# CARRIER TRANSPORT AND BIAS STRESS STABILITY OF IGZO TFT WITH HETEROJUNCTION CHANNEL

Mamoru Furuta, Kochi University of Technology, Japan
Furuta.mamoru@kochi-tech.ac.jp
Daichi Koretomo, Ryunosuke Higashi, Syuhei Hamada, Kochi University of Technology, Japan

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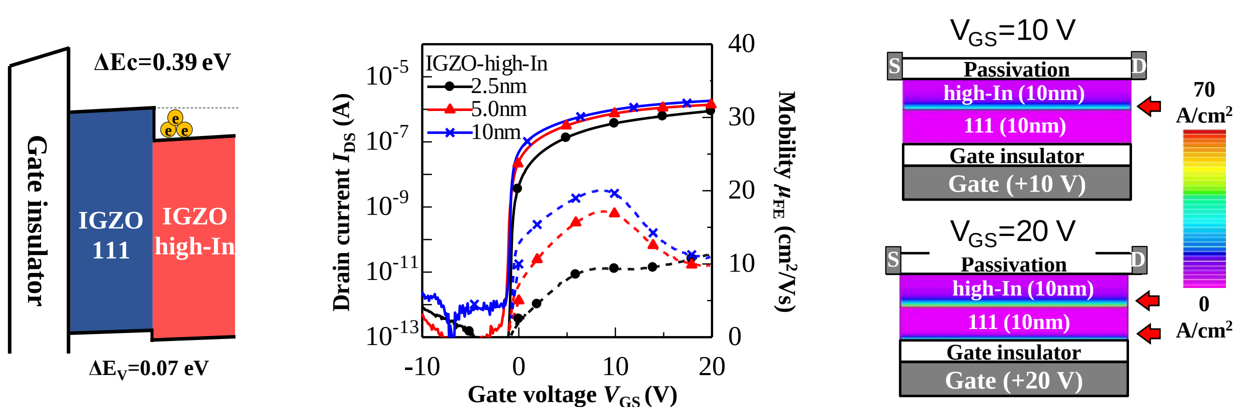
An InGaZnOx (IGZO) thin-film transistor (TFT) has been received considerable attention for use in next-generation displays owing to their excellent electrical properties. Although a field effect mobility ($m_{FE}$) of the IGZO TFT (10~15 $cm^2V^{-1}s^{-1}$) is over ten times larger than that of an amorphous silicon TFT, further enhancement of the $m_{FE}$ is desired to expand their applications. Several approaches have been proposed to improve the $m_{FE}$ of oxide TFT. Among them, it is known in the IGZO material system that an increase of In content is effective to enhance the $m_{FE}$ of the IGZO TFT since a conduction band of the IGZO is mainly composed of an In 5s orbitals. However, high In composition leads to an increase carrier concentration (oxygen vacancy) in the film, result in a degradation of TFT properties such as negative shift of threshold voltage and hump in transfer characteristics.

In this presentation, the TFT with a heterojunction IGZO channel was investigated to enhance $m_{FE}$ and bias stress and temperature stability (PBTS). For the hetero-junction channel, a high-In composition IGZO layer (IGZO-high-In) was deposited on a typical compositions IGZO layer (IGZO-111) to form the type-Ⅱ energy band diagram which possess a conduction band discontinuity (ΔEc) of 0.39 eV as shown in Fig. 1(a). Thickness of the IGZO-high-In layer was varied at 2.5, 5.0, and 10 nm, while that of the IGZO-111 layer was maintained to 10 nm to keep the constant electric field in the hetero-junction interface when gate voltage ($V_{GS}$) was applied. Figure 1(b) shows the transfer characteristics of the hetero-IGZO TFTs with the IGZO-high-In thicknesses of 2.5, 5.0, and 10.0 nm. The hetero-IGZO TFT with a 2.5-nm-thick high-In on IGZO-111 showed a $m_{FE}$ of 11.3 $cm^2V^{-1}s^{-1}$, which is almost the same value as the homogeneous IGZO-111 TFT. However, the $m_{FE}$ of the hetero-IGZO TFT increased with an increase of the IGZO-high-In thickness deposited on IGZO-111. In particular, the $m_{FE}$ of the hetero-IGZO TFT with a 10-nm-thick high-In back-channel exhibited 20.1 $cm^2$ $V^{-1}s^{-1}$ which was twice as high as conventional IGZO-111 TFT. To investigate the carrier transport mechanism in the hetero-IGZO TFTs, current densities in the IGZO channel were extracted by device simulation (ATLAS) as shown in Fig. 1(c). Since the ΔEc is formed at the hetero-junction interface, it acts as an energy barrier for electron confinement at the hetero-junction interface. At a gate voltage of below 10 V, a drain current mainly flowed at the high-In layer; resulting in the $m_{FE}$ improvement. On the other hand, when the $V_{GS}$ further increased to +20 V, the drain current flowed through both the front and hetero-junction interfaces. These results indicate that the changing of carrier transport pass, which depends on the applied $V_{GS}$, leads to the single peak of the $m_{FE}$ of the hetero-IGZO TFTs as shown in Fig. 1(b). Detail carrier transport mechanism and their PBTS reliability of hetero-IGZO TFTs will be discussed at the conference.




(a) (b) (c)

*Figure 1 (a) Schematic illustration of energy band diagram, (b) transfer characteristics (experiments), and drain current density (extracted by device simulation) of the hetero-IGZO TFT*