Sustainable indium-free oxide TFTs for flexible displays

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Indium-gallium-zinc oxide (IGZO) thin-film transistors (TFTs) have been one of the major focus of interest of display industry over the last years. In fact, this TFT technology can offer superior electrical performance and stability when compared to a-Si TFTs, low temperature fabrication as organic TFTs and superior uniformity over large areas over poly-Si TFTs. Furthermore, oxide semiconductors as IGZO can be deposited by a large variety of techniques ranging from sputtering to ink-jet printing, resulting in great process flexibility adaptable within a thermal budget/performance/cost compromise. However, alternative oxide semiconductors are required as IGZO contains two critical elements, indium and gallium, that inhibit a clear cost advantage and sustainable approach over competing technologies. In this presentation zinc-tin oxide (ZTO) will be shown to be a viable replacement to IGZO. Sputtered ZTO TFTs fabricated at UNINOVA present comparable performance to IGZO TFTs after annealing at 300 °C (i.e., $\mu_{FE}\approx14$ cm^2/Vs, $V_{on}\approx0$ V, S=0.18 V/dec and On/Off ratio>10^8) and acceptable properties even at 150 °C ($\mu_{FE}\approx5$ cm^2/Vs, $V_{on}\approx$-5 V, S=1.3 V/dec and On/Off ratio>10^8). Still, it will be shown that (post-)deposition tuning (such as different processing atmosphere or annealing with rapid thermal annealing) can dramatically improve both performance and stability of low temperature devices, to values typical of high temperature ones.

Spin-coated ZTO TFTs will also be shown, based on sol-gel and combustion processing routes. ZTO TFTs fabricated at 350 °C show excellent idle shelf life stability, with negligible properties variation after 7 months of fabrication. Static characterization shows $\mu_{FE}\approx3.5$ cm^2/Vs, V_{on}=-0.5 V, S=0.3 V/dec and On/Off ratio$\approx10^7$). Extensive gate bias stress analysis was carried out, with ΔV_T being well fitted by a stretched exponential equation both in air and vacuum environments. Stress measurements at different temperatures reveal activation energies in the range of 0.6 eV, suggesting that the dielectric surface (rather than the oxide semiconductor itself) controls ΔV_T.

For both sputtering and solution processing, different analogue and digital building blocks will be shown operating at frequencies in the kHz range, including a 2T1C OLED pixel diving circuit on flexible substrate.

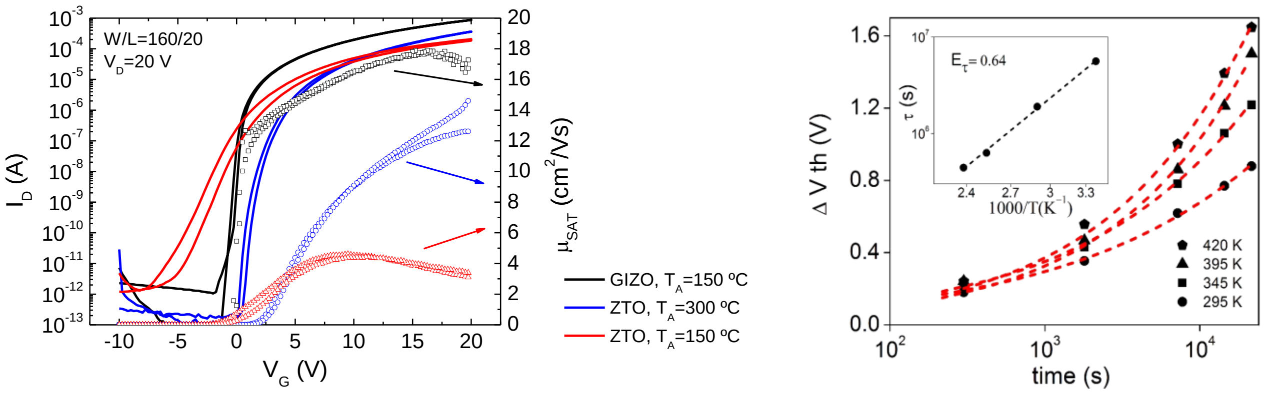

Fig. 1. (a) Transfer characteristics of sputtered GIZO and ZTO TFTs; (b) Electrical stability under positive gate bias stress at different temperatures of spin-coated ZTO TFTs. Inset shows activation energy.

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