Effects of Zr doping on inkjet-printed ZnSnO thin-film transistor

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Display devices have become common due to the development of mobiles phones, next generation flat-screen TVs, personal computer monitors, etc. The essential element for such flexible and large area device is a thin-film transistor (TFT). Among four kind of TFTs, oxide-based TFTs employing oxide semiconductors such as indium gallium zinc oxide (IGZO) and zinc tin oxide (ZTO) are promising devices for active matrix display applications and sensor arrays because of their high mobility, visible light transparency, good uniformity and solution process ability. One of efficient printing techniques to enable drop-on-demand patterning is inkjet with large area and mass production for electrical devices. Inkjet printing with exact control of the drop volume and position can substitutes the production of complex patterns with expensive and chemical waste photolithographic processes.

Solution-processed ZTO TFTs that are easily inclined to make oxygen vacancies do not show good device performances. It also has poor leakage gate current with increasing drain current. Thus, if oxygen vacancies in the patterned ZTO thin film are adequately suppressed, electrical properties of TFTs will be improved. One of effective methods for controlling oxygen vacancies is a material doping considering the SEP, bandgap and electronegativity. The second is the control of annealing temperature. An appropriate control of zirconium doping concentration as suppressor is necessary because it has a low electronegativity (1.33) and the high bandgap(7 eV) and low SEP(-1.45 V) compared to the zinc and tin. Although a study on Zr mole ratio in solution processed ZTO TFTs was conducted previously, it is needed to optimize a doping concentration to obtain better electrical properties and to make patterned thin film to prevent gate leakage current through inkjet printing. So, we proposed a doping of Zr which is a stable material and carrier suppressor into ZTO system is expected to help in controlling the number of oxygen vacancies. We found the optimized doping mole ratio and annealing temperature of Zr into patterned ZTO system (ZZTO) in channel region to control for suitable oxygen vacancies.

Electrical characteristics of inkjet-printed ZZTO TFT are measured by semiconductor parameter analyzer and the prepared solutions are analyzed by TGA-DSC and thin films are analyzed by XRD and XPS. Mobility, on/off ratio, threshold voltage and sub-threshold voltage of a inkjet-printed 0.0025M ZZTO TFT at 500℃ are 6.43cm^2/Vs, 3.72 x 10^8, 3.35V and 0.53V, respectively. Also we obtained a better bias stress.

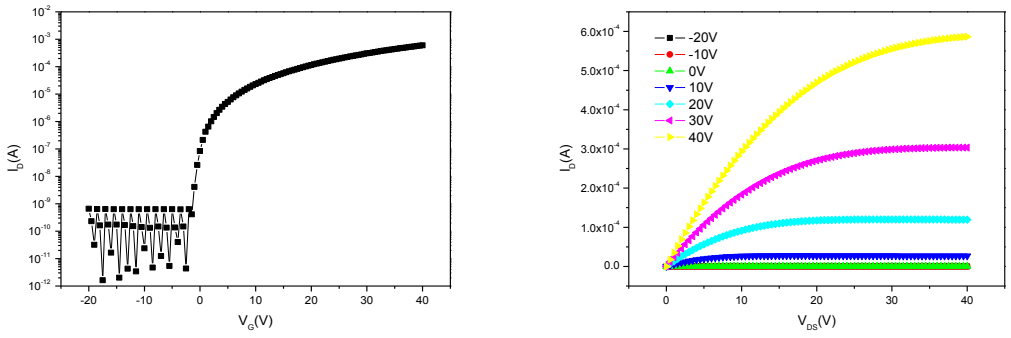

Fig. 1 Transfer curve and output curve of a inkjet-printed ZZTO TFT at 500℃

Acknowledgment

This work was supported by the Basic Science Research Program through the NRF funded by the Ministry of Education, Science and Technology (2012-039948).

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