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MRSEC

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GROUP-IV SEMICONDUCTORS INCORPORATING Sn

The development of GeSn and SiGeSn alloys has created new opportunities for expanding the range of applications of group-IV materials [1]. These alloys also provide a new tool to probe into the fundamental physics of group-IV alloys. The incorporation of Sn into Ge lowers the band gap into an energy range of great interest for telecommunications [2]. For modest Sn concentrations (~10%), this alloy is expected to become the first viable group-IV material with a direct band gap, opening up new opportunities for the integration of opto- and microelectronics. The availability of the ternary SiGeSn makes it possible, for the first time, to decouple strain and band-gap engineering in group-IV semiconductors. A tunable direct absorption edge has already been demonstrated in lattice-matched SiGeSn alloys grown on Ge-buffered Si [3]. This ternary system has been identified as a possible barrier material for tensile-strained Ge quantum wells and as a key material in multi-junction solar cells [4,5].

In this talk, we present the electronic, vibrational and transport properties of the alloys. The E0, E0+?0, E1, E1+?1, E0', and E2 optical transition energies and associated critical point parameters have been measured in the alloys using spectroscopic ellipsometry and photoreflectance [2,6]. The results indicate a strong nonlinearity(bowing) in the compositional dependence of these quantities. The bowing coefficients are found to scale according to the difference in bond lengths and electronegativity between Si, Ge, and ?-Sn. The infrared dielectric function of the doped alloys is dominated by the free carrier contribution. In addition, the dielectric function of p-type alloys shows features due to optical transitions between split-off (SO), light-hole (LH), and heavy-hole (HH) bands. The resistivities and mobilities of the alloys are comparable to those found in Ge samples with similar doping concentrations. Raman spectroscopy has been used to study the compositional dependence of the optical vibrational modes [7,8]. We find that the phonon frequencies follow a remarkable pattern that allows us to predict their values in GeSn alloys from their known SiGe counterparts. This behavior is explained in terms of a simple model that describes the compositional dependence of alloy Raman modes in terms of mass and bond perturbations.

References
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Vijay D'Costa received his Ph.D. in Physics from Arizona State University. His Ph.D. research focused on electronic and vibrational properties of GeSn and SiGeSn semiconductors. He uses optical techniques such as spectroscopic ellipsometry (IR, visible and UV), Raman spectroscopy, photoreflectance and photoluminescence for measuring the optical properties of materials. His current focus is on applying ellipsometry to measure the electronic and transport properties (resistivity, mobility and doping including profile) of doped Ge, GeSn, SiGeSn alloys and device hetero-structures based on these materials. He is very proficient in carrying out the derivative analysis of dielectric function of a material to determine the energy gaps in the bandstructure of a new material. He currently works as an Assistant Research Scientist in José Menéndez research group, Department of Physics, Arizona State University. Prior to his Ph.D, he worked as a lecturer

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237 WSEC
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