

Growth and magnetic properties of laterally modulated epitaxial Fe₃Sn₂-based kagome multilayers on Pt(111)

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Magnetic compounds with a kagome lattice have attracted wide attention in condensed matter physics due to their unique magnetic and electronic properties related to the non-trivial spin arrangements and the electronic structure that hosts Dirac cones and flat bands. Intermetallic compounds Fe_xSn_y are layered materials composed of Fe₃Sn kagome layers sandwiched between two-dimensional tin (stanene) layers. Depending on the layers sequence, the crystals can have e.g. Fe₃Sn₂ stoichiometry, being ferromagnetic at room temperature, or FeSn, being antiferromagnetic. The Fe_xSn_y intermetallics have been studied relatively extensively as bulk crystals, but their properties in thin-film form remain comparatively unexplored [1][2].

We have prepared Fe_xSn_y epitaxial thin films on Pt(111)/Al₂O₃(0001) using molecular beam epitaxy in an ultrahigh vacuum (UHV) system. Directly after growth of 10-nm thick films, crystalline order was checked using low-energy electron diffraction (LEED). Subsequently, the samples were capped by MgO protective layers for ex-situ measurements including conversion electron Mössbauer spectroscopy (CEMS) and magnetic force microscopy (MFM). The cross-section of the multilayer structure was obtained using transmission electron microscopy (TEM).

We find that over a wide range of deposition temperatures (room temperature to 200°C) and Fe:Sn flux ratios (1:1 to 3:2), laterally confined regions (10 nm) with different stackings: Fe₃Sn₂, Fe₃Sn, and FeSn form locally within the film. These regions coexist coherently, giving rise to a laterally modulated crystalline phase with long-range in-plane order. The resulting films are ferromagnetic with in-plane anisotropy at room temperature and significant near-surface spin canting as evidenced by MFM. Our results demonstrate the power of CEMS, in combination with TEM, to resolve nanoscale phase coexistence beyond the reach of surface-sensitive techniques. We believe that Fe-based stannides prepared in thin film form will be useful for future spintronic applications.

References:

- [1] I. Lyalin et al. Nano Lett, 21.16 (2021), 6975-6982.
- [2] D. Zhang et al., Appl. Phys. Lett, 120 (2022), 232401

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