TECHNISCHE UNIVERSITÄT WIEN

INSTITUT FÜR FESTKÖRPERPHYSIK
Institute of Solid State Physics

Wiedner Hauptstr. 8–10/138, 1040 Wien
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INVITATION to IFP-SEMINAR

Superconducting phase diagram of multi-layer square-planar nickelates

Dan Ferenc Segedin

Department of Physics, Harvard University, Cambridge, MA, USA

Host: Neven Barišić
Date: 10.06.2026, 16:00
Place: TU Wien, Freihaus Building
Wiedner Hauptstraße 8-10, 1040 Wien
Seminar Room DC red 07 (red section, 7. OG)
Zoom: https://tuwien.zoom.us/j/65583073066?pwd=gtRK6YsrRnzUvNjDrAcLGCF4X6WvH7.1

Abstract:

The discovery of superconductivity in square-planar nickelates has uncovered a versatile materials platform for studying cuprate-like superconductivity [1]. While most work has focused on chemically doped infinite-layer nickelates, $R_{1-x}A_x\mathrm{NiO}_2$ ($R = 3+$ rare-earth cation, $A = 2+$ alkaline metal), these compounds represent only the $n = \infty$ endmember of a broader homologous series: the multi-layer square-planar nickelates, $R_{n+1}\mathrm{Ni}_n\mathrm{O}_{2n+2}$ [2]. In this structural family, n $\mathrm{RNiO_2}$ layers are separated by $\mathrm{RO_2}$ spacer layers, enabling systematic tuning of dimensionality and nickel 3d filling ($d^{9-1/n}$) through layering, n. Indeed, superconductivity was observed in five-layer $\mathrm{Nd_6Ni_5O_{12}}$, which shares the same formal $d^{8.8}$ electron count as the chemically doped superconductor $\mathrm{Sr_{0.2}Nd_{0.8}NiO_2}$ [3].

In this talk, I will present the superconducting phase diagram of multi-layer square-planar $\mathrm{Nd}_{n+1}\mathrm{Ni}_n\mathrm{O}_{2n+2}$ thin films ($n = 3$–10) synthesized via ozone-assisted molecular-beam epitaxy (MBE) and subsequent topochemical reduction [4]. We observe signatures of superconductivity in $n = 4$–8 compounds, with a maximum $T_{c,\mathrm{onset}}$ of 12.8 K for $n = 6$. With decreasing dimensionality n, the electronic structure approaches cuprate-like behavior and neodymium 4f moment effects modify the superconducting anisotropy. This work establishes a superconducting dome determined purely by structural layering, demonstrating that hole doping can be achieved without chemical substitution in square-planar nickelates.

In the remainder of the talk, I will show that topochemical oxidation of Ruddlesden–Popper nickelates reveals a distinct structural family through oxygen intercalation of rock salt spacer layers, broadening the accessible phase space of layered nickelates [5].

[1] Danfeng Li et al., “Superconductivity in an infinite-layer nickelate,” *Nature* **572**, 624–627 (2019).

[2] Lacorre, “Passage from T-type to T′-type arrangement by reducing $\mathrm{R_4Ni_3O_{10}}$ to $\mathrm{R_4Ni_3O_8}$ (R = La, Pr, Nd),” *J. Solid State Chem.* **97**, 495–500 (1992).

[3] Grace A. Pan, Dan Ferenc Segedin, et al., “Superconductivity in a quintuple-layer square-planar nickelate,” *Nat. Mater.* **21**, 160–164 (2022).

[4] Grace A. Pan*, Dan Ferenc Segedin*, et al., “Superconducting phase diagram of multi-layer square-planar nickelates,” accepted in *Science* (2026).

[5] Dan Ferenc Segedin et al., “Topochemical Oxidation of Ruddlesden–Popper Nickelates Reveals Distinct Structural Family: Oxygen-Intercalated Layered Perovskites,” *J. Am. Chem. Soc.* **148**(6), 5873–5880 (2026).

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