Luminance efficiency of PDP having phosphor layers formed via osmosis coating process

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Abstract

Phosphor layers on rear plate of PDP were formed via osmosis coating process in an attempt to improve thickness uniformity of phosphor layer and eventually to enhance luminance and its efficiency of plasma display panel. The phosphor layers were formed uniformly not only on the sidewalls of barrier ribs but also on the dielectric layer of rear plate by the process. The processing parameters affecting the thickness uniformity of the phosphor layer formed by the osmotic coating process were investigated.

1. Introduction

Plasma display panel realizes images by using visible lights emitted from phosphor layers coated on the surface of rear plate. Currently, the phosphor layer is formed by printing the pastes of phosphor powders on rear plates with barrier ribs. The coating process has limited control over the thickness uniformity of the layer. The thickness uniformity as their morphology is controlled by gravity, viscosity and amount of pasted printed. Thickness of the layer can vary significantly from 5 to 40 μm depending on the location within the cell. The variation in thickness leads to reduction in discharge space within the cells, which will eventually affect the luminance and luminance efficiency of the cell.

In this study, therefore, a new coating process for phosphor layer was developed. The process consisted of formation of green tapes containing phosphor powders and coating utilizing osmosis pressure developed between the green tape and rear plate. Thickness uniformity of phosphor layer is crucial in keeping similar discharge volume of each cell, thereby maintaining uniform luminance and its efficacy throughout the panel. The effects of parameters that might affect the thickness uniformity of the layer were studied for highly uniform phosphor layer formation. The parameters include type of coating solvent, compositions and thickness of the green tape. The luminance and its efficiency using the phosphor layers formed via the osmotic coating process were studied.

2. Experimental

Green tape for the osmotic coating process was prepared using slurries consisted of phosphor powder, binder, plasticizer, dispersant and solvent. The slurries were cast into the green tape using doctor blade type tape casting machine and was dried by exposing to atmospheric condition for 24 hours. The thickness of the tape prepared was 30 μm, coating thickness was varied from 6μm to 23μm controlled by lamination of green tape or using different coating solvent. Figure1 shows schematic illustration of the osmotic coating process. In this process, osmotic pressure developed by coating solvent pulls the tape to the wall of barrier ribs to form the phosphor layer. The microstructure of the rear plate with the reflection layer was examined using scanning electron microscopy (SEM).

Using rear plates with the phosphor layer, test panels were manufactured and their luminance and luminance efficacy were evaluated. For the discharge gas, Ne + 4%Xe gas mixture was used. A simple square voltage pulse was applied for the luminance measurement. The frequencies of current were 10, 20, 30, 40, and 50 kHz.

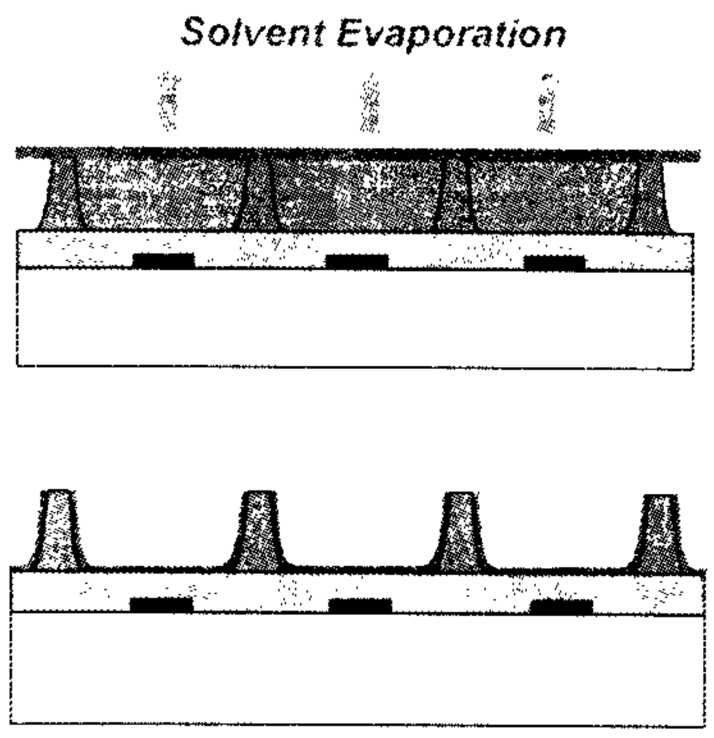


Figure 1. SEM micrograph of green tape for osmotic coating process.

3. Results

One of important features required as a green tape for the osmotic coating process is a homogenous microstructure. The phosphor powder must distribute uniformly throughout the green tape. Organic constituents were tested for its effects on the microstructure of the green tape and an optimum composition was selected. Figure 2 shows SEM micrograph of a green tape prepared for the osmotic coating process. As noted from the figure, phosphor powders were distributed evenly in the green tape.

When a coating solvent of reasonable solubility to the organic constituents of the green tape was used, a phosphor layer with very uniform thickness was obtained as noted in Figure 3(a).

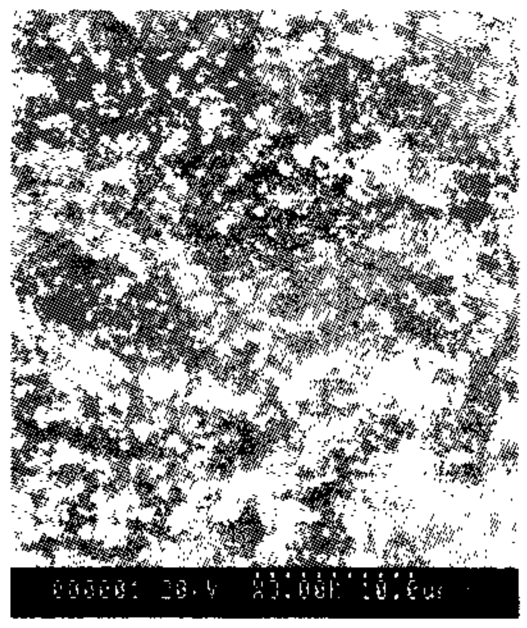
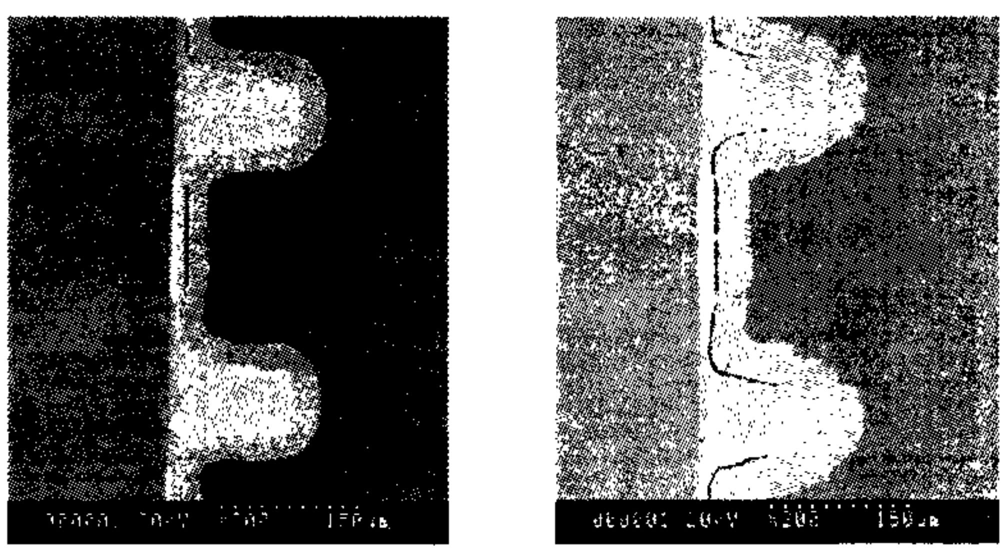


Figure 2. SEM micrograph of green tape for osmotic coating process.

As noted from the figure of higher magnification (Figure 4(a)), a phosphor layer with an uniform thickness was formed not only on the sidewalls of barrier ribs but also on the surface of dielectric layer of rear plate. The thickness uniformity was varied with the change in organic components of green tape and the type of powder used. On the other hand, when a solvent with low solubility was selected, the phosphor layer with cracks were formed as in Figure 3(b). This is mainly due the lack of swelling of green tape.



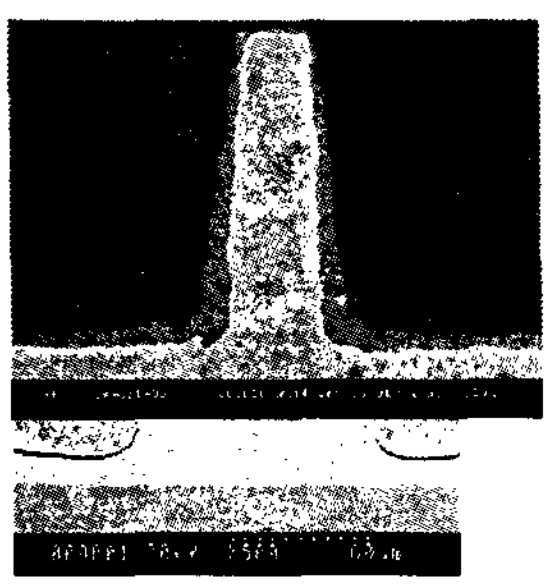
(a) (b)

Figure 3. SEM micrographs of phosphor layer using coating solvent of (a) reasonable solubility and (b) low solubility to organic constituent of green tape.

Finally, when a solvent with very high solubility to the organic constituents of the green tape was used (Fig. 4(b)), the thickness of the layer, however, varied rather appreciably along the wall of barrier ribs. The thickness of the layer was thin near the top of the barrier ribs and became thick at the bottom of the barrier rib. This variation of the phosphor layer thickness is mainly due to the extensive swelling as well as partial dissolution of green tape during the coating process.

Effects of phosphor layer thickness on the luminance and luminance efficiency were by changing the thickness to 7.6 μm, 13.4 μm, and 23.4μm. As noted in Figure 6, the luminance was increased with the increase in the thickness of phosphor layer. The increase in luminance and luminance efficiency became saturated when the thickness was increased from 13.4 μm to 23.4 μm. This indicates that the packing density of the phosphor layer is low, such that a significant fraction of VUV radiation penetrates through the pores of the layer.

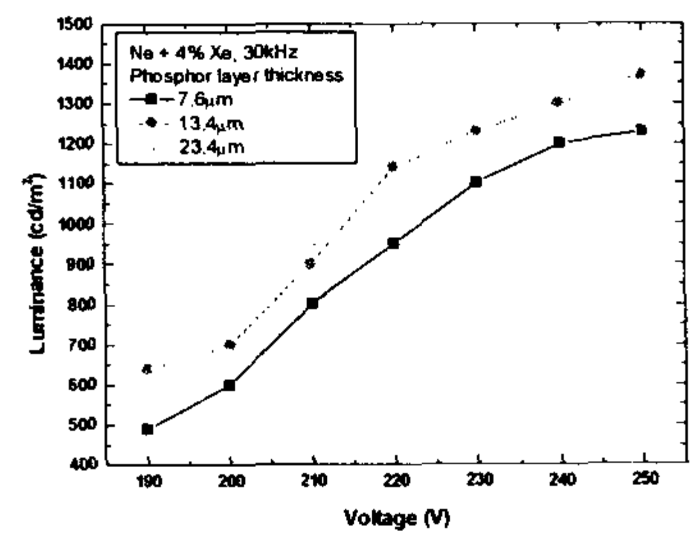
The packing density of the phosphor layer formed via the osmotic coating process is



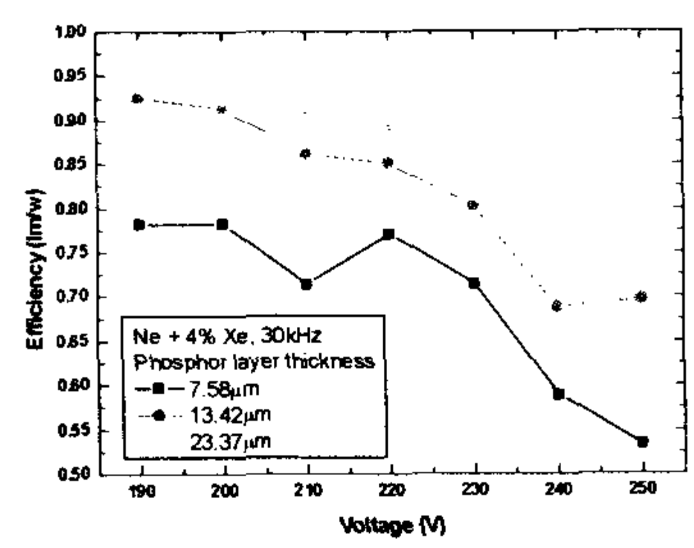
(a) (b)

Figure 4. (a) SEM micrograph of phosphor layer formed using a solvent of reasonable solubility. (b) SEM image of phosphor layer formed using solvent with a solvent of high solubility.

content of organic constituents in the green affect by various parameters including tape, particle size and its distribution of phosphors, and degree of agglomeration of phosphor powder. In this study, the green phosphor powders with two different average sizes, 3μm and 500nm, were mixed at 7:3 ratio to produce green tape for the osmotic coating process. Figure 6 shows SEM micrographs of phosphor layers after calcinations treatment. When the phosphor powder of 3 μm diameter was used only (Fig. 6(a)), the phosphor layer appeared to be quite porous with large pores inside. With the mixed powders, the size and density of pores in the layer became reduced significantly.

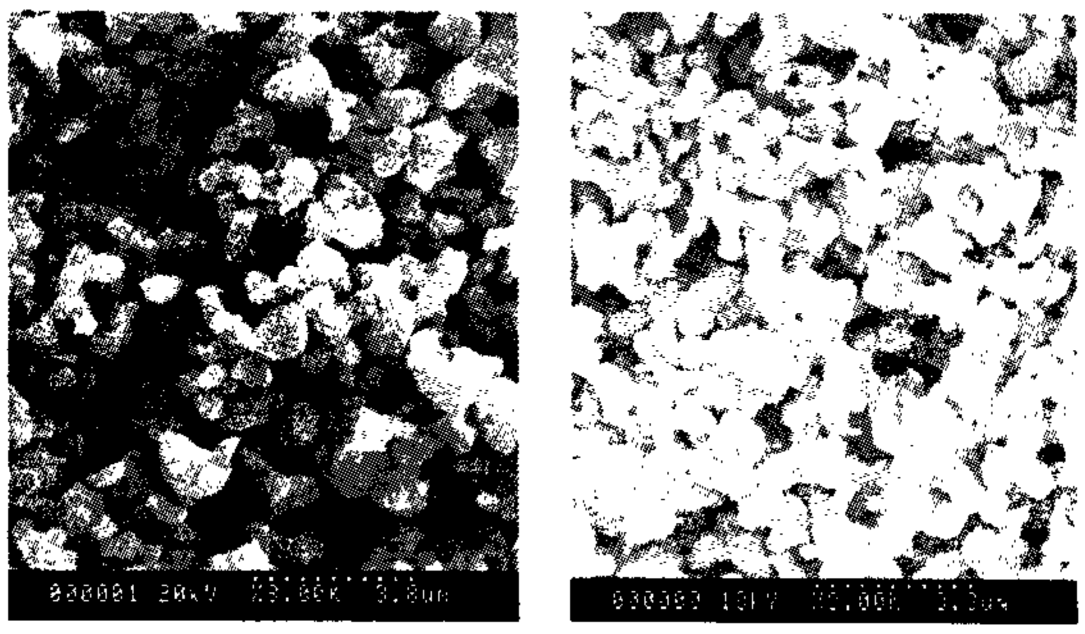


(a)



(b)

Figure 5. Effect of phosphor layer thickness on the luminance(a) and luminance efficiency(b) of PDP panel. The discharge gas pressure was 400 torr.



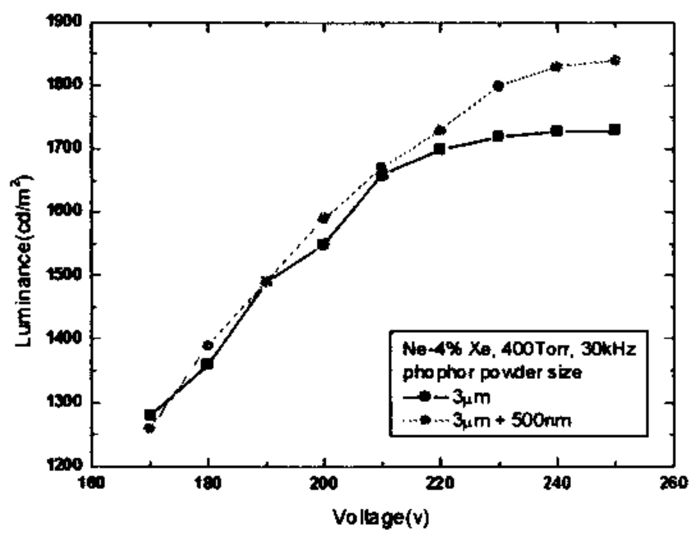
(a) (b)

Figure 6. SEM micrographs of phosphor layers formed using (a) 3μm powder and (b) mixed powders.

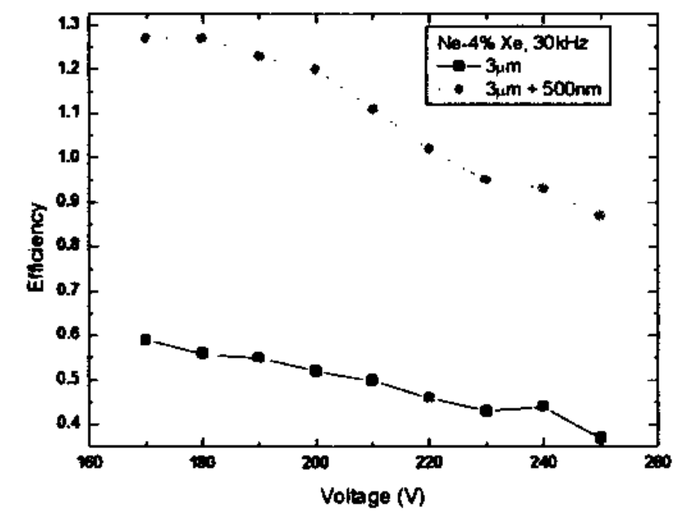
The effects of packing density of phosphor layer on luminance and luminance efficiency of the panel were studied using the phosphor layers(Figure 7). As shown in Figure 7(a), the luminance of the panels was similar to each other at low sustaining voltages. The effect became prominent when the sustaining voltage is higher than 220V. The luminance efficiency of the panel with mixed powder (Figure 7(b)), however, was significantly improved with the use of the mixed powder.

4. Conclusion

It was demonstrated that phosphor layer can be formed via osmotic pressure coating process. The morphology of the phosphor layer formed was affected by process parameters especially the solubility of organic constituents in the green tape into the coating solvent. Thickness and packing density of the phosphor layer formed via the process were found to affect the luminance and luminance efficiency of the PDP panel significantly.



(a)



(b)

Figure 7. Effects of packing density of phosphor layer on luminance (a) and luminance efficiency (b) of PDP panel.

5. References

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