of the MgO films have been also measured.

3. Results and discussion

Figure 1 shows the thickness of the MgO films deposited as parameters of the oxygen gas flow rates for 20 min. The growth rate of the MgO coating layers shows around 40 nm/min at the oxygen flow rates ranged from 15 to 25 sccm but drastically decreases to around 28 nm/min at 40 sccm. This abrupt decrease of the growth rate with the increase of the oxygen flows is associated with the oxidation of the Mg metal target. Namely, it is well known that the deposition mode of the arc deposition operated under oxygen ambient will change from the metal mode to the ceramic mode.

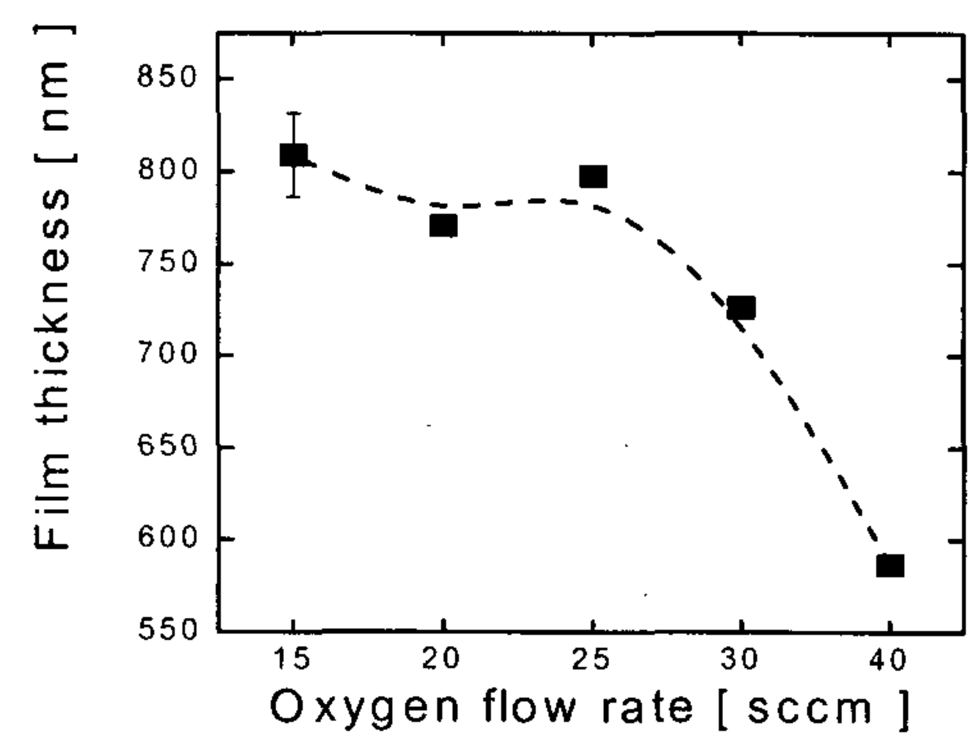
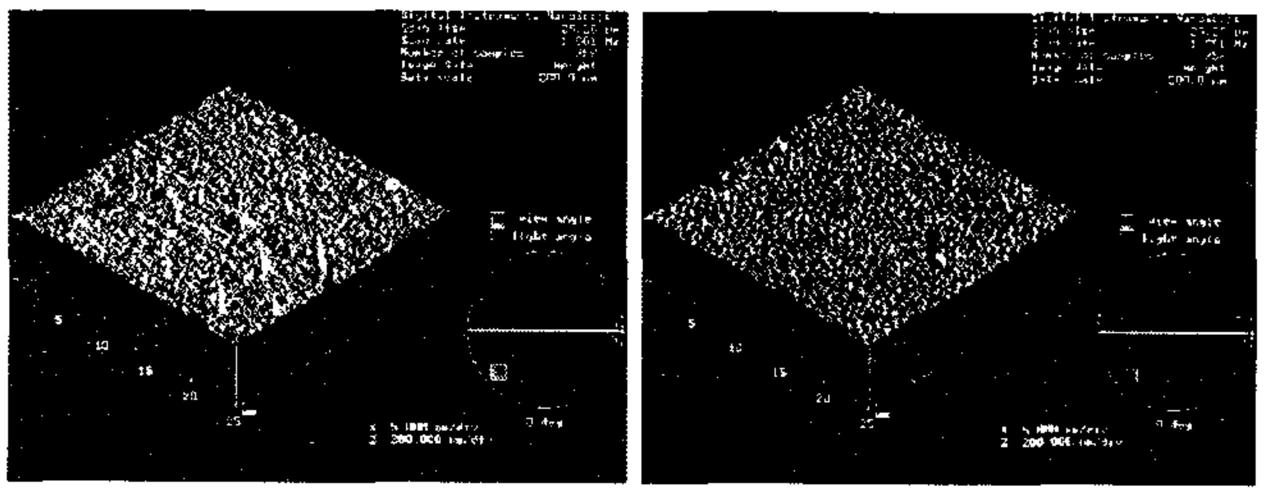


Figure 1. The thickness of the MgO protective layers with various oxygen gas flow rates.

The surface AFM images of the MgO films are presented in Fig. 2. The surface roughness of the samples were also revealed to 1.6 nm for O_2 20 sccm and 1.7 nm for O_2 30 sccm flow rates. Considering that the surface morphologies and the optical transmittance of MgO films prepared by other methods exhibited rather high roughness and irregular grains as well as lower optical transmittance compared to the our results, the newly introduced arc ion plating method revealed that the improved qualities of the MgO protective layers could be obtained.



(a) (b)

Figure 2. The AFM images of the MgO films deposited at (a) O_2 20 sccm, and (b) O_2 30 sccm flow rates.

XRD patterns have been utilized to examine the effect of the oxygen flow rates on the structural changes of the MgO films as shown in Fig. 3. For the sample of the O_2 15 sccm, the XRD pattern shows (220) preferred orientation. With increasing of oxygen flow rate, however, the texture orientation of the MgO films are changed from (220) for the O_2 15 sccm sample to random or a bit (200) for the O_2 30 sccm sample.

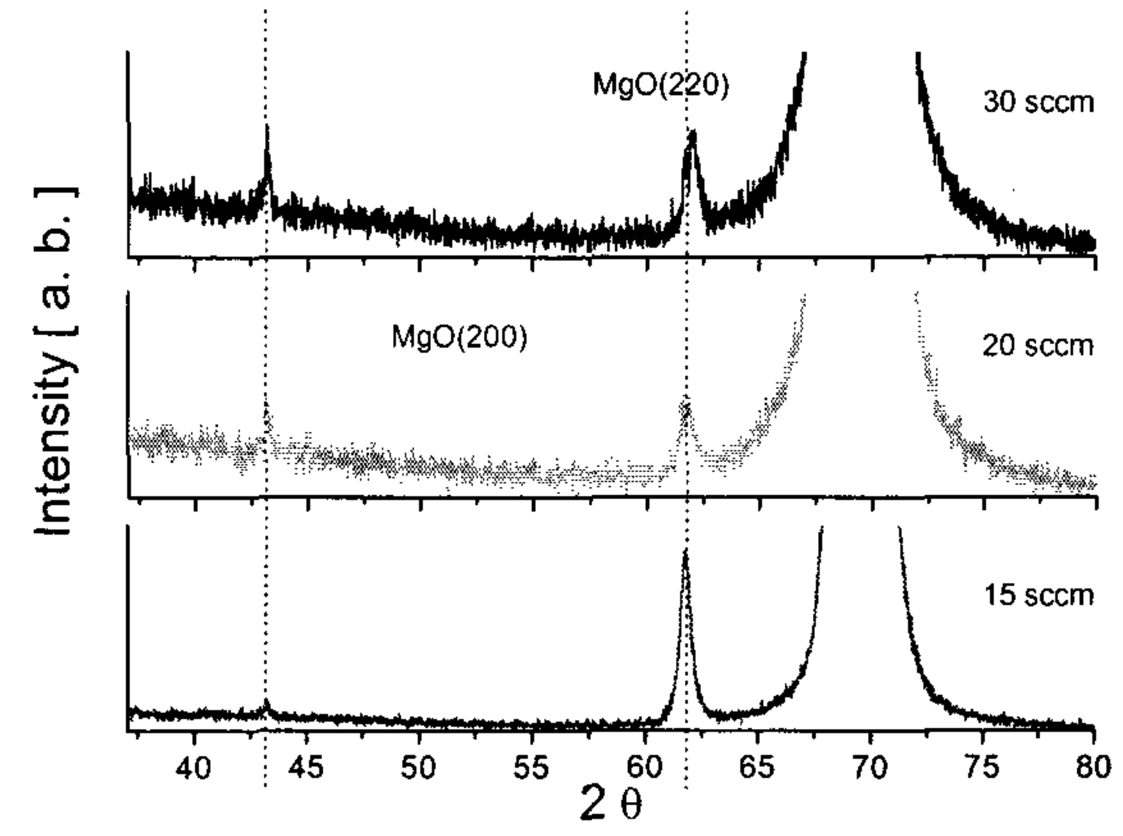


Figure 3. The XRD patterns obtained from the MgO films deposited at different O_2 flow rates.

Figure 4 shows the optical transmittance results obtained from the MgO films with respect to the various oxygen flow rates. The samples prepared with various oxygen flow rates exhibit excellent results showing around 90 ~ 98 % of the optical transmittance compared to an uncoated glass, while the sample of O_2 15 sccm shows less than 87 % of optical transmittance. For the O_2 15 sccm, the buckling occurred already during deposition the due to the induced stress of the films against the substrate, which made the decreased optical transmittance of the sample.

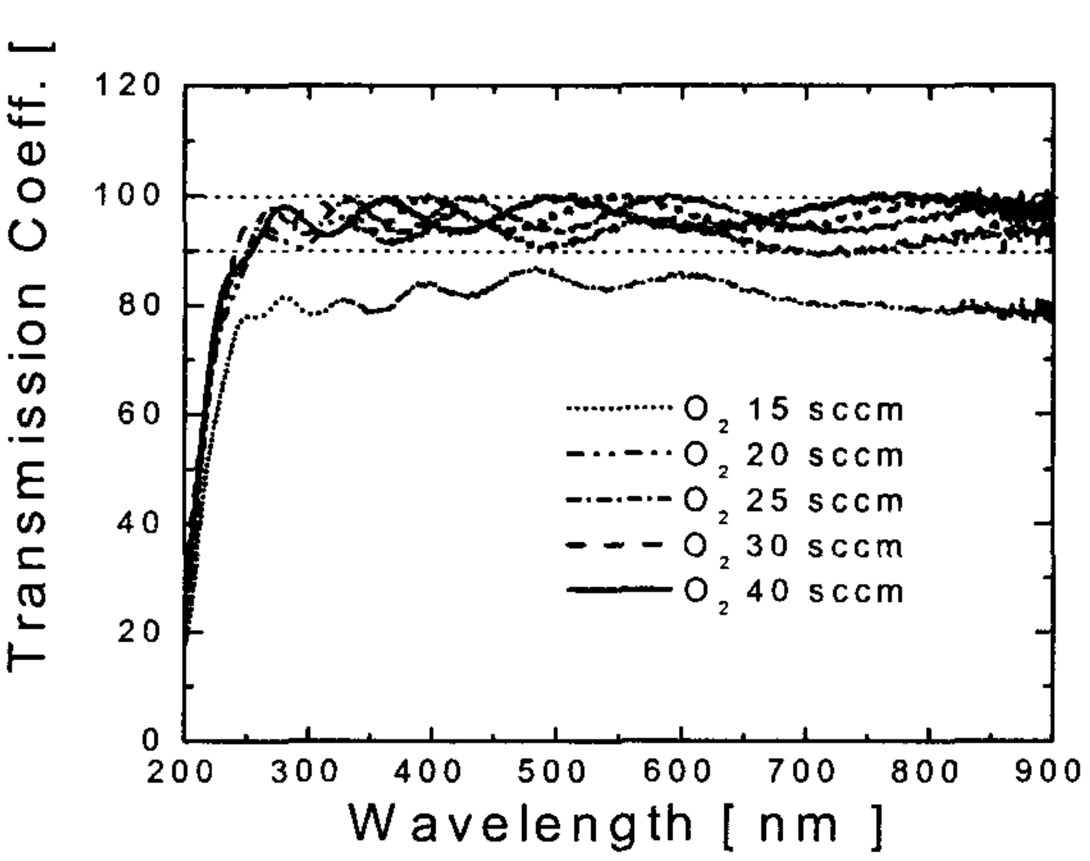


Figure 4. Optical transmittance of the MgO films with respect to the various oxygen flow rates.

The MgO protective layer should be electrically insulated. We used a four-point probe to examine the resistivity of the samples. The resistivity of the deposited MgO films, not shown here, was gradually increased form 0.17 G ohm/□ to 0.35 G ohm/□ with the oxygen flow rates.

Figure 5 shows the results of ion-induced secondary electron emission coefficient (γ) obtained at the saturation collector voltage, where the secondary electron emission current was saturated, for the different oxygen flow rates of 20 sccm and 30 sccm, respectively. The secondary electron emission coefficient was accomplished by increasing the Ne+ ion accelerating voltage from 70 V up to 200 V. The sample of 30 sccm shows higher γ from 0.04 to 0.13 than that of the 20 sccm sample.

The recent reports [4,5] that the secondary electron emission coefficient was affected by the orientation of MgO single crystal and films. Considering the result of the structural variation with the oxygen flow rates as shown in Fig. 3, thus, the different γ values of the samples is resulted from the structural differences of the samples.

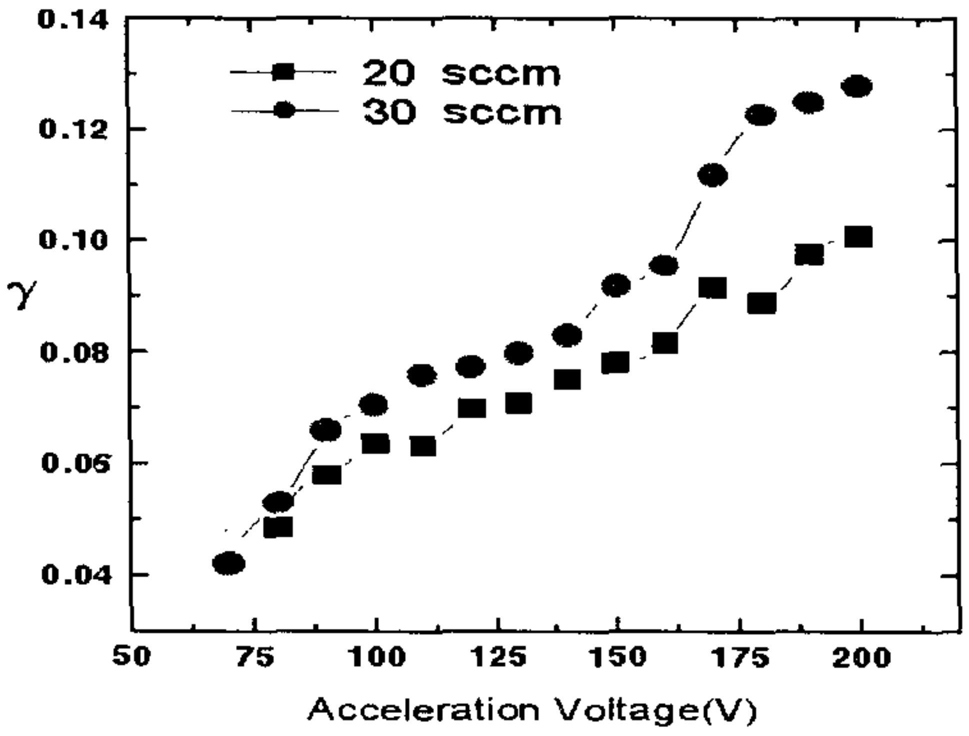


Figure 5. Secondary electron emission coefficient (γ) obtained from the MgO films deposited at O_2 20 sccm and 30 sccm flow rates.

4. Conclusion

MgO protective layers for AC PDP applications were successfully prepared by an Arc Ion Plating method using a magnesium metal target at various oxygen flow rates.

We have obtained comparatively high growth rate of the MgO coating layers, which are around 40 nm/min at the oxygen flow rates ranged from 15 to 25 sccm, and high optical transmittance showing over 90 %. With increasing of oxygen flow rates, the texture orientation of the MgO films were changed from (220) for the O_2 15 sccm sample to random or a bit (200) for the O_2 30 sccm sample.

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6. References

[1] B. W. Byrum, Jr., IEEE Trans., Electron Devices 22 (1975) 685

[2] T. Ugrade, T. Iemori, M. Osawa, N. Nakayama and I. Morita, IEEE Trans., Electron Devices 23 (1976) 313

[3] Y. P. Raizer, Gas Discharge Physics (Springer, Berlin, 1991), p. 133

[4] E. H. Choi, H. J. Oh, Y. G. Kim, J. J. Ko, J. Y. Lim, J. G. Kim, D. I. Kim, G. S. Cho and S. O. Kang, Jpn. J. Appl. Phys., 37 (1998) 7015

[5] D. I. Kim, J. Y. Lim, Y. G. Kim, J. J. Ko, C. W. Lee, G. S. Cho and E. H. Choi, Jpn. J. Appl. Phys. 39 (2000) 1890