Comparative Study of the Effect of Hydrogen Content on Electrical Properties of Zn-Sn-O (ZTO) and In-Ga-Zn-O (IGZO) Thin-Film Transistors

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An amorphous InGaZnO\(_x\) (IGZO) thin film transistor (TFT), as a representative of oxide-based TFTs, has superior characteristics such as field-effect mobility (\(\mu_{FE}\)) of ~10 cm\(^2\)/Vs. However, rare-metal of In and Ga are used in an IGZO material. In this study rare-metal free zinc tin oxide (ZTO) TFT was investigated. \([1]\) In our previous publication, it was reported that hydrogen content in the IGZO channel influenced threshold voltage (\(V_{th}\)) and sub-threshold swing (S.S.) of the TFT, and it could be controlled by the nitrous-oxide/silane (N\(_2\)O/SiH\(_4\)) gas ratio during the SiO\(_x\) etch-stopper (ES) layer deposition. \([2]\)

In this research, the effect of hydrogen in channel on electrical properties of the ZTO TFT was compared with that of the IGZO TFT. To compare the effect of hydrogen on electrical properties of the TFTs, IGZO (In:Ga:Zn=1:1:1 at.\%) and ZTO (Zn:Sn=2:1 at.\%) were utilized as the channel of bottom-gate TFTs. After preparing the channel layer, an etch-stopper (ES) of SiO\(_x\) was deposited on top of the channel by plasma-enhanced chemical vapor deposition used SiH\(_4\), N\(_2\)O, and nitrogen as source gases. To control hydrogen content in the channel, N\(_2\)/SiH\(_4\) gas ratio was varied during the ES-SiO\(_x\) deposition.

Fig. 1 shows the variation of transfer characteristics of ZTO and IGZO TFTs with different N\(_2\)/SiH\(_4\) gas ratio of the ES-SiO\(_x\) deposition. The \(V_{th}\) of ZTO and IGZO TFTs shifted negative \(V_{GS}\) direction when the N\(_2\)/SiH\(_4\) gas ratio decreased. Fig. 2 shows \(V_{th}\) and S.S. of the ZTO and IGZO TFTs as a function of N\(_2\)/SiH\(_4\) gas ratio of ES deposition. The \(V_{th}\) of ZTO and IGZO TFTs exhibited similar tendency when N\(_2\)/SiH\(_4\) gas ratio was reduced. While the S.S. of ZTO TFT was quite steeper than that of the IGZO TFT. Moreover, it is noted that when N\(_2\)/SiH\(_4\) gas ratio decreased, the S.S. almost unchanged for ZTO TFTs, whereas that for IGZO TFTs improved gradually. These results suggest that the effect of hydrogen or hydrogen content in the channel was different between the ZTO and IGZO TFTs. Thus, the hydrogen contents in the ZTO and IGZO channels were quantitatively analysed by secondary ion mass spectrometry (SIMS) to investigate the effect of hydrogen in more detail. The influence of hydrogen on electrical properties of ZTO and IGZO TFTs will be presented at the conference.

![Fig. 1](image1.png) **Fig. 1 Transfer characteristics of ZTO and IGZO TFTs with SiO\(_x\)-ES layer deposited at different N\(_2\)/SiH\(_4\) gas ratio.**

![Fig. 2](image2.png) **Fig. 2 The \(V_{th}\) and S.S. of the ZTO and IGZO TFTs as a function of N\(_2\)/SiH\(_4\) gas ratio during SiO\(_x\)-ES deposition.**

**References**