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Strain or Defects? An Important Question for the Nickelate Superconductors Answered via a Platform: A User Facility that also Facilitates Collaboration

Julia A. Mundy (Harvard), Antia S. Botana (Arizona State University), Ismail El Baggari (Harvard), Lena F. Kourkoutis (Cornell)

The nickelate superconductors were inspired by the cuprate superconductors, which remain today's highest temperature superconductors at atmospheric pressure. Theorists have suggested straining the nickelate superconductors to enhance their superconducting properties and also assess how they differ from the cuprate superconductors. Importantly, strain can also introduce defects. It can be challenging to disentangle the effects of strain *vs.* defects. Here, a team of **PARADIM users from Harvard and Arizona State Universities** investigates the role of epitaxial strain in the competing requirements for the synthesis of the $n = 3$ Ruddlesden-Popper compound, $Nd_4Ni_3O_{10}$, and subsequent reduction to the square-planar phase, $Nd_4Ni_3O_8$. Using PARADIM's signature MBE system they synthesize highest quality $Nd_4Ni_3O_{10}$ films under compressive strain on $LaAlO_3$ (001), while $Nd_4Ni_3O_{10}$ on $NdGaO_3$ (110) exhibits tensile strain-induced rock salt faults but retains bulk-like transport properties. A high density of extended defects forms in $Nd_4Ni_3O_{10}$ on $SrTiO_3$ (001). Films reduced on $LaAlO_3$ become insulating and form compressive strain-induced *c*-axis canting defects, while $Nd_4Ni_3O_8$ films on $NdGaO_3$ are metallic. This work provides a pathway to the synthesis of $Nd_{n+1}Ni_nO_{2n+2}$ thin films and sets limits on the ability to strain engineer these compounds via epitaxy.

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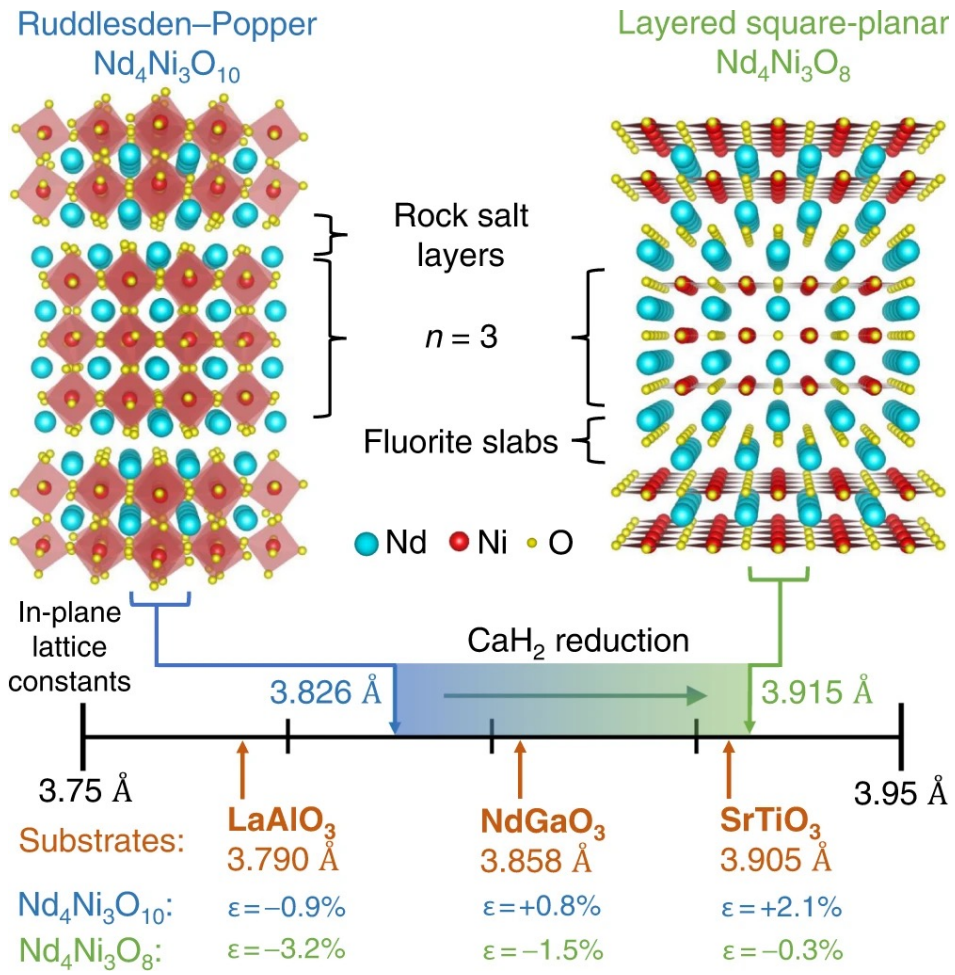

Figure: The nickelate superconductor $Nd_4Ni_3O_8$ is metastable and synthesized by removing oxygen from the stable parent phase $Nd_4Ni_3O_{10}$ at low temperature, where kinetics prevents decomposition. The number line shows the lattice parameters of $Nd_4Ni_3O_{10}$, $Nd_4Ni_3O_8$, and the substrates upon which $Nd_4Ni_3O_{10}$ can be grown. Strain arises from growth as well as the $Nd_4Ni_3O_{10} \rightarrow Nd_4Ni_3O_8$ transformation. The mismatch between $Nd_4Ni_3O_{10}$, $Nd_4Ni_3O_8$, and the substrates are shown.