Investigating the Structural and Electronic Properties of FeSn on $LaAlO_3$ (111) Grown By Molecular Beam Epitaxy

T. Erickson,[1] S. Upadhyay,[1] H. Hall,[1] A. Shrestha,[1] A. Abbas,[1] D. Ingram,[1] S. Kaya,[2] and A. R. Smith[1]

[1] Ohio University Department of Physics and Astronomy, 136 University Terrace Athens, Oh 45701
[2] Ohio University Department of Electrical Engineering and Computer Science, 1 Ohio University Stocker Center 270 Athens, Oh 45701

The Kagome lattice of 3-d transition metals produces exciting electronic excitations through correlated topological phases due to a mixture of the unique geometry and spin-orbit coupling [1,2]. Research into these materials continues to provide insight into electronic properties of Dirac-bands in transition metal materials. FeSn with its Fe_3Sn Kagome layers separated by honeycomb Sn_2 layers provides ample opportunity to study these phenomena. Recent scanning tunneling microscopy (STM) studies into FeSn confirm the expected antiferromagnetic spin order consistent with bulk measurements, demonstrating a ferromagnetic alignment within Kagome layers and antiferromagnetic coupling between separate layers [3,4]. Currently, these findings are for bulk FeSn samples transported to and cleaved in ultra-high vacuum chambers. Here, we perform direct *in-situ* UHV-STM analysis of FeSn samples *as-grown* by molecular beam epitaxy. We grew our FeSn on $LaAlO_3$ substrates at temperatures ranging from 450 to 550 °C and Fe:Sn flux ratios of 0.64:1 to 1.52:1. $LaAlO_3$ and FeSn have a lattice match with a difference of only 1%. We also compare the results samples by means of RHEED, XRD, RBS, and AFM. In all cases, smooth streaky RHEED patterns are observed, and from the streak spacing we calculate the *in-plane* lattice constants which are then complemented by the lattice constants calculated from the XRD spectra. For the case of the 1.52:1 flux ratio, using RHEED we find an $a = 5.240 \pm 0.017$ Å as compared to the expected value for the FeSn lattice parameter $a = 5.297$ Å [2], and using XRD we find $c = 4.436 \pm 0.042$ Å as compared to the expected c for FeSn = 4.481 Å [2]. In this presentation, we will discuss the lattice parameters as functions of the incident flux ratios as well as the phases and phase purity of the resultant samples. Additionally, AFM and RBS results are used to describe the smoothness and stoichiometry respectively.

This work is supported by the U.S. Department of Energy, Office of Basic Energy Sciences, Division of Materials Sciences and Engineering under Award No. DE-FG02-06ER46317.

[1] Kang, M., Ye, L., Fang, S. et al. Nat. Mater. 19, 163–169 (2020).
[2] Yin, JX., Zhang, S.S., Li, H. et al. Nature 562, 91–95 (2018).
[3] Li, H., Zhao, H., Yin, Q. et al. Sci Rep 12, 14525 (2022).
[4] Lee, SH., Kim, Y., Cho, B. et al. Commun Phys 5, 235 (2022).
[+] Author for correspondence: te467518@ohio.edu

Supplementary

RHEED is conducted *in-situ* to observe sample growth and calculate in-plane lattice parameters after growth has finished. The RHEED profiles are taken along both directions and show 6-fold symmetry, indicative of a hexagonal lattice. The XRD profiles are taken from a tabletop Rigaku powder diffractometer *ex-situ*.

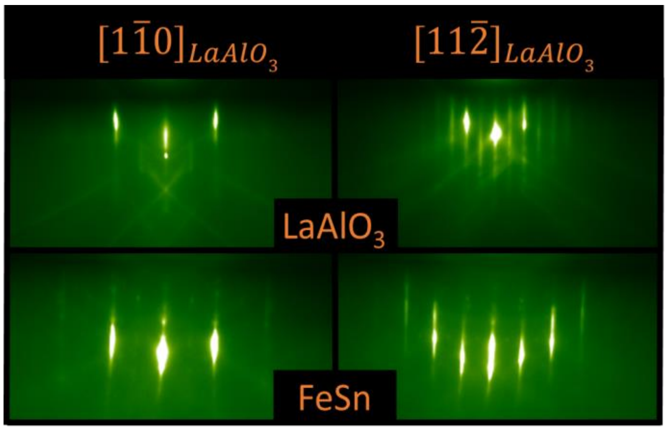

Figure 2. RHEED image of sample 216 grown at 500 °C with Fe:Sn flux ratio of 0.64:1. The RHEED patterns for the FeSn are taken after the growth has finished and the sample has come back down to room temperature.

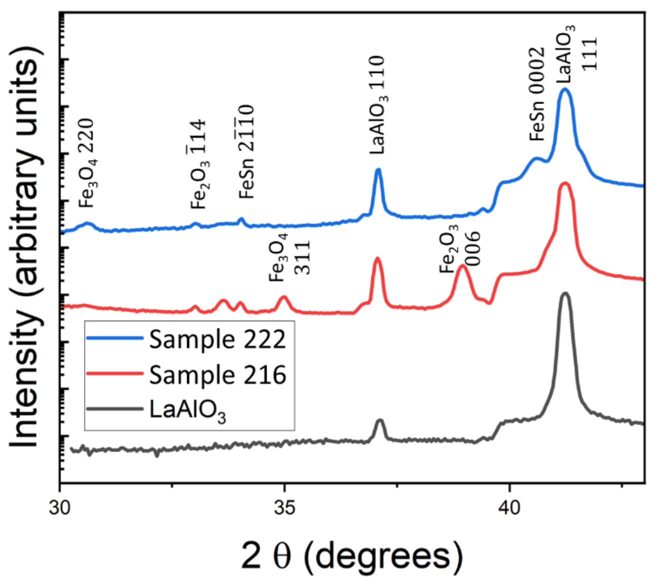

Figure 1. XRD plot of FeSn on $LaAlO_3$. Samples 216 and 222 grown at 500 °C with Fe:Sn flux ratios of 0.64:1 and 1.52:1. The samples are offset from one another to show the positions of identifiable peaks.