Photo-assisted activation and conductivity enhancement of solution-processed InZnO

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Solution processed fabrication of oxide semiconductors is an attractive method due to its simplicity and versatility. Another advantage is its high material utilization when employing additive processes such as printing. Nevertheless, low performance (mobility (μ) < 1 cm^2/Vs) and high temperature processes (>400 °C) inhibit the wide adoption of solution processed oxide semiconductors in thin-film transistors (TFT) [1]. Here, we demonstrate the activation of InZnO through various photo-assisted methods such as excimer laser annealing (ELA) [2] and its combination with UV-ozone (UV/O_3) to enhance the TFT performance with μ up to 4 cm^2/Vs at reduced temperatures (T≤300 °C). We also demonstrate the instantaneous semiconductor-to-conductor transformation of InZnO through ELA and UV treatment.

To show the activation of InZnO by a photo-assisted process, we fabricated bottom gate top contact InZnO TFT. The InZnO precursor was spin-coated on a SiO_2 gate insulator/Si gate substrate and baked using a 2-step baking process at 150 °C and 300 °C to form a thin (~10 nm) InZnO film. This was repeated 5 times to form a 5-layered InZnO channel (~50 nm). 20 nm Pt on 80 nm Mo for source/drain electrodes were deposited by radiofrequency magnetron sputtering. Electrical characteristics were then measured before the photo-assisted process (Fig. 1(a)). Instead of a 300 °C furnace annealing for 2 h, two types of photo-assisted process were performed: ELA and a combination of ELA and UV/O_3 treatment at 290 °C. Fig 1(b) shows the improvement of electrical characteristics from an average μ of 0.15 cm^2/Vs before ELA to an average of 3.30 cm^2/Vs after ELA at 80 mJ/cm^2. A similar mobility enhancement (1.16 cm^2/Vs) was observed with the combination of ELA and UV/O_3. Photo-assisted methods can also induce a semiconductor-to-conductor transformation by decreasing the sheet resistance of InZnO (Table 1). Through this UV-induced conversion, we fabricated a transparent all solution-processed oxide TFT by selectively converting InZnO semiconductor regions into conductors to form source, drain, and gate electrodes (Fig 2).

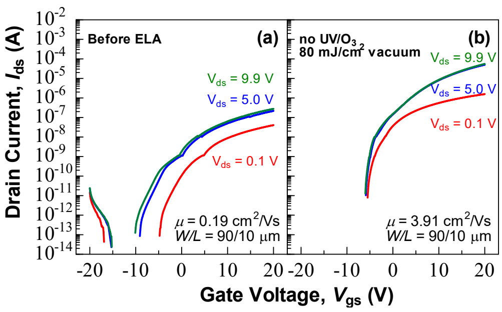

Fig 1. Transfer characteristics (a) before ELA and (b) ELA at 80 mJ/cm^2 in vacuum

Method	R_S (Ω/□)
As-fabricated	~10^4-10^5
ELA (80 mJ/cm^2, air)	3.35 × 10^4
ELA (120 mJ/cm^2, vac)	2.98 × 10^2
UV/O_3 (wet, 290 °C)	1.36 × 10^3
UV (115 °C)	1.35 × 10^2

Table 1. Sheet resistance (R_S) after various photo-assisted methods

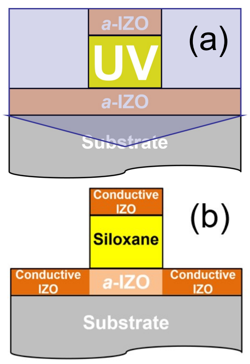

Fig 2. Transformation of all-solution oxide TFT (a) before and (b) after UV

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