Characteristics of Si impurity doped MgO in an ac PDP

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Abstract

In this work, the discharge characteristics and temporal distribution of surface charges on the Si-doped MgO have been investigated and elucidated with the results of photon-induced surface current. Even though the Si doped MgO shows lower static voltage margin, higher luminous efficacy, and shorter statistical delay time, its discharge characteristics become deteriorated as the timing of scanning is delayed from the ramp type reset pulse down. Overall features of Si-doped MgO in discharge characteristics are well correlated with surface current characteristics.

1. Introduction

Plasma display panel (PDP) has been properly established in the TV market as one of the high image quality and large-sized flat display devices. However, it still needs to improve the luminous efficacy, reduction of manufacturing cost, and image quality to compete with other flat display devices such as liquid crystal display (LCD) and organic light emitting diode (OELD).

Among the elements to compose of an ac PDP, MgO layer is directly exposed to plasma discharges, and therefore, the durability against the ion bombardment and the secondary electron emission yield γ_i are important characteristics. Recently, MgO attracts the attentions of PDPs researchers because it seems to be a key element for the achievement of full HD(1920 × 1080) PDP addressing with single scan. Accordingly, the studies about impurities doping or additional high-gamma materials on the MgO layer are being reported.[1-3] In this research, we studied photon-induced surface current of impurity(Si) doped MgO whose features on the discharge characteristics in an ac PDP was already reported in the affirmative.[1] We also investigated discharge characteristics such as the static and dynamic voltage margin, address delay time and spatio-temporal surface charges in various experimental conditions and discussed the results with surface current.

2. Experimental set up

We already studied the surface conductivity of MgO in various kinds of environmental conditions such as under the change of temperature and the illumination of vacuum ultra violet(VUV), and correlated them to the discharge characteristics of PDPs having those films, which showed that the electron-trapping defect level or impurity level in the forbidden band of MgO is helpful for the improvement of the discharge characteristics. However, the impurity doping into the MgO layer increases the electrical conductivity, which affects the surface charge formation and thus the driving characteristics of ac PDP.[4-6]

In order to investigate the discharge characteristics of Si doped and conventional MgO, Si doped MgO with 300ppm concentration and conventional MgO(Mitsubishi Material Co., 99.9%, sintered type) were used as the protective layers and partially deposited on the same front panel. The test panel used in this research was a conventional coplanar type 4-in. diagonal ac PDP in Ne-Xe(4%) at 400Torr. Wall charge measurement was also conducted by the longitudinal electro-optic amplitude modulation method with BSO($Bi_{12}SiO_{20}$) single crystal which shows a change of its refractive index when an electric field is applied to it. The magnitude of surface charges was observed by measuring the phase retardation of light passing through the crystal which was generated by the change of the refractive index due to the electric field.[7]

In this research, we also studied the surface current of each MgO layer by exposing them to the monochromatic VUV synchrotron radiation.[4,5]

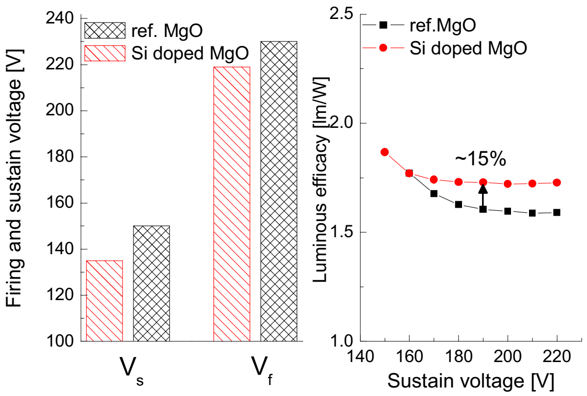


Fig. 1 Static voltage margin and luminous efficacy of test panel whose protective layers are made from the Si doped MgO and ref. MgO.

Normally incident VUV beam whose wavelength ranges from 60nm to 240nm was irradiated across the ring shaped MgO surface and surface current induced by the monochromatic VUV was measured by pico-ammeter(Keithley 617). The detailed condition for surface charge and photon-induced surface current measurement can be found else where.[4,5,7]

3. Results and Discussion

It had been examined that the optimum value of Si concentration on the improvement of discharge voltage, luminous efficiency, address delay time and image sticking is about 300ppm by Lee. et. al.[1] As shown in Fig. 1, we also found that 300ppm-concentrated Si doped MgO shows about 15V lower firing and minimum sustaining voltage and 15% higher luminous efficacy at 190V sustaining voltage compared to those of conventional MgO, which may result from the increase of secondary electron emission characteristics by proper amount of impurity(Si) doping on MgO.

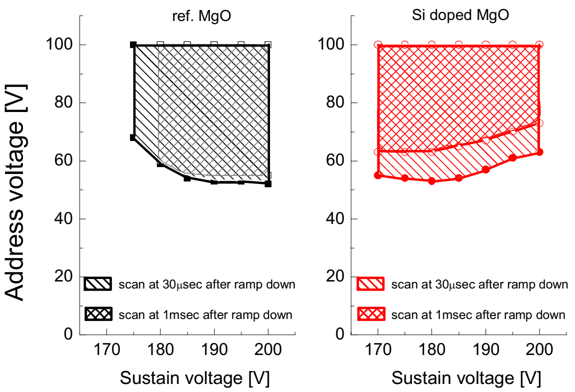


Fig. 2 Address and sustain voltage margin of test panel whose protective layers are made of Si doped MgO and ref. MgO.

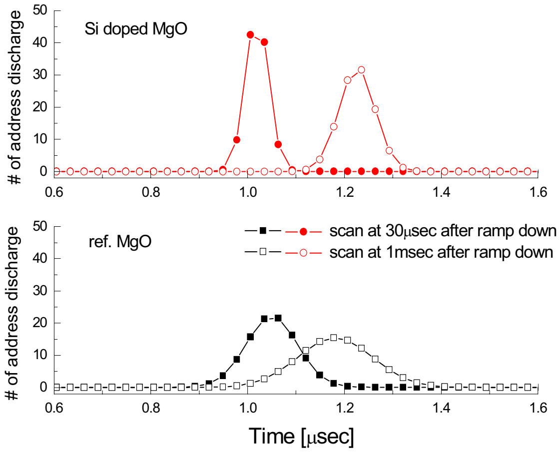


Fig. 3 Address discharge distribution with respect to the timing of scanning.

Fig. 2 shows the address and sustain voltage margin of Si doped and conventional MgO during the full driving operation, where the full driving waveform consists of ramp type reset pulse with 8 subfield and the timing of address discharge were set at 30µsec and 1msec after the ramp type reset pulse down. Even though Si doped MgO shows the extended sustain and address driving voltage margin(V_s: 5V, V_a:~10V) at 30µsec after the ramp type reset pulse down, its

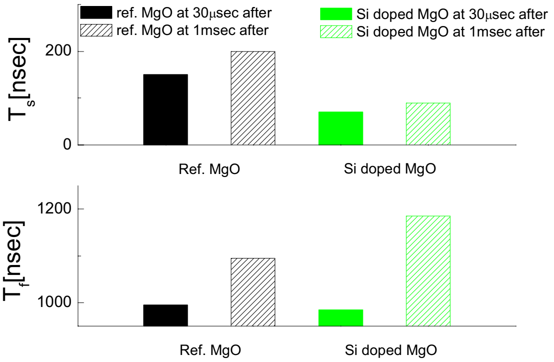
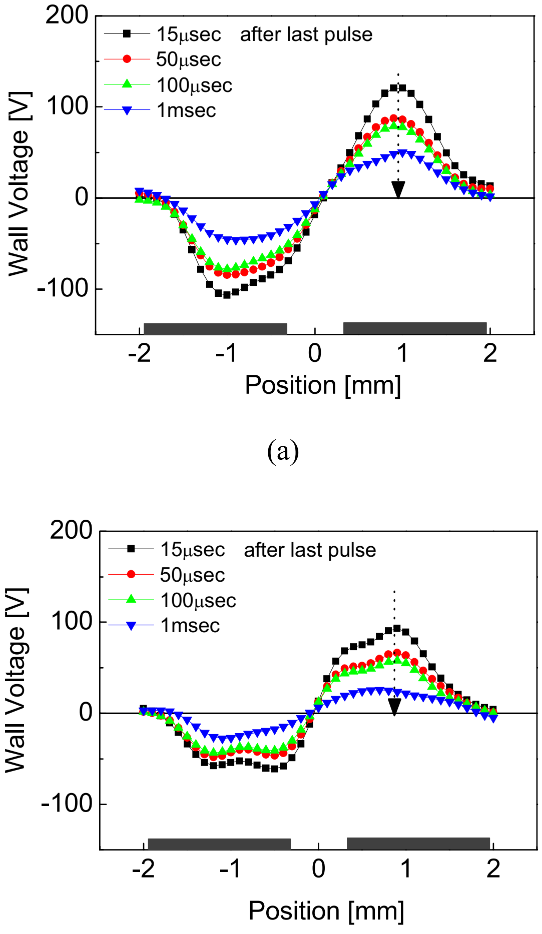


Fig. 4 Statistical and formative delay time of test panel with respect to the timing of scanning.



(a)

(b)

Fig. 5 Temporal surface charge distribution on MgO surface. (a) Ref. MgO (b) Si doped MgO

address voltage margin becomes diminished about 10~20V at 1 msec after ramp pulse down.

Address delay time was also measured by changing the timing of address discharge which was set at 30μsec and 1msec after the ramp type reset pulse down. At fixed address and sustain voltage(V_s: 170V, V_a: 50V), the address discharge delay time was acquired 300 times by measuring the time duration from the address pulse rising to IR emission. Fig. 3, 4 show the address discharge distribution and address discharge delay time with respect to the timing of scanning. While Si-doped MgO shows shorter address delay time(90nsec) at 30μsec after the ramp type reset pulse down, it also shows more increased formative delay time(985nsec→1185nsec) at 1 msec after the ramp down, which seems to be related with the increased electrical conduction characteristics in impurity doped MgO layer.[4,5]

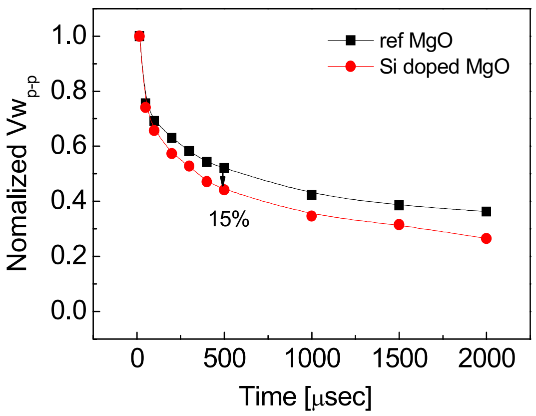


Fig. 6 Temporal decay characteristics of peak to peak wall voltage.

In order to study the temporal distribution of wall charges on each MgO layer, surface charge measurement was conducted by applying 33.3kHz pulse train at 340V accompanied by 5-msec rest period. As shown in Fig. 5, the distribution on the Si doped MgO shows broader distribution than that on reference MgO, which seems to be resulted from the annihilation of surface charges on the MgO layer due to the increased electrical conductivity by the impurity doping. Fig 6 shows decay behavior of peak to peak wall voltage on each MgO layer normalized with respect to the value at 15μsec after the last pulse. Si doped MgO shows faster decay behavior and becomes 15% smaller than that of conventional MgO in the long term behavior after 500μsec.

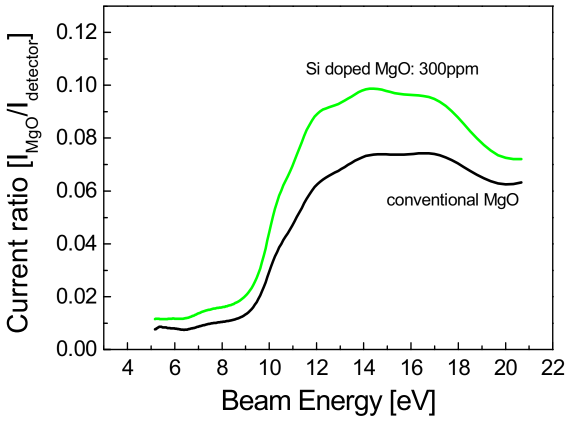


Fig. 7 Photon-induced surface current of Si doped and conventional MgO.

Through the investigation of discharge characteristics and temporal behavior of wall charges on the Si-doped and conventional MgO, it is found that the attempt to increase the interband impurity levels in MgO band gap decreases the firing voltage and discharge delay, which may inadvertently involve the loss of voltage margins due to the increased surface conduction of surface charges. Accordingly, the photon-induced surface current measurement was conducted to confirm these conjectures. As shown in Fig. 7, while the overall features of each curve are nearly the same for the whole energy range, the level of surface current of Si-doped MgO shows much higher than that of conventional one.

4. Summary

In this research, we examined the driving characteristics of ac PDPs with the impurity doped MgO layer. Si doped MgO with 300ppm concentration shows lower static voltage margin, higher luminous efficacy, and shorter statistical delay time, but on the other hand, its discharge characteristics become deteriorated as the timing of scanning is delayed from the ramp type reset pulse down. It also shows relatively vulnerable surface charge behavior during the long term rest period. These experimental results can be well explained by the results surface current compared to those of conventional MgO. Accordingly, it is concluded that the attempt to increase the secondary electron emission yield γ_i through the introduction of impurities in the forbidden band of MgO and decrease the firing voltage and discharge delay may inevitably accompany the loss of voltage margins due to the increased surface conduction of surface charges.

5. References

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