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Discharge Characteristics of MgO Nano-Powdered Functional Layer in AC-PDP

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We have studied discharge characteristics of MgO nano-powdered functional layer in accordance with their particle sizes in AC-PDP. The MgO nano-powder's size was controlled and confirmed that the different particle sizes were distributed according to the sintering times throughout the particle size analyzer (PSA) measurement. We made the different 6 inch test panels, in which the different particle size's functional layers were applied, for measurements of the firing voltage, secondary electron emission coefficient and cathodoluminescence (CL) spectrum. It is shown that the functional layer makes the firing voltage and sustain voltage low, and the particles with large size have the lowest firing voltage and sustain voltage, which are related to the high secondary electron emission coefficient.

Keywords AC-PDP; functional layer; ion-induced secondary electron emission coefficient; MgO; powder

Introduction

Nowadays, PDP trend is high efficiency and high resolution. Specially, high efficiency is most important factor in AC-PDP. So, many research groups try to solve the high efficiency problem [1]. Recently, additional functional layer on MgO protective layer receives much attentions and key issues of AC-PDP [2]. In this study, we made different particle size functional layer, then performed pre-studies for optimization of the particle size through the various measurements such as discharge characteristics, secondary electron emission coefficient, and electro-optical characteristics. Figure 1 shows the structure of AC-PDP front panel, to which applied functional layer is coated. There are many functional layer coating methods such

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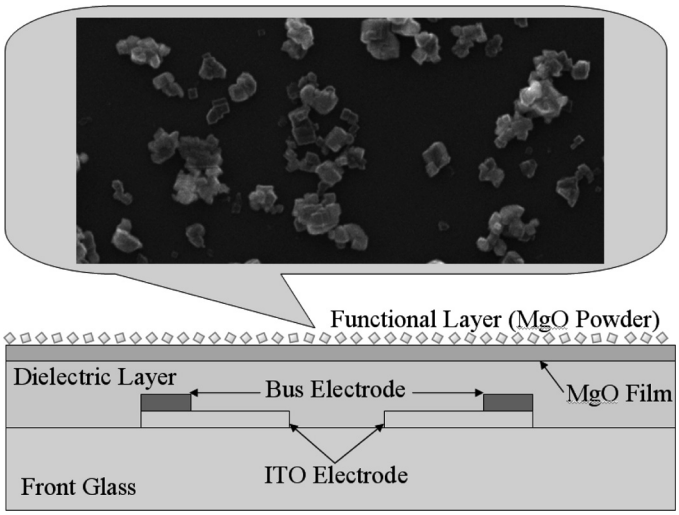

Figure 1. Structure of AC-PDP front panel with functional layer.

as spray coating, screen printings, etc. In this experiment, we used the 6 inch test panel with the functional layer by the spray coating method.

MgO Particle Size

In this experiment, we controlled MgO particle sizes by adjusting the powder sintering time. The case 1 and case 2 are the 6 and 12 hours sintering times, respectively. Figure 2 shows the SEM (Scanning Electron Microscopy) image of each case functional layer surface. As seen in the Figure 2, it seems that the case 2 particle is larger than the case 1 particle. However, it is very hard to know exact particle size for each other. So we measured the particle size for each case by using PSA

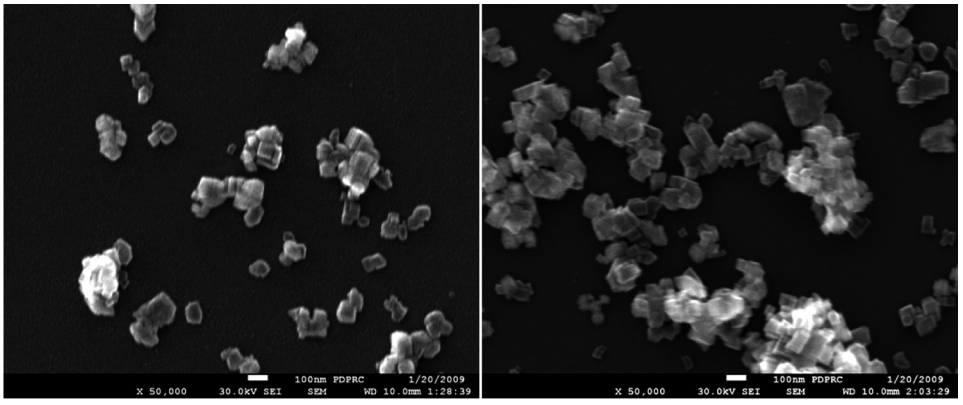

Figure 2. SEM (Scanning Electron Microscopy) images of functional layer for both cases 1 and 2.

(Particle Size Analyzer). Figure 3 shows the PSA results for each case. According to the Figure 2(A), The peak particle sizes are 0.14 μm and 0.17 μm, respectively, for the cases 1 and 2. However, these peak results are not representative of mean particle size. Total number of particles with different size distribution is obtained by integration of particle size distribution for getting the average particle size. As you see the Figure 2(B), the average particle sizes are 0.18 μm and 0.23 μm, respectively, in which they are captured at the 50% of total particle numbers, for the both cases 1 and 2. These results show that we could control the MgO particle size by sintering times.

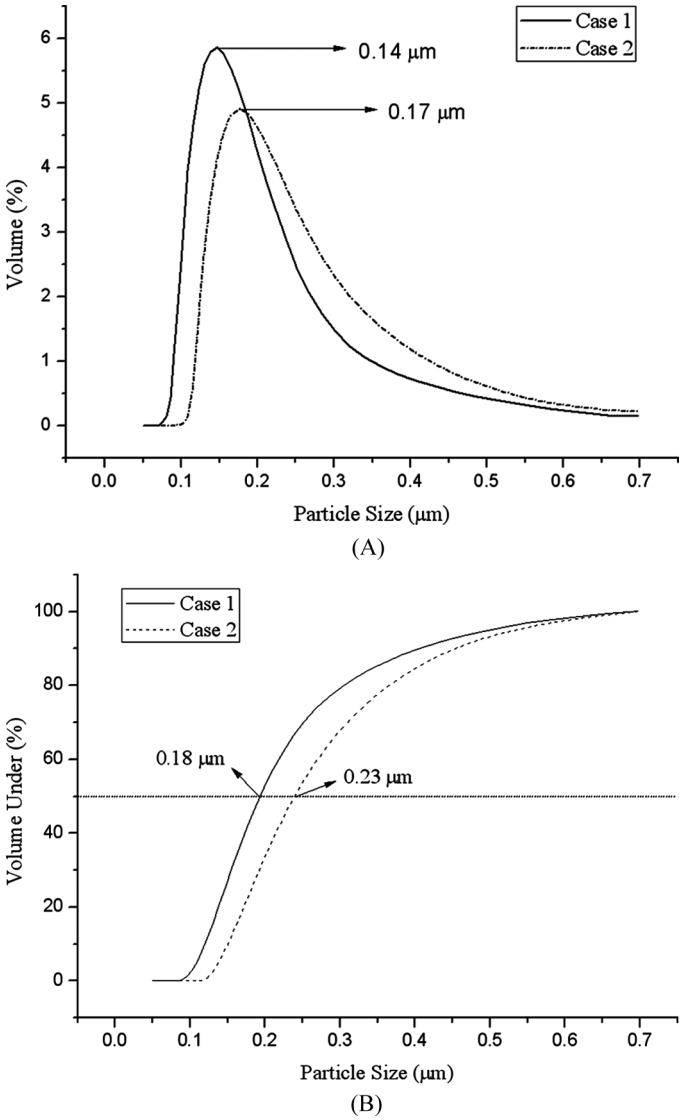

Figure 3. PSA (Particle Size Analyzer) distributions for the both cases 1 and 2. (A) Particle size distribution and (B) Total number of particles.

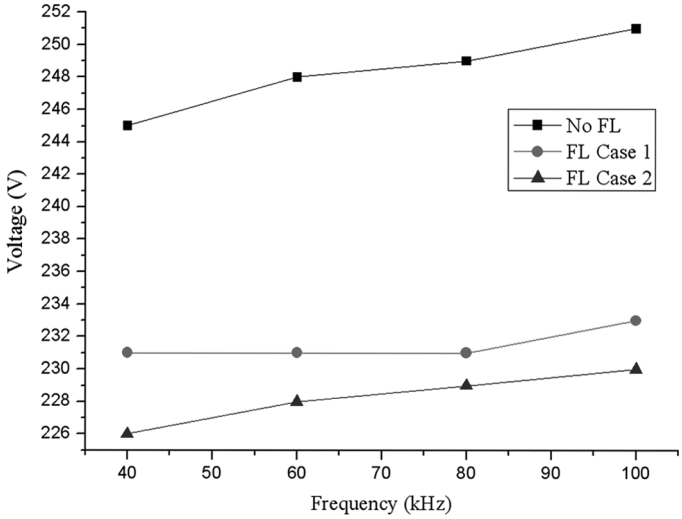

Figure 4. Firing voltage of each test panels with the functional layers of cases 1 and 2 versus the driving frequency.

Discharge Characteristics

We have fabricated the 6 inch test panels, which have electrode gap 60 μm, width 310 μm for VGA class with a cell pitch of 1080 μm. Bus electrode width is 90 μm, barrier rib width and height are 100 μm, and 120 μm, respectively. MgO protective layer was deposited by electron beam evaporation method under evaporation rate 20 Å/s, thickness is 7000 Å, substrate temperature 200°C, and vacuum annealing process at 300°C during 30 minutes. After MgO protective layer formation, we made the functional layer by spray method for each case. The MgO protective or functional layer

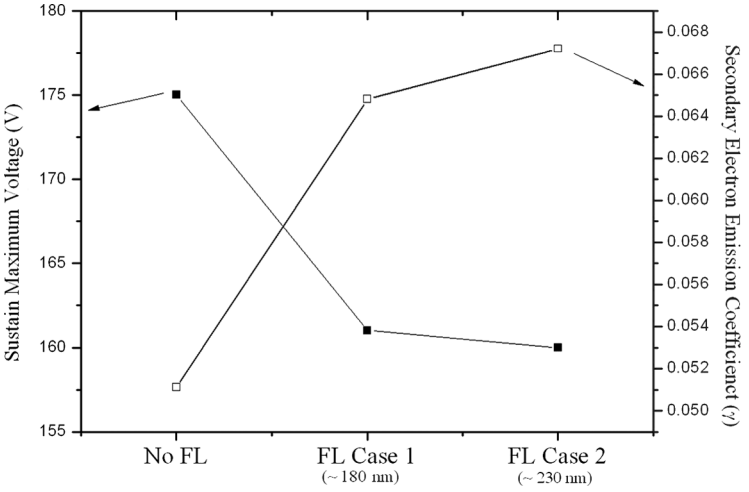

Figure 5. Sustain maximum voltage and the secondary electron emission coefficient of test panels with and without functional layer.

has been sputtered in part by the sustaining discharge, however, simultaneously the re-deposition or grain growth has been occurred during the discharge [3]. The sputtering yield for MgO protective layer is about 0.35 atom/ion for Ga ions with energy of 10 keV [4], from which the life time can be estimated by 60,000 hours based on the Xe ions with energy of 200 eV. Hence the life time for the MgO nano particle functional layer has been estimated to be about 12,000 to 24,000 hours with thickness of 100 to 200 nm. The real life time is actually unaffected by sputtering process because of simultaneous re-deposition or grain growth. Therefore, functional layer plays enough role in their function during the sustaining discharge. Discharge gas, we used Ne + Xe (15%) mixture gas and its pressure was 400 Torr. Figure 4 shows the firing

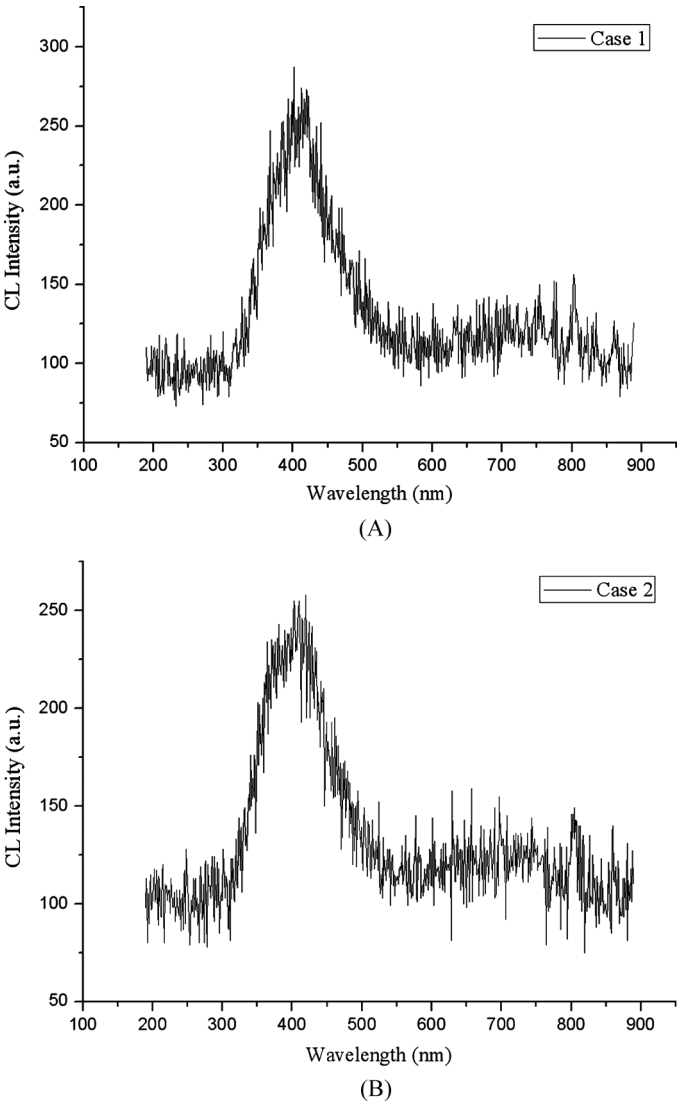

Figure 6. Cathodoluminescence (CL) spectrum of test panel with functional layer of (A) case 1 and (B) case 2.

voltage of each test panels versus the driving frequency with their respective functional layer. It is noted that the test panel with the case 2's functional layer has the lowest firing voltage from 227 to 230 V and the test panel without the functional layer has the highest firing voltage from 245 to 251 V for the above driving frequency ranges. Then we measured the secondary electron emission coefficients with functional layer and non functional layer in the test panels under the case 1, by using the gamma-focused ion beam system (γ-FIB) [5–7]. As seen in the Figure 5, the secondary electron emission coefficient of test panel with functional layer is higher than that without functional layer. Therefore, the firing and sustain maximum voltages of test panel with the functional layer is lower than that without functional layer. The decrease of discharge voltage is caused by the enhancement of the secondary electron emission coefficient caused by the functional layer. It is also noted that the luminous efficiency η can be increased by enhancement of the secondary electron emission coefficient, i.e., $\eta \propto a\gamma \exp(-b/\gamma)/[(1+\gamma)\ln(1+1/\gamma)]$ [8,9], where a and b are coefficients determined by the experimental fitting to the theoretical predictions. It is noted in this experiment that the higher secondary electron emission coefficient is obtained for the bigger particle size of the functional layer, while the discharge voltage is shows the reciprocal behavior to that of the secondary electron emission coefficient. Figure 6 shows the CL spectrum of front panel with the functional layer of the (A) case 1, and (B) case 2. As you see the Figure 6, the CL spectra for the both cases of 1 and 2 are in similar tendency. These results confirm that the sintering times do not change material characteristics. Therefore, sintering time is related only to MgO powder particle size, and in turn particle size is related to the secondary electron emission coefficient.

Conclusions

In this study, we have shown the different discharge characteristics in accordance with the MgO nano-particle sizes used for the functional layer. We controlled nano-particle size by adjusting the sintering times and these are coated onto the MgO protective layer by spray method. It is shown that the functional layer make the firing voltage and sustain voltage low, and the particles with large size have the lowest firing voltage and sustain voltage, which are related to the high secondary electron emission coefficient. However, the optimization of the particle size is not yet defined. Therefore, we have to do more experiment for optimization particle size for functional layer.

Acknowledgments

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