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Stability of ITO Films with Oxide Buffer Layer Grown onto PES Substrates

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In this paper, ITO films with the oxide buffer layers were deposited by magnetron sputtering technique onto the PES. The oxide buffer layer was formed by a radio frequency (RF) magnetron sputtering method, using SiO_2 or TiO_2 target. The ITO layers were deposited by a low-frequency (LF) magnetron sputtering technique onto PES/Buffer layer. The sheet resistances of ITO films with the oxide buffer layers grown onto PES substrate were investigated as a function of time in the air and the vacuum. In both cases, the increasing rates of the sheet resistance of the PES/Buffer layer/ITO films are lower than those of the PES/ITO films. In addition, the increasing rates of sheet resistances of the films with the TiO_2 buffer layer are lower than those of the films with the SiO_2 buffer layer.

Keywords: buffer layer; ITO film; PES

INTRODUCTION

Transparent conducting oxide films have been the topic of many studies due to their transparency and electrical conduction, which make them useful in various applications such as solar cells, liquid crystal displays, optoelectronics, etc [1,2].

In particular, the interests of transparent flexible plastic substrates with a transparent conducting oxide layer such as ITO have been

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increased in the fields of portable devices, roll-up displays, and conformable displays.

The plastic substrate suitable for an OLED display must satisfy numerous requirements: the high optical transmission (>85%), the ability to withstand processing temperatures, the good barrier to moisture and oxygen, the good dimensional stability.

However, the plastic substrates do not have good barrier to moisture and oxygen. Consequently, the ITO films onto plastic substrate tend to increase in the electrical sheet resistance. In this paper, for the sake of improving the aging behavior, we prepared ITO films with the oxide buffer layers grown onto PES substrate and investigated the sheet resistances as a function of time in the air and the vacuum.

EXPERIMENTAL

The flexible ITO substrates with oxide buffer layer were prepared by a magnetron sputtering technique onto PES substrates. The oxide buffer layers were deposited by a RF (13.56 MHz) magnetron sputtering technique onto the PES at the room temperature, using SiO_2 or TiO_2 target. The base pressure in the chamber was adjusted to 5×10^{-6} Torr, and the Ar gas pressure during the deposition was maintained at 2.1×10^{-3} Torr. The ITO layers were deposited by a LF (60 Hz) magnetron sputtering technique onto PES/Buffer layer at the room temperature. Table 1 represents the sputtering conditions of ITO/Buffer layer/PES thin films.

The sheet resistances of ITO films were measured as a function of time in the vacuum and the air by using a 4-point probe method (Mitsubishi, MCP-T 360). The optical transmittances of ITO/Buffer

TABLE 1 The Sputtering Conditions of ITO/Buffer Layer/PES Thin Films

Sputtering parameters	Values
LF Power [V]	320
RF Power [W]	50
Base pressure [Torr]	5×10^{-6}
Working pressure [mTorr]	2.1
T-S distance [mm]	100
Deposition time [min]	25 (LF), 10 (RF)
Ar flow rate [SCCM]	30
Substrate temperature [°C]	Room temperature

layer/PES films were investigated with UV-Visible spectrophotometer (Shimadzu, UV-1601PC).

RESULTS AND DISCUSSION

Figure 1 shows the transmittance of the ITO/PES, ITO/Buffer layer/PES thin films. Both the transmittances of ITO/SiO_2/PES and ITO/TiO_2/PES appeared to be about 80% in the visible region, compatible with that of ITO/PES films. The results show that the transmittance is not so heavily influenced by the buffer layer. This can be explained that the transmittance of ITO thin film is influenced by the thickness of ITO films, the number of conducting electron of interior film, the surface uniformity of deposited thin film, the crystallization degree, and the fine structure of films [3,4].

The sheet resistance change of PES/ITO and PES/Buffer layer/ITO thin film in the air and the vacuum is shown in Figures 2 and 3, respectively. In both cases, the change rate of sheet resistance of PES/Buffer layer/ITO thin film is lower than that of PES/ITO thin film. Thus, the introduction of a buffer layer into the flexible ITO substrates yields an decrease in a sheet resistance. This may be primarily due to preventing the impurities, composed of the organic component in PES polymer or other residual gases in it.

As seen in Figures 2 and 3, the aging process proceeds at higher rate in the case of films aged in air. This can be explained that the presence of moisture in the air accelerates the aging process.

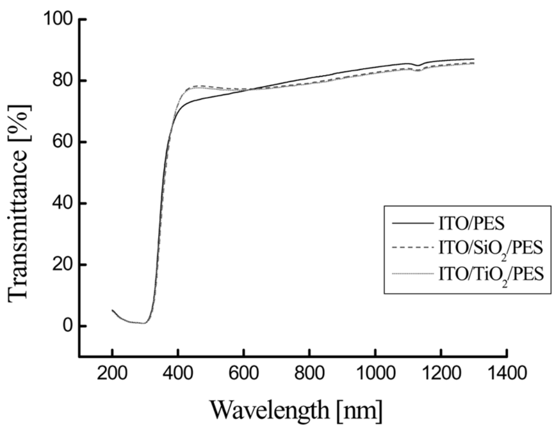

FIGURE 1 Optical transmittance of ITO/PES, ITO/Buffer layer/PES.

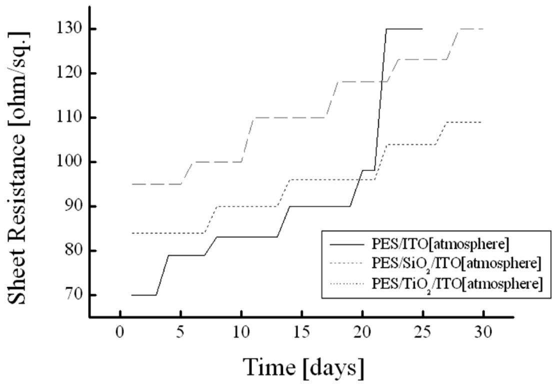

FIGURE 2 Sheet resistance change of PES/ITO, PES/Buffer layer/ITO in the air.

Our samples show the aging behavior even in the vacuum. This fact indicates that an inevitable aging through the polymer substrates occurs, regardless of the vacuum environment. Also, this fact implies that a suitable way such as introduction of gas barrier layers will be needed in reducing the instability of ITO films grown onto polymer substrates.

Finally it should be noted that the sheet resistances of PES/TiO_2/ITO thin films change at lower rates, compared with those of PES/SiO_2/ITO thin film. This means that a material such as TiO_2 is

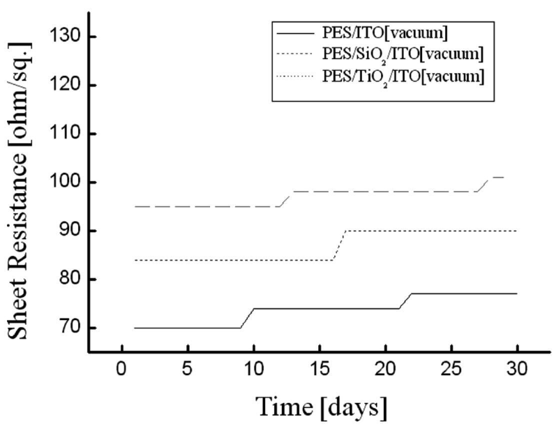

FIGURE 3 Sheet resistance change of PES/ITO, PES/Buffer layer/ITO in the vacuum.

a promising buffer layer for the PES/ITO system, as opposed to the view, SiO_2 is usually used in the buffer layer.

CONCLUSIONS

We fabricated ITO films with a oxide buffer layer grown onto PES substrates to improve the stability of ITO films. The characteristics of sheet resistance and optical transmittance of PES/Buffer layer/ITO ITO thin film are somewhat lower than those of PES/ITO thin film. But the changes in the sheet resistance of PES/Buffer layer/ITO thin film appear smaller than that of PES/ITO thin film. The stability of ITO film can be improved by introducing the buffer layer grown into plastic substrates, especially by the TiO_2 buffer layer.

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