Amorphous indium zinc tin oxide (IZTO) semiconductor materials and the associated thin film transistor properties deposited by atomic layer deposition

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Oxide semiconductor thin film transistors (TFTs) have been extensively researched as a backplane technology in display industry. Comparing to the indium gallium zinc oxide (IGZO) which has been widely used as TFT active layer material, indium zinc tin oxide (IZTO) has been suggested as a promising material due to its attractive performance, including relatively high mobility (>25cm^2/Vs) and superior stability performance. Relying on the self-limiting reaction, the atomic layer deposition (ALD) takes advantage of uniformly depositing the films over large areas with precisely controlled thickness that makes ALD become a promising technology to apply in thin film transistor, including of active layer fabrication.

In this research, the ALD Sn doped IZO thin films are first investigated, which are deposited using the concept of "super-cycle" – IZO (1 cycle InO_x – 1 cycle ZnO), IZTO111 (1 cycle InO_x – 1 cycle ZnO – 1cycle SnO_x) and IZTO112 (InO_x 1 cycle – 1 cycle ZnO – 2 cycle SnO_x). The chemical composition of the IZO IZTO111 and IZTO112 thin films are measured by AES (Auger electron spectroscopy) and listed in Table 1, which proves Sn element is uniformly and homogeneously doped into IZO thin film with increasing of SnO_x sub-cycle number. It is also found, by doping with SnO_x, the band gap structure, micro-structure as well as the electrical characteristics were changed.

Then, the bottom gate top contact IZO, IZTO111 and IZTO112 thin film transistors were fabricated by ALD process. The devices with Sn doped IZO active layer exhibited increased mobility (27.8cm^2/Vs for IZTO111 and 22.7cm^2/Vs for IZTO112) and stability under positive bias temperature stress (threshold voltage shift of 1.8V and 0.7V) than IZO TFTs (mobility of 18.0cm^2/Vs and threshold voltage shift of 2.2V), as shown in figure 1. To figure out the mechanism for device performance difference, the thin film oxygen defect and morphology analysis are processed. Besides, the flexible ALD IZTO TFT also fabricated on the PI substrate, and 200,000 cycles bending test was processed to investigate the degradation mechanism of flexible ALD TFT under mechanical stress.

Table 1. Atomic composition of IZO, IZTO111 and IZTO112 thin films grown via ALD obtained by AES.

Thin film	C%	In%	Sn%	Zn%	O%
IZO(1:1)	0.7	19.3	0	29.6	49.8
IZTO(1:1:1)	1.1	17.0	9.0	20.6	51.4
IZTO(1:1:2)	2.1	15.2	15.8	14.8	51.7

Figure 1. Transfer characteristics (I_D vs V_{GS}) of the TFTs with the ALD (a) IZO, (b) IZTO111 and (c) IZTO112 active layers.