

Effects of Wet O₂ Annealing on the Transfer Characteristics of Solution Processed Amorphous Indium Zinc Oxide Thin-film Transistors

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Research on transparent amorphous oxide semiconductor (TAOS) materials have seen a dramatic rise in activity ever since its introduction¹. Different materials such as IGZO, HIZO, and IZO have been explored by acting as the switching element in active matrix displays². The devices produced need to be annealed at temperature $\geq 300^\circ\text{C}$ to remove any existing defects during the fabrication process¹. There has also been growing interest in lowering the device fabrication process temperature to enable deposition on low thermal budget, flexible, and transparent substrates. In a previous study, we have demonstrated that low temperature annealing (150°C) of IGZO devices in a humid environment (wet O₂ annealing – WO₂) can significantly enhance the TFT's electrical characteristics by improving the M-O network and decreasing oxygen vacancies³. In this work, solution processed IZO TFTs were fabricated at a maximum process temperature of 250°C . Furthermore, the electrical characteristics of devices subjected to channel layer activation using a humid annealing environment were investigated and compared to those that were not.

IZO films were fabricated by spin coating a 77:23=In:Zn solution on a Si substrate with 100 nm SiO₂ which serves as the bottom gate and dielectric respectively. Formed films have a nominal thickness of 40-50nm. Patterning was performed via photolithography and wet etching. Two sets of devices were fabricated at a max process temperature of 250°C . The fabricated devices were split into two groups: w/o WO₂ anneal and w/ WO₂ anneal after the channel formation step. Then, the Mo(80nm)/Pt(20nm) source/drain electrodes were deposited via sputtering and were patterned via the lift-off technique. Afterwards, the devices were annealed in an O₂ environment for 1 hour and were also cooled down in the same environment. Finally, electrical characteristics were measured by using an Agilent 4156C semiconductor parameter analyzer.

Both devices exhibit switching behavior but the WO₂ annealed devices exhibited less negative shifting of the threshold voltage (V_{th}) and higher $I_{on/off}$ ratios compared to the devices which did not undergo channel activation. During the channel activation step, the humid annealing environment may help in decreasing oxygen deficiencies, point defects, and help in the formation of higher percentage M-O networks, as evidenced in our previous study³. This may be explained by the suppression of the outward diffusion of oxygen related molecules as well as increased diffusivity of water vapor during the channel activation process. Despite the improvement in the electrical characteristics, noticeable humps can be observed especially at higher drain voltages which may be a manifestation of donor-like traps due to the annealing condition. Thus further tests such as secondary ion mass spectroscopy (SIMS), positive bias stress (PBS) and negative bias stress (NBS) tests should be done to identify the cause.

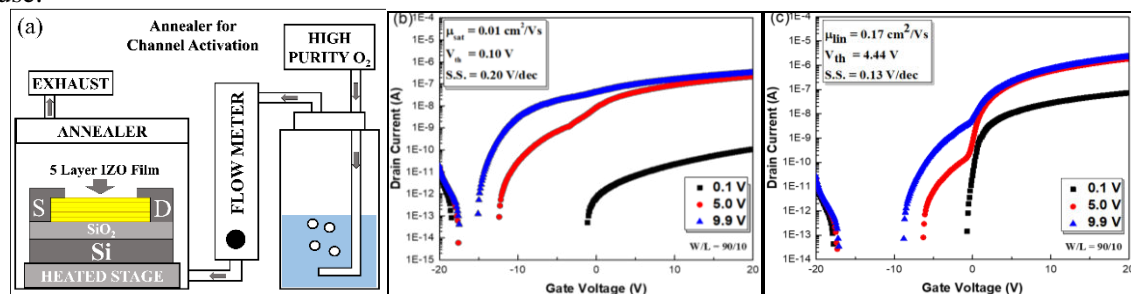


Figure 1. a) Wet O₂ annealer schematic, b) device without WO₂, and c) with WO₂ anneal. Characteristics are measured for $V_d = 0.1\text{ V}$.

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