Effect of UV-irradiation Time on the Transfer Characteristics of All Solution-processed a-IZO Thin-Film Transistor

Umu Hanifah[1], °Juan Paolo Bermundo[1], Dianne Corsino[1], Mutsunori Uenuma[1], and Yukiharu Uraoka[1]

[1]Nara Institute of Science and Technology

E-mail: b-soria@ms.naist.jp

The next-generation devices need a simple fabrication process, transparent materials, flexible substrates, and low-temperature fabrication. From these criteria, the solution-process approach is a promising fabrication method. Previous report showed that a high-performance all-solution process TFT via simple photo-induced process has many benefits such as simplicity, rapid process time, no additional process for depositing separate source and drain electrodes [1]. Other report also displayed that photo-assisted treatment can be one of the alternatives to produce high-performance amorphous Indium Zinc Oxide (a-IZO) TFT even at low-temperature fabrication [2]. A few studies that focus on electrical performance improvement of the a-IZO TFT have been reported, but using a quick and simple way of improving the TFT performance by varying the UV-irradiation time still need further investigation. This research aims to study the effect of UV-irradiation time on the transfer characteristics of all-solution processed a-IZO TFT.

IZO precursor solution were spin-coated on Si substrate with a 100 nm thermal SiO_2. Fluorinated-polysilsesquioxane (F-PSQ) with a thickness around ~200 nm was spin-coated as a gate-insulator. Then a-IZO layer was deposited as the top layer. Self-aligned patterning, gate etching and gate insulator etching were then performed. Lastly, the photo-assisted treatment was done by UV-irradiation at 115°C for either 60 min, 90 min, or 120 min. After UV-treatment, exposed IZO layers transform as gate, source and drain, respectively. The transfer characteristics and bias stress tests were obtained using an analyzer. Bias stress was performed by application of a gate voltage (V_{gs}) of = + 10V and –10V with a total stress time of 10^4s.

Fig. 1(a) shows the structure of the all-solution processed a-IZO TFT after UV-irradiation. The UV-irradiation time combine with low temperature heating was performed to enhance the transfer characteristics of a-IZO TFT. Transfer curves before- and after-UV treatment are displayed in fig 1(b). The mobility increases after UV irradiation for 60 min and 90 min, with a value of 8.57 and 13.72 cm^2/Vs respectively. This possibly happens due to the UV wavelength (~254 nm) with an energy of 4.9 eV is expected to break In-O and Zn-O bonds which have bond energies of 1.70 eV and 1.52 eV respectively, and resulting in more oxygen vacancies [2]. The effect of additional low heating treatment also decreases the concentration of oxygen-vacancy-related defects and increasing the concentration of metal−oxide bonds formation [3]. But, after 120 min, the mobility slightly decreases until it reaches 1.09 cm^2/Vs. This degradation value might be caused by the competitive mechanism between UV irradiation and simultaneous low heating. The device shows lower mobility which may be mainly due to excessive heating which can generate more metal-oxide bond but with significantly lower oxygen vacancies concentration in the exposed IZO film. The result shows that 90 min UV-irradiation is the optimum duration to improve the performance. In summary, this work has demonstrated that varying UV-irradiation time is a simple and promising method to improve the performance of a-IZO TFT at a low temperature process, which is useful for flexible substrate application.

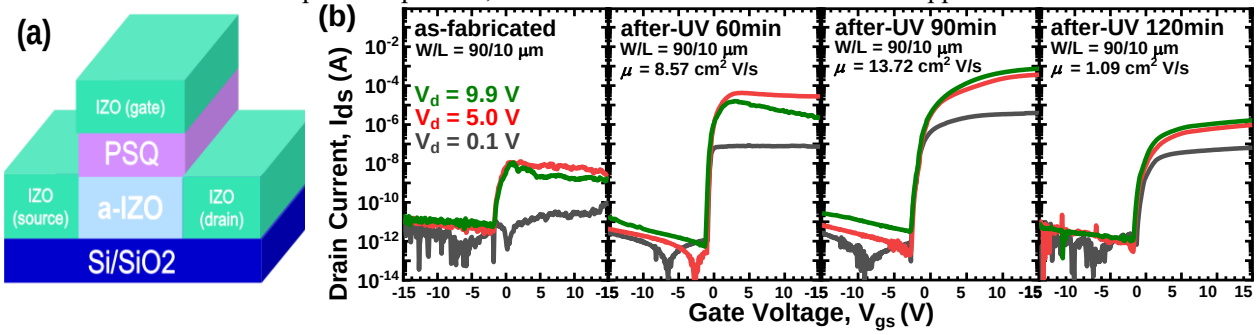

Fig. 1(a) a-IZO TFT structure and (b) Transfer characteristics of the all solution processed a-IZO TFT at varying UV time

Acknowledgment:
We would like to thank Nissan Chemical Corporation for providing the InZnO precursor solutions.

[1] J. P. S. Bermundo, et. Al. SID Symp. Dig. Tech. Pap. (2019)
[2] D.C. Corsino, et. al. ACS Appl. Electron. Mater. 2, 8, 2398 (2020)
[3] Y. J. Tak et.al., ACS Appl. Mater. Interfaces 6, 6399−6405 (2014)