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Infinite layer nickelates solid solutions: unusual magnetic field driven re-entrant superconductivity

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We explore the synthesis and emergent electronic behavior of infinite-layer nickelate thin films, focusing on $Nd_{1-x}Eu_xNiO_2$ (NENO) and $Sm_{1-2x}Nd_x Eu_xNiO_2$ (SNENO) solid solutions. These compounds are derived from perovskite nickelates via topotactic reduction, first demonstrated by D. Li [1] using CaH_2 or NaH to selectively remove apical oxygens and induce a square planar NiO_2 coordination. Following the solid-state route proposed by W. Wei [2,3], we implement the reaction $2Al + 3NdNiO_3 \rightarrow Al_2O_3 + 3NdNiO_2$ to obtain the 112 phase. All thin films were synthesized via RF off-axis magnetron sputtering, with the aluminum layer deposited in situ on-axis.

This method leverages our established expertise in growing high-quality 113 nickelate films and heterostructures [4,5,6], enabling successful reduction and stabilization of the 112 phase in NENO and SNENO on LSAT and $NdGaO_3$ (NGO) substrates, respectively.

We investigate the interplay between magnetism and superconductivity in these infinite-layer systems under out-of-plane magnetic fields. While the higher-T_c SNENO exhibits a monotonic suppression of superconductivity with field, the lower-T_c samples displays a striking re-entrant superconducting behavior. In such samples, distinct superconducting domes in the magnetic phase diagram are observed, consistent with the Jaccarino–Peter effect [7] arising from compensation between the applied field and an internal exchange field induced by Eu^{2+} and Nd^{3+} moments. Hall effect data can be modeled by including an anomalous Hall term proportional to the spin paramagnetic response of the two aforementioned magnetic ions, further supporting our hypothesis.

References:

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