Ion-induced secondary electron emission coefficient and work function for MgO thin film with O_2 plasma treatment

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ABSTRACT

The ion-induced secondary electron emission coefficient γ and work function for MgO thin film with O_2 plasma treatment has been investigated by γ -FIB (focused ion beam) system. The MgO thin film deposited from sintered material with O_2 plasma treatment is found to have higher γ and lower work function than those without O_2 plasma treatment. The energy of various ions used has been ranged from 100eV to 200eV throughout this experiment. It is found that the highest secondary electron emission coefficient γ has been achieved for 10 minutes of O_2 plasma treatment under RF power of 50W .

INTRODUCTION

The characteristics of MgO protective layers are very important for the development of recent AC-type plasma display panel (AC-PDP) [1,2]. The ion-induced secondary electron emission coefficient γ is one of the characteristics of the MgO protective layer which correlates to the ignition voltage of AC-PDPs[3]. Recently many researchers have been studying to get the highest γ. Therefore we selected the method of oxygen (O_2) plasma treatment for improvement of secondary electron emission coefficient γ from MgO protective layer. In this research, we used two steps of MgO protected layer growing method to get higher quality of it. First MgO thin films were prepared by using electron beam evaporation method from sintered materials. And then they were treated by oxygen plasma by using RF-plasma generation system. The ion-induced secondary electron emission coefficient γ and work function of MgO protective layer have been measured by γ -FIB (Focused Ion Beam) system throughout this experiment [4] to investigate the influence of oxygen plasma treatments on it.

Experimental Configuration

The MgO protective layers are deposited on the glass by electron beam evaporation method and vacuum annealed under 200℃ about 20 minutes after the deposition. The thickness of MgO thin film is 5000Å. The deposition rate is 5Å/s. In this experiment, Ne^+ ions are used for the measurement of γ by varying its energy from 100eV to 200eV. The MgO thin films deposited from sintered material are treated by the O_2 plasma by RF plasma generator under fixed RF power of 50 W. The O_2 plasma treatment durations of the MgO thin films are adjusted by 5 and 10 minutes, respectively. The one of two MgO thin films are treated by O_2

plasma, while the other MgO thin film has not been treated by the O_2 plasma in this experiment.

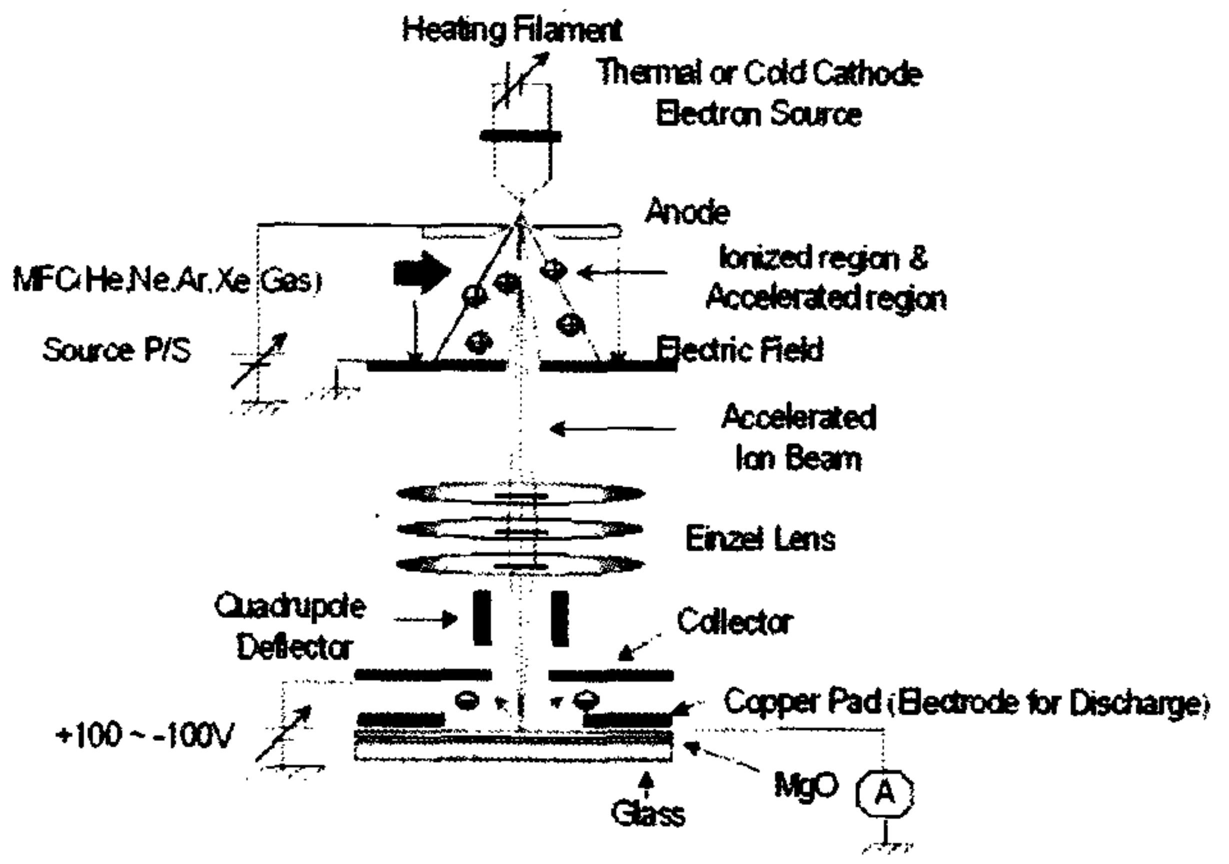

Fig. 1. The schematic of **γ-FIB system**

Figure 1 shows the schematic γ-FIB system for measurement of secondary electron emission characteristics from MgO thin film. The γ -FIB system is broken down into five basic components: the diode consisting of thermionic electron source and anode, electron-impact ion formation and its acceleration region, electrostatic single Einzel lens for ion beam focusing, quadrupole deflector, and substrate for γ measurement of MgO thin film, respectively. The background vacuum pressure of γ -FIB is maintained at 1.6×10^{-5} Torr, whereas it is kept by up 7×10^{-5} Torr during ion beam formation mainly at the nearby region of 2mm-diam. anode hole by gas feeding. The ions are produced by impact collisions of thermal electrons emitted from filament to the He, Ne, Ar, N_2, and Xe atoms. The kinetic energy of ions is depended on the ion accelerating voltage applied to the anode. The anode positive biased and can be +50 up to +500V for the ion acceleration, and these ions are passed through the 0.5mm-diam. beam defining aperture along downstream of the system. The ion beam is the focused by single electrostatic Einzel lens and scanned by the quadrupole deflector onto the MgO surface with fixed beam diameter of 80 um throughout this experiment, which can be achieved by adjusting the filament heating current under the given ion acceleration energy.

RF-plasma generator has been used for the O_2 plasma treatment in this experiment. The RF-plasma treatment conditions are summarized in table 1. The oxygen plasma treatment time have been chosen to be 5 and 10 minutes, and their RF-discharged plasma has been maintained at gas pressure of 110 mTorr in this experiment. The RF power has been optimized to be 50W, where the ion-induced secondary electron emission characteristics from MgO thin film has the highest value in comparison with other RF powers. .

Experimental variable	Value	
Substrate temperature	R.T. 300	(°C)
Base pressure	6.0 10 [illegible]	(Torr)
Treatment pressure	110	(mTorr)
Treatment time I	5	(min)
Treatment time II	10	(min)
RF power at treatment	50	(Watt)

Table 1. Plasma treatment conditions

Experimental Results and Discussions

Figure 2 shows the ion-induced secondary electron emission coefficient versus Ne^+ ion accelerating voltage from 100 eV up to 200 eV, which has been obtained for MgO protective layers with O_2 plasma treatment by 5 (solid circles) and 10 minutes (solid squares), and they are compared with that without plasma treatment (solid triangles). The MgO thin film with O_2 plasma treatment by 10 minutes has been found to have higher γ values than those for other MgO films for above Ne^+ ion energy ranges. It is noted that the γ of MgO films with O_2 plasma treatments by 10 minutes is shown to be from 0.13 up to 0.28, which is 3 times of those with 5 minutes and without plasma treatment, versus Ne+ ion energies ranged from 100 eV to 200 eV.

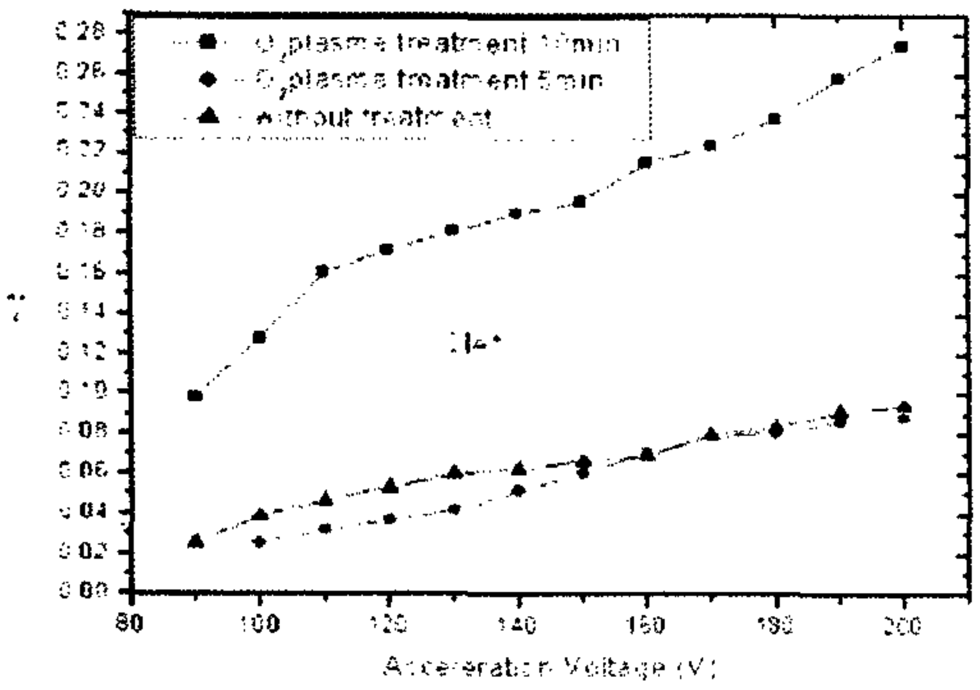

Fig.2. γ from the MgO thin film with plasma treatment with different treatment time.

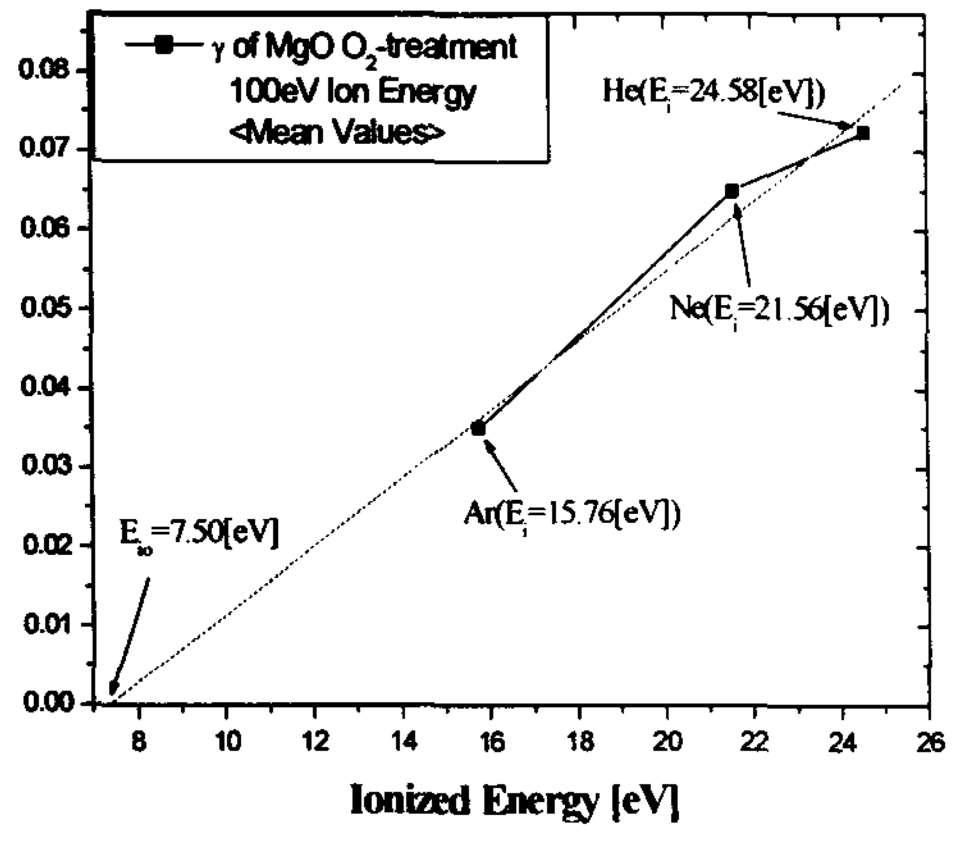

Fig. 3. Work function determination from ion-induced secondary electron emission coefficient of various ions.

Figure 3 shows the ion-induced secondary electron emission coefficient γ versus various ionization energies Ei of several gases used in this experiment. All ion energies for Ar^+, Ne^+, and He^+ are fixed to be 100 eV in Fig. 3. For the zero emission of ion-induced secondary electrons, i.e. $\gamma = 0$ from specified MgO surface, the maximum kinetic energy E_k^{max} of ejected electrons might be zero, which results in work function, $\phi = E_{i0} /2$, where E_{i0} is the ionization energy satisfying the zero emission of ion-induced secondary electrons, which can be obtained by least-squared-error-fitting extrapolation of γ versus the ionization energies for various slow ions of Ar^+, Ne^+, and He^+[5]. The extrapolated intersection point of the ion-induced secondary electron emission coefficient γ with the horizontal axis of ionization energies Ei for various gases of He, Ne, and Ar determines the value of E_{i0}= 7.50 eV, which is the ionization energy satisfying zero emission of secondary electrons. It is noted that the work function for O_2 plasma treatment is shown to be low value of 3.75eV, while it is 4.64eV for MgO thin film without treatment. These results indicate that the ion-induced secondary electron emission coefficient γ and work function of MgO thin film are dependent on the O_2 plasma treatment.

Conclusion

It is found that secondary electron emission coefficient γ of MgO thin film with O_2 plasma treatments by 10 minutes has been remarkably increased from 0.13 up to 0.28, which is 3 times of those with 5mintues and without plasma treatment versus Ne^+ ion ranged from 100 eV to 200 eV in this experiment. It is also found in this experiment that the work function for O_2 plasma treatment is shown to be low value of 3.75eV in comparison with that of 4.64eV for MgO thin film without treatment.

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