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From Flat to Curved: Substrate Morphology as a Design Tool for Magnetic Thin Films

Topography and curvature at the nanoscale offer unique opportunities to tailor magnetic properties in thin film systems, relevant for future spintronic and neuromorphic applications. In this work, we investigate how substrate morphology introduced via self-assembled SiO_2 nanospheres affects the magnetic behavior of Fe_3O_4 and CoPd alloy thin films, compared to their counterparts grown on flat substrates.
For Fe_3O_4, STEM and GISANS confirm conformal growth with preserved lateral order, while XMCD-PEEM imaging reveals in-plane magnetic domains that span both curved and flat regions. Despite reduced net magnetization in the curved regions, domain alignment across interfaces indicates strong magnetic coupling between structurally distinct areas.
In CoPd thin films, curvature significantly enhances magnetic properties. Polarized neutron reflectometry shows that thinner curved films exhibit higher magnetic scattering length density than thicker ones. SQUID magnetometry reveals increased coercivity and modified anisotropy, while GISANS confirms structural ordering without lateral magnetic coherence, likely due to perpendicular anisotropy or domain averaging.
Together, these results demonstrate that nanoscale topography and curvature can be leveraged to modulate magnetism in both oxide and metallic thin films. This highlights a promising strategy for engineering domain textures and magnetic anisotropy through substrate design, offering pathways toward flexible and high-performance spintronic architectures.

Topical Area

Hard matter: quantum, electronic, semiconducting materials

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