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Nanoscale electrical characterization of Oxide and II-VI semiconductors for optoelectronic applications

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Abstract – Copper indium oxide, copper oxide, In_2O_3, CdS, CdTe and Cu_2S thin film and nanorod structures have been grown using physical and chemical methods. Nanoscale electrical properties of these layers have been studied using CAFM and STM techniques. These thin film and nanorods structures are suitable for transparent electrical contacts, p-n transparent junctions, resistive memory device and solar cells applications

In this presentation, optical, structural and electrical properties of a number oxide and II-VI semiconductor materials in thin film and nanorod forms will be discussed. Undoped and tin doped $CuInO_2$ thin films grown by reactive rf magnetron sputtering technique show nanocolumnar structure with (110) and (006) preferred orientation, respectively. The observed decrease in activation energy from 0.9 eV to about 0.10 eV and a large decrease in conductivity from 2.11×10^{-10} Scm^{-1} to 1.66×10^{-1} Scm^{-1} on Sn doping is due to the change in preferred orientation from (110) to (006) along with efficient doping. Due to thermally activated carrier transport along O-A-O layers and activated carrier generation along BO_6 layers, crystallite orientation becomes a crucial factor controlling the electrical conduction in delafossite thin films. The anisotropy of electrical conduction along (006) and (110) directions among the tin doped samples has been further established using CAFM measurements. The CAFM measurements shows the presence of nanoconducting region when the current flow direction is aligned along the BO_6 layer and complete absence of conducting regions when the current direction is perpendicular to the film surface. In addition to crystallite orientation, tin doped samples exhibit a band gap value of 4.5 eV as compared to 3.4 eV exhibited by undoped samples. The possibility of bipolar conducitivity (p and n type) and wide band gap make these layers potentially suitable for transparent passive contact and p-n junction applications. Results of another study involving nanocrystalline copper oxide layer grown by DC sputtering technique will be discussed. CAFM and I-V characteristic of these layers show the formation of conducting paths on application of a threshold voltage. In another study, monocrystalline In_2O_3, CdS, CdTe and Cu_2S nanorods having well defined dimensions have been grown using CVD and solvo-thermal routes. Preliminary results of the nanoscale electrical characterization carried out on semiconductor nanorods using CAFM and STM techniques and formation of p-n junction solar cells will be discussed.

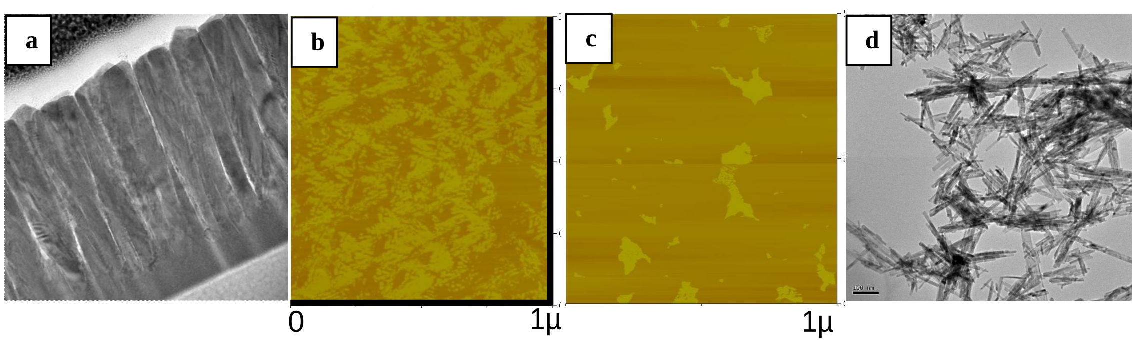

Figure a: Cross-sectional HRTEM image of a copper indium oxide thin film showing nanocolumnar structure. **b:** CAFM image showing nanoconducting regions with current parallel to the substrate, **c)** absence of conducting paths with current perpendicular to the substrate **d)** HRTEM image of CdS nanorod structures.

References:1. Applied Physics Letters, 93, 192104 (2008)
2. Applied Physics Letters, 92, 171907 (2008)
3. Nanotechnology, 20, 235608 (2009)