Effect of Conducting Carbon Layer on AC Thin Film EL Device

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Abstract

The effect of conducting carbon layer on the performance of AC thin film EL display was examined. It was found that incorporation of small amount of carbon nano-tube and conducting additive greatly improve the luminance of the inorganic EL compared to the one with only conducting carbon black.

1. Introduction

Organic EL technologies do not yet provide affordable displays for the general consumer. Even with the enormous world-wide momentum enjoyed by technologies such as organic light emitting diodes and field emission displays, key issues such as lifetime, cost, and reliability remain unsatisfied. However, inorganic thin-film electroluminescence has provided the highest level of monochrome display reliability.

In this study the carbon black layer of inorganic EL device was modified by incorporation of carbon nano-tube and conducting additive in addition to the commonly used conducting carbon black/vehicle formulation. The effect of modified carbon paste on the luminance intensity of EL device was examined while keeping other pastes and fabrication conditions constant.

2. Experimental

2.1 Materials

Binder polymers for the preparation of inorganic EL paste include poly(vinylidene difluoride) (PVDF, M_w=180,000g/mol, Sigma Aldrich Co.) and synthesized polymers ; poly(isobutyl methacrylate-co-methacrylic acid) (poly(IBMA-co-MAA) and poly(methyl methacrylate-co-methacrylic acid) (poly(MMA-co-MAA). Solvents for the dissolution of binder polymer were 3-methoxy-3- methyl butanol (3MMB) and menthanol (MTA).

Green phosphor (ZnS:Cu) and dielectric powder ($BaTiO_3$) were from Osram Co.. Conducting carbon black (HI-Black 41Y) was obtained from Korea Carbon Black Co.. Commercial silver paste obtained from Samsung Chemical Paint Co. was used to make silver electrode. Dispersant BYK Chemical-130 was used to make carbon black paste. Carbon nano-tube (MWNT 95BM) from Iljin Nano-Tech was also used in the formulation of conducting carbon black paste.

2.2 EL Paste Formulation and Rheological Properties

In case of phosphor paste binder polymer (poly(IBMA-co-MAA), M_w=80,000g/mole) was dissolved in 3MMB solvent. To this solution were added dispersant (BYK-110) and then green phosphor (ZnS:Cu) powder. This mixture was stirred with mechanical stirrer for 30 min. And then dispersed in the three roll mill (Exact Co., Germany) for 1hr to give FOG value of 8-10㎛. For the conducting carbon paste, poly(MMA-co-MAA) with M_w=15,000g/mole was used as binder polymer and menthanol (MTA) as solvent. In some carbon pastes carbon nano-tube was also incorporated in the formulation. Typical formulations for conducting carbon paste and phosphor paste are shown in Table 1.

Table 1. Typical formulation for conducting carbon paste & phosphor paste

Phosphor paste	Poly(IBMA-co-MAA)	3MMB	Phosphor powder	Additives
	13	27	60	~ 0.2
Carbon paste	Poly(MMA-co-MAA)	MTA	Carbon powder	Additives
	18	72	10	~ 40

The rheological property of the EL pastes is one of the most important factor affecting the performance of the resulting inorganic EL devices. The rheology of paste is strongly dependent on the components of the organic vehicle, especially the binder polymer/solvent pairs. Fig. 1 shows the different rheological curves of vehicles; poly(vinylidene difluoride)/DMF and poly(MMA-co-MAA)/MTA used in the dielectric and conducting carbon paste, respectively.

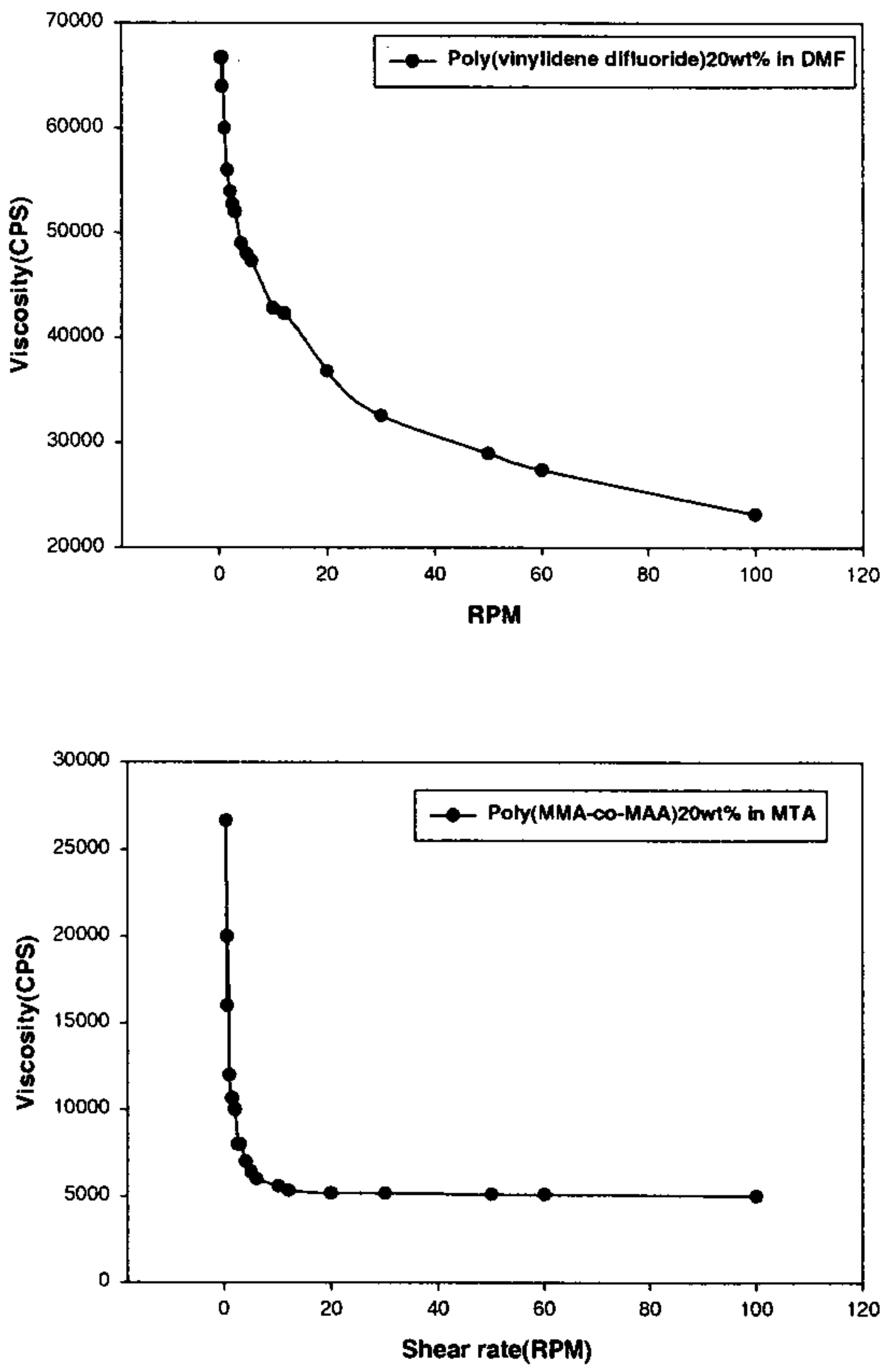

Fig. 1. Rheological curves of vehicles

From Fig. 1 and Table 1 it is noted that vehicle (poly(MMA-co-MAA)/MTA) for conducting carbon paste has lower viscosity than that of dielectric or phosphor paste (poly(vinylidene difluoride/DMF). Since carbon black powder has high surface area with low density, the vehicle needs to have low viscosity. This also requires that the binder polymer, poly(MMA-co-MAA), should have low molecular weight (ca. 15,000g/mole) and functional groups with good dispersing property such as carboxylic moiety.

The comparison of rheological curves of conducting carbon and silver paste is shown in Fig. 2. Carbon paste has much higher viscosity due to a large number of particles and surface area compared to the silver particles.

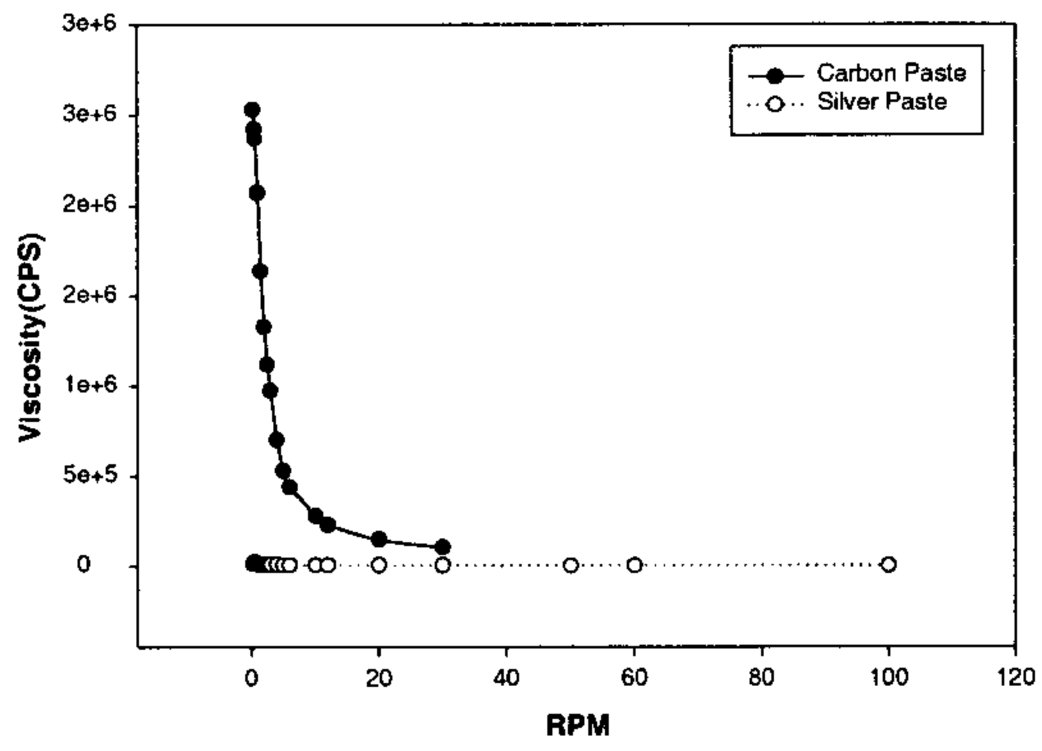

Fig. 2. Rheological curves of carbon and silver paste

2.3 Fabrication of Inorganic EL Devices

A typical structure of EL devices fabricated is shown in Fig. 3. First phosphor paste was coated on indium tin oxide (ITO) deposited polyester (PET) film to a dry thickness of 60μm. Then dielectric layer was coated to about 30μm, follow by conducting carbon layer to about 20μm. Finally silver paste was coated to about 10μm thickness using 250 mesh screen printer. The whole process of manufacturing inorganic EL device for electro-optical measurement is shown in Fig. 4.

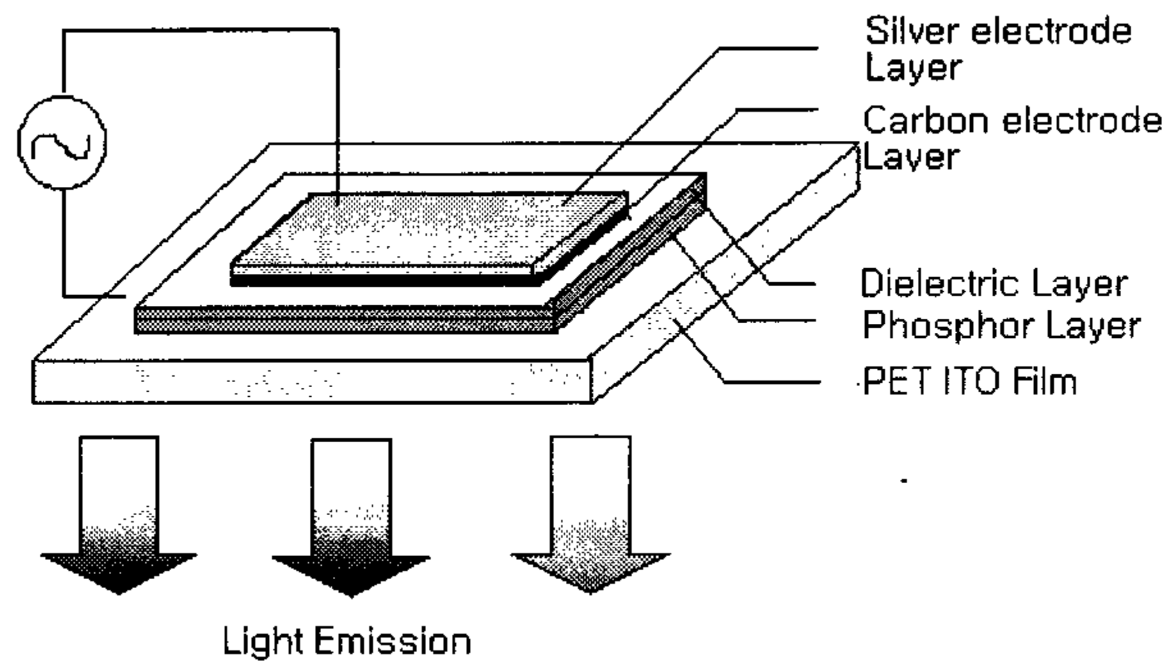

Fig. 3. Structure of inorganic EL device

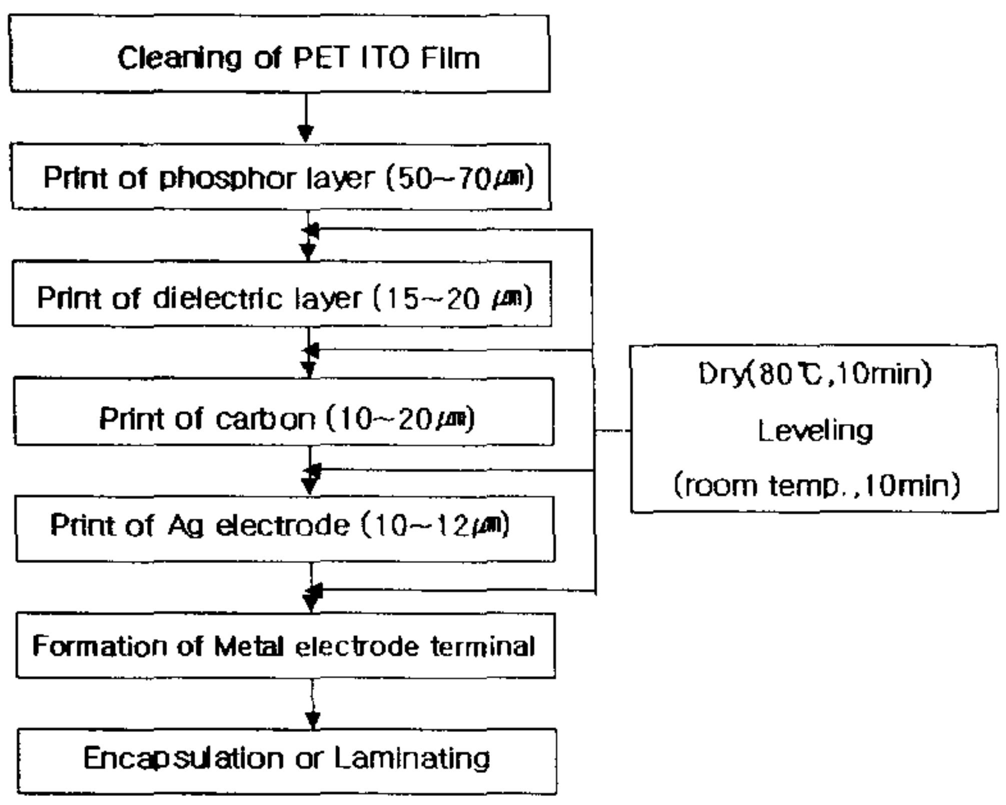

Fig. 4. Manufacturing process of inorganic EL device

3. Results and discussion

In order to examine the different formulation of conducting carbon layer on the luminance intensity of inorganic EL device, four different carbon pastes were formulated as shown in Table 2.

Table 2. Carbon paste formulation and Resistance

Carbon Paste(wt%)	Thickness (㎛)	Resistance (Ω/□)
Carbon black(CB) /Vehicle = 10/90	20	1100-1400
CB/CNT/Vehicle = 7.0/3.0/90	20	900-1000
CB/CA/Vehicle = 10/5.0/85	20	800-900
CB/CNT/CA/Vehicle = 7.0/3.0/5.0/85	20	750-850

CNT : CVD MWNT 95BM, CA : BYK-ES80

It is noted that incorporation of small amount of carbon nano-tube and conducting additive greatly improve the luminance of the inorganic EL compared to the one with only conducting carbon black.

4. Conclusion

Conducting carbon paste for inorganic EL device was modified with the incorporation of carbon nano-tube and conducting additive. The new carbon paste exhibited improved luminance compared to the one with only conducting carbon black. The increased luminance intensity was considered to be due to the low sheet resistance of the modified carbon paste.

5. Acknowledgements

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6. References

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