Effect of Ag Powder Sources on the Patterning of PDP Electrodes

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Abstract

In this work we compared different sources of composition of Ag powders obtained by dry and wet process on the photolithographic patterning of PDP electrode and resistance of sintered Ag electrode. It was found that 90 : 10 wt% ratio of Ag powder made by dry and wet processes gave optimum result both on the PDP electrode pattern and resistance of PDP electrode after sintering.

1. Introduction

Plasma Display Panel (PDP) electrodes include address and bus electrode patterned on rear and front panel of PDP, respectively. These electrodes are patterned by the photolithographic method utilizing photosensitive silver (Ag) paste. The photosensitive Ag paste is composed of organic vehicle including binder polymer, UV oligomer/ monomer, photoinitiator and additives and inorganic powders of silver and glass frit. The inorganic powder mixture is added to the organic vehicle and dispersed with mechanical stirrer and three roll mill to give photosensitive Ag paste. This paste is screen printed on the glass substrate, dried and UV exposed through the photomask and developed with aqueous alkaline solution. After development the Ag electrode pattern is dried and sintered up to 580℃ for 30min to give final silver metal electrode pattern on PDP panel [1-5].

The Ag powders used in the photosensitive Ag paste for PDP are usually obtained by wet process. For example $AgNO_3$ aqueous solution containing reductant and stabilized are reacted to give nano-size Ag particle slurry. This slurry is then dried and heat treated to give Ag particles of mean diameter about 1.5 ㎛. On the other hand dry process Ag powder is made by spray pyrolysis of $AgNO_3$ aqueous solution without additives and then heat treated to give about same size as that of wet process Ag particles. The two Ag powders exhibit the differences on the surface morphology of Ag particles. In this study we examined the effect of using different source Ag powder in the Ag paste on the photolithographic patterning of PDP electrodes.

2. Results

2-1. Fabrication of photosensitive Ag Paste

In this study, poly(isobutyl methacrylate-co-methacrylic acid-co-2-hydroxyl ethyl meth-acrylate)s were synthesized as binder polymers which could be burnt out at relatively low temperature without residue. UV curable monomers and oligomers used include penta-erythritol triacrylate (PETA), trimethylol propane-triacrylate (TMPTA) and trimethylolpropane ethoxy-triacrylate (TMPEOTA). Photoinitiator (HSP-188) was purchased from SK-ucb Co. Ltd and used as received. Silver powder made by dry process was obtained from Kornatech Co. Ltd and Ag powder by wet process was purchased from Sigma-Aldrich Co. Both Ag powders had average size (d_{50}=1.5 ㎛). Silver powder mixtures of dry and wet process were used with certain amount of glass frit to ensure good adhesion of thin silver film on the glass substrate of PDP. The photosensitive vehicle, Ag powder, glass frit powder were initially mixed with mechanical stirrer and then subjected to three roll mill for about 2 hour.

Typical photosensitive Ag paste formulation is shown in the Table 1.

Table 1. Typical formulation of photosensitive Ag paste

Component	Photosensitive Vehicle				Inorganic powder	
	Binder	Solvent	Monomer	Additives[a]	Ag	Glass frit
Composition (wt%)	7.6	14.1	7.2	1.1	66.5	3.5

a : additives such as photoinitiator and dispersing agent

2-2. Photolithographic Patterning

For the photolithographic pattering of PDP electrode, photosensitive Ag paste was printed on the glass substrate and dried. Photomask with address electrode pattern of PDP was placed on top on the dried Ag layer and then irradiated with UV lamp to a total dose of 300 ~ 500 mJ/cm^2. After UV exposure the Ag layer was developed with aqueous alkaline solution at 1.0 kg/cm^2 pressure for 10 ~ 20 sec and then dried in the 110 ℃ oven for 10 min. After dry the patterned Ag electrode was examined with optical microscope (Olympus STM6) to check Ag pattern morphology. The patterned electrode panel was finally sintered in the electric oven up to 580 ℃ for 30 min [6].
The examination of Ag electrode pattern prepared with dry, wet, and dry/wet process Ag powders are shown in the Table 2.

Table 2. PDP address electrode pattern obtained with different Ag powders

UV Dose (mJ/cm^2)	Wet process Ag Powder			Dry process Ag Powder			dry/wet=90/10 process Ag powder		
	Width (㎛)	UC (㎛)	EC (㎛)	Width (㎛)	UC (㎛)	EC (㎛)	Width (㎛)	UC (㎛)	EC (㎛)
100	Pattern Lost			Pattern Lost			Pattern Lost		
150	Pattern Lost			100	10	7	100	10	5
200	Pattern Lost			100	5	5	100	5	3
250	95	30	7	100	5	3	100	5	0
300	100	25	5	105	0	0	105	0	0
350	105	20	3	110	0	0	105	0	0
Electrical resistance	4.2Ω			3.3Ω			2.8Ω		

Note : UC = Under Cut EC = Edge Curl

As shown in th Table 2, Ag electrode patterns obtained with photosensitive Ag paste with dry process Ag powder exhibited better pattern ability and lower electrical resistance compared to the one with wet process Ag powder.

It is noted that the Ag powder mixture (dry/wet = 90/10 wt%) gave lower electrical line resistance than dry and wet process Ag powder alone. In Figure 1 and Figure 2 dry process Ag powder exhibited less edge curl compared to the wet process Ag powder. This difference in patterning of Ag address electrodes depending on the sources of Ag powder may be due to different surface morphology of Ag powder.

SEM image of surface of wet process Ag powder showed many micro-crators or orange peel morphology compared to dry process Ag powder as shown in Figure 3.

Figure 1. Optical images of Ag electrode patterns

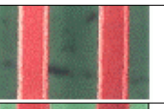
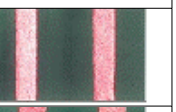
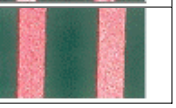
Sample	After developing	After sintering
Wet process Ag		
Dry process Ag		

Figure 2. SEM images of Ag electrode cross-sections

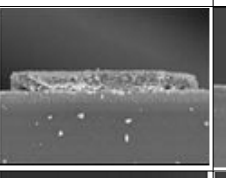
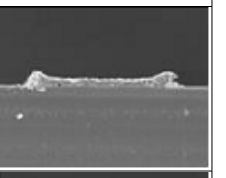
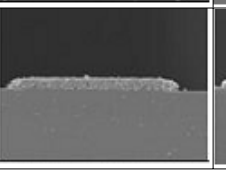
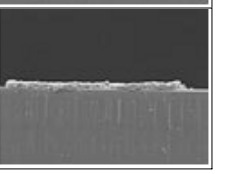
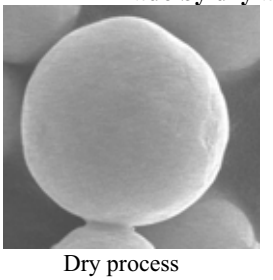
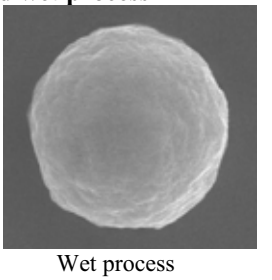
Dry Process	After developing	After sintering
Wet Process Ag		
Dry Process Ag		

Figure 3. SEM images of surface of Ag powders made by dry and wet process


Dry process


Wet process

3. Conclusion

In pattering of address electrode of PDP the photosensitive Ag paste prepared with dry process Ag powder or combination of dry/wet process Ag powder in 90/10 wt% resulted in lower electric resistance than the one prepared with wet process Ag powder. The high resolution of Ag electrode pattern and low electrical resistance of Ag electrodes could make contribution to the high performance of PDP.

4. Acknowledgements

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5. References

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