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ITO/Al Transparent Electrode for Near Ultraviolet Light Emitting Diodes

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1. Introduction

Research on transparent conductive oxides (TCO) has been emphasized in the recent years, largely due to an increasing demand for electrode of optical semiconductor device like light emitting diodes (LED), solar cell etc. TCO films for optical device need to have low resistivity and high optical transmittance. Indium tin oxide (ITO) is a well-known material for the use in TCO for optical device electrode in visible region, but it has poor transmittance in near-ultraviolet (NUV) region under 385 nm. In this work, we suggest ITO/Al layer for high transmittance and low sheet resistance in NUV LED electrode.

2. General Instructions

Prior to deposition, glass substrates were ultrasonically cleaned in acetone, methanol, de-ionized water and dried by nitrogen gas, subsequently. A 110 nm thick ITO(90 wt.% In_2O_3-10 wt.% SnO2) film was deposited by RF magnetron sputtering with working pressure of 5 mTorr, and RF power of 150 W. Subsequently, a 3 nm thick Al layer was deposited by E-beam evaporation with base pressure of 2×10^{-6} Torr. After deposition, some ITO/Al films were annealed in rapid thermal annealing system at 550 to 750 °C for 1 minute in nitrogen ambient. Optical transmittance was measured in the range of 200-700 nm by UV-VIS spectrophotometer. Sheet resistance was measured by 4-point probe.

Figure 1 shows the transmittance of ITO and ITO/Al layer films annealed at 750 °C. It is obviously shown that the transmittance of ITO/Al layer is higher than that of the ITO because of Burstein-Moss effect that free electrons in the Al diffused into the ITO expand effective energy band gap. The transmittance of the ITO layer and the ITO/Al layer is 87.4 and 91.0 % at a wavelength of 385 nm, respectively.

Figure 2 shows the sheet resistance of the ITO and the ITO/Al layers. The Sheet resistance of the ITO/Al layer is lower than that of the ITO layer. Total sheet resistance of the ITO/Al layer can be described as

$$\frac{1}{R_{total}} = \frac{1}{R_{ITO}} + \frac{1}{R_{Al}}$$

where R_{total}, R_{ITO}, and R_{Al} mean the sheet resistance of the total ITO/Al layer, the ITO, and the Al, respectively [1]. So, the sheet resistance of the ITO/Al is lower than that of the ITO because of parallel resistance effect. The sheet resistances of the ITO layer and the ITO/Al layer are 95.1, and 22.6 Ω/□ after annealed at 750 ℃, respectively.

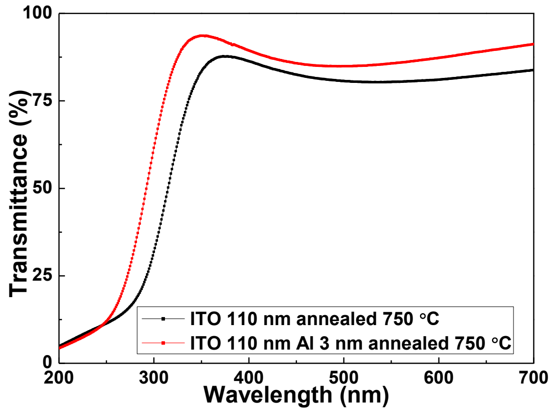

Figure 1. Transmittances of the ITO, ITO/Al layer annealed at 750 °C

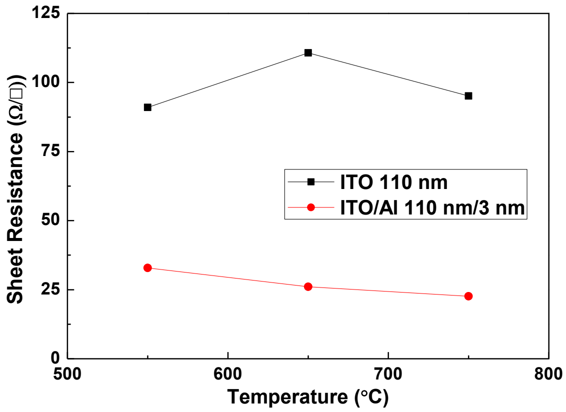

Figure 2. Sheet resistances of the ITO, ITO/Al layer varied with annealing temperature split.

3. Conclusions

In this experiment, the properties of the ITO/Al layer with the variation of annealing temperature were investigated. The transmittance results indicate that the ITO/Al layer have higher transmittance than the ITO layer. Also, the sheet resistance of the ITO/Al layer was lower than that of the ITO layer.

References

[1] E. N. Cho, P. Moon, C. E. Kim, I. Yun, Expert. Syst. Appl. 39 (2012) 8885-8889