Doctoral thesis/dissertation Digest Form

Title of Doctoral Thesis: Elucidation of photoinduced structural modification in oxide semiconductors for fully solution-processed thin-film transistors
(完全溶液プロセス型薄膜トランジスタに向けた酸化物半導体における光誘起構造変化の解明)

Name: CORSINO Dianne Cabrejas

(Summary)

The realization of next-generation electronics requires large-scale device production using cost-effective and low-energy techniques. Thin-film transistors (TFTs), the key element in many electronic systems, must therefore be produced using simple fabrication strategies to achieve target functionalities. In terms of scalability, affordability, and simplicity, solution processing is considered advantageous compared to the conventional vacuum techniques. While numerous reports have demonstrated improvement in solution-processed oxide TFT performance, successful integration of all solution-based components is necessary to realize high throughput device production.

This thesis aims to: (1) develop a low-temperature vacuum-free approach to high-performance oxide TFT fabrication; (2) achieve tunable properties of solution-processed oxide semiconductors for transparent electrode applications using photo-assisted methods; and (3) understand the mechanism for the photoinduced semiconductor-to-conductor transformation of oxide semiconductors.

Fully solution-processed oxide TFTs were fabricated based on InZnO (IZO) channel and electrodes, and fluorinated polysilsesquioxane gate insulator (F-PSQ GI). IZO electrode functionalization was achieved using various photo-assisted treatments, namely UV irradiation, KrF excimer laser annealing (ELA), and continuous wave (CW) laser irradiation. Excellent TFT switching properties were attained after performing the photo-assisted treatments signifying electrode functionalization. Specifically, high-performance fully solution-processed a-IZO TFTs with an average mobility of 38.0 $cm^2\ V^{-1}\ s^{-1}$ were achieved using a combination of UV irradiation and ELA in vacuum with a laser fluence of 120 $mJ\ cm^{-2}$. Meanwhile, a single treatment of CW laser irradiation resulted in *a*-IZO TFTs with a mobility of 14.6 $cm^2\ V^{-1}\ s^{-1}$, while its combination with UV irradiation resulted in degraded performance. Elemental analysis revealed fluorine diffusion from the F-PSQ GI to the a-IZO channel which mainly affected the high mobility obtained.

This work also thoroughly discussed the effects of photo-assisted treatments on the structural properties of IZO that enable conductivity enhancement and provide electrode functionality. XPS analysis revealed oxygen vacancy (V_o) generation after performing the photo-assisted treatments which raised the carrier concentration and eventually improved the conductivity of IZO. Meanwhile, laser-induced crystallization of the IZO electrodes after ELA was confirmed by XRD and TEM analyses which was further explained using two-dimensional simulation of temperatures. Findings suggest V_o generation and crystallization as vital factors to achieve the outstanding performance of the fully solution-processed *a*-IZO TFTs.

This research demonstrates a fully solution approach to high-performance oxide TFT fabrication using photo-assisted methods such as UV irradiation, ELA, and CW laser irradiation. These approaches for tailoring the functionality of solution-processed oxide films will be valuable for the realization of future electronic systems.