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Ion Induced Secondary Electron Emission of MgO with Patterned Gold Line Charge Neutralization

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Abstract

Ion induced secondary electron emission coefficients γ of protecting layers of an AC plasma display panel(AC-PDP) have been measured. In order to solve the surface charging effect during the measurement at insulating samples like MgO, a new method with the patterned gold line charge neutralization has been introduced. The measurement was performed at the samples, MgO and MgO+MgF_2, which showed a great difference in the firing voltage between the two protecting layers. The γ value has been compared with the firing voltage V_f of the AC-PDP with the same protecting layer. Correct relationship between γ and V_f has been observed. Thus, the patterned gold line method has been proven to be successful for the measurement of the secondary electron emission yield at insulator sample surfaces.

1. Introduction

The color AC-PDP is recently one of the most promising candidates for the flat, thin, and large-area display. However its luminous efficiency, contrast ratio, and lifetime should be improved further. It has been reported that the protecting layer plays an important role on the improvement of the performances of color AC-PDPs [1]. One of the required properties of the protecting layer is to reduce the firing voltage V_f which depends on the ion induced secondary electron emission coefficient γ.

There have been a lot of works on the measurements of the secondary electron emission yield, especially on the MgO material [1-7]. Various crystal orientations of the MgO have been investigated [2,4,6] and the instability of the measurement was pointed out [3]. The major problem in measuring the secondary electron emission yield of an insulating material like MgO is the surface charging effect, which can affect the result [8]. Some methods have been given to solve the problem of the surface charging effect [2,9].

In this work, we have introduced a new method, namely the patterned gold line charge neutralization, to compensate the charging effect during the measurement of the secondary electron emission yield.

2. Experiment

The secondary electron emission yield was measured with Ar^+ ions. All measurements were performed in a high vacuum chamber with a base pressure of about 10^{-7} Torr. The apparatus is schematically drawn in Fig. 1. The secondary electron collector was designed like a Faraday cup with an aperture of 1 mm in diameter. The spot size of the ion beam, which has no focussing lenses, was about 5 mm in diameter at the sample surface. The ion beam acceleration voltage can be adjusted

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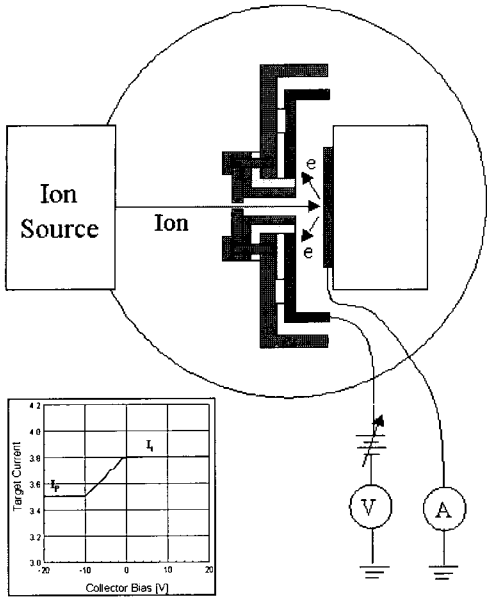

Fig. 1 Schematic diagram of the analysis chamber with the Faraday cup for the secondary electron current measurement. Inset shows a typical feature of the measured sample current as a function of the collector voltage in a metal sample. The secondary electron emission coefficient γ can be calculated by $(I_t - I_p)/I_p$.

from 50 V to 1200 V. The ion beam current, however, was very unstable below 200 V. So, the measurement was performed at 300 V and 400 V. The collector voltage is given to the collector to produce the electronic field between the sample and the collector. The collector voltage was varied from -100 V to 200 V. At a given collector voltage, the sample current was measured with an ammeter(Keithley 617). The primary ion current I_p was measured on the sample by applying the collector with negative voltage below -50 V so as to suppress all the secondary electrons which come from the bombarded target surface. Whereas for the secondary electron current measurements the collector voltage was varied to positive voltage above +100 V and the corresponding target current I_t was recorded. Because the target current I_t is composed of the primary ion current I_p and the secondary electron emission current I_s, the secondary electron emission coefficient γ can be calculated by

$$\gamma = \frac{I_s}{I_p} = \frac{I_t - I_p}{I_p} \quad (1)$$

The inset of Fig. 1 shows a typical feature of the measured sample current as a function of the collector voltage in a metal sample. The amount of the step difference is the secondary electron emission current I_s.

As mentioned above, the major problem in measuring the secondary electron emission yield at an insulating sample like MgO is the charging effect at the sample surface. E.-H. Choi *et al.* [2] developed a γ -focused ion beam system with scanning-area adjustment techniques. We introduce here a new method, namely the patterned gold line charge neutralization. The structure of the patterned gold lines is shown in Fig. 2. Total nine gold lines are patterned within the 10×10 mm^2 MgO surface area which is exposed to the collector side of the Faraday cup. A conductor pad [2] with a 10×10 mm^2 slot is tightly covered onto the gold line patterned MgO surface. The width of the gold line is 150 μm and the thickness 80 nm. The distance between the neighboring gold lines is 350 μm. The patterning process of the gold lines at the MgO sample surface is described elsewhere [10]. The primary ion beam, which has 5 mm spot size in diameter, is irradiated at the center of the sample. So,

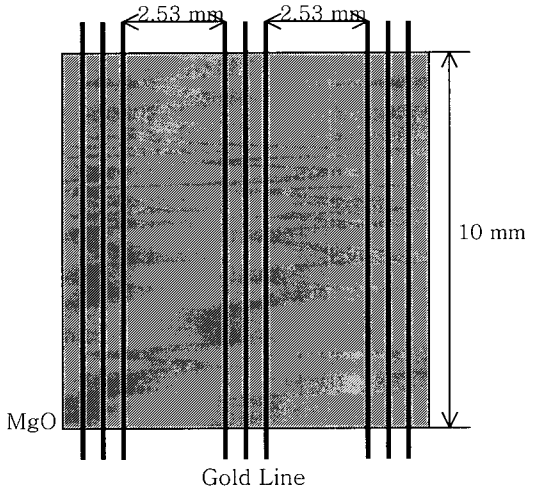

Fig. 2 The structure of the patterned gold lines on the measured MgO sample surface.

three gold lines is also bombarded by the primary Ar^+ ions. Thus, the measured secondary electrons come from the MgO surface as well as from the gold line surface. The ratio of the ion bombarded surface area of the gold line to the MgO surface, however, is about 3 %, which will also affect the uncertainty of the result.

For the measurement of the firing voltage V_f, a test panel of the size of 3×3 cm^2 was prepared. The dimension of the pixel was 1×1 mm^2 and the barrier height was about 150 μm, which is a typical PDP cell structure of 40″ VGA PDP panel [7]. We chose two protecting layers, namely MgO and MgO+MgF_2, which was formed by the method of electron beam evaporation. The thickness of each protecting layer was about 500 nm. The concentration of MgF_2 in the MgO+MgF_2 protecting layer was about a few percent. But the difference in the firing voltage between the two layers was very large. The firing voltage V_f of the MgO protecting layer was 220 V and that of MgO+MgF_2 was 320 V. So, we measured the secondary electron emission coefficient γ of the two protecting layers in order to see the relationship between γ and V_f which is governed by the formula

$$V_f=\frac{Apd}{ln\left\{\frac{Bpd}{ln(1+1/\gamma)}\right\}} \tag{2}$$

where coefficients A and B are constants and p and d are gas pressure and distance between anode and cathode, respectively.

3. Results and Discussion

Fig. 3 shows a measurement of the target current as a function of collector voltage at a sample without the patterned gold line charge neutralization. One can observe that the target current decreases as the collector voltage increases. This reveals the fact that charges are accumulating at the insulating sample surface during the ion bombardment. In this case, we can not determine the primary ion current I_p and the target current I_t. So, it is impossible to calculate the secondary electron emission coefficient γ.

Fig. 4 shows the measurements of target currents with the patterned gold line charge neutralization. Contrary to Fig. 3, one can observe stable behaviors of the target currents in negative and also in positive collector voltage regions. So, we can determine the primary ion current I_p and the target current I_t as well and thus the secondary electron emission coefficient γ. The measurement was performed at the samples, MgO and MgO+MgF_2 with two ion beam energies, 300 eV and 400 eV.

Table 1 summarizes the results of the measured values of the ion induced secondary electron emission coefficient γ and the firing voltage V_f of MgO and MgO+MgF_2

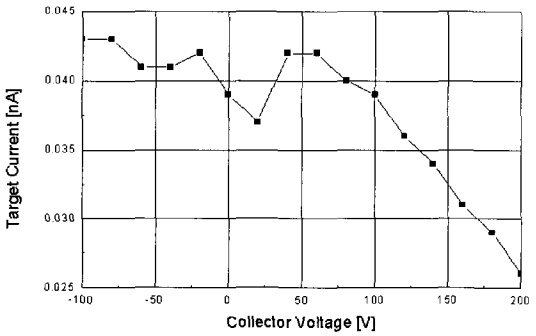

Fig. 3 Measurement of the target current as a function of collector voltage at a sample without the patterned gold line charge neutralization. Charges are accumulating at the insulating sample surface during the measurement.

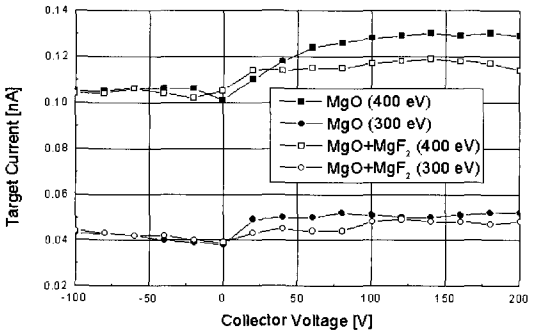

Fig. 4 Measurements of target currents with the patterned gold line charge neutralization. The measurement was performed at the samples, MgO and MgO+MgF_2 with two ion beam energies, 300 eV and 400 eV.

Table 1 Summary of the measured values of the ion induced secondary electron emission coefficient γ and the firing voltage V_f of MgO and MgO+MgF_2 protecting layers.

Protecting Layers	γ		V_f
	300 eV	400 eV	
MgO	0.18	0.24	220 V
MgO+MgF_2	0.08	0.12	320 V

protecting layers. The γ increases as the ion beam energy increases from 300 eV to 400 eV in both samples. This can be explained with the theory of kinetic electron emission. In case of MgO, the γ values are in good agreement with the results of Rajopadhye et al. which has measured the γ at a 20 nm thin MgO layer on a semiconducting substrate [9]. The γ value of MgO is greater than that of MgO+MgF_2 sample in both ion energies. On the contrary, the firing voltage V_f of MgO is smaller than that of MgO+MgF_2 sample. This shows a correct relationship between γ and V_f which is described in equation (2) above.

4. Summary

Ion induced secondary electron emission coefficients γ of MgO and MgO+MgF_2 protecting layers of an AC-PDP have been measured with the new method of the patterned gold line charge neutralization. The γ value has been compared with the firing voltage V_f of the AC-PDP with the same protecting layer. Correct relationship between γ and V_f has been observed. Thus, the patterned gold line method has been proven to be successful for the measurement of the secondary electron emission yield at insulator sample surfaces.

Acknowledgement

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