Epitaxial Growth and Electronic Characterization of GdSb

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In recent years, the class of rare-earth monopnictides (RE-Vs) has received renewed interest due to predictions of topological semimetal states[1] and observations of extremely large magnetoresistance (XMR)[2], phenomena holding great promise in novel physics devices and magnetic sensing technologies. The wide range of lattice constants and simple rock salt structure of RE-Vs also allows to easily incorporate them epitaxially with III-V semiconductors. Coupled to III-Vs, RE-Vs have potential applications as buried ohmic contacts, THz emitters and detectors, thermoelectrics, reaction barriers, and plasmonic heterostructures.[3] In the family of RE-Vs, GdSb shares the common features of antiferromagnetic type II ordering and unusually high magneto-resistance.[4] Due to the absence of orbital momentum in the $4f^7$ configuration of Gd^{3+} and the simple magnetic phase diagram, GdSb can serve as a model system for the study of the effect of biaxial strain on band dispersion in RE-Vs, and the interplay between magnetism and XMR.

In this talk, we will demonstrate the first epitaxial growth and characterization of GdSb thin films with thickness varied from 3-30 nm and biaxial strains ranging from -2% to +2% lattice-mismatch. We utilize molecular beam epitaxy to grow GdSb films on $In_{1-x}Al_xSb$ and Be-doped $In_{1-x}Ga_xSb$ buffer layers deposited on undoped and Zn-doped GaSb (001) substrates for magnetotransport and angle-resolved photoemission spectroscopy measurements, respectively. Reflection high-energy electron diffraction patterns observed during growth and *in-situ* X-ray photoelectron spectroscopy and scanning tunneling microscopy (STM) were used to determine the formation of a rock salt phase with the characteristic surface reconstruction of 1×1, indicating the absence of interfacial reactions between the GdSb films and underlying buffer layers. Surface morphology was examined with STM to confirm the growth of continuous films at thicknesses down to 3nm. To determine the in-plane lattice constant and strain of the GdSb thin films we have recorded reciprocal space maps on asymmetric reflections. The thickness dependence in lattice-matched buffers and the effect of biaxial strain on magnetotransport behavior and the bandstructure of GdSb will also be discussed.

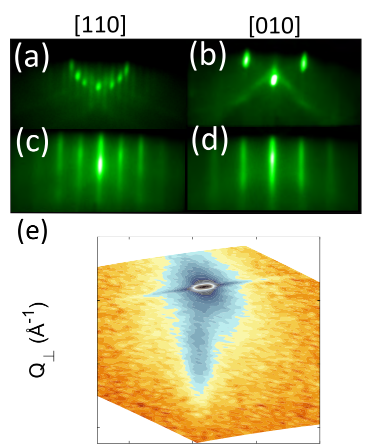

Figure 1: RHEED patterns: (a)-(b) c(2X6) reconstruction of the GaSb substrate and (c)-(d) (1X1) reconstruction of the GdSb film. (e) Asymmetric (226) reciprocal space map demonstrating biaxial straining and epitaxial growth of GdSb on GaSb (001)

[1] Duan, Xu, et al. Commun. Phys. 1 (1) (2018): 71.
[2] Tafti, F. F., et al. Nat. Phys. 12 (3) (2016): 272.
[3] Bomberger, Cory C., et al. JVST B 35 (3) (2017): 030801.
[4] Li, D. X., et al. Phys. Rev. B 54 (15) (1996): 10483.

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Supplementary Pages

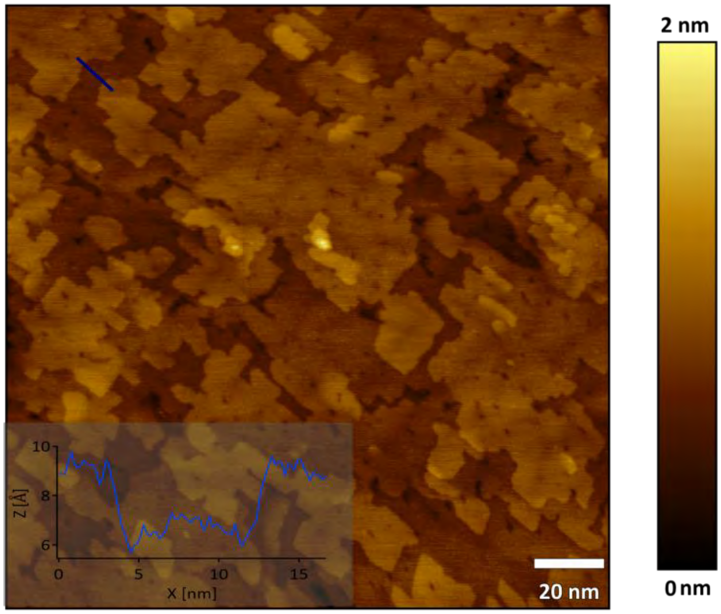

Figure 2: Scanning tunneling image demonstrating continuous coverage of GaSb by a 3nm thick GdSb film. Inset shows a monolayer step height across GdSb islands.

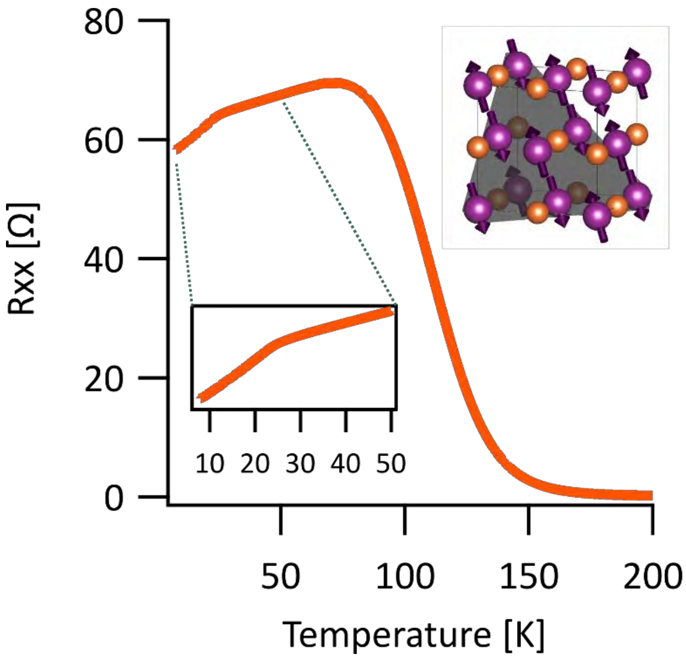

Figure 3: Longitudinal resistance of a 3nm GdSb film grown on GaSb under zero magnetic field showing a kink in resistance at the Neel temp T_N =23.2K.

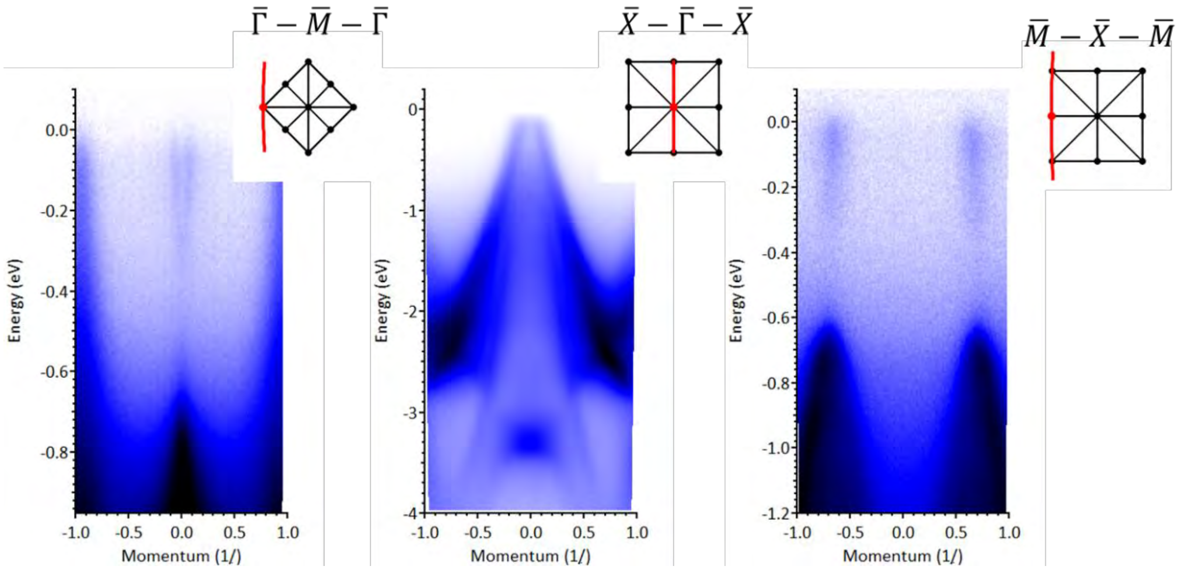

Figure 4: 1.5% tensile strained GdSb ARPES E-k spectral maps along high symmetry lines indicated by insets.