Photon-induced surface conductivity measurement of MgO in an AC PDP

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Abstract

In order to study the relationship between the discharge characteristics of an ac PDP and the surface conductivity of MgO thin film, the surface current across a ring shaped MgO film was measured by exposure to monochromatic vacuum ultraviolet from the synchrotron radiation source whose wavelength ranges from 60nm to 240nm (5.5 eV ~ 25 eV). The experimental results show that the surface current begins to increase rapidly at the photon energy of about 9 eV which might correspond to the valence band edge of MgO. The difference in the surface current level correlate well with the differences in the preparation method of MgO films and their respective discharge characteristics such as the firing, minimum sustain voltages, address voltage margin and address discharge delay time.

1. Introduction

In an ac PDP, the MgO layer is directly exposed to plasma discharges, and therefore, the durability against the ion sputtering and the secondary electron emission yield γ_i are important characteristics. What is more, the secondary electron emission yield γ_i is very closely related to the firing voltage and luminous efficiency of PDP.

For the evaluation of MgO surface characteristics in an ac PDP, many measurement methods such as γ_i measurement by the ion beam irradiation[1], cathode luminescence(CL) spectra[2], and etc. had been proposed. But these methods do not provide needed information on MgO thin film such as the energy band structure or its temperature characteristics.

We already studied the MgO surface conductivity with varying the film temperature and VUV(Vacuum Ultra Violet) irradiation which showed that MgO surface can have a significant conductivity under VUV irradiation.[3]. As shown in figure 1, if VUV energy is high enough to generate electron in the conduction band of MgO surface, electric current can pass through the MgO surface and its current amount can be varied as to VUV energy and intensity, which might give some information on the energy band structure of MgO thin film.

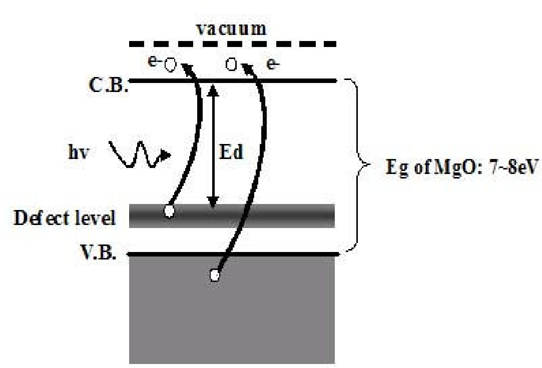

Fig. 1 Schematic diagram of MgO energy band structure.

In this paper, we studied the photon-induced surface conductivity of MgO thin films, using the monochromatic vacuum ultra violet rays from a synchrotron radiation source and tried to correlate them to the discharge characteristics of PDPs having those films.

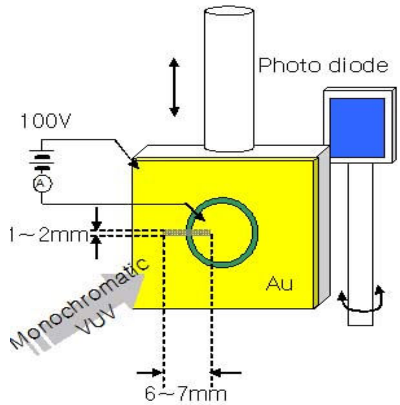

Fig. 2 Schematic diagram of MgO surface current measurement.

2. Experimental results

A. Photon-induced surface conductivity of MgO

In this research, we measured the surface conductivity of MgO layer by exposing it to the monochromatic VUV synchrotron radiation. To evaluate the MgO surface characteristics, we made the sample as shown in figure 2, and carried out the experiment by using the synchrotron light source in Pohang Synchrotron Light Source whose wavelength ranges from 60nm to 240nm. A 3000Å thick Au film was deposited on MgO thin film prepared by e-beam evaporation to leave a circular ring shaped MgO surface. The diameter of inner conductor is 10mm, that of outer one is 10.6mm respectively which results in 300μm ring width. VUV beam form synchrotron source was irradiated across the ring shaped MgO surface and photon-induced surface current by monochromatic VUV was measured by pico-ammeter(Keithley 617) with 100V DC biased.

Figure 3 shows the surface current of each MgO sample as to the photon energy. Especially for low energy range(5~6eV), MgO with O_2 feeding sample shows higher photon-induced surface current compared to that of without O_2 feeding sample, which might be due to the higher density of defect levels(Oxygen vacancy: F and F^+) in the MgO film with O2 feeding.[2] Figure 3 also shows an abrupt increase of photon induced current from the photon energy of about 9eV which might correspond to the valence band edge of MgO.

Figure 4 shows the photon-induced surface current of Si-doped MgO by changing the substrate temperature from 25℃ to 100℃. At 100℃, the current was decreased compared to that at room temperature. The temperature-dependent discharge characteristics of Si-doped MgO film in PDP can be inferred from the result of current shape as to photon energy, and which will be discussed with panel results.

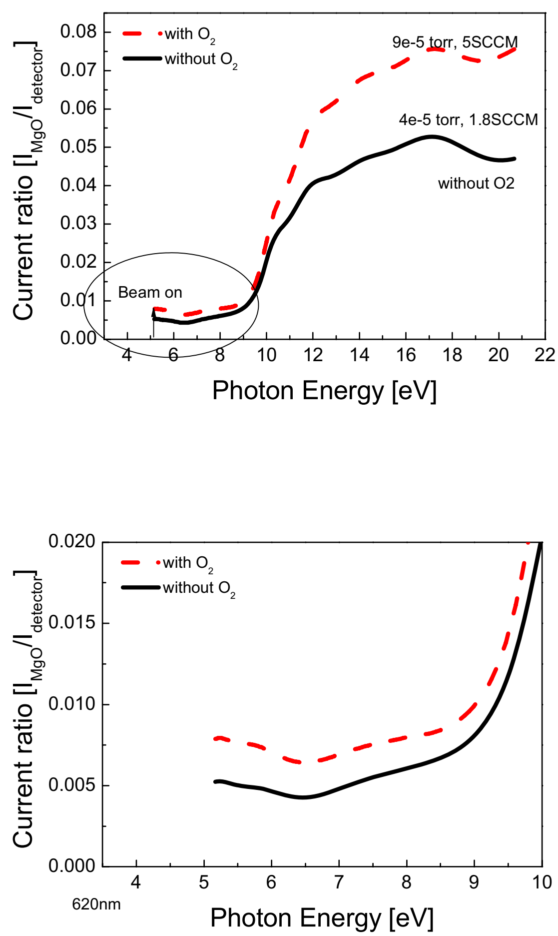

Fig. 3 Photon induced surface current of MgO film as to irradiated VUV energy.

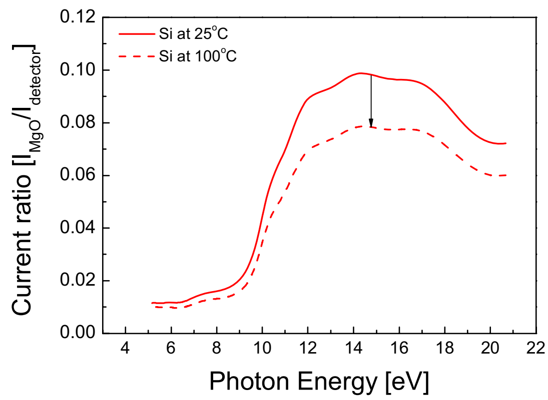

Fig. 4 Photon induced surface current of conventional and Si-doped MgO film as to temperature.

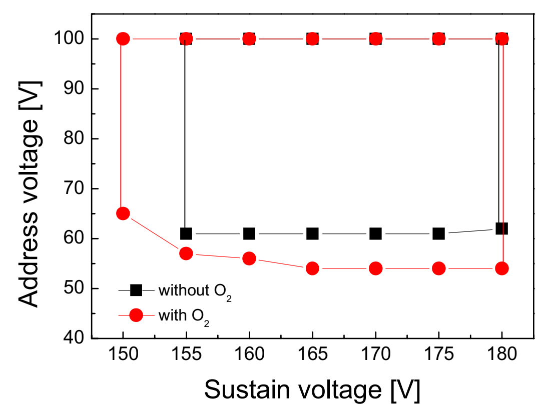

Fig. 6 Full driving voltage characteristics of PDP for each MgO sample.

B. Correlation between the Photon-induced surface conductivity and discharge results.

In Ref. 2, as the O2 partial pressure increases during the MgO deposition, the intensity of cathode luminescence from F+ center increases, which results in the decrease of breakdown voltage of PDP with Xe gas.

Figure 5 shows the firing and sustain voltage of test panel as to the Xe gas content. The firing voltage of panel with O_2 fed MgO is about 15V lower than that of without O_2 at Ne-Xe(4%) 300 Torr and the difference of discharge voltage steadily increases up to 70V at 50% of Xe.

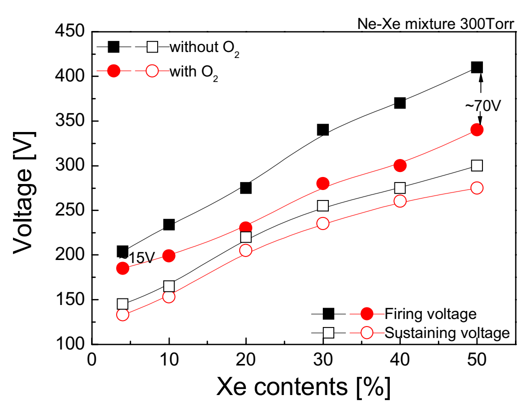

Fig. 5 Firing and sustain voltage of PDP as to Xe contents.

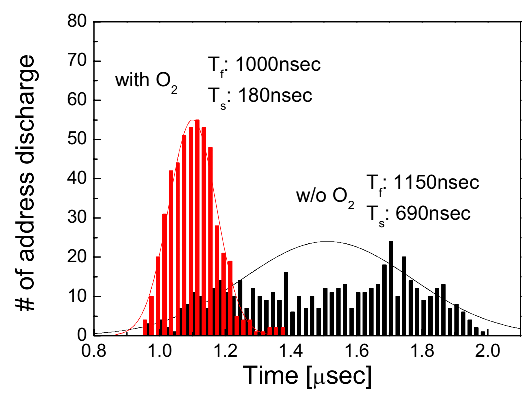

Fig. 7 Address delay time characteristics of PDP for each MgO sample.

The positions of F and F+ centers are known to be about 5 or 6 eV below the conduction band of MgO[2], which means that Xe ion(12.1eV) may be able to participate to the secondary electron emission by the Auger neutralization process. Photon-induced surface current of each MgO sample also shows differences in the current level for the photon energy of 5 to 6eV.

Figure 6, and 7 show the results of full driving voltage characteristics, and address delay time of test panel for each MgO sample at Ne-Xe(4%) 400 Torr. Applied full driving scheme consists of ramp type reset pulse with 8 sub-field method, and address delay time was acquired 300 times for each

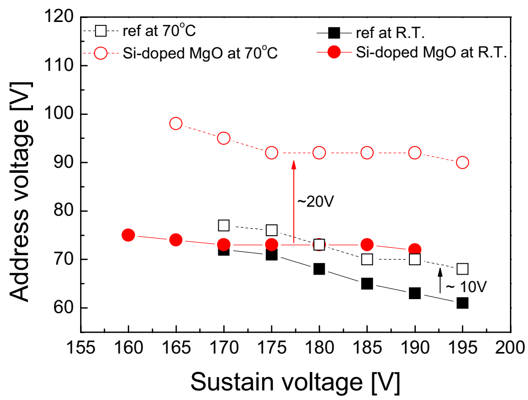

Fig. 8 Full driving voltage characteristics of Si-doped MgO sample for ambient temperature.

measurement. Statistical delay time and formative delay time of address discharges are defined as follows. The time from the address pulse rising to the time of 10% of total accumulated discharge time is determined to be the formative delay time and statistical delay time is defined as the difference of the time of 10% and 90% of total accumulated discharge time.

The sustain and address voltage of panel with O_2 fed MgO are 5V and ~7V lower than that of without O_2 fed MgO respectively, and the formative and statistical delay time of O_2 fed MgO are 150nsec and 510nsec shorter than those of without O_2 fed MgO, which shows the consistent results with the photon-induced surface current of each sample.

Figure 8 shows the result of full driving voltage characteristics of Si-doped and conventional MgO by changing the ambient temperature from R.T. to 70℃. The minimum address driving voltage of Si-doped panel increases more than 20V when the panel temperature increase from room temperature to 70℃ while that of un-doped MgO panel less than 10V. The much increased address voltage of the Si-doped MgO panel might be related with the much higher surface current density compared to that of un-doped case as shown in Fig. 3 and 4.

3. Summary

In this research, we examined the photon-induced surface conductivity of MgO thin film which shows correlations with the discharge characteristics of an ac PDP. Regarding to the evaluation method of MgO thin film in an ac PDP, the photon-induced surface current of MgO carries some information on its band gap structure and defect levels. The results of panel experiment shows that the effects of O_2 feeding during MgO deposition on the driving voltage and delay can be explained with the changed defect level densities. The enhanced minimum address voltage increases of the Si-doped MgO panel with panel temperature increase could be correlated with the enhanced surface current change which might be due to the increased defect level trapped electrons when MgO is doped with Si.

Reference.

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[3] C. H. Ha, D. C. Jeong, J. K. Kim, and K. W. Whang, IMID’05 Digest, pp.714-716