Electromagnetic Interference(EMI) Shielding Efficiency(SE) characteristics of IMI multilayer/PMMA structure for Plasma Display Panel(PDP) filter.

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Abstract

This study was made to examine the electromagnetic interference(EMI) shielding effect (SE) of multilayered thin films in which indium-tin oxide(ITO) and Ag were deposited alternately from 3layer to 9 layer on Poly Methyl Meth Acrylate(PMMA) substrate at room temperature using a RF sputtering. We measured optical and electrical characteristics by UV-spectrometer and 4 point probe. The measurement of EMI SE in frequency range from 50MHz to 1.5GHz was performed by using ASTM D4935-89 method. We compared the measured EMI SEs with theoretical simulation data. We obtained relatively low resistivity and high transmittance from the EMI SE multilayers. In this study, we obtain good optical and electrical characteristics with a minimum transmittance of about 60% at 550nm wavelength and sheet resistance of 2~3ohm/sq., respectivity. Measured EMI SEs were over 50dB and similar to theoretical simulation data.

1. Instroduction

Today, electrical display industry is rapidly developing. Specially, FPD (Flat Panel Display) field is hugely being invested and researched like LCD (Liquid Crystal Display), PDP (Plasma Display Panel) and OLED (Organic Light Emitting Diodes). In spite of much efforts, PDP has several defects to overcome, such as high consumption electric power and radiation of EM(Electromagnetic) wave to have a bad influence upon human health and other machines. PDP use needs a filter to shield EM waves. Conventional EMI SE filters are composed of mesh type films and are attached on glass panel. This kind of glass type PDP filter is unhandy because of glass weight. In this work, we developed a multilayer that EMI SE filter coated on PMMA substrate in order to improve defects of glass type PDP filter and investigated their characteristics for filter.

2. Experiment.

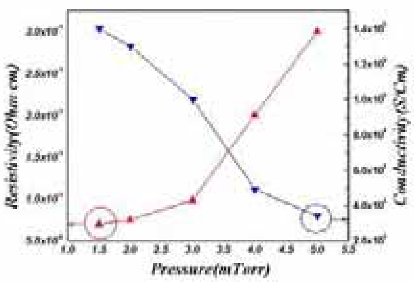
The EMI filters were made of the indium-tin oxide(ITO) thin film and the Ag film, deposited alternately from 3layer to 9layer on poly methyl meth acryl ate(PMMA) substrate at room temperature using a RF sputtering.

Disk-shaped target is 3 inches diameter ITO (In_2O_3:SnO_2 = 90:10 wt%) and Ag 99.99% purity.

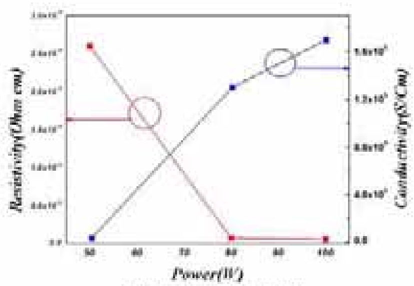
Optical transmittance of multilayered thin films were measured by UV-VIS-NIR spectrometer (Shimazu Co...) in the wavelength range from 300nm to 1000nm. The measurement of EMI SE in frequency range from 50MHz to 1.5GHz was carried out by using ASTM D4935 method.[9)] Electrical sheet resistance of multi-layers was determined by the 4 point probe method

3. Results and Discussion.

First, we optimized coating conditions of ITO and Ag single-layer. As for Ag single-layer, we made experiments with changing value of working pressure from 1.5mTorr to 5.0mTorr and one of supplied power from 50W to 100W. As seen in Fig. 1 Ag thin films have good electrical characteristics when they are deposited at low working pressures or high supplied powers.



(a) as working pressure.



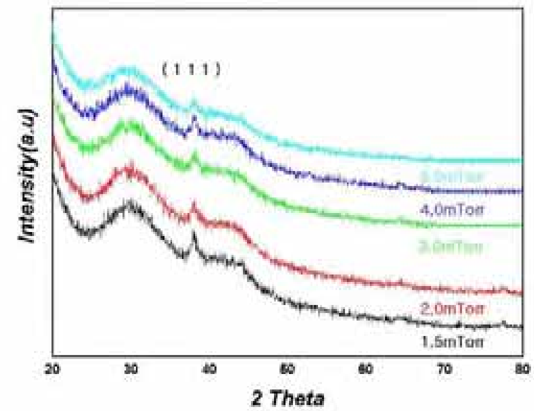
(b) as supplied power.

Fig. 1 Electrical characteristic of Ag films vs coating conditions.

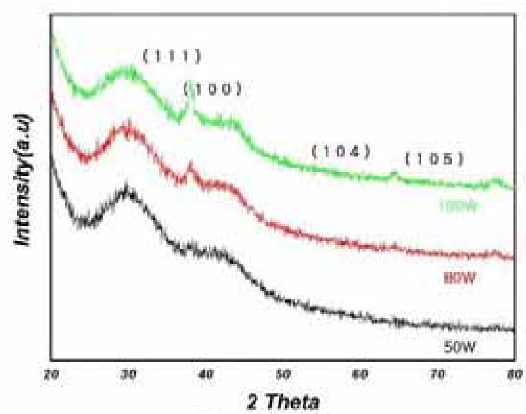
Fig 2 shows XRD pattern of Ag films according to coating conditions. All samples showed the (1 1 1) XRD peak It was found that that higher supplied power yield better crystallization while working pesssures seldom affect it.

Second, as for ITO single-layer, we made experiment as changing working pressures from 1.5mTorr to 5.0mTorr, supplied power from 80W to 120W and ratio of O_2/Ar from 0% to 0.5%.

Fig. 3 shows that specific resistivity of ITO film became lower and rate became higher in the low working pressure and high supplied power regions.



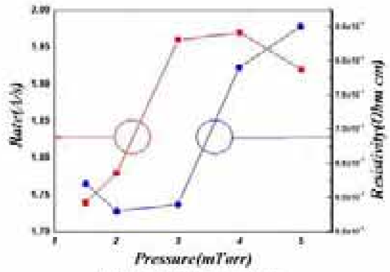
(a) working pressures.



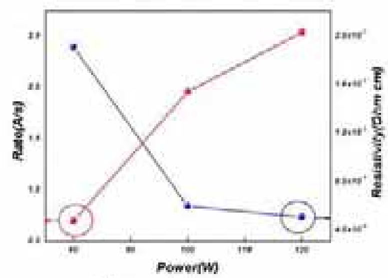
(b) supplied power.

Fig. 2 The XRD patterns of Ag films according to coating conditions.

Fig. 4 shows change of the sheet resistance and transmittance as a function of O_2/Ar ratio. We could know increasing ratio of O_2/Ar leads to decreasing the transmittance and increasing the sheet resistance.

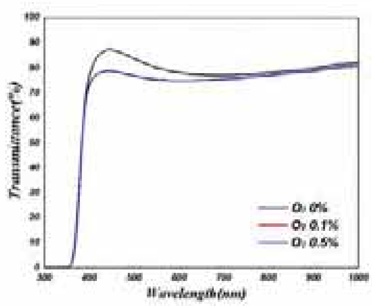


(a) working pressures.

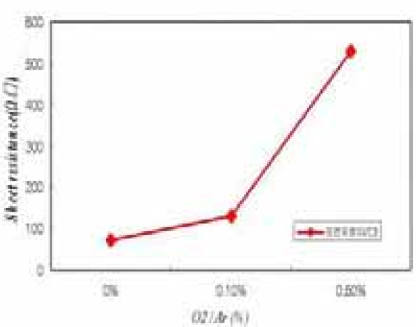


(b) supplied power.

Fig. 3 Rate and specific resistivity of ITO films as coating condition.



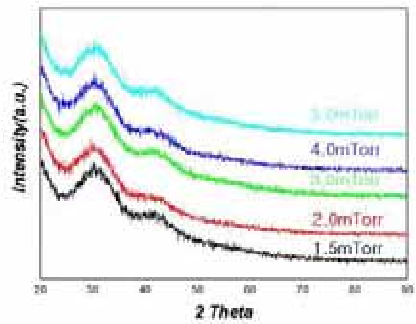
(a)



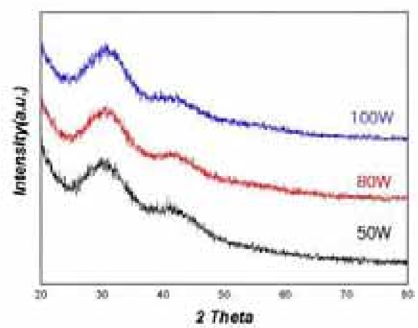
(b)

Fig. 6 Change characteristic of ITO film vs ratio of O2/Ar (a) Transmittance, (b) Sheet resistance

Fig. 5 shows XRD pattern of ITO films according to coating conditions. All samples had no XRD peak., denoting a natural result that all ITO films are amorphous since we coated on PMMA at room temperature and we could not perform any heat-treatment.



(a) as working pressure.



(a) as supplied power.

Fig .5 The XRD patterns of ITO films vs coating conditions.

We prepared EMI SE multilayers with optimized single layer coating conditions and measured the transmittance, sheet resistance and EMI SE.

Fig. 6 shows the measured EMI SE and transmittance characteristics of 3 layered EMI SE filters, as functions of the Ag and ITO films thickness. In Fig. 6, we can find that the Ag film largely decides EMI SE characteristics while the ITO film decides optical transmittance characteristic.

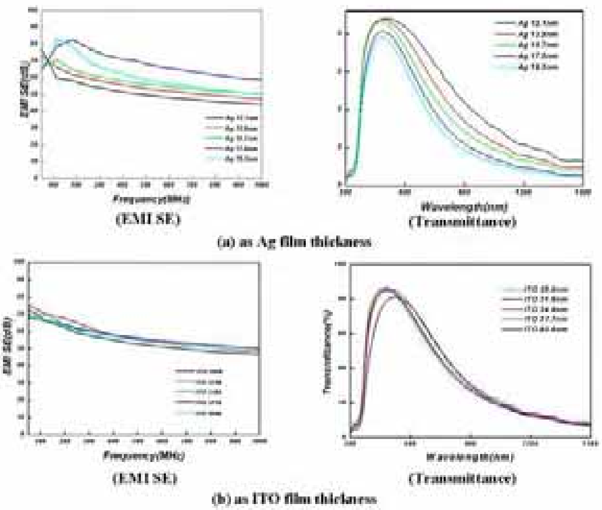


Fig .6 Change characteristic of EMI SE filter vs film thickness. (a) Ag film thickness, (b) ITO film thickness

In Fig .7 the measured and computational EMI SE values are compared in frequency from 50MHz to 1.5GHz. The computational EMI SE values were obtained by using an equation [11)12)]

$$SE = 20\log\left|\frac{1}{4n}\left[(1+n)^2\exp(-ikd)-(1-n)^2\exp(ikd)\right]\right|$$

As shown in Fig. 7 computational EMI SE values were higher than measured ones, approximately 10dB.

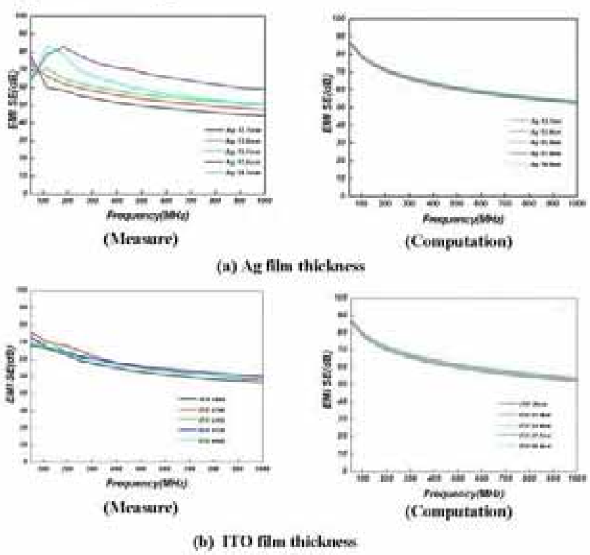


Fig. 7 Measured and computational EMI SE.

We made EMI SE filter 3, 5, 7 and 9layer structure. Fig. 8 shows the results of the measured transmittance and EMI SE according to the number of layer from 3 layered Air / ITO / Ag / ITO / PMMA to 9 layered Air / ITO / Ag / ITO / Ag / ITO / Ag / ITO / Ag / ITO / PMMA. In Fig 8, we could figure out that the more increasing the number of layer, the more increasing of EMI SE and decreasing of optical transmittance and sheet resistance. Specially, in EMI SE filters with over 5layer, we could obtain good optical and electrical characteristics with a minimum transmittance of about 60% at 550nm wavelength and sheet resistance of1~3Ω/□, respectively. We think that it can produce a good PDP filter with capability of a good EMI SE .

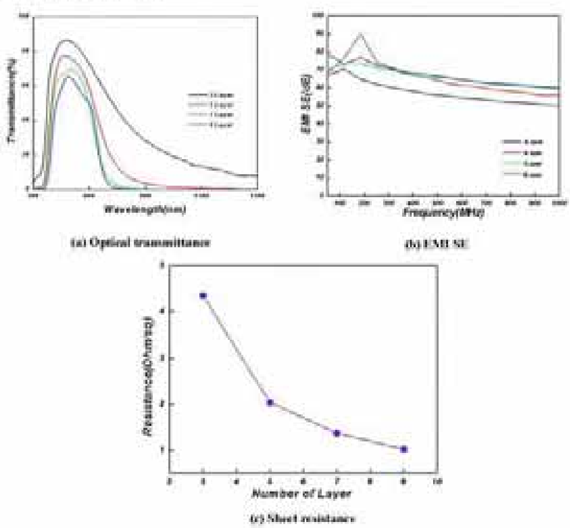


Fig. 8 Characteristic of EMI SE filter as number of layer. (a) Optical transmittance, (b) EMI SE (c) Sheet resistance

Fig.9 is SIMS patterns of EMI SE filters. We could find that our films have diffusion layers contained a little In, Sn and O composition. We think that this fact is a reason for EMI SE difference seen in measured and computational ones.

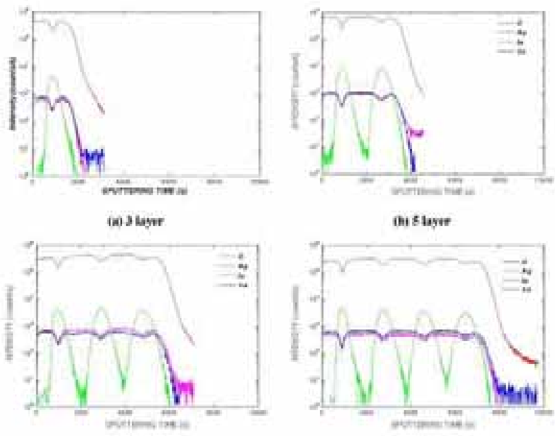


Fig 9. SIMS patterns of EMI SE filter as number of layer. (a) 3layer, (b) 5layer, (c) 7layer, (d) 9layer

Fig. 10 is XRD patterns of EMI SE filters. The results reveal that the more increasing number of layer, the more increasing Ag peak, but we couldn't find ITO peak. It means that Ag peak get increased with increasing Ag film thickness but. ITO films could not grow crystallized in this way.

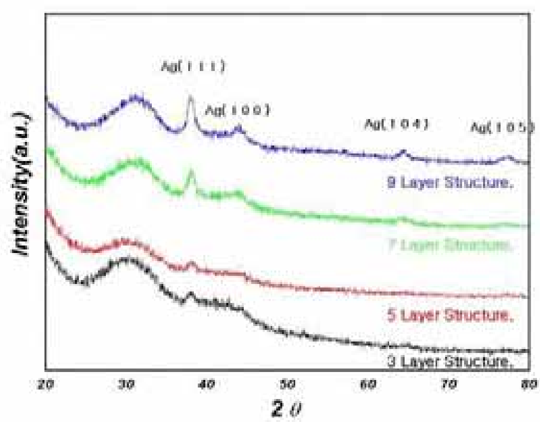


Fig 10. XRD result of EMI SE filter as number of layer.

3. Conclusions

In this study, we fabricated an multi-layerd EMI SE filter for plasma display panel(PDP) with ITO and Ag thin films. It was found that the Ag films decide mainly EMI SE characteristics while the ITO films do the optical transmittance. The SIMS results show EMI SE filters deposited alternately ITO and Ag films have a diffustion layer in the boundary between the ITO and the Ag film. This diffusion layer leads to an decrease in the measured EMI SE, compared computation one.

4. References

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