Electrical Stability Enhancement of the Thin Film Transistor with the Back-channel Deposited by Co-sputtering Amorphous In-Ga-Zn-O and SiOx

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In recent years, a-In-Ga-Zn-O thin film transistor has gained wide attention due to their good uniformity, high field-effect mobility and low cost process [1−2]. Although a -IGZO TFT has high device performance, it is certainly necessary to obtain the device stability under high temperature-relative humidity. The improvement of device stability under external environments is considered to be an important subject for the development of a-IGZO TFTs.

To improve the a-IGZO TFTs characteristic and stability, the double active layer with a-IGZO/a-SIGZO was invested. The TFTs have an inverted staggered bottom gate structure with a channel width (W) of 500 µm and a channel length (L) of 50 µm. A 60 nm thick double active layer is grown by sputtering at room temperature, which contains 40 nm thick front-channel of a-IGZO and 20 nm thick back-channel with a-SIGZO by using cosputtering a-IGZO target and SiOx target at room temperature. Si concentration is changed with the rf power which split into 30, 40, 50, and 60 W.

Figure 1 shows the transfer curves of the TFTs with various Si concentrations in a-SIGZO channel layer. As increasing Si concentration in back-channel, the I_{DS} is lowered and the V_{th} shifted in the negative direction. The electrical properties reveal that Si is acting as a carrier suppressor due to reducing V_O in the a-IGZO system. The bonding-strengths of silicon (775 KJ/mol) is higher than those of zinc (385 KJ/mol), and indium (<470 KJ/mol) [3].

Figure 2(a) shows that the V_{th} of the conventional a-IGZO TFT was negatively shifted from 26.7 to 21.4 V. The H_2O molecules were adsorbed on the a-IGZO from the high humidity conditions lead to the decrease of the V_{th}. It may be attributed by the increase of carrier density in the a-IGZO bulk-channel due to the role of H_2O molecules as donor. Compared to the conventional a-IGZO TFT, there are almost no difference on the V_{th} value between as-deposited sample and that of after 15 days, as shown in Fig. 2(b). The maximum and minimum of V_{th} are 30.7 and 29.6 V, respectively. It is reasonable that Si-metal cation suppress the formation of V_O during the stability test. Additionally, SiO_2 distributed on the a-IGZO surface reduce H_2O adsorption site on a-IGZO back-channel surface [4].

In our presentation, we will review the mechanism why the co-deposition of SiOx enhance the stability of a-IGZO TFT by analyzing the standard electric potential (SEP) and bonding strengths of Si.

* This work was financially supported by the Industrial Strategic Technology Development Program (10039191, The Next Generation MLC PRAM, 3D ReRAM, Device, Materials and Micro Fabrication Technology Development) funded by the Ministry of Trade, Industry and Energy (MOTIE), Republic of Korea.

Reference

[1] K. Nomura, H. Ohta, A. Takagi, T. Kamiya, M. Hirano and H. Hosono: Nature 432 (2004) 488.
[2] M. K. Ryu, S. H. Yang, S. H. Park, C. S. Hwang: Appl. Phys. Lett. 95 (2009) 0173508.
[3] J. K. Jeong, H. W. Yang, J. H. Jeong, Y. G. Mo, and H. D. Kim: Appl. Phys. Lett. 93 (2008) 123508.
[4] S. H. Yang, K. H. Ji, U. K. Kim, C. S. Hwang, S. H. K. Park, C. S. Hwang, J. Jang, and J. K. Jeong: Appl. Phys. Lett. 99 (2011) 102103.

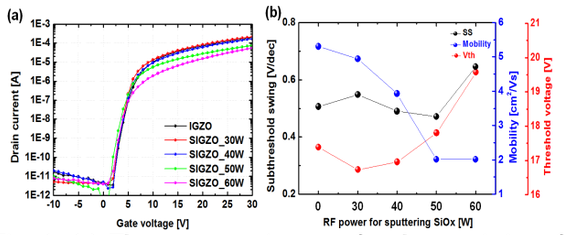

Fig. 1. (a) The representative transfer characteristics of various sputtering powers of TFTs and (b) extracted subthreshold swing (S.S.), mobility and threshold voltage with various Si concentrations.

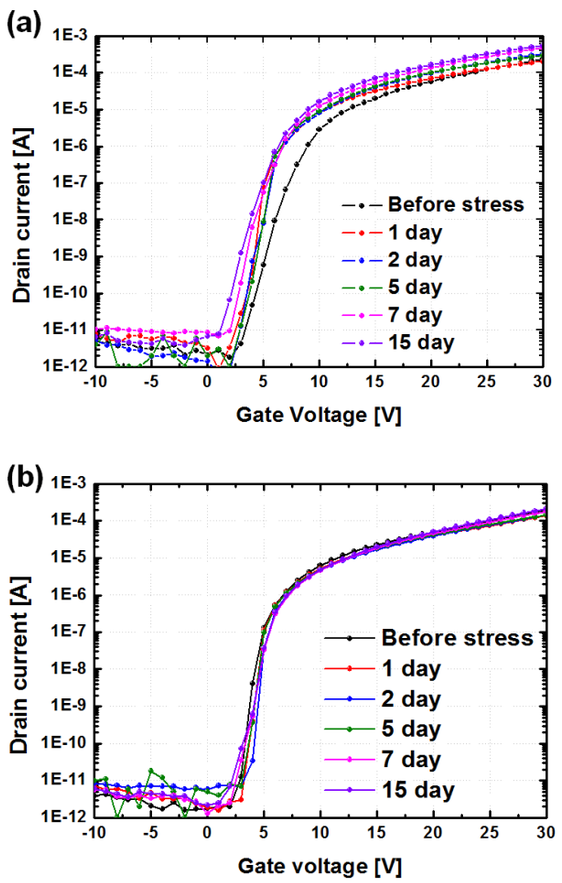

Fig. 2. Change of transfer curve between (a) conventional a-IGZO TFT and (b) a-IGZO/a-SIGZO double layered TFT under 50% relative humidity/50°C temperature condition for 15days.