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Towards the stabilization of infinite-layer nickelate membranes

The recent discovery of superconductivity in hole-doped infinite-layer nickelate thin films [1] has sparkled a renewed interest in the condensed matter community. This is motivated by the possibility to add another puzzle piece to the understanding of unconventional superconductivity, a phenomenon that has not yet been observed in infinite-layer polycrystalline samples[2]. The strain state induced by the substrate is suspected to play a key role in stabilizing the phase of superconductivity. Inspired by recent advances in the epitaxial lift-off of oxide films[3], our idea is to free our nickelate thin films from substrate-induced stresses.

In this context, here, we present our preliminary results on the use of epitaxial lift-off techniques to fabricate free-standing membranes of nickelate films with the final goal to perform a topotactic reduction process and study the transport properties. By using a pulsed laser deposition technique assisted by high-energy reflection electron diffraction, we have epitaxially grown $(\mathrm{Nd}, \mathrm{Sr})\mathrm{NiO}_3$-based heterostructures on a sacrificial layer of water-soluble $(\mathrm{Ca}, \mathrm{Sr})_3\mathrm{Al}_2\mathrm{O}_6$[4]. Those sacrificial layers are particularly adapted to study the effect of the strain on the stabilization of the infinite-layer phase, since by selecting an opportune Ca/Sr ratio, they can be grown on various substrates. This allow a better integrity of the released membranes while minimizing cracks formation. We can create membranes as large as 5x5 mm^2 that can be also fully transferred on PET or PDMS supports. Structural analyses conducted via X-ray diffraction and atomic force microscopy confirm the preservation of the crystalline quality of the membranes, close to that of the seed films.

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