Epitaxial Phase Control and Defects in MnTe Thin Films

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Manganese telluride (MnTe) is an antiferromagnetic semiconductor whose polymorphism gives rise to distinct magnetic and electronic properties, making it a promising platform for quantum and spintronic devices. Of particular interest are the altermagnetic phases of MnTe, which combine compensated magnetic order with spin-polarized electronic bands. This symmetry-driven spin polarization enables unconventional proximity effects in superconductor – altermagnet heterostructures, including the generation of spin-triplet superconducting correlations without net magnetization, which is a key ingredient for low-dissipation and potentially fault-tolerant quantum computing [1].

Here, we report molecular beam epitaxy growth and structural characterization of MnTe thin films with emphasis on phase selectivity and defect formation. By controlling substrate material and surface termination, MnTe is shown to be stabilized in several distinct structural–magnetic phases: (i) the NiAs-type altermagnetic phase with nonrelativistic spin splitting [2], (ii) the wurtzite phase exhibiting stripe-type collinear antiferromagnetism [3], and (iii) the zinc blende phase with conventional type-III antiferromagnetic order. Furthermore, we demonstrate that phase stabilization is primarily governed by surface energetics rather than lattice-constant or thermal-expansion mismatch.

X-ray diffraction provides macroscopic information on phase composition and strain state, while photoluminescence enables complementary phase identification via optical band-gap analysis. High-resolution transmission electron microscopy reveals planar defects, including stacking faults and twin boundaries, as well as two-dimensional inclusions of secondary phases within the film volume. Cathodoluminescence and atomic force microscopy mapping allow further analysis of surface-related phase inclusions on a micron scale (Figure. 1).

References

[1] N. Heinsdorf, M. Franz, Phys. Rev. B, 113 (2026) L020501.
[2] J. Krempasky, et al., Nature, 626 (2024) 517
[3] H. Mavani, et al., et al. *arXiv preprint*, (2025) *arXiv:2512.23904*

Figures

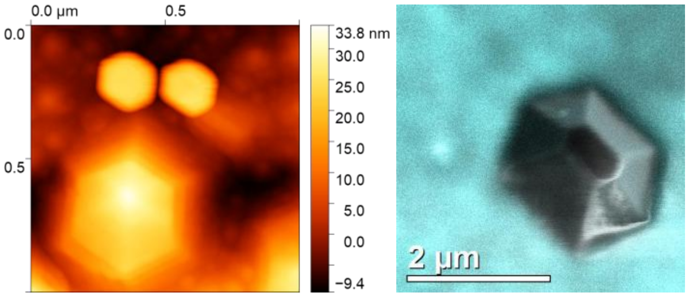

Figure 1: Atomic force microscopy (left) and catodoluminescence microscopy (right) images of NiAs-phase MnTe island on the (111) surface of *zinc blende* MnTe film