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Investigating the Morphology and Optoelectronic Properties of Solution-Processed ITO Multilayer Thin Films using Neutron Scattering and Complimentary Advanced Multimodal Characterization Techniques

Indium Tin Oxide (ITO), a transparent conducting oxide, is used industrially as an electrode for usage in LEDs, computers/phone screens, and photovoltaic devices. Most ITO thin films are deposited using RF vacuum deposition. An alternative deposition method known as sol-gel deposition, has the benefit of device fabrication under atmospheric conditions and wastes less material than sputtering. However, solution processing methods tend to have higher sheet resistances compared to vacuum-deposited films [1,2] and can suffer from formation of large pores [3]. The spin-coat method was employed to deposit ITO multilayer thin films onto sodium silicate glass substrates. Samples were characterized using a battery of techniques including NR, XRR, ToF-SIMS, TEM and S/STEM.

In this study, we synthesized ITO inks following previously used procedures [4,5] but lowered the relative humidity to 19% during film deposition in hopes of minimizing the formation of voids in the thin film structures. AFM did not reveal any surface pores in contrast to earlier samples. The results of the X-Ray and Neutron scattering length density experiments depicted peaks and troughs located at the interfacial layers of the 1L-5L ITO thin films, respectively. These features are a function of Indium-ion scattering length density being different than that of ITO for both NR and XRR. Additionally, STEM-HAADF images reveal porous ITO layers with increased density at the interfacial regions between layers. EELS was employed, confirming that density rises with increased through-plane depth in the multilayer films. Additionally, EELS revealed increased Indium and Oxygen intensity peaks at the interfacial regions. However, Tin did not experience increased peak intensity at the interface. ToF-SIMS results support EELS data, simultaneously depicting increased Indium-ion content and banded Tin-deficient regions at interfacial layers.

Topical Area

Emerging research and multimodal techniques

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