Flexible IGZO TFTs deposited on PET substrates using magnetron radio frequency co-sputtering system

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ABSTRACT

The structure of the flexible IGZO TFTs was deposited on PET substrates using a magnetron radio frequency co-sputtering system at a low temperature. The resulting flexible IGZO TFTs exhibited the lower subthreshold swing value of 0.25 V/decade and the higher field-effect mobility of 24.4 cm^2/V-s. The field-effect mobility stability was measured by a bending radius of 1.17 cm under stress time for 1500 seconds. The experimental result revealed that the varied stability was less than 5%. The interface state density between the gate insulator and the channel layer was about 2.13×10^{11} $eV^{-1}cm^{-2}$ in which verified the better interface quality of the flexible IGZO TFTs.

1. INTRODUCTION

Recently, the flexible displays were investigated and applied in the electronic book (e-books) displays and the electronic paper (e-paper) displays. The glass substrate displays have been gradually replaced by the flexible displays due to the thinner thickness and lighter weight. The flexible thin film transistors (TFTs) have received a considerable interest in the last two decades. Among the TFTs, the amorphous Si (a-Si) with a higher deposition temperature (300^oC~450^oC) and a lower electron mobility (lower than 1 cm^2/V-s) were widely used in TFTs of glass substrate. The higher deposition temperature would damage and deform the flexible substrates. To improve the performances of the resulting TFTs, the transparent oxide semiconductor (TOS) have been applied in the flexible displays. Wide bandgap oxide-based thin film transistors, using zinc oxide (ZnO) [1-3] and indium gallium zinc oxide (IGZO) [4-6] have attracted much attention for applying in flexible electronic devices [7, 8]. These

TFTs exhibited a high electron mobility (over 10 cm^2/V-s) and a higher switching speeds. In this work, the structure of the flexible IGZO TFTs was deposited by the magnetron radio frequency (RF) co-sputtering system at a low temperature. The performances of the resulting TFTs were measured and analyzed.

2. EXPERIMENTS AND DISCUSSION

Figure 1 shows the schematic configuration of the flexible IGZO TFTs. The barrier layer of 150-nm-thick Si_3N_4 film was first deposited on the plastic polyethylene terephthalate (PET) substrate. The Si_3N_4 gate insulator and the IGZO channel layer (atomic ratio of In:Ga:Zn:O = 2:2:1:7) were sequentially deposited on the patterned Al gate metal without vacuum breaking using a magnetron co-sputtering system. It would be important for decreasing the interface state density between the interface of the Si_3N_4 gate insulator and the IGZO channel layer. Finally, a 15-nm-thick SiO_2 film worked as passivation layer was deposited on IGZO channel layer to prevent the pollutant affections. The IGZO channel layer of the flexible TFTs can be optimized by setting the gas flow ratio of depositing atmosphere as Ar/O_2 = 35/65, and the depositing RF power as 100 W. The channel width (W) and the channel length (L) of the flexible TFTs were 100 μm and 10 μm, respectively.

The electrical characteristics of the flexible IGZO TFTs were measured using an Agilent 4156C semiconductor parameter analyzer. The drain-source current-drain-source voltage (I_{DS}-V_{DS}) characteristics of the flexible IGZO TFTs with 15-nm-thick SiO_2 passivation layer were shown in Fig. 2. Furthermore, the corresponding drain-source current-gate-source voltage (I_{DS}-V_{GS}) characteristics of the flexible IGZO TFTs operated at V_{DS} = 2 V were shown in Fig. 3. The effective field-effect mobility (μ_{FE}) of the flexible IGZO TFTs was estimated from the equation (1) [9]:

$$I_{DS}=\frac{W\mu_{FE}C_{OX}}{2L}\left[2\left(V_{GS}-V_T\right)V_{DS}-V_{DS}^2\right] \quad , \tag{1}$$

where V_T is the threshold voltage, C_{OX} is the capacitance per unit area, W is the channel width, and L is the channel length. The subthreshold swing (SS) of the flexible IGZO TFTs was estimated by using the equation (2) [10]:

$$S=\frac{dV_{GS}}{d\log I_{DS}} \quad , \tag{2}$$

The flexible IGZO TFTs owned the SS value and the μ_{FE} value of the flexible IGZO TFTs were 0.25 V/decade and 24.4 cm^2/V-s, respectively. Figure 4 shows the field-effect mobility and threshold voltage as a function of the stress times. The stability of the field-effect mobility was measured with bending radius of 1.17 cm under stress time for 1500 seconds. The variation of the field-effect mobility was less than 5%. From the results of the capacitance-voltage measurement in the IGZO MOS structure (like IGZO TFTs), the interface state density was about 2.13×10^{11} $eV^{-1}cm^{-2}$. It verified the better interface quality between the gate insulator and the channel layer of the IGZO TFTs was obtained.

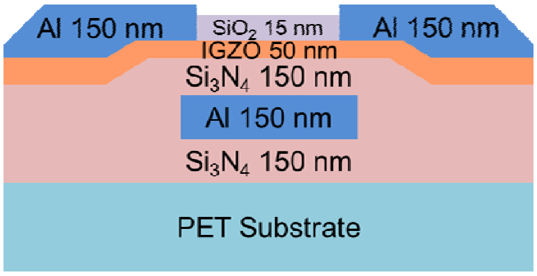

Fig. 1 The schematic configuration of the flexible IGZO TFTs.

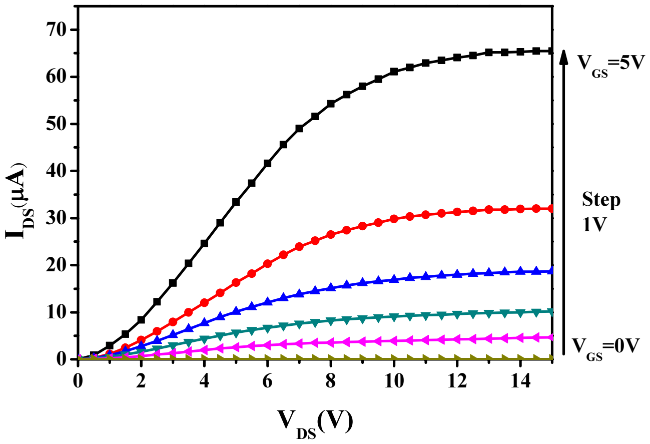

Fig. 2 The I_{DS}-V_{DS} characteristics of flexible IGZO TFTs with 15-nm-thick SiO_2 passivation layer.

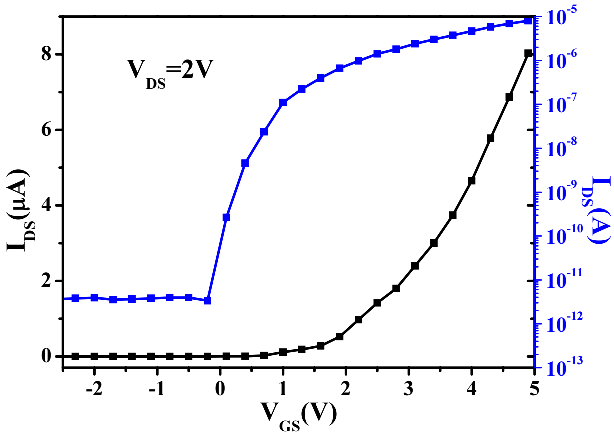

Fig. 3 The I_{DS}-V_{GS} characteristics of flexible IGZO TFTs with 15-nm-thick SiO_2 passivation layer.

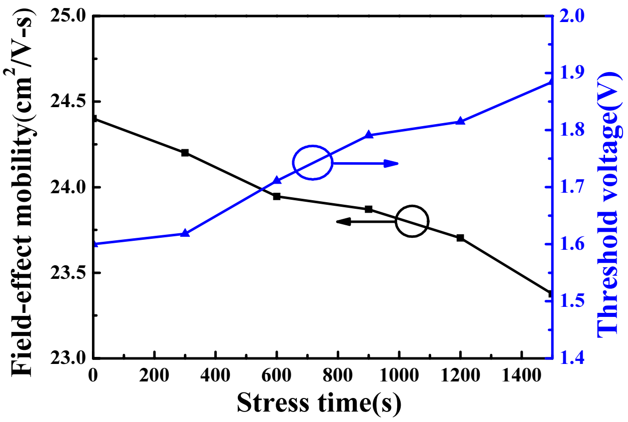

Fig. 4 The field-effect mobility and threshold voltage as a function of the stress times.

3. CONCLUSIONS

The structure of the flexible IGZO TFTs was deposited on the PET substrate using a RF magnetron co-sputtering system. The resulting flexible IGZO TFTs possessed the lower SS value of 0.25 V/decade and the better μ_{FE} of 24.4 cm^2/V-s. The variation of the field-effect mobility under stress time 1500 seconds was less than 5%. Furthermore, the interface state density between the gate insulator and the channel layer measured by MOS diodes was about 2.13×10^{11} $eV^{-1}cm^{-2}$. The lower interface state density verified the good interface quality in the flexible IGZO TFTs.

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