Optimization of ZnO thin films for dye-sensitized solar cells applications

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Abstract: We present the fabrication and optimization of compact ZnO thin films prepared by sol-gel processing. There upon we employed these thin films as a photo-anode in a dye-sensitized solar cell using an anthracene derivative molecule.

Zinc Oxide (ZnO), a semiconductor material exhibits a direct band gap of 3.4eV, qualifying it as a suitable candidate for absorbing in the UV spectral regime. In addition ZnO has been proven to be a multifunctional material. The high exciton binding energy of ZnO (~ 60 meV) makesit feasible for excitonic transitions even at room temperature, meannga high radiative recombination efficiency for spontaneous emission as well as a lower threshold voltage for laser emission. Here in this work we optimized the fabrication of ZnO thin filmsvia sol-gel processing. We then employed high performance anthacene based molecule to fabricate a dye-sentized solar cell with planar architecture and obtained an photoconversion efficiency of 0.6%. ZnO nanoparticles were prepared by sol gel method using two different solvents(ethanol and 2MEA) while the precursor was the same Zinc Acetate Dihydrate. Then this sol was used to prepare thin films of ZnO using spin coating method. The thickness of the multiple coated films were found out to be roughly 100nm while the roughness was measured to be around 20nm when observed using Zeta 3D Profilometer. UV-Vis. Spectroscopic analysis of the samples were done using UV-3600 PLUS spectrophotometer. The analysis showed peaks at around 345nm which corresponds to the band gap of ZnO. This evidence of ZnO being deposited on the substrates was substantiated by the GIXRD patterns of the thin films which was done using Bruker D8 Discover. The XRD patterns of the samples confirmed the presence of the expected phase with little impurities. Using G1 dye, dye sensitized solar cells were fabricated using the standard procedure with redox iodide based liquid electrolyte. The solar cells were then investigated under a solar simulator under 1 sun illumination. We obtained V_{OC} of 612.6mV with an efficiency of 0.53%.J vs. V plots showed maximum J values for the cells with the film containing 3 coats of the sol. Using Photoluminescence spectroscopy were used to observe PL quenching of G1 when interfaced with ZnO suggesting electron transfer process.

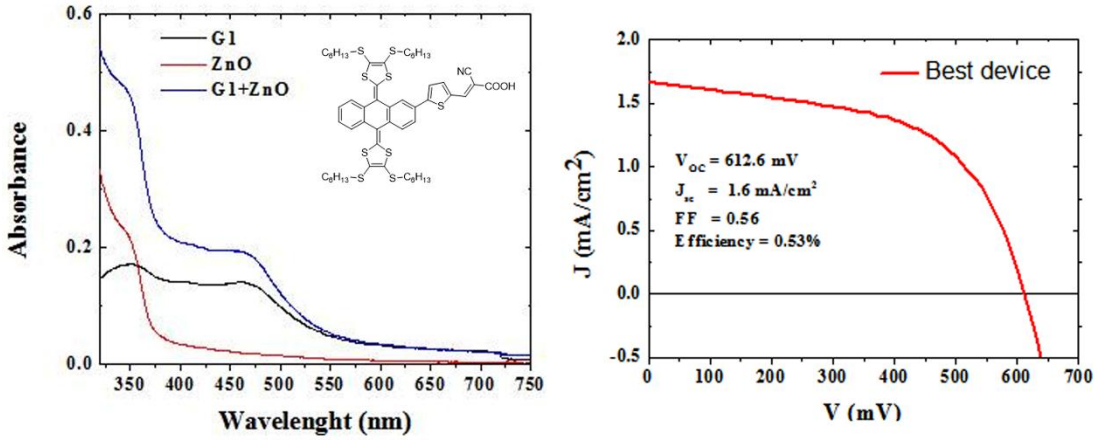

Fig. 1: (left) Absorption spectra of the G1 moleculeand the G1+ZnO thin films on fused silica substrate; (right) photovoltaic device data of the fabricated DSSC