

Molecular beam epitaxy of hybrid heterostructures interfacing an altermagnet (CrSb) with a 2D ferromagnet (CrTe₂) and a topological insulator (Sb₂Te₃)

Sandra Santhosh¹, Kalana Halanayake², Soumyanil Adhikary², Supriya Ghosh³, Anthony Richardella^{1,4}, Danielle R. Hickey^{2,4,5}, K. Andre Mkhoyan³, and Nitin Samarth^{1,4,5,*}

¹Dept. of Physics, Pennsylvania State University, University Park, 16802, PA, USA

²Dept. of Chemistry, Pennsylvania State University, University Park, 16802, PA, USA

³Dept. of Chemical Engineering and Materials Science, University of Minnesota, Minneapolis, 55455, MN, USA

⁴Materials Research Institute, Pennsylvania State University, University Park, 16802, PA, USA

⁵Dept. of Materials Science and Engineering, Pennsylvania State University, University Park, 16802, PA, USA

*Corresponding author: nxs16@psu.edu

Altermagnetism is a theoretical classification of magnetic materials exhibiting a unique coexistence of long range antiferromagnetic order and non-relativistic spin-polarized electronic band structure. NiAs-type CrSb in the bulk is theoretically and experimentally categorized as a metallic altermagnet at room temperature with g-wave symmetry. We recently reported the molecular beam epitaxy (MBE) of thin films of epitaxial CrSb on insulating SrTiO₃ (111) substrates via a buffer layer of topological Sb₂Te₃, using angle resolved photoemission spectroscopy (ARPES) and polarized neutron reflectometry to verify the altermagnetic nature of these films [1].

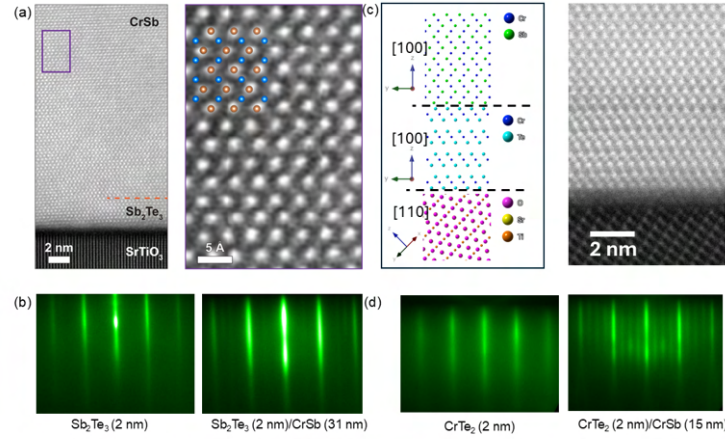


Figure 1: Characterization of the MBE-grown CrSb thin films on SrTiO₃. HAADF-STEM cross-section image of the Sb₂Te₃(2 nm)/CrSb(31 nm) heterostructure (a) (left panel) and CrTe₂(2 nm)/CrSb(15 nm) heterostructure (c) with the schematic of the heterostructure. Atomic resolution image from the CrSb layer in the purple box (a) (right panel), showing the atomic arrangement of Cr (blue) and Sb (gold). (b) RHEED patterns of the Sb₂Te₃ buffer layer and the CrSb film. (d) RHEED patterns of the CrTe₂ buffer layer and the CrSb film.

Here, we discuss a detailed comparison of the MBE growth of CrSb on insulating SrTiO₃ (111) using two different buffer layers, Sb₂Te₃ and CrTe₂. Reflection high energy electron diffraction, X-ray diffraction, and transmission electron microscopy confirm the epitaxial growth of good quality films of NiAs-type CrSb (0001) in both cases. We also use *in vacuo* angle resolved photoemission spectroscopy at room temperature to verify the g-wave symmetric altermagnetic band splitting in 10 nm thick CrSb films grown on both types of buffer layers. We discuss how the synthesis of these hybrid heterostructures that interface a room temperature altermagnet with topological insulators and 2D magnets provides a promising platform for novel spintronics devices.

Acknowledgements

This work is supported by the Penn State Two-Dimensional Crystal Consortium-Materials Innovation Platform (2DCC-MIP) under NSF Grant No. DMR-2039351 and the Penn State MRSEC Center for Nanoscale Science via NSF award DMR 2011839.

References

- [1] S. Santhosh *et al.*, Adv. Mater. **37**, e08977 (2025).

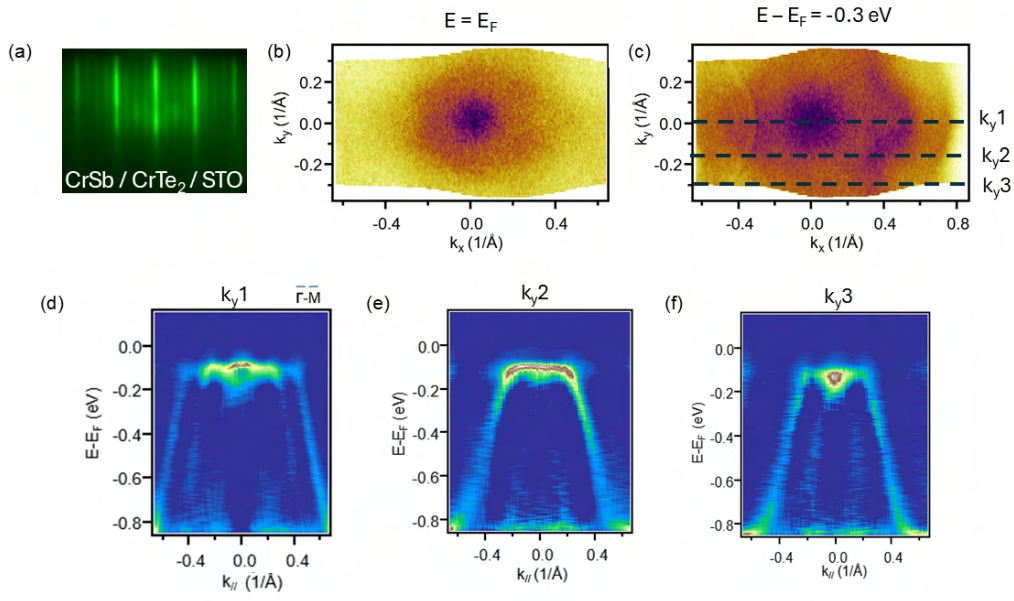


Figure 2: He lamp ARPES measurements on CrTe₂(2 nm)/CrSb(15 nm) films at 77 K. **(a)** RHEED pattern of the MBE grown thin film. **(b)** Fermi surface map. **(c)** Constant energy surface mapping at a binding energy value of - 0.3 eV integrated over 50meV. The corresponding band mapping **(d)**, **(e)**, **(f)** for k_{y1} , k_{y2} and k_{y3} respectively, shows the evolution of band splitting from high symmetry to low symmetry momenta cuts in the Brillouin zone. k_{y1} , k_{y2} and k_{y3} are represented by dashed lines in **(c)**.