Infrared ellipsometry from 300 K to 10 K for 30 nm α-Sn films.

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α-Sn is the low-temperature phase of tin that crystallizes in an FCC diamond like lattice structure. MBE was used to grow 30 nm thick α-Sn films on bulk undoped single side polished InSb (100) substrates [3]. The α-Sn layer on sample AE225 was grown on an Indium rich c(8x2) reconstruction and the α-Sn layer on sample AE227 was grown on an Antimony rich c(4x4) reconstruction. It has been shown that the band occupancy of α-Sn is strongly influenced by the preparation methods [2,4].

Due to relativistic effects in heavy atoms, the Γ_7^- band maximum is negative for α-Sn. There is a degeneracy at Γ and a curvature inversion of the light hole band. The degeneracy and inversion lead the Γ_8^{+v} band to appear as a valence band and the Γ_8^{+c} band to appear as a conduction band. Consequently, intervalence band transitions are allowed from the Γ_7^- band into the Γ_8^{+v} band. The oscillator strength of this transition, $\bar{E}_0$, depends on the occupancy of each band that is influenced by changing the concentration of acceptor or donor ions in the α-Sn lattice. Growth on an Indium rich interface leads to higher concentrations of acceptors that cause the oscillator strength of the $\bar{E}_0$ transition to increase. $\bar{E}_0$ is observable using infrared spectroscopic ellipsometry and has been recorded previously at 0.41 eV [2,4].

We use temperature dependent Fourier Transform Infrared Spectroscopic Ellipsometry to measure intrinsic and n-type doped 30 nm thick α-Sn layers grown on InSb (100) substrates from 300 K to 10 K. We model the dielectric function at all temperatures using a basis spline (b-spline) polynomial. Using the oscillator strength of the $\bar{E}_0$ transition we find the integrated peak intensity after a linear background subtraction and determine the hole density at each temperature by applying the Thomas-Reiche-Kuhn f-sum rule [5]. The results for the intrinsic and n-type doped samples are compared to experimental data for 70 nm α-Sn layers on InSb and CdTe substrates collected previously by [2]. We compare the experimental results to literature values obtained by using degenerate Fermi-Dirac carrier statistics [1]. We find that the carrier density is strongly influenced by substrate preparation.

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