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Molecular Beam Epitaxy Growth and Stoichiometry-Induced Ferromagnetism in Altermagnetic Candidate MnTe

Matthew Brahlek[1+],
An-Hsi Chen[1], Michael Chilcote[1], Alessandro R. Mazza[1,2], Qiangsheng Lu[1], Isaiah Gray[3], Qi Tian[3], Qinwen Deng[3], Duncan Moseley[1], Jason Lapano[1], Jason S. Gardner[1], Gyula Eres[1], T. Zac Ward[1], Erxi Feng[4], Huibo Cao[4], Michael McGuire[1], Raphael Hermann[1], David Parker[1], Myung-Geun Han[5], Liang Wu[3], Timothy R. Charlton[4], Robert G. Moore[1]
[1]Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA
[2]Materials Science and Technology Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA
[3]Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, PA, 19104, USA
[4]Neutron Scattering Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA
[5]Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory, Upton, New York 11973, USA

The field of spintronics has seen much excitement around predictions of altermagnetism due to potential applications related to the associated novel spin-moment textures. MnTe stands out as a prominent altermagnetic candidate because of its layered A-type antiferromagnetic structure, high Néel temperature (approximately 310 K), and semiconducting properties. However, critical challenges remain regarding (1) how to synthesize high-quality, well-controlled samples and (2) understanding the fundamental properties of this material.

Our study presents two key findings. The first is that on lattice-matched InP(111), slight differences in the InP surface can be used to effectively select different polymorphs of MnTe when grown by molecular beam epitaxy (MBE). More specifically, the termination of the InP (111) substrate seems to be critical factor. In termination ((111)A)) triggers the nucleation of the NiAs structure, the candidate altermagnetic structure, whereas termination with P ((111)B stabilizes the ZnS structure, which is also antiferromagnetic and has a relatively large bandgap of ~2 eV.

Regarding the properties of MnTe in the NiAs structure, we reveal that the electronic and magnetic properties are influenced by the natural stoichiometry of MnTe [1]. Electronic transport measurements and in situ angle-resolved photoemission spectroscopy reveal that the films are inherently metallic, with the Fermi level situated in the valence band. The band structure aligns well with first-principles calculations for altermagnetic spin-splitting. Neutron diffraction confirms the antiferromagnetic nature of the film with planar anisotropy, while polarized neutron reflectometry indicates weak ferromagnetism, attributed to a slight Mn-richness inherent to the MBE-grown samples. Combined with the anomalous Hall effect, this work demonstrates that the electronic properties are significantly impacted by the weak ferromagnetism.

Overall, this research highlights potential mechanisms for investigating and ultimately controlling altermagnetic properties, thus paving the way for diverse spintronic applications.

[1] Michael Chilcote, Alessandro R Mazza, Qiangsheng Lu, Isaiah Gray, Qi Tian, Qinwen Deng, Duncan Moseley, An-Hsi Chen, Jason Lapano, Jason S Gardner, Gyula Eres, T Zac Ward, Erxi Feng, Huibo Cao, Valeria Lauter, Michael A McGuire, Raphael Hermann, David Parker, Myung-Geun Han, Asghar Kayani, Gaurab Rimal, Liang Wu, Timothy R Charlton, Robert G Moore, Matthew Brahlek, Advanced Functional Materials 2405829 (2024) **10.1002/adfm.202405829**

+ Author for correspondence: brahlekm@ornl.gov

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