Optimization of address delay time in PDP by controlling the MgO characteristics

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Abstract
MgO thin film is widely used in PDP panel for protecting the dielectric layer and making firing voltage low. In this paper, the MgO thin film and discharge characteristics was analyzed as hydrogen flow rate increasing. Using hydrogen in deposition chamber makes add delay time of PDP module longer or shorter. It is the reason why thin film surface layer thickness on the MgO surface changes.

1. Introduction
MgO thin film has influence on life time, power consumption, and discharge characteristics of PDP. As PDP maker, SDI has studied characteristics of MgO source, durability of plasma gun, time reduction of preventive maintenance, and process control for MgO thin film characteristics, etc. Recently in the forefront of Japanese company, MgO technology is focusing on adding another layer on MgO thin film.

Address delay time also plays an important role of driving with high speed and low voltage

Recent paper about MgO deposition process indicated that oxygen flow rate, temperature of substrate, deposition rate are related to the preferred orientation and cathode luminescence of MgO thin film and discharge delay time and firing voltage. [1] [2] [3]

However, in case of MgO thin film by plasma-assisted ion beam deposition, the relation of characteristics not yet been studied systematically

This paper introduces process controlling for MgO thin film characteristics using the hydrogen. It is from the point of microscopic morphology, surface layer thickness, index of refraction and address delay that the effect of hydrogen flow rate with wide range is reviewed.

2. Experiments
MgO thin films were deposited by plasma assisted ion beam system (SGX-3601 and SGL-3601, Canon Anelva). A high purity polycrystalline MgO pallet was used as target. Deposition was performed in Ar, H2, and O2 atmosphere. To monitor and control the atmosphere in deposition chamber, the residual gas analyzer(XPR3, Inficon) exteded pressure range and Tware32 software.

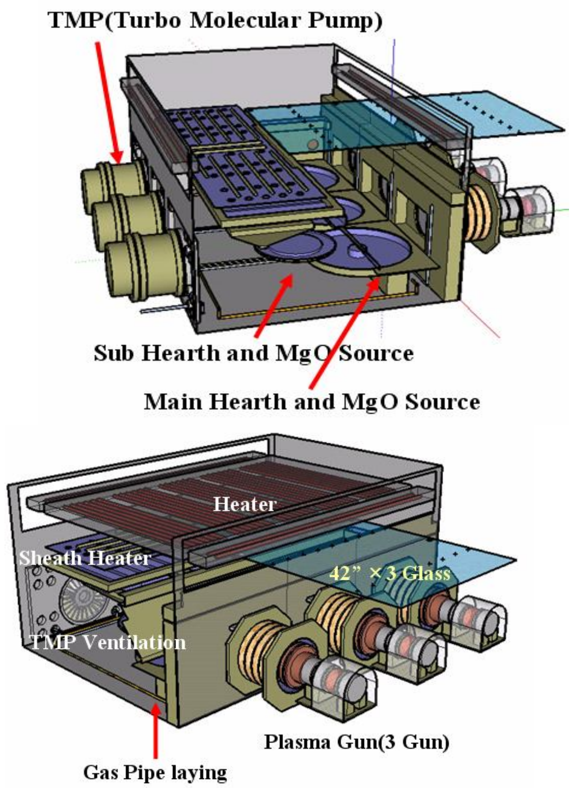

Figure 1 Schematics of plasma assisted ion beam deposition system

In our experiment only hydrogen flow rate was changed and all other significant factors were fixed. Hydrogen flow rate was chosen from 0 to 160 sccm (standard cubic centimeter per minute). Film thickness was 7000~8000 Å, and substrate temperature was up to 400 ℃, and base pressure was 0.09 Pa, and oxygen flow rate was 420 sccm.

All samples were characterized by FE-SEM, XRD, spectroscopic ellipsometer. Surface and cross-sectional images of MgO films were acquired by FE-SEM (S-4800, Hitachi High-tech). The acceleration voltage was set to 5 keV and Pt film was coated on samples.

Crystal phase and preferred orientation were examined by XRD (PW-1710, Philips). A Cu K radiation line (λ=1.54Å) was used at 40 kV and 40 mA and 2θ scanning range was from 30 to 80 degree.

Optical properties were obtained by spectroscopic ellipsometer (V-VASE, J. A. Woollam) equipped with Xe lamp in the visible and near-infrared region, 400-1000 nm. We used WVASE32 software to analysis film thickness and refractive index. Our fitting model consists of 3 layers: the substrate, MgO film, and surface roughness layer. The refractive index of MgO film was calculated by Cauchy model and surface layer was approximated by EMA model.

PDP cell design for evaluating the discharge characteristics was as shown in Fig. 2.

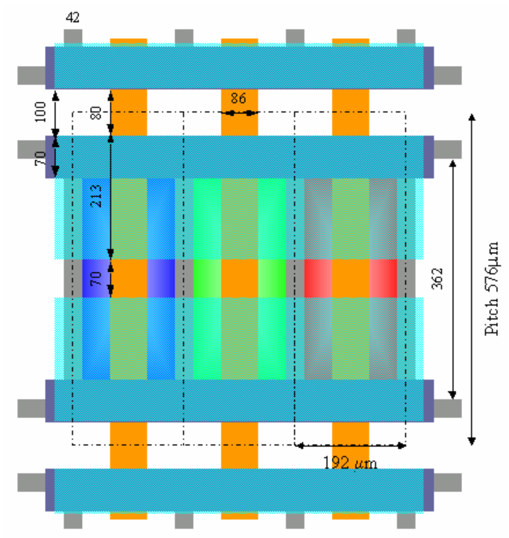

Figure 2 Schematic diagram of cell design

3. Results

3.1 Analysis of thin film characteristics

Although hydrogen was used up to 160 sccm in deposition chamber, it was conformed that the crystallinity still remained. But preferred orientation changed a lot. Low hydrogen flow rate makes the preferred orientation of (111) like other researches.[4]

The hydrogen of inflow associated the oxygen in the deposition chamber. As a result vapor was produced, OH^- and H^+ of vapor reacted with Mg^{2+} and O^{2-}. We guessed that $Mg(OH)_2$ encourage the defects, and those defects made alteration to the preferred orientation (111) to (200), (220) and (311). Altered crystallinity could be verified by XRD as show in table. 1

Preferred orientation	Low flow rate ←				→ High flow rate
(111) (36.9°)	○	○	○	○	×	×
(200) (42.9°)	×	×	×	○	○	×
(220) (62.3°)	×	×	○	○	○	○
(311) (74.7°)	×	×	×	×	×	○
(222) (78.6°)	○	○	○	○	×	×

Table 1 Preferred orientation of MgO thin film as hydrogen flow rate

3.2 Analysis of address delay

The relation of hydrogen flow rate to add delay can be plotted with regression analysis as shown in fig. 3. Low flow rate of hydrogen means longer address delay time. As flow rate of hydrogen increased, address delay time became shorter. But much more flow rate made add delay longer again.

Address delay time = 1442 - 19.39 (Hydrogen flow rate) + 0.1149 (Hydrogen flow rate) ^{2}
Standard deviation = 84.1162, R-sq =74.2%

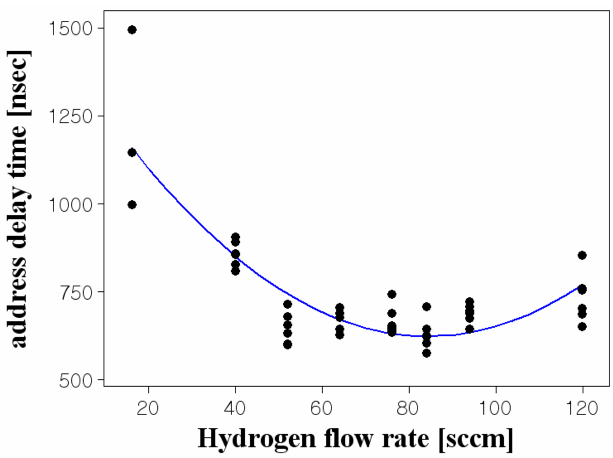

Figure 3 Add delay as hydrogen flow rate changes

3.3 Morphology index by hydrogen flow rate

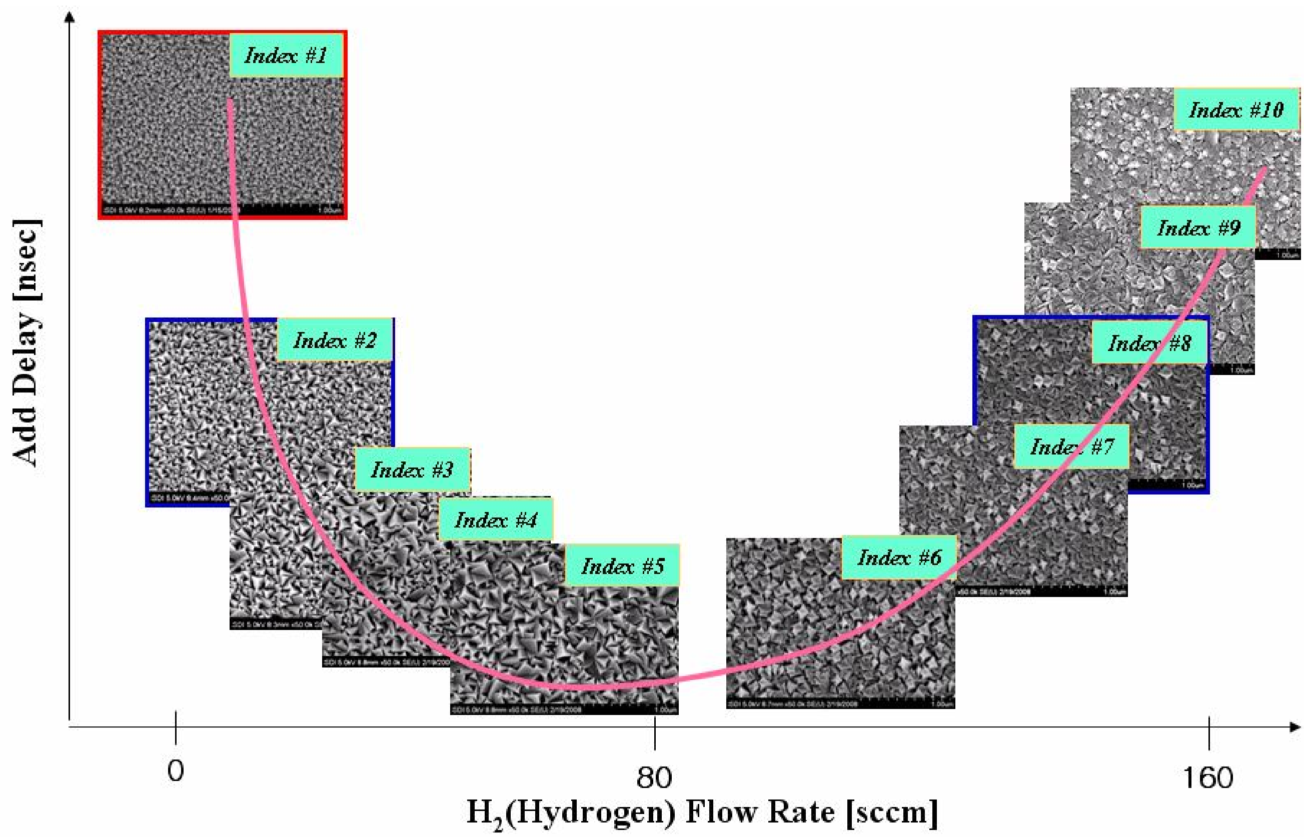

Figure 4 MgO morphology index by hydrogen flow rate

MgO Morphology is graded by index #1~10 as shown in fig. 4. Index #1 is characterized by small triangle with the size of about 40~80nm. As increasing hydrogen flow rate, the size of triangle becomes bigger to 100~150nm shown in index #4~5. In case of #5 and 6, triangle turns to be quadrangle. Index # 6~7 is characterized with small quadrangle like roses. At index #9~10, edges disappears and small circles, size of 100~150nm, are observed

3.4 Further analysis of MgO Surface

Fig 5 shows the typical MgO surface morphology and cross-sectional view analyzed by FE-SEM. MgO film has dense and columnar structure but rough surface at the same time. The surface layer is virtual layer as mixed with MgO and air. Actually we cannot disregard this surface layer to analyze film thickness and refractive index of MgO film from ellipsometric data.

Surface layer thickness determined by ellipsometer was affected by two key factors: preferred orientation and MgO grain size. As shown in Fig 6, increase of the hydrogen flow rate makes the surface layer thicker at first time because MgO grain size become larger. As the hydrogen flow rate become much larger, the surface thickness decrease smaller again because preferred orientation changed from (111) to (100) and (110) shown in Fig.4.

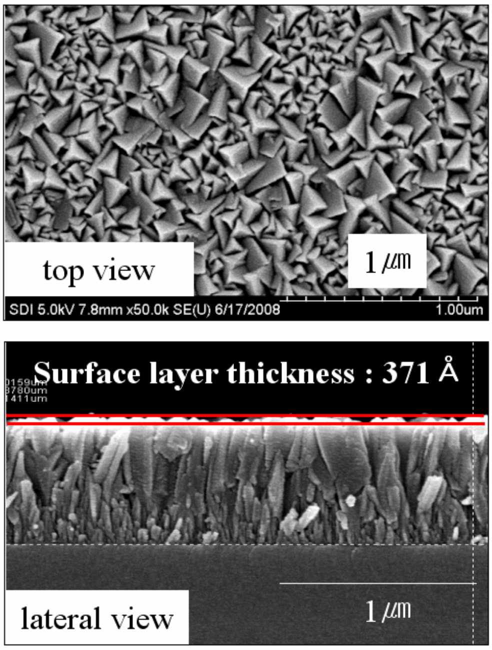

Figure 5 Top and lateral view of MgO Surface layer

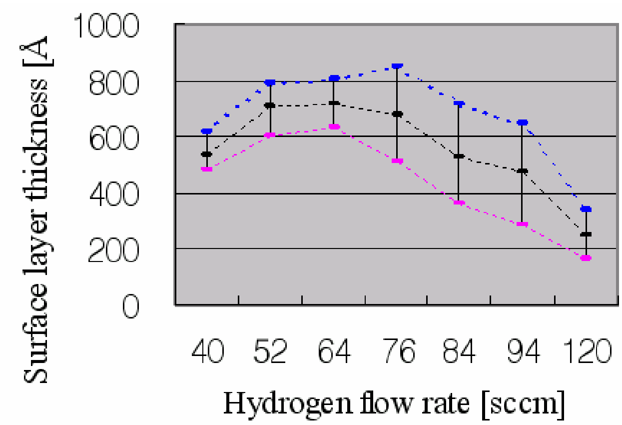

Figure 6 Surface layer thickness on MgO varying the hydrogen flow rate

In figure 7, relation between refractive index and hydrogen flow rate was plotted. As the hydrogen flow rate was increased, refractive index became decreasing, but at some point of hydrogen flow rate, index of refraction reversely increasing. Because refractive index was related with film density closely, we can deduce the hydrogen amount affect the density MgO film.

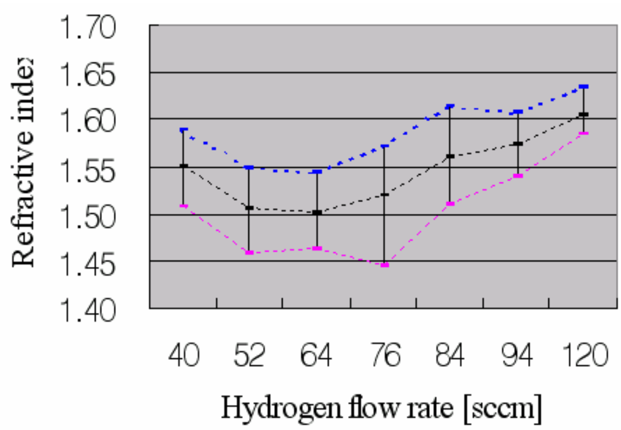

Figure 7 3 Index of refraction over the hydrogen flow rate varing

3.5 Controlling and predicting MgO thin film using RGA

Characteristics of MgO thin films could be controlled and predicted using residual gas analyzer (RGA).

Vapor in deposition chamber could change the MgO thin film. Moisture absorption of MgO is so well-known. Vacuum deposition equipment needs periodical preventive maintenance. During the maintenance, deposited MgO on the equipment absorbed the moisture, so degassing, getting rid of the moisture is needed. In case of running short of the degassing process, the moisture could change the MgO thin film, so partial pressure of vapor need to know. Also in case of chamber size and evacuation conductance changed, MgO thin film could be altered due to varying the number of vapor molecule, so partial pressure of vapor need to know, too.

For stable process, RGA is used to control the vapor pressure and predict the characteristics of MgO thin film in the face of the maintenance and equipment deviation.

4. Conclusion

A study was executed by the factor of hydrogen flow rate up to 160 sccm. At the highest hydrogen flow rate, the crystallinity still remained. As hydrogen flow rate changed, address delay time varied between 600 and 1200nsec. It is assumed that variation of address delay time was closely related to refractive index and the surface layer thickness, affected by grain size and preferred orientation of MgO.

4. Acknowledgements

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5. References

[1] Ion beam-assisted deposition of magnesium oxide thin film for PDP Applications, Ari Ide-Ektessabi, Hiroshi Nomurab, Nobuto Yasuib, Yuji Tsukudac in Surface and Coatings Technology 163 –164 (2003) 728–733,

[2] The effect of the MgO process on the properties of AC-PDP, Young-Sung Kim, Min-Soo Park, Byung-Gil Ryu, in IMID 2007 Digest

[3] The Characteristics of Sustain and Address Discharge on the MgO Thin Films in Alternating-Current Plasma Display Panels, E. Y. Jung, J. C. Ahn, K. J. Suh, B. K. Park, E. G. Heo, and B. H. Lee in SID p. 88 (2006)

[4] Stoichiometry dependency of the firing and sustain voltage properties of 一해 thin films for alternating current plasma display panels, Choongyong Son, Jinhui Cho, and Jong-Wan Park in American Vacuum Society, A 17(5), (Sep/Oct 1999).