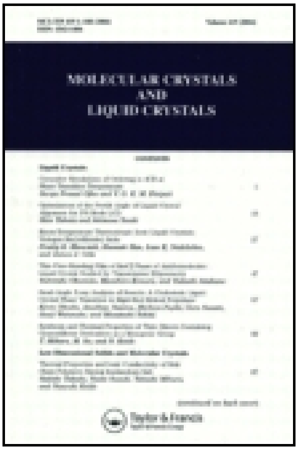

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Correlation between the Secondary Electron Emission Coefficient of MgO Protective Layer and Luminous Efficiency in Alternating Current Plasma Display Panel (AC-PDP)

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Correlation between the Secondary Electron Emission Coefficient of MgO Protective Layer and Luminous Efficiency in Alternating Current Plasma Display Panel (AC-PDP)

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We have investigated the correlation between the secondary electron emission coefficient (γ) of MgO protective layer and discharge luminous efficiency in alternating current plasma display panel (AC-PDP) by varying the O_2 flowing rates of 0, 10, 20, and 30 sccm. It is found that the secondary electron emission coefficient and the brightness are maximum, and the discharge voltage is minimum at the O_2 flowing rate of 20 sccm. As a result, the discharge luminous efficiency is the highest at the O_2 flowing rate of 20 sccm in comparison with others.

Keywords: alternating current plasma display panel (AC-PDP); gamma-focused ion beam (γ-FIB); luminance efficiency; MgO protective layer; secondary electron emission

INTRODUCTION

The industry of flat TV display is now divided into AC-PDP and LCD. AC-PDP has so many advantages that response time is rapid, dark room contrast ratio is good, and large size manufacturing is simple.

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However, AC-PDP needs more studies of high discharge luminous efficiency. The discharge luminous efficiency can be improved by the optimizations of cell structure, the mixture ratio of gases, the property of materials, especially of the secondary electron emission coefficient of MgO protective layer. The secondary electron emission coefficient of MgO protective layer has close relation to the discharge voltage and its luminous efficiency. It is of great importance to investigate the influence of O_2 flowing rate on the secondary electron emission coefficient of MgO protective layer. Hence we have investigated the correlation between the secondary electron emission coefficient (γ) of MgO protective layer and discharge luminous efficiency in alternating current plasma display panel (AC-PDP) by varying the O_2 flowing rates of 0, 10, 20, and 30 sccm.

EXPERIMENTAL CONFIGURATION

MgO protective layer has been deposited by an electron beam evaporation, in which the oxygen (O_2) flowing rates have been varied to be 0, 10, 20, and 30 sccm in this experiment. During the MgO protective layer, the O_2 flowing rate has been adjusted by the mass flow controller (MFC). The deposition rate of a MgO layer has been fixed to be 5 Å/sec, and the substrate temperature is 300°C.

Figure 1 shows a schematic of cell structure used in the experiment. The 4 inch test panel with VGA class has been used in this experiment. A MgO protective layer is deposited over the dielectric layer with 0.5 μm thickness. The electrode width and cell pitch are kept at 360 and 1080 μm. The sustain discharge in AC-PDP occurs between the parallel sustaining electrodes of X and Y, which are separated by gap distance of 60 μm. On the rear glass, the address electrodes of

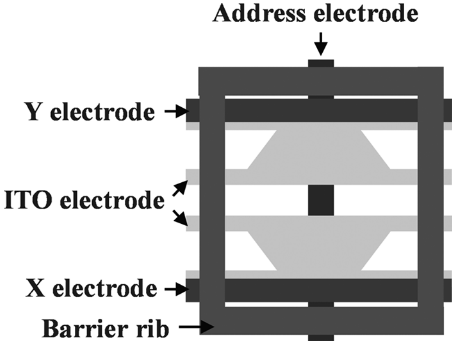


FIGURE 1 Schematic of the cell structure.

100 μm in width and barrier rib of 120 μm in height are located perpendicular to the two sustaining X-Y electrodes. The filling gas is a mixture of Ne (85%) and Xe (15%), and the total pressure is maintained at 400 Torr in this experiment.

The secondary electron emission coefficient of MgO protective layers has been investigated by gamma-focused ion beam (γ-FIB) system according to the respective O_2 flowing rates of 0, 10, 20, and 30 sccm. Figure 2 shows that a schematic of γ-FIB system for measurement of ion-induced secondary electron emission coefficient from the MgO protective layer [1]. The system consists of five basic components: the diode consisting of thermionic electron source, the region of electron impact ion formation and acceleration, an electrostatic Einzel for ion-beam focusing, a quadrupole deflector, and the MgO substrate for measurement. The Ne ions are accelerated by the applied anode voltage and focused by the electrostatic lens. The acceleration voltage at the anode varies from 50 V to 500 V. The secondary electrons are emitted from the MgO layer whenever ions hit it.

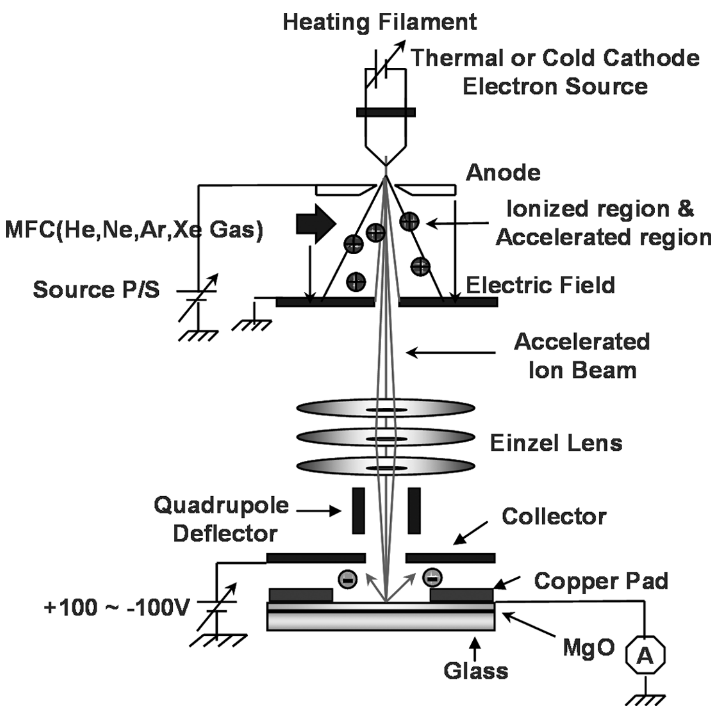


FIGURE 2 Schematic of γ-FIB system for measurement of ion-induced secondary electron emission coefficient.

The measurement range of accelerating voltages is from 120 V to 210 V in this experiment.

We measured the firing voltage by PDP driving system (PDS) [2]. The driving waveforms of AC-PDPs are consisted of reset, address, and sustaining period. Reset period initialize accumulating wall charge of cell. Address period selected the cell which will be discharge by memory effect of wall charge. After address period, sustain pulse makes the discharge for displaying information. The PDS system generates the sustaining squared pulses for actual discharges. The deriving frequency, duty and voltages can be easily changed in the PDS system. Here the frequency and duty are fixed to be 35 kHz and 25%, respectively.

EXPERIMENTAL RESULTS AND DISCUSSIONS

A. Observation of the Surface of MgO Layer

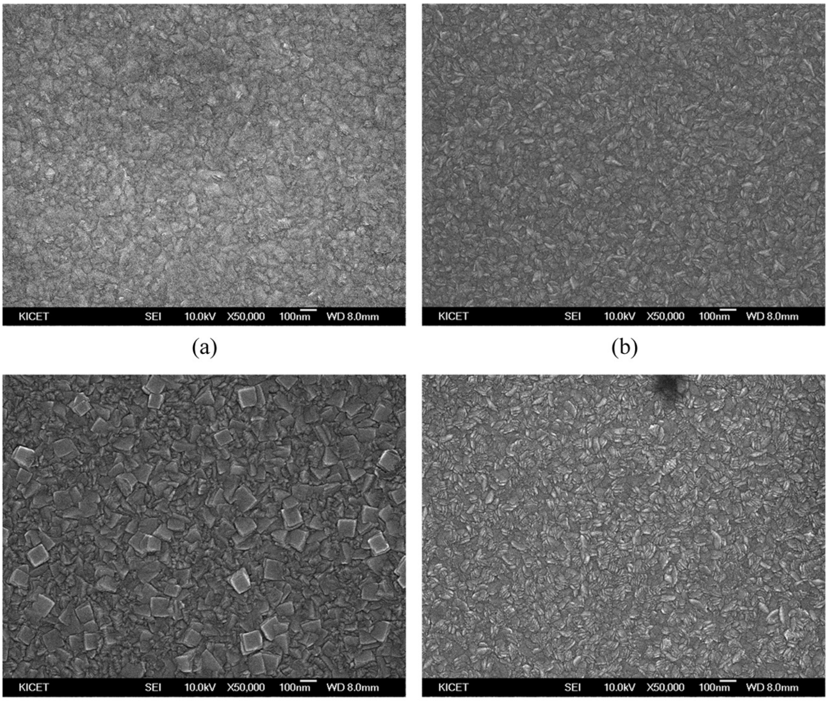
Figure 3 shows the scanning electron microscope (SEM) images of the surface of MgO layer with respective O_2 flowing rates. It is noted that O_2 flowing rates have an effect on the surface of MgO layer. The grain size of the surface of the MgO layer with O_2 flowing rate of 20 sccm is larger than other O_2 flowing rates. Figure 4 shows the atomic force microscope (AFM) images of the surface of MgO layer with respective O_2 flowing rates. The surface of MgO layer with O_2 flowing rate of 20 sccm is rougher than other O_2 flowing rates. It is noted from Figures 3 and 4 that the surface characteristics of MgO layer such as the crystal orientation and its density could be changed by the respective O_2 flowing rates according to the respective O_2 flowing rates.

B. Secondary Electron Emission Coefficient and the Firing Voltage

Figure 5 shows the secondary electron emission coefficient versus Ne ion accelerating voltage for MgO layer with respective O_2 flowing rates. The acceleration voltage is equal to energy of focused ion-beam, thus the stronger energy of focused ion-beam is to be higher value of γ. It is found that the secondary electron emission coefficient from MgO layer is the highest with O_2 flowing rate of 20 sccm at given Ne ion acceleration voltages among other O_2 flowing rates.

The firing voltage V_b, i.e., breakdown voltage, can be expressed by the so called Paschen's laws [3],

$$V_b = \frac{Bpd}{\ln[Apd/\ln(1+1/\gamma)]} \tag{1}$$



(a) (b) (c) (d)

FIGURE 3 SEM images of MgO layer with respective O_2 flowing rates. (a) 0 sccm, (b) 10 sccm, (c) 20 sccm, and (d) 30 sccm.

where A and B are experimental constant determined by the electrode geometry and gases, p is gas pressure, and d is the gap distance between the electrodes. It is noted that the secondary electron emission coefficient γ is in inversely proportional to the breakdown voltage. Therefore, the breakdown voltage is decreased with increasing the value of γ, when the gas pressure p and electrode gap distance d is fixed. Figure 6 shows the firing voltage versus the O_2 flowing rate. It is noted that the firing voltage for O_2 flowing rate of 20 sccm is the lowest 258 V among other O_2 flowing rates according to the highest secondary electron emission coefficient.

Figure 7 shows the brightness versus the sustaining voltages for the respective O_2 flowing rates of 0, 10, 20, and 30 sccm. It is noted that the brightness is higher at the higher sustaining voltages. It is also noted that the test panel with the O_2 flowing rate of 20 sccm has the highest brightness in comparison with the others due to the highest secondary electron emission coefficient.

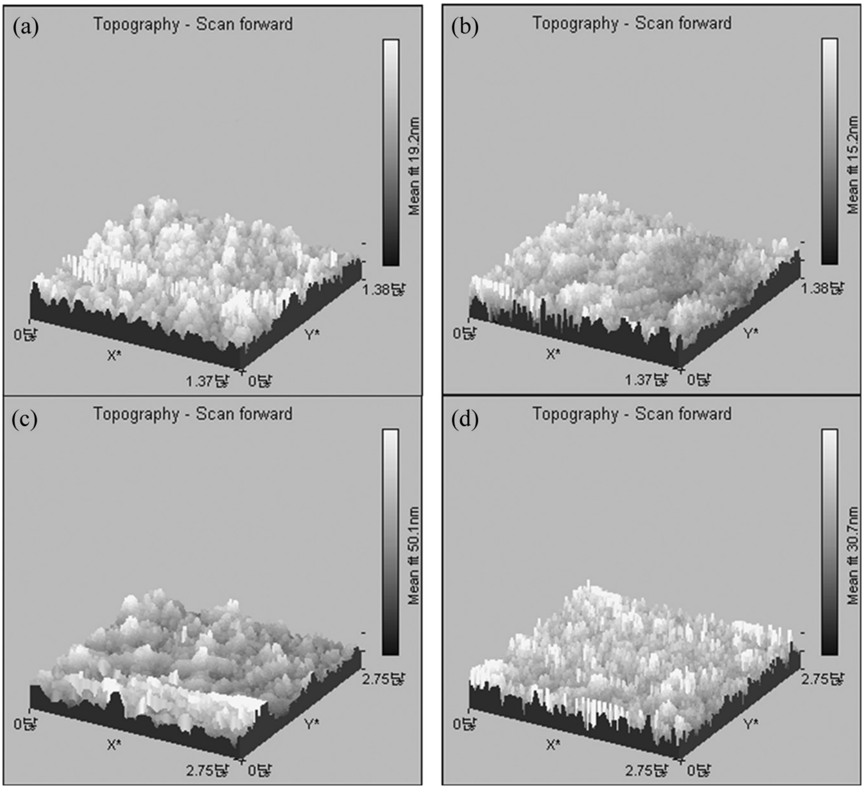


FIGURE 4 AFM images of MgO layer with respective O_2 flowing rates. (a) 0 sccm, (b) 10 sccm, (c) 20 sccm, and (d) 30 sccm.

C. Correlation Between the Secondary Electron Emission Coefficient and Luminance Efficiency

Luminance efficiency can be written by

$$\eta = \frac{\pi Y A}{P_0} \tag{2}$$

where η is the luminance efficiency, Y is the brightness, A is the discharge area, and P_0 is electrical power. The brightness Y is proportional to the Xe* [4,5], which is the excited Xe atoms density, then

$$\frac{dXe^*}{dt} \propto n_e v_e Xe^* \sigma \propto \gamma I_i \exp[-E^*/kT_e] \tag{3}$$

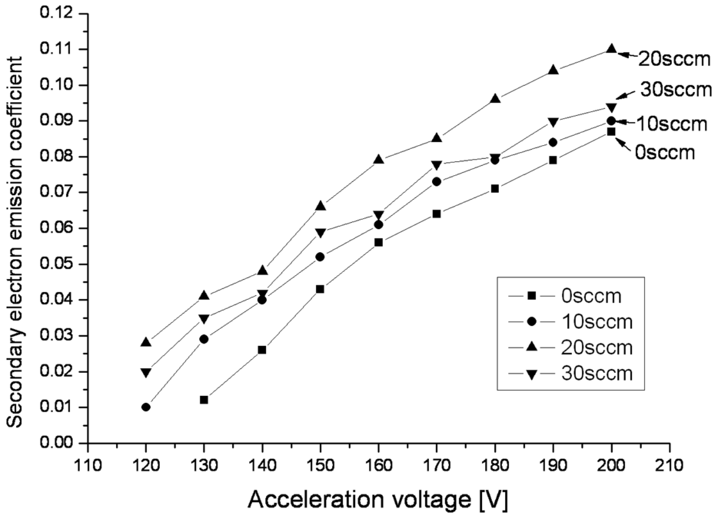


FIGURE 5 Secondary electron emission coefficient of MgO layer with respective O_2 flowing rates.

where $n_e v_e \propto \gamma I_i \propto \gamma n_i T_e^{1/2}$ is the number of electrons colliding to the xenon atoms since $\gamma = I_e/I_i$ and

$$\sigma_{Xe} \propto \exp(-E^*/kT_e) \propto \exp(-b/\gamma) \tag{4}$$

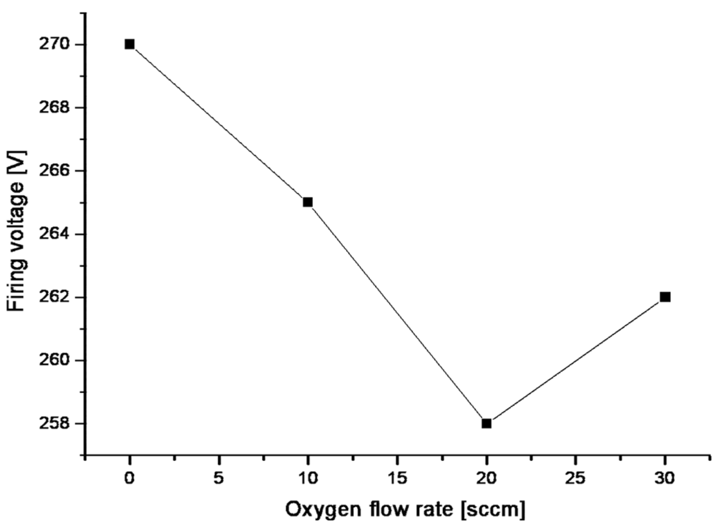


FIGURE 6 The firing voltage of test panels with respective O_2 flowing rates.

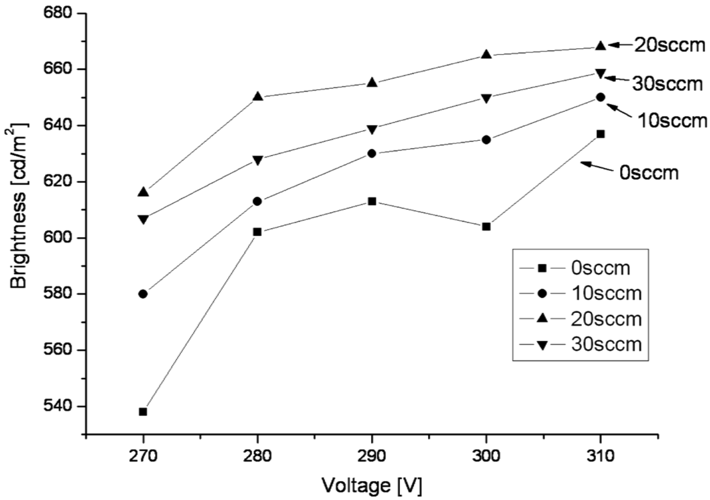


FIGURE 7 Brightness versus driving voltage of test panel with respective O_2 flowing rates.

Equation (4) is the collisional xenon cross section with excitation energy $E^* = 12.1\,\mathrm{eV}$, where kT_e is proportional to the $eE\lambda$. Here E is electric field and λ is the mean free path of electrons. It is also noted that the electric field $E \propto n_e \propto \gamma$. Hence the intensities or brightness Y of VUV lines by

$$Y \propto n_e v_e X_c^* \propto a\gamma n_i T_e^{1/2} \exp(-b/\gamma), \tag{5}$$

Electrical power P_0 could be theoretically expressed by

$$P_0 = IV_b \propto (I_e + I_i)V_b \propto (1+\gamma)n_i T_e^{1/2} \ln(1+1/\gamma) \tag{6}$$

where a and b are coefficients determined by the experimental fitting to the theoretical predictions. It is noted that the luminous efficiency η can finally be expressed in terms of the secondary electron emission coefficient γ by

$$\eta \propto a\gamma \exp(-b/\gamma)/[(1+\gamma)\ln(1+1/\gamma)] \tag{7}$$

We can know from Eq. (7) that the secondary electron emission coefficient γ of MgO protective layer and discharge luminous efficiency η are in strong correlation each other. Figure 8 shows the secondary electron emission coefficient γ (solid squares) and the luminance efficiency

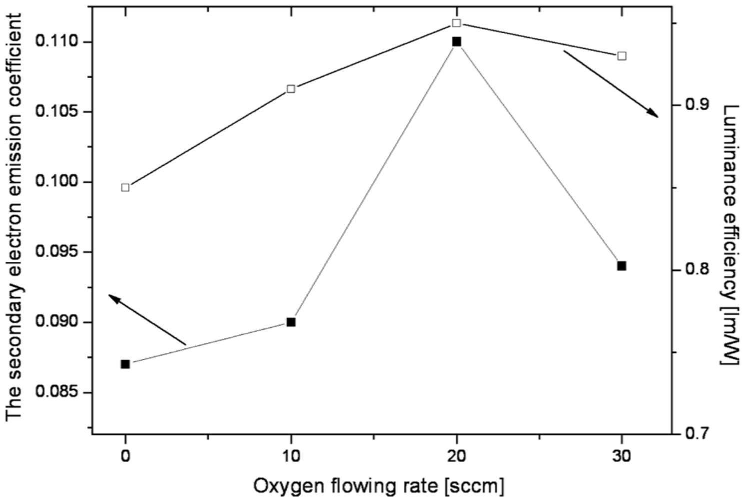


FIGURE 8 Luminance efficiency of test panel with respective O_2 flowing rates.

(open squares) of test panel versus the respective O_2 flowing rates. It is found that the luminance efficiency η is the maximum at the O_2 flowing rate of 20 scccm, where the secondary electron emission coefficient γ is the also maximum among other flowing rates, which is in good agreement with the theoretical prediction of Eq. (7).

CONCLUSION

We investigated the secondary electron emission coefficient of MgO protective layers according to the respective O_2 flowing rate. It is found that the secondary electron emission coefficient from MgO layer is the highest with O_2 flowing rate of 20 sccm at given Ne ion acceleration voltages among other O_2 flowing rates. Then, we found that the secondary electron emission coefficient of MgO protective layer and discharge luminous efficiency are in strong correlation in this experiment, which is in good agreement with our predictions.

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