Area: Area 2 Thin-Film Compound Semiconductor PV

In$_2$S$_3$:M (M=V, Ti, Nb) FILMS FOR INTERMEDIATE BAND SOLAR CELLS

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One concept for surpassing the Shockley-Queisser-Limit of solar cells is the introduction of an intermediate band (IB) inside the band gap of the absorbing semiconductor. Using density-functional-theory, In$_2$S$_3$:M with M=Ti, V, Nb has been identified as a promising IB material. In this study we use co-evaporation to grow In$_2$S$_3$:M thin films on glass substrates [1]. For structural-chemical analysis we use X-ray diffraction, Raman spectroscopy, scanning electron microscopy, and energy dispersive X-ray spectroscopy. We find co-evaporated In$_2$S$_3$ film to crystallize in the $\beta$-phase exhibiting strong texture effects upon increasing the substrate temperature from 300$^\circ$C to 500$^\circ$C. Texture is along (103) in tetragonal notation. Well defined Raman peaks can be observed with two so-far not reported additional modes. Raman line width reduces upon film annealing. We find that even excessive incorporation of Vanadium into the host structure is possible without formation of secondary phases. However, Raman peak analysis indicates increasing line width and thus reducing crystalline quality upon Vanadium doping (see figure below). The same is true for Ti and Nb doping which are also fully incorporated in the structure. The In$_2$S$_3$:M thin films then are employed in glass/FTO/In$_2$S$_3$:M/Zn$_2$CoO$_4$/Au heterostructure solar cells. The diode currents from these devices exhibit rectification values of up to $10^4$. The non-optimized solar cells hitherto show small open circuit voltages of up to 300 mV and small short circuit currents. The quantum efficiency points towards a small collection zone. Employing 2-photon excitation, we find the first indication of an intermediate band effect in the photo current.