The Direct Band Gap of α-Sn Investigated by Infrared Ellipsometry

R. A. Carrasco,[1+] C.M. Zamarripa,[1] S. Zollner,[1] José Menéndez[2]

[1] *Department of Physics, New Mexico State University, P.O. box 30001, Las Cruces, NM 88003, USA*

[2] *Department of Physics, Arizona State University, Tempe, AZ, 85287, USA*

Interest in gray tin has been revived because it is the endpoint constituent of $Ge_{1-x}Sn_x$ alloys, which have potential applications as mid-infrared detectors and lasers,[1][2] and becomes a topological insulator or Dirac semimetal due to stress[3][4]. The band structure for gray tin is similar to Ge, but the Γ_7^- s-antibonding band, which is the conduction band in Ge, moves downward in gray tin and appears in between $\Gamma_8^+$and Γ_7^+ with a negative energy E_0 if we conventionally choose Γ_8^+ as the zero energy level.

Using Fourier-transform infrared ellipsometry, we provide spectroscopic evidence about the valence band structure of α-tin. The mid-infrared dielectric function of α-tin grown pseudomorphically on InSb or CdTe by molecular beam epitaxy shows a strong $\bar{E}_0$ peak near 0.41 eV (Fig. 2). The peak can be attributed to the allowed intravalence band transitions from the Γ_7^- (electron-like) to the Γ_8^{+v} heavy hole valence band and/or interband transitions from the Γ_7^- band to the Γ_8^{+c} light "hole" conduction band. Possible sources for the strength of the peak, and its temperature dependence will be discussed. We would like to thank Dr. Arnold M. Kiefer and Stephanie Chastang for providing us the strained α-tin samples.

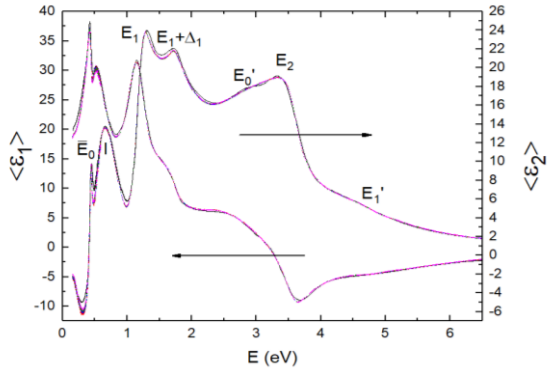

Figure 1. Pseudo-dielectric function for 127 nm α-Sn on InSb (001) measured by spectroscopic ellipsometry. Critical points and an interference fringe (I) are labeled.

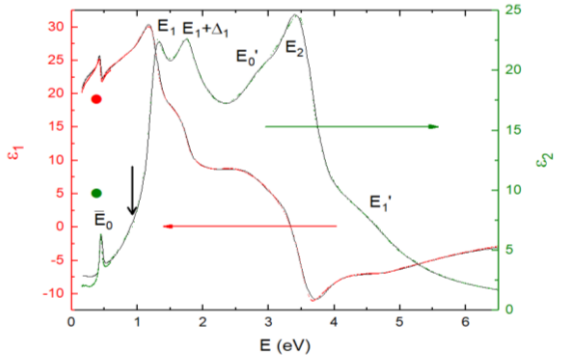

Figure 2. Dielectric function of three α-Sn layers grown on InSb.

[1] C.L. Senaratne, P.M. Wallase, J.D. Gallagher, P.E. Sims, J. Kouvetakis, and J. Menéndez, J. Appl. Phys. **120**, 025701 (2016).

[2] S. Wirths, R. Geiger, N. von den Driesch, G. Mussler, T. Stoica, S. Mantl, Z. Ikonic, M. Luysberg, S. Chiussi, J.M. Hartmann, *et al*., Nat. Photonics **9**, 88 (2015).

[3] H. Huang and F. Liu, Phys. Rev. B **95**, 201101 (2017).

[4] A. Barfuss, L. Dudy, M.R. Scholz, H. Roth, P. Höpfner, C. Blumenstein, G. Landolt, J.H. Dil, N.C. Plumb, M. Radovic, *et al*., Phys. Rev. Lett. **111**, 157205 (2013); **112**, 239903

[+] Author for correspondence: rigocs95@nmsu.edu