Improvement of Electrical Properties and Low-Temperature Development of Sol-gel Processed In-Ga-Zn-O Thin-Film Transistors Using UV-DI

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The vulnerability of solution-processed metal-oxide semiconductors is significantly influenced by organic chemical-induced defects such as voids, holes, and organic residues. Moreover, solution-processed Oxide TFTs require a high temperature process. Hydroxyl radicals (OH•), known as strong oxidants, are effective in eliminating and decomposing organic compounds. In this study, we introduced UV-DI with hydroxyl radicals into the IGZO Sol-Gel mixture to produce lower boiling points components and deposit IGZO layers with fewer defects. Hydroxyl radicals were generated in deionized (DI) water through an O_3/UV process, confirmed via potassium iodide (KI) and ultraviolet-visible (UV-vis) spectroscopy analysis. The intensity of the absorbance peaks at wavelengths of 290 nm and 350 nm increased with longer UV irradiation times. Thermogravimetric and differential scanning calorimetry (TG-DSC) analysis revealed that the organic materials in the IGZO solution mixture with UV-DI treatment began to decompose at a lower temperature (121.6℃) than those in the pristine IGZO mixture (144.5℃) (Fig.1). The field-effect mobility and sub-threshold slope of the a-IGZO TFTs made with ozonated water were improved compared to the conventional process, increasing from 1.37 to 1.44 cm^2/V·s and decreasing from 0.24 to 0.20 V/dec, respectively. (Fig.2) These results suggest that the addition of ozonated water to the sol-gel mixture is a simple method to achieve high-performance TFTs through low-temperature processing.

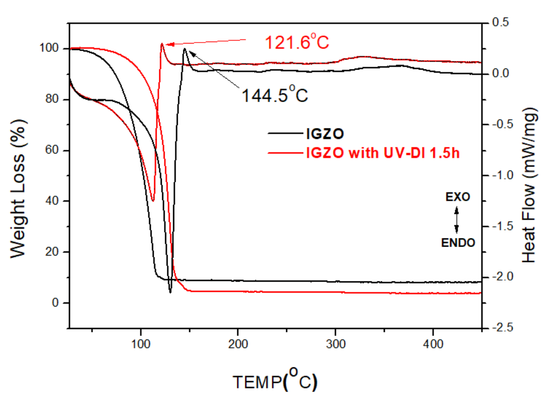

Figure 1 Tg-DSC analysis result of IGZO solution and IGZO solution with UV irradiated DI water

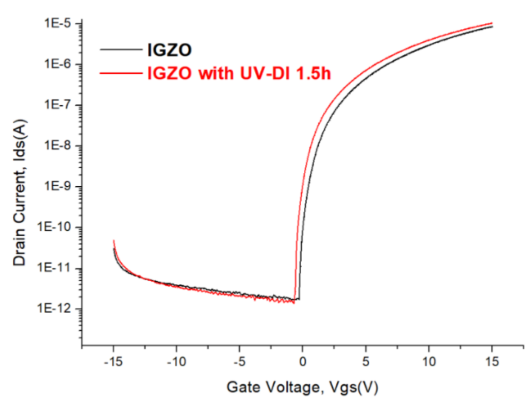

Figure 2 Transfer curves of IGZO TFT with and without addition of UV-DI in IGZO solution

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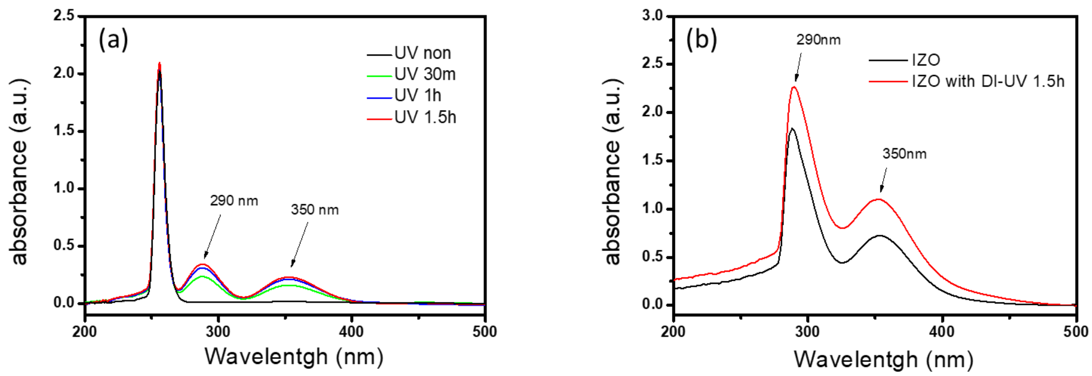
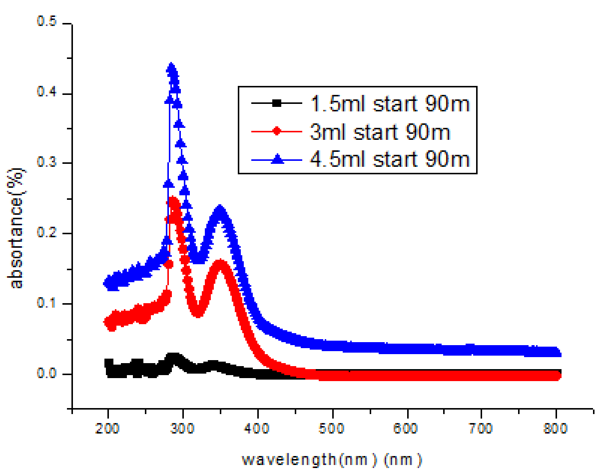
Supplementary Pages

The intensity of the absorbance peaks at wavelengths of 290 nm and 350 nm increased with longer UV irradiation times. Additionally, the peaks were more pronounced in the IGO solution mixed with UV-DI compared to the IZO solution without UV-DI.



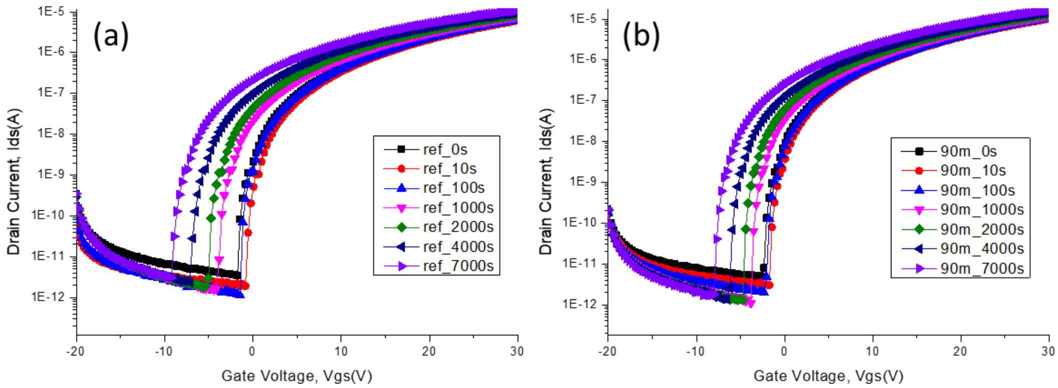
Supporting Figure 1. KI/UV-vis spectroscopy analysis result of KI solution mixture with (a) UV irradiated DI water (b) IZO solution and UV irradiated DI water

the density of hydroxyl radicals in DI water could be modified by adjusting the initial volume of DI water while maintaining the same UV irradiation duration. A DI water volume of 4.5 ml resulted in a higher concentration of hydroxyl radicals compared to 1.5 ml of DI water.



Supporting Figure 2. KI/UV-vis spectroscopy analysis result of KI solution mixture with different initial DI water volume

Threshold voltage shifts over 7000 seconds under negative-bias stress conditions (NBS) were -7.25 V and -5.67 V for pristine IGZO and IGZO with UV-DI, respectively



Supporting Figure 3. Positive Bias stress test result of IGZO TFT (a)with and (b)without addition of 1.5h UV-DI in IGZO solution