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High mobility In-Ga-Zn-oxide thin-film transistor with Sb_2TeO_x gate insulator fabricated by reactive sputtering

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1. Introduction

One of the issues in the development of oxide semiconductor based thin-film transistors (TFTs) uses a low temperature gate insulator (GI) so as to be applied to flexible substrates [1]. Up to now, various gate insulators for the low temperature processing have been researched including Al_2O_3 by ALD [2], ZrO_2 by sol-gel method [3], $Zn_{0.7}Mg_{0.3}O$ by reactive sputtering method [4], BST by sputtering [5], Mn-doped BST by sputtering [6], Y_2O_3 by sputtering [1], BZN by sputtering [7], HfO_x, $HfSiO_x$ by ALD [8], TiOx by PEALD [9], and so on.

Sb_xTe_{1-x} materials are the typical chalcogenide alloys, which show fast and reversible transitions between resistive amorphous and conductive crystalline phases. These materials are usually used for non-volatile memory called phase change random access memory (PRAM) [10], and for high-density optical recording media [11]. On the other hand, these materials could be easily oxidized by a reactive sputtering at the normal condition. In this study, we will fabricate a Sb_2TeO_x gate insulator by a reactive sputtering method, using a metallic Sb_2Te target.

2. Experimental results

As a active channel, an indium-gallium-zinc oxide (IGZO, In:Ga:Zn=2:1:2, atomic raio) semiconductor was deposited by the RF magnetron sputtering, using a ceramic target (ANP, 99.99% purity, 3 inches). Fig. 1 is indicating the schematic cross-section of IGZO-TFT with Sb_2TeO_x GI. The TFT is a top-gate type (staggered) structure, where the source & drain electrodes were made by ITO (indium-tin oxide, In:Sn = 90:10, weight percent) via RF magnetron sputter, and gate was formed by Pt (t=100 nm).

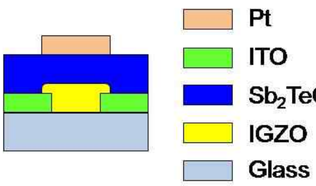


Figure 1. The schematic cross-section of IGZO-TFT

Sb_2TeO_x could be obtained by a reactive sputtering at the condition of 20 mTorr, 50 W, 15% O_2 in the total gas (Ar + O_2), but as a function of the substrate temperatures from room temperature to 250 ℃. Fig. 2 shows the transmittance of the glass substrate, and Sb_2TeO_x film (t=100 nm) on the glass, where GI was fabricated at the condition of 250 ℃. The transmittance of Sb_2TeO_x film had a maximum point around the wavelength of 490 nm, showing a weak blue-like color.

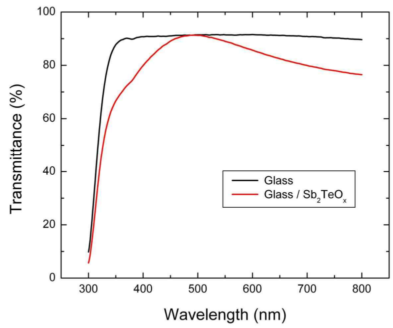
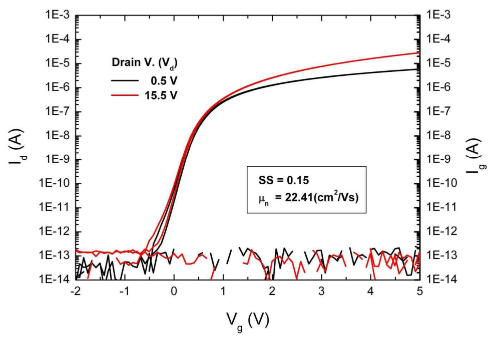
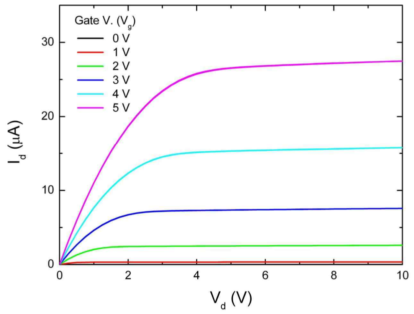


Figure 2. Transmittance of a glass substrate, and glass/Sb_2TeO_x (100 nm) (The reference is air).

Figure 3(a) illustrates the dc transfer characteristic [log(I_d)-V_g] & gate leakage current [log(I_g)-V_g] curves of the IGZO-TTF after the annealing process at 200 ℃-1 hour in O_2 ambient. The gate insulator was fabricated at 250 ℃ with the thickness of 100 nm. The transfer plot shows a drain current on-off ratio of ~ 10^8, a subthreshold-swing (SS) of 0.15 V/decade, and a saturated mobility of 22.41 cm^2/Vs. The gate leakage could be sustained at 10^{-13} A, up to about 7 V (gate voltage). The breakdown voltage increased with the film thickness and the growth temperatures.



(a)



(b)

Figure 3. The dc transfer characteristic [log(I_d)-V_g] & gate leakage current [log(I_g)-V_g] curves of an IGZO-TFT with a Sb_2TeO_x gate insulator (a), the output [I_d-V_d] curves (b) after the annealing process at 200℃-1 hour in O_2 ambient, respectively.

Fig. 3(b) is showing the output curves of Fig. 3(a), where the classical MOSFET theory could be acceptable. These profiles can be applied to the low power consumption devices operated in the range low driving voltages.

3. Conclusions

Using a Sb_2TeO_x gate insulator (100 nm) by a reactive sputtering, we could fabricate a low temperature IGZO-TFT. After the annealing process at 200℃-1 hour in O_2 ambient, the mobility of IGZO-TTF was 22.41 cm^2/Vs, and a drain current on-off ratio was ~ 10^8.

Acknowledgements

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