Study of Optimum Post-Annealing Nitrogen Ambient of Indium Tin Oxide for Organic Light-Emitting Diode (OLED)

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Indium tin oxide (ITO) films are widely used in liquid crystal display (LCD) and organic light-emitting diode (OLED), because of its low resistivity, high optical transparency in the visible region. Recently, the OLED has attracted much attention due to the excellent advantages such as self-emission, and lightweight. Furthermore, the OLED towards to development thinner, lighter and not easy cracking device. Certainly, the plastic substrate is more suitable as substrate in OLED among usually employed substrate such as glass, flexible thin glass and plastic. In this article, the ARTON plastic substrate (ARTON, JSR Co.) is used because it own many kinds of advantage compare with another plastic such as PET, PMMA and PES. The typical properties of the ARTON film are listed in table I. The ITO film was deposited by DC magnetron reactive sputter without substrate heating [1-2], and the annealing is performed at nitrogen ambient after ITO film deposited. Figure 1 shows the DC power versus sheet resistance. The sheet resistance is decreased with increasing DC power due to the bigger grain size. It is well aware that the plastic has low thermal resistance, non-rigidity, weak mechanical characteristics except lighter, thinner and unbreakable compare with glass. Base on this reason, for avoiding the ARTON bend, the process power is performed at 80 W although the sheet resistance of 90 W is less than 80 W. As ITO films were deposited on ARTON, annealing is carried out at 150℃ nitrogen ambient. It is observed the ITO films have started crystalline at 150℃ nitrogen ambient for 2hr, as shown in Fig. 2. After annealing 2hr, 4hr, 6hr and 8hr at 150℃ nitrogen ambient, the grain size of ITO films which calculated by Scherrer formula is 30.882Å, 38.484Å, 40.233Å and 43.777Å, respectively [3]. Subsequent to annealing, the sheet resistance of the ITO is reduced from 94Ω/sq to 65Ω/sq with increasing annealing time and towards to stable above annealing 7hr. The transmittance of ITO films is shown in Figure 3. According to Burstein-Moss effect [4], it is well known that the band gap of ITO films affects directly transmittance and depends on crystalline of ITO films. The more the crystalline is, the bigger the band gap is. It is obviously shows that the annealing time plays a key role in improving the transmittance because of increasing the grain size diminished optical scattering and accordingly increased the transmittance. In summary, the optimum post-annealing of ITO films on ARTON for OLED is observed at 150℃ nitrogen ambient for 8hr. The minimum sheet resistance and optical transmittance is arrived 65Ω/sq and above 85%, respectively.

Reference:
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Specific Gravity	1.08
Water Absorption: 23℃, 1 week, in water	0.4%
Refractive Index	1.51
Transmittance	92%
Deflection Temperature	162 to 164℃
Glass Transition Temperature	171℃

Table I Typical properties of ARTON.

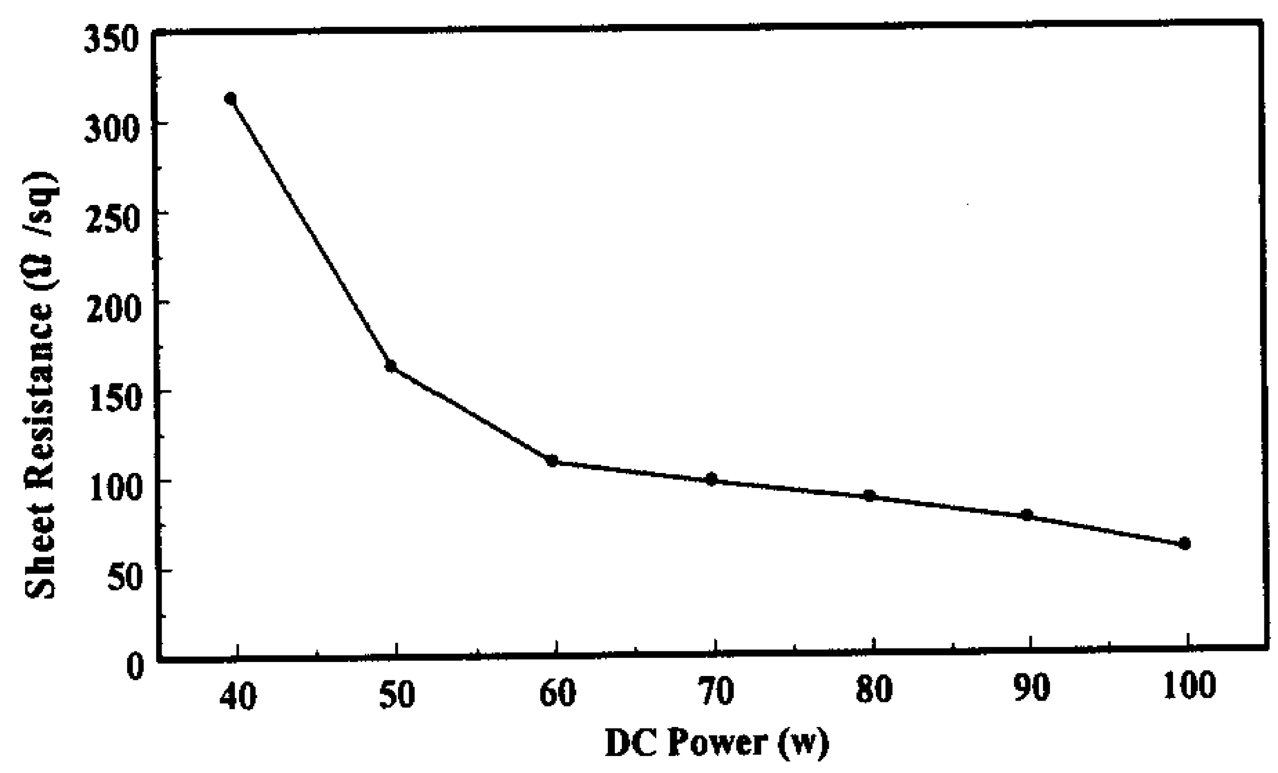

Fig. 1 The DC power versus sheet resistance without heating substrate.

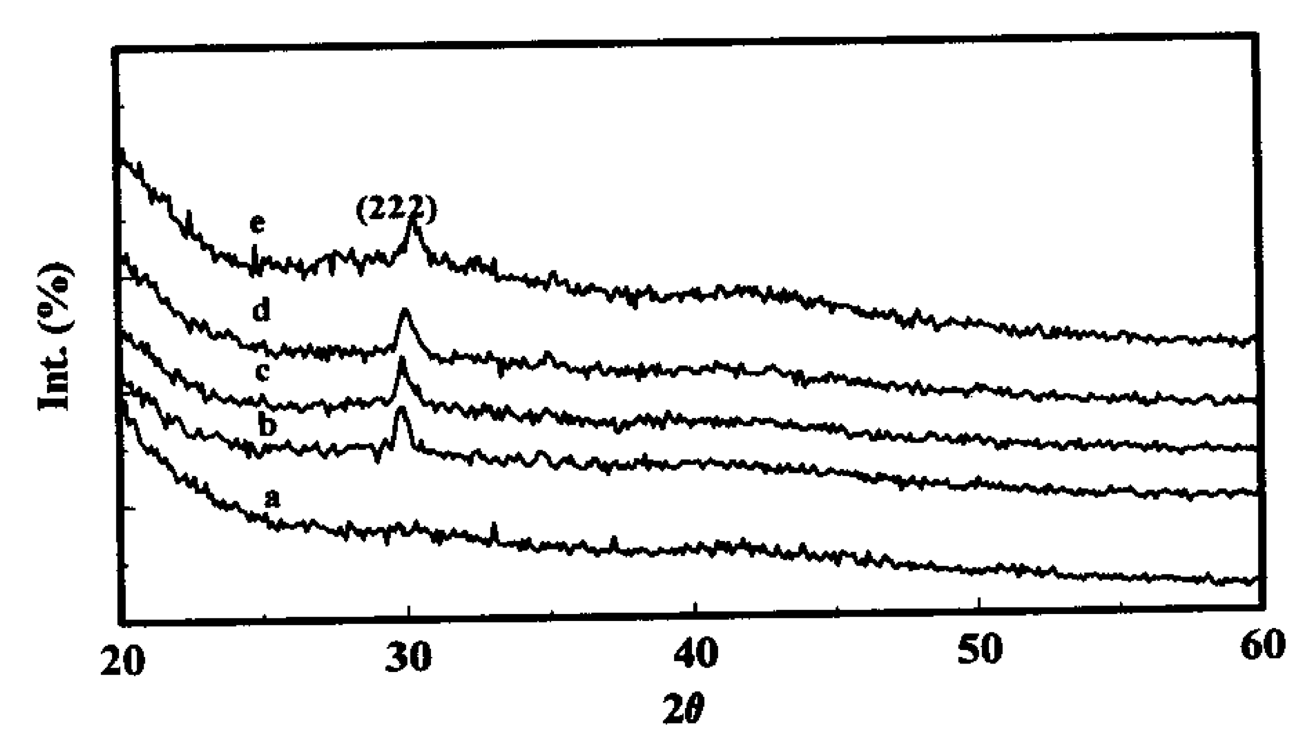

Fig. 2 XRD patterns for ITO films samples after annealing at N_2 ambient 150℃: (a) as-deposition; (b) 2hr; (c) 4hr; (d) 6hr and (e) 8hr.

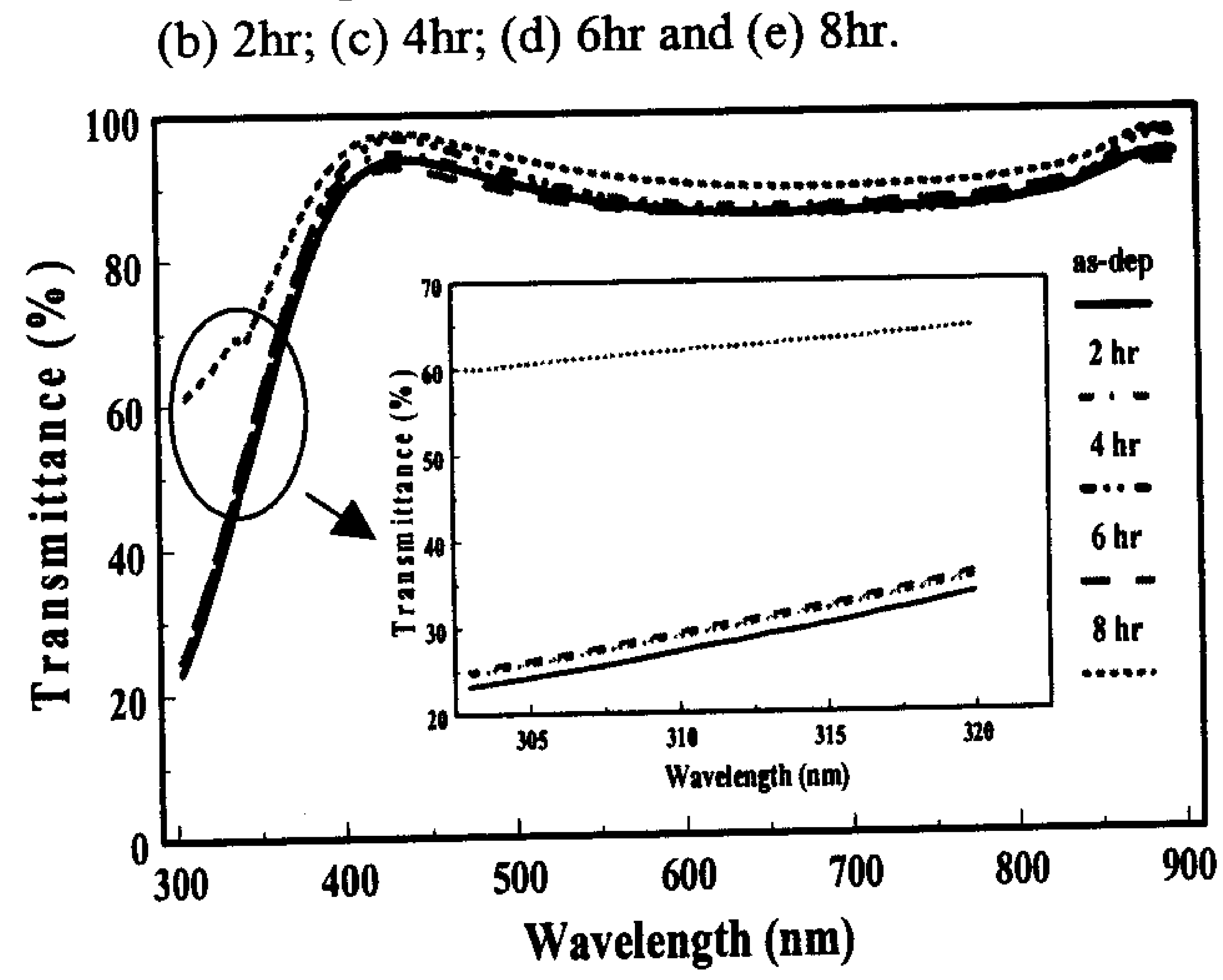

Fig. 3 Transmittance of ITO films as a relation-ship of the wavelength for as-deposited and various annealing time at N_2 ambient in 150℃.