Influence of gas mixture ratio on the secondary electron emission coefficient (γ) of MgO single crystals and MgO protective layer in surface discharge AC-PDPs

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Abstract

The secondary electron emission coefficient γ of MgO single crystals according to the gas mixture ratio of Xe to Ne have been investigated by γ–focused ion beam system. It is found that the MgO single crystals of (111) crystallinity has the highest γ from 0.09(0.03) up to 0.16(0.04), while from 0.07(0.02) to 0.15(0.03) for (200) and from 0.06(0.01) to 0.13(0.02) for (220) crystallinity for operating Ne (Xe) ions ranging from 50eV to 200eV throughout this experiment. And it is found that the γ ranged from 0.03 up to 0.06 for Ne-Xe mixtures are much smaller than those of 0.09 up to 0.16 for pure Ne ions under accelerating voltage ranged from 50V to 200V.

Introduction

The secondary electron emission coefficient γ of a MgO protective layer in AC plasma display panels (AC-PDP) is an important factor to determine firing voltage and sustain voltage. The MgO films have important role in lowering the firing voltage [1] due to a high γ. Recently it is reported that (111) crystallinity of MgO protective layer has the highest γ in comparison with other layers with orientation of (200) and (220) [2]. For clarification and verification of this result, it is of great importance to investigate the γ of MgO single crystals at first before various deposited MgO films characteristics are extensively discussed among PDP people.

Experimental Configuration

The MgO single crystals of (111), (200), and (220) are used for measurement of γ in γ -FIB system. Their sizes are 10 mm × 10 mm and 0.2 mm in thickness. In this experiment, Ne and Xe ions as well as their mixtures are used for the measurement of γ. It is of great importance to investigate the γ from MgO single crystals and MgO protective layer in real AC-PDP with various gas mixtures ratio of Xe to Ne buffer gas. The real AC-PDP front panel size is 35 mm × 35 mm and 3.5 mm in thickness. The MgO protective layer is deposited on the dielectric layer by electron beam evaporation method and its thickness is about 5000 Å.

Experimental Results and Discussions

Figure 1 shows the γ obtained for MgO single crystals of (111), (200), and (220), which are characterized by solid squares, solid circles, and solid triangles, respectively, versus Ne ion accelerating voltage from 50V up to 200V. The single crystallinity (111) is found to have the highest γ from 0.09 up to 0.16, while from 0.07 to 0.15 for (200) and from 0.06 to 0.13 for (220) crystallinity for operating Ne ions ranging from 50eV to 200eV throughout this experiment. Figure 2 shows the similar results to figure 1 for Xe ions. The MgO single crystals of (111) orientation is also found to have the highest γ from 0.03 up to 0.04, while from 0.02 to 0.03 for (200) and from 0.01 to 0.02 for (220) crystallinity, respectively. Figure 3 shows the γ from MgO single crystals of (111) orientation for the pure Ne, Xe, and their various mixtures versus ion accelerating voltage ranged from 50V to 200V. In this experiment, the gas mixture ratios of Ne:Xe are 99:1, 98:2, 96:4, 93:7, and

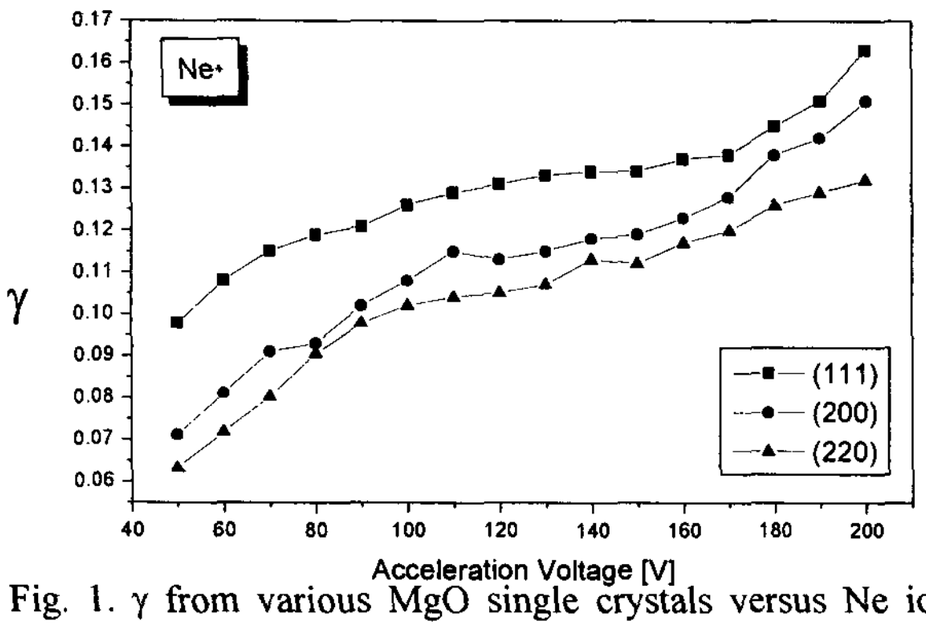

Fig. 1. γ from various MgO single crystals versus Ne ion accelerating voltage

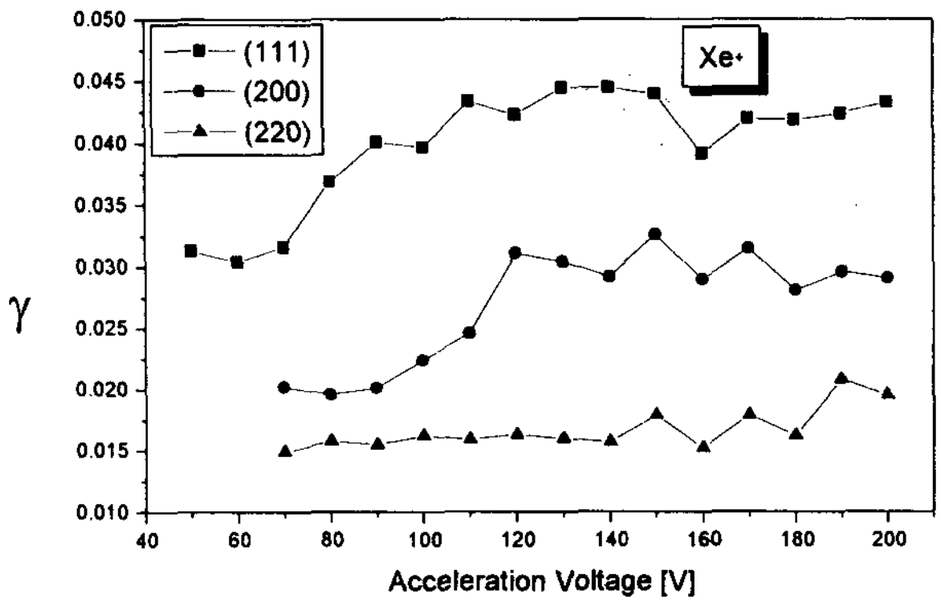

Fig. 2. γ from various MgO single crystals versus Xe ion accelerating voltage

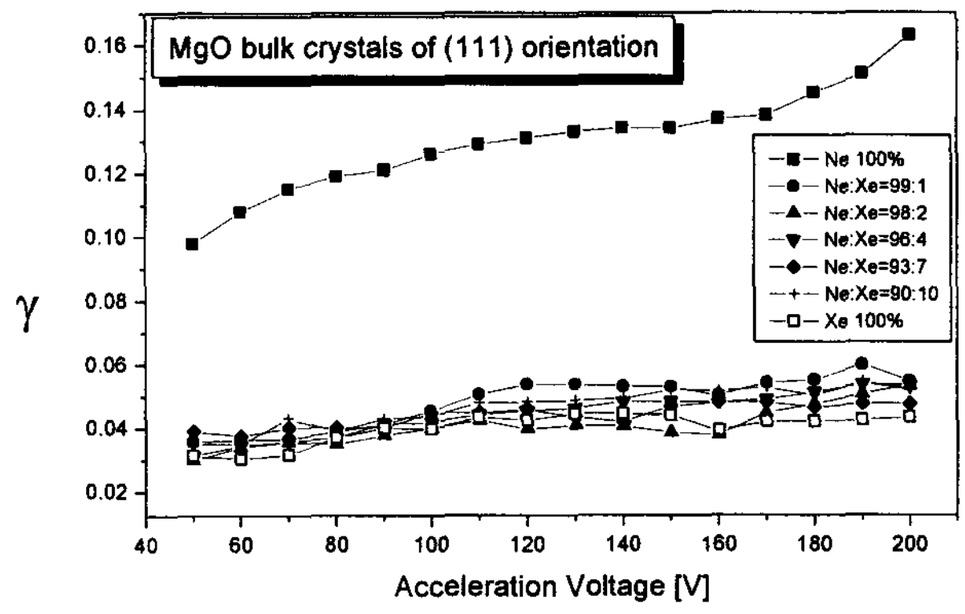

Fig. 3. γ from MgO single crystals of (111) orientation for the Ne, Xe and their various mixtures versus ion accelerating voltage

90:10. The γ for pure Ne and Xe ions also represented by solid squares and open squares, respectively, in figure 3. It is noted that the γ ranged from 0.03 up to 0.06 for Ne-Xe gas mixtures are shown to be much smaller than those ranged from 0.09 up to 0.16 for pure Ne ions at above ion energy ranges. It is found that the γ for Ne-Xe gas mixtures are very close to those for pure Xe ions at above ion energy ranges, because most ions are Xe species rather than Ne ions due to low ionization energy of Xe. Figure 4 shows

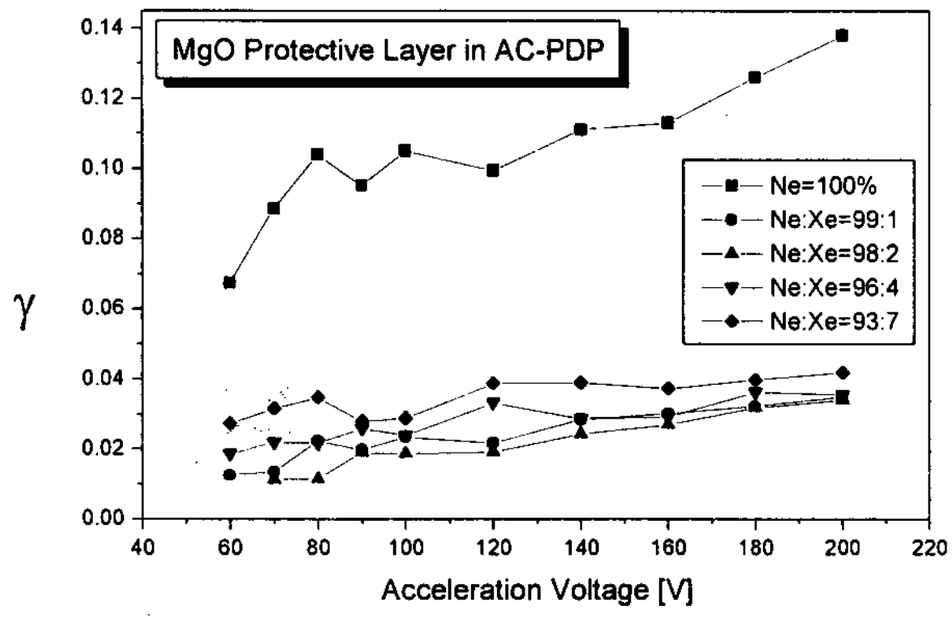

Fig. 4. γ from MgO protective layer in AC-PDP with different mixture ratio of Xe to Ne versus ion acceleration voltage

the results of γ from MgO protective layer in real AC-PDP with different gas mixture ratios of Xe to Ne versus ion acceleration voltage 60V up to 200V. It is also noted that γ ranged from 0.01 up to 0.05 for Ne-Xe gas mixtures are much smaller than those ranged from 0.07 up to 0.14 for pure Ne at above ion energy range. It is noted that the γ from MgO protective layer in real AC-PDP for various Ne-Xe gas mixtures are very similar to those in figure 3.

From Auger neutralization mechanism, maximum kinetic energy E_{kmax} of the ejected secondary electron from MgO single crystal is given by $E_{kmax}=E_i-2\phi_\omega$, where $E_i=21.56eV$ is the ionization energy of Ne ion and ϕ_ω is the work function for the MgO. The maximum kinetic energy of the ejected electrons for specified crystal orientation could be obtained by differentiating the secondary electron current with respect to collector voltage.[2] For correlation between the γ and work function of MgO single crystal with specified orientation, the slow Ne ions less than 100eV have been used in this experiment. The work function ϕ_ω can be obtained by $\phi_\omega=(E_i-E_{kmax})/2$, which is based on the Auger neutralization mechanism.

Figure 5 shows the results of the work function ϕ_ω of MgO single crystal with specified orientation (111) represented by solid squares, (200) by solid circles, and (220) by solid triangles, respectively, versus Ne ion energies ranged from 50 to 100eV. It is noted that the work function ϕ_ω for crystal orientation (220) is shown to be at the highest 9.43eV, while 8.43eV for (200) and 7.52eV for (111) for slow Ne ion energy of 60eV. These results indicate that the work function of MgO single crystal is dependent on its respective orientation so that the γ is in turn different from each other according to its orientation.

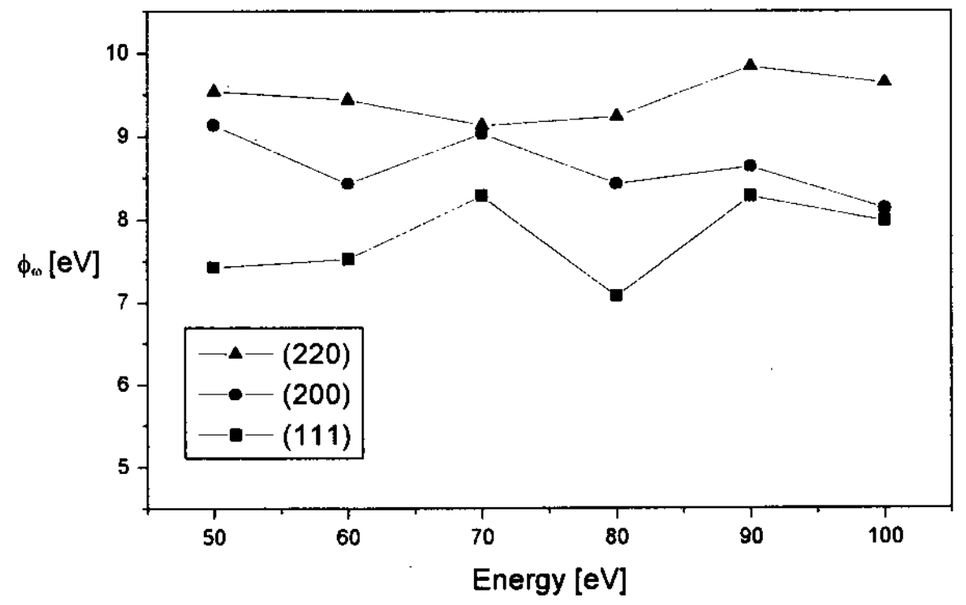

Fig. 5. Work function ϕ_ω of MgO single crystal with specified orientation (111), (200), and (220) versus Ne ion energies from 50 to 100eV

Conclusion

The secondary electron emission coefficient γ of MgO single crystals and MgO protective layer in real AC-PDP have been investigated by γ-focused ion beam system. The single crystallinity (111) is found to have the highest γ from 0.03 up to 0.04 , while from 0.02 to 0.03 for (200) and from 0.01 to 0.02 for (220) crystallinity for operating Xe ions ranging from 50eV to 200eV throughout this experiment. Based on these facts, it can be concluded that (111) crystallinity in MgO protective layer plays an important role in lowering the firing voltage in AC-PDP compared with the other crystallinities of (200) and (220).

The γ for Ne-Xe gas mixtures are shown to be much smaller than those for pure Ne ions for accelerating voltages from 50V to 200V. The γ for the Ne-Xe gas mixtures has been approached to those for pure Xe ions since most ions are Xe species rather than the Ne ions due to low ionization energy of Xe.

The work function ϕ_ω for MgO single crystal of (220) orientation is found at the highest to be 9.43eV, while to be 8.43eV for (200) and to be 7.52eV for (111) orientation for slow Ne ion energy of 60eV. These results indicate that the work function of MgO single crystal is dependent on its respective orientation so that the γ is in turn different from each other according to its orientation.

References

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