Amorphous Transparent Conducting Oxides for Photovoltaics

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Thin film transparent conducting oxides (TCOs) are critical to most thin film photovoltaic (PV) technologies including Si Heterojunctions, $CuInSe_2$ (CIS), CdTe and Organic Photovoltaics (OPV). For the traditional TCOs such as Al:ZnO, Sn:In_2O_3 and F:SnO_2, good crystallinity is generally required for optimal properties. However, over the past decade, a new class of TCOs that are amorphous has emerged based on double (or triple) oxides of heavy metal cations with nominal ionic electronic configuration $(n-1)d^{10}ns^0$. This class is typified by In-Zn-O (IZO) and these materials are of increasing interest due to the excellent opto-electronic properties and smoothness (R_{RMS} < 0.5 nm) obtained for sputtered films deposited at less than 100 °C. For example, conductivities ≥ 2500 S/cm are common for amorphous In-Zn-O (a-IZO) films grown from a ceramic In_2O_3/ZnO target with 84 cation % (cat%) indium, the current industry standard. This talk will cover the materials growth, properties and PV application testing of two prototypical a-TCOs, a-InZnO (a-IZO) and a-ZnSnO (a-ZTO) being considered at NREL. First, co-sputtering composition-spread combinatorial methods are used to survey the overall all amorphous alloy space. Then, selected compositions are further optimized using DC, RF and RF-superimposed DC sputtering. Finally, these a-TCO materials are further developed by actual testing in PV devices including organic photovoltaics (OPV), Cu(In,Ga)Se_2 and Film Si Heterojunctions.

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