

Strain and Defect-Tailored Magnetotransport in Ferrimagnetic Spinel NiCo₂O₄ Thin Films and Freestanding Membranes

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The ferrimagnetic spinel NiCo₂O₄ (NCO) is a promising material for designing high-performance spintronic devices, while epitaxial strain and disorder can significantly modify its electronic and magnetic properties [1-3]. Here, we use epitaxial NCO thin films and freestanding NCO membranes as model systems to reveal the complex roles of strain and defects in determining its metallicity and magnetotransport [4]. Epitaxial 30 nm NCO films are deposited on spinel MgAl₂O₄ and perovskite SrTiO₃ and LaAlO₃ substrates. Freestanding NCO membranes are achieved by depositing 30 nm NCO film on Sr₃Al₂O₆ buffered LaAlO₃ followed by water etching. The NiCo₂O₄ films on MgAl₂O₄ show metallic behavior, small linear magnetoresistance (MR) with weak temperature dependence, and strong perpendicular magnetic anisotropy. In contrast, NCO on perovskite substrates and freestanding NCO membranes show insulating behaviors that can be well described by the contributions from thermal activation, nearest-neighbor hopping, and 3D variable range hopping. MR and anomalous Hall studies point to the existence of phase separation and spin canting in these samples, which is corroborated by electron microscopy studies. Comprehensive anisotropic magnetoresistance (AMR) studies show that NCO films on MgAl₂O₄ exhibit two-fold sinusoidal AMR, which can be well described by coherent rotation model. Additional four-fold AMR component emerges in the insulating samples, which can be attributed to disorder-induced spin scattering and strain-induced tetragonal magnetocrystalline anisotropy. It is noted that the NCO membrane exhibits highly consistent magnetotransport properties as the NiCo₂O₄/Sr₃Al₂O₆ film, showing that water etching does not alter the strain and disorder level in the system. Our study provides effective material strategies for engineering spin transport and magnetic anisotropy in NCO and presents a promising venue for designing flexible magnetic memory, sensor, and spintronic applications.

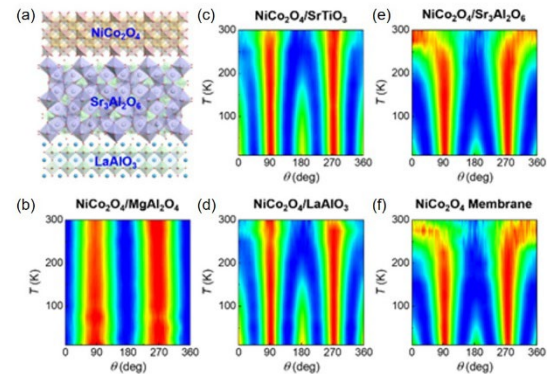


Figure 1. (a) Schematic of NCO/SAO/LAO. (b)-(f) Contour plot of normalized ρ_{AMR} vs θ and H at 10 K for NCO thin films on MAO, STO, LAO, SAO, and freestanding NCO membranes.

[1] Chen et. al., Adv. Mater. **31**, 1805260 (2019).

[2] Chen et. al., Appl. Phys. Lett. **120**, 242401 (2022).

[3] Xu et. al., J. Appl. Phys. **132**, 020901 (2022).

[4] Wu et. al., ACS Nano **20**, 11008 (2026).

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