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Enhanced carrier transport of Amorphous In-Al-Zn-O: The effect of Al doping

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In recent years, the demand for oxide semiconductors which exhibit low resistivity (~10-4 Ω-cm) and high transparency in the visible regime (>85%) has significantly increased due to the emergence of next-generation display devices and photovoltaic. Conventional amorphous-Si display devices, while still broadly used, possess relatively low field effect mobility (≤1 cm_2/V-s) in thin-film transistor (TFT) applications, thus limiting crucial characteristics such as pixel-switching speeds. However, recent investigations into transition-metal oxide semiconductors, such as In-Ga-Zn-O, have revealed promising high field effect mobilities of ≥10 cm_2/V-s, indicating faster switching speeds required by ultra-high-definition display devices. Additionally, certain transition-metal oxide materials, such as In-Zn-O, exhibit the ability to serve as both conducting and semiconducting materials depending on fabrication parameters - expanding transition-metal oxide applications to transparent electrodes in devices such as photovoltaic (PV) cells. Not only do the high carrier mobilities exhibited in these materials allow for an increase in conductivity without compromising the transparency of the material, they also help extract charge more rapidly from the donor/acceptor interface in PV cells, hence reducing recombination rates and increasing device performance. In this study, it is shown that aluminum-doped indium zinc oxide (IAZO) can possess a promisingly high carrier mobility of ~90 cm^2/V-s, while also maintaining desirable transparent conducting oxide characteristics such as low-temperature fabrication (<100 oC), low resistivity (~3x10-4 Ω-cm in as-deposited conditions), and optical transparency in the visible regime of >85%. IAZO films have been prepared via DC/RF magnetron co-sputter systems. Post-fabrication analysis consists of a thorough investigation of the electrical and optical properties of IAZO such as carrier mobility, carrier density, resistivity, visible regime transmittance (%T), and optical band gap. As-deposited IAZO's mobility of ~40 cm^2/V-s increases to ~90 cm^2/V-s after a 1hr low- T air anneal at 100°C and then decreases to ~60 cm^2/V-s while the annealing T approaches 300°C. X-ray diffraction (XRD) analysis was performed on the IAZO samples in order to investigate amorphous/crystalline structures. XRD results indicate excellent amorphous phase stability after annealing process. UV-vis data indicates that all IAZO films fabricated show excellent %T (>90%) in the majority of the visible spectrum and that the optical band gap of IAZO films is a function of both RF power and annealing temperature.

Biography

Austin Reed received his BSME from Baylor University in 2016. He is currently pursuing a Master's of Science in Mechanical Engineering at Baylor University. His research focuses on the innovation of transparent flexible electronics and renewable energy devices under the guidance of his advisor, Dr. Sunghwan Lee.

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