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# Structural and Electrical Properties of Fluorine-doped Zinc Tin Oxide Thin Films Prepared by Radio-Frequency Magnetron Sputtering

**Rina Pandey[1,2], Se Hee Cho[1], Do Kyung Hwang[1,2], and Won Kook Choi[1,2]***

[1]Interface Control Research Center, Korea Institute of Science and Technology, Sungbuk Gu, Hwarangro 14 Gil 5, Seoul 136-791, Korea, [2]Department of Nanomaterials Science and Engineering, University of Science and Technology, Gajeong-ro 217, Yuseong-gu, Daejeon 305-350, Korea

Over the past several years, transparent conducting oxides have been extensively studied in order to replace indium tin oxide (ITO). Here we report on fluorine doped zinc tin oxide (FZTO) films deposited on glass substrates by radio-frequency (RF) magnetron sputtering using a 30 wt% ZnO with 70 wt% SnO2 ceramic targets. The F-doping was carried out by introducing a mixed gas of pure Ar, CF4, and O2 forming gas into the sputtering chamber while sputtering ZTO target. Annealing temperature affects the structural, electrical and optical properties of FZTO thin films. All the as-deposited FZTO films grown at room temperature are found to be amorphous because of the immiscibility of SnO2 and ZnO. Even after the as-deposited FZTO films were annealed from 300～500°C, there were no significant changes. However, when the sample is annealed temperature up to 600°C, two distinct diffraction peaks appear in XRD spectra at 2Θ=34.0° and 52.02°, respectively, which correspond to the (101) and (211) planes of rutile phase SnO2. FZTO thin film annealed at 600°C resulted in decrease of resistivity 5.47×10-3 Ωcm, carrier concentration ～1019 cm-3, mobility～20 cm2 V-1s-1 and increase of optical band gap from 3.41 to 3.60 eV with increasing the annealing temperatures and well explained by Burstein-Moss effect. Change of work function with the annealing temperature was obtained by ultraviolet photoemission spectroscopy. The increase of annealing temperature leads to increase of work function from ϕ=3.80 eV (as-deposited FZTO) to ϕ=4.10 eV (600°C annealed FZTO) which are quite smaller than 4.62 eV for Al-ZnO and 4.74 eV for SnO2. Through X-ray photoelectron spectroscopy, incorporation of F atoms was found at around the binding energy of 684.28 eV in the as-deposited and annealed FZTO up to 400oC, but can't be observed in the annealed FZTO at 500oC. This result indicates that F atoms in FZTO films are loosely bound or probably located in the interstitial sites instead of substitutional sites and thus easily diffused into the vacuum from the films by thermal annealing. The optical transmittance of FZTO films was higher than 80% in all specimens and 2-3% higher than ZTO films. FZTO is a possible potential transparent conducting oxide (TCO) alternative for application in optoelectronics.

**Keywords:** Fluorine doped ZincTin Oxide, Transparent Conductive Oxide, Electrical and Optical properties