Electro-optical characteristics of MgO protective layer after RF plasma treatment using Ar, O_2 and H_2 gases

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Abstract

One of the important problems in recent AC-PDP technology is high efficiency. In this research, we have been investigated electro-optical characteristics of MgO protective layer after radio frequency(RF) plasma treatment using Ar, O_2, and H_2 gases. The breakdown voltage order was O_2 > Ar > Non-treatment > H_2. Also, brightness order was O_2 > Ar > Non-treatment > H_2. In this experiment, the best result was obtained after O_2-plasma treatment.

1. Introduction

The MgO protective layer is an important element of AC-PDP. This thin film protects the dielectric layer above the electrodes from sputtering while at the same time yielding a high-ion induced secondary electron emission coefficient(γ)[1]. Because of its large secondary electron emission coefficient, the MgO protective layer plays an essential role in keeping the breakdown voltage relatively low. But, hydration is one of the serious problems of MgO protective layer, since MgO absorbs moisture chemically, forming $Mg(OH)_2$ easily[2, 3]. Hydration of MgO caused γ to decrease, resulting in an increase of discharge voltage. We used RF plasma treatment using various gases of Ar, O_2 and H_2, which caused a combination of chemical reactions and sputtering effects. Plasma treatment has been widely used in industrial treatment to clean or improve the properties of materials surface. In recent experiment, RF plasma treatment bring about ion induced secondary electron emission coefficient(γ) increase.

"Figure 1." shows γ versus the acceleration voltage, which was obtained from MgO protective layers after plasma treatment.[4] The O_2-plasma treatment was obviously found to have the highest γ.

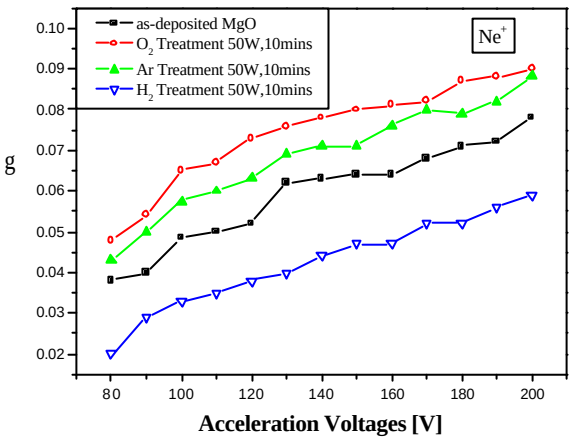

Figure 1. γ versus ion acceleration voltage applied to anode using Ne gas.

In this study, we measured breakdown voltage, brightness and margin after RF plasma treatment using Ar, O_2 and H_2 gases. Through these characteristics compared using reference MgO panel's efficiency with using RF plasma treatment MgO panel's efficiency.

2. Experimental Configuration

The MgO protective layers were deposited on the test panel by electron beam evaporation method and were

followed by annealing in vacuum at 300℃ for 30 minutes. The test panel for this experiment is a 3.5 inch, VGA class AC-PDP with a cell pitch of 1080㎛. The thickness of MgO protective layer was 6,000Å and the deposition temperature was 200℃ and deposition ratio was 5Å/s in this experiment. The gas(Ar, H_2, O_2) plasma treatment was done on the film to modify the surface using RF(13.56MHz)-generated plasma. The plasma treatment was carried out at room temperature for 10minutes with RF power of 50W, where base pressure was at 6.0×10^{-6} Torr and process pressure was kept at 110mTorr. Gas flow rate was 38 sccm(standard cubic centimeter per minute) of Ar, 100 sccm of H_2, 13 sccm of O_2. "Figure 2." shows RF-plasma treatment phenomenon using Ar.

Figure 2. RF-plasma treatment phenomenon using Ar gas.

Discharge condition was that using Ne + Xe(4%) and gas pressure was 400 Torr. Before the discharge experiment, test penal have 10minutes aging time. Driving condition is square sustain pulse with 35 kHz, 25% positive duty ratio. The discharge characteristics and brightness of test panel were measured by using the PDP Driving System(PDS200) and brightness-measuring device(MINOLTA LS-100) in PDP-Chamber. Also, we observed MgO surface properties using FE-SEM.

3. Experimental result

"Figure 3." shows static-margin curve, which was obtained from MgO protective layers after RF-plasma treatment using Ar, H_2, O_2 gases. The O_2 plasma treatment was found to have the lowest breakdown voltage. But H_2 plasma treatment was highest breakdown voltage. These result agreed with secondary electron emission coefficient result.

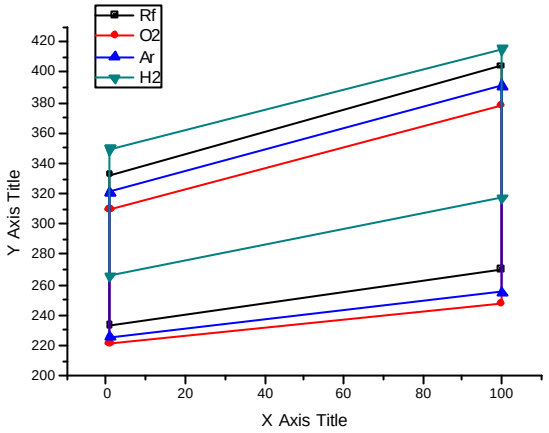

Figure 3. Static margin curve after RF-plasma treatment using Ar, H_2, O_2 gases.

	Vf_{min}	Vf_{max}	Vs_{max}	Vs_{min}	Brightness (cd/m^2)
Reference	332.5	404	270	233	305
O_2	310	378	248	221.5	402
Ar	321	391	255	225.5	302
H_2	349.5	415.5	317	265.5	282

Table 1. Compare non-treatment MgO with RF-plasma treatment MgO firing voltage, sustain voltage and brightness

"Table 1." shows average brightness, which was measured same voltage. The O_2 plasma treatment was found to have the highest brightness value, and H_2 plasma treatment was lowest it. These results relate to efficient. We calculated relativity efficiency using Q-V Lissajous method. From Q-V Lissajous curve, we obtained spent energy during one sustain pulse period. Between spent energy and spent power is proportion relation. So, we could decide relativity efficiency to spent power and brightness. The results present "Table 2." which shows that O_2 plasma treatment increase 44% relativity efficiency. These results indicate that both the physical etching and the

chemical reaction of O_2 plasma removed the contaminating materials from the surface of MgO.

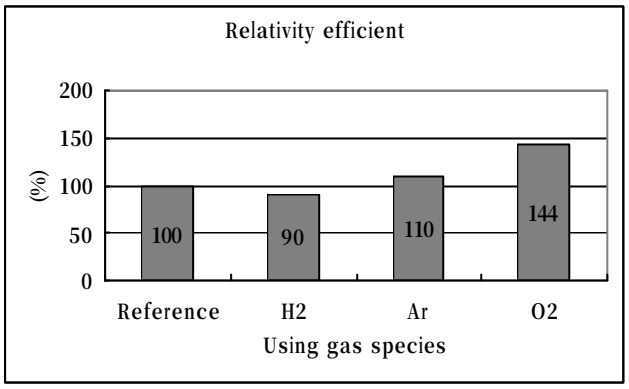

Table 2. Change of relativity efficiecy after RF plasma treatment.

Beside, the H_2 plasma could not make any effective physical etching due to the small mass of hydrogen atom and molecule in the plasma while the hydration of H_2 plasma could grow some contaminating materials on the surface of MgO, which could explain the high breakdown voltage, low brightness and low efficiency after H_2 plasma treatment. The other hand Ar plasma was physical etching only. The difference of these electro-optical characteristics was strongly dependent on the gas used for plasma process. Ar plasma treatment showed a similar behavior as O_2 plasma treatment, which indicates that the chemical process is quite dominant compared to the physical process. So, we observed MgO surface after RF plasma treatment. "Figure 4", "Figure 5", "Figure 6", "Figure 7" shows non treatment, Ar treatment, H_2 treatment and O_2 treatment MgO surface using FE-SEM.

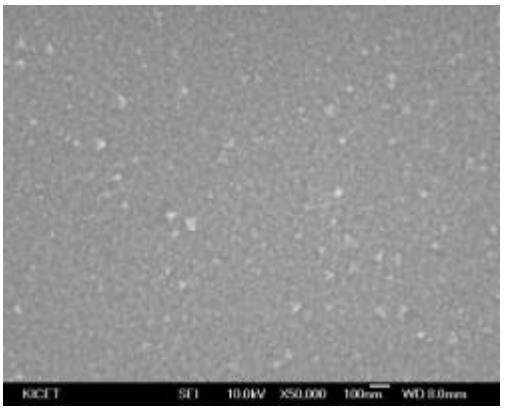

Figure 4. SEM image of non treatment MgO surface

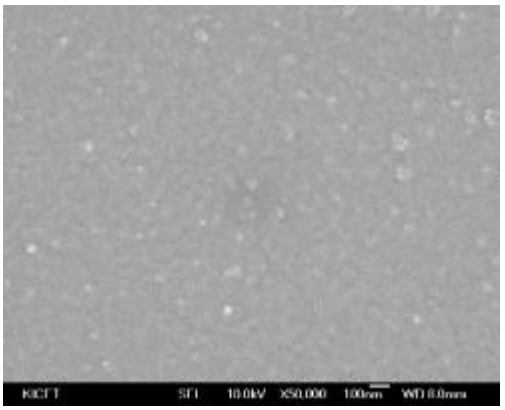

Figure 5. SEM image of Ar treatment MgO surface

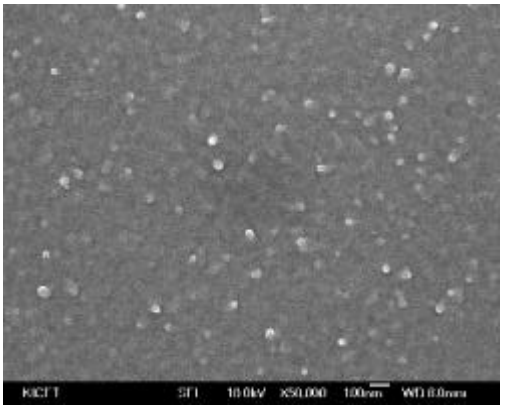

Figure 6. SEM image H_2 treatment MgO surface

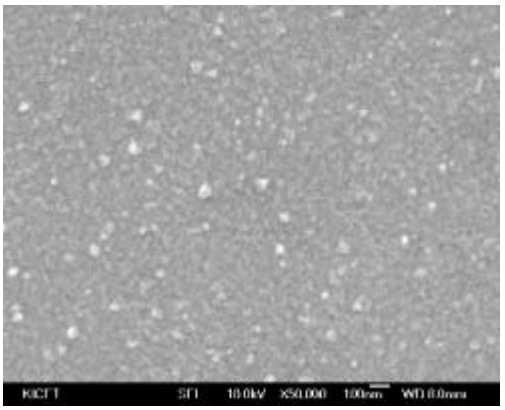

Figure 7. SEM image O_2 treatment MgO surface

4. Conclusion

The issue of AC-PDP is currently various. We are making efforts in various directions as cell structure, discharge gas kinds, etc. These common goals are

high efficiency of AC-PDP. The key point of this research is MgO protective layer, which makes many influences at the discharge. We enhance the characteristic of MgO protective layer used RF plasma treatment. The change of electro-optical characteristic was strongly dependent on the gas used for plasma process. Ar plasma treatment showed a similar behavior as O_2 plasma treatment, which indicates that the chemical process is quite dominant compared to the physical process, because the means of O_2^+ is heavier that of Ar^+. H_2 plasma showed least effective for the removal of degrading layers, which we think it is due to poor chemical reactivity and the light atomic mass of H_2 plasma.

7. References

[1] J. P. Boeuf, J. Phys. D : Appl. Phys. 36 , p.66-70, (2003)

[2] J. H. Lee, J. H. Eun, S. Y. Park, S. G. Kim, H. J. Kim, Thin Solid Films 435, p.95-101, (2003)

[3] O. Engkvist, A. J. Stone, Surface Science 437, p.239-248, (1999)

[4] J. C. Jung, H. S. Jung, W. B. Park, E. H. Choi, J. W. Cho, IDW'04, p.764-769

[5] J. Y. Lim, J. S. Oh, B. D. Ko, J. W. Cho, S. O. Kang, G. S. Cho, H. S. Uhm, E. H. Choi, J. Appl. Phys. 94, p.764-769, (2003)

[6] J. C. Jung, Work function changes of MgO protective layer by RF plasma treatment, Kwangwoon Univ. Master candidate graduation thesis p.22-30, (2004)

[7] H. S. Jung, Influences of degradation and surface treatment of MgO protective layer and phosphors on the ion-induced secondary electron emission coefficient and discharge characteristics in AC-PDP, Kwangwoon Univ. Master candidate graduation thesis, p.16-23, (2003)