NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2020-2021

Search of high temperature superconductivity in bulk nickelates

General Scope:
Superconductivity is a fascinating macroscopic state of quantum matter showing no resistance to electric current and expulsion of magnetic flux. Very recently, a major breakthrough was the report of superconductivity up to $T_c = 15K$ in a $(Nd_{1-x}Sr_x)NiO_2$ (x up to 0.2, i.e. a formal valence $Ni^{1.20+}$) thin film (obtained after reduction of the perovskite $(Nd_{1-x}Sr_x)NiO_3$ film) made of infinite NiO_2 layers, by the Hwang group at Stanford university [1]. It opens a new area in the story of superconductivity, with already an enormous interest of the scientific community. This discovery is particularly important because $LnNiO_2$ (Ln=La, Nd, Sm…) is isostructural to that of the high T_c cuprate superconductors, discovered more than 30 years ago and not yet fully understood. Those "112" phases present the same filling of electron $3d^9$ (Ni^+) as Cu^{2+} in undoped cuprates, which suggests that this new family could help to a better understanding of superconductivity in these oxides.

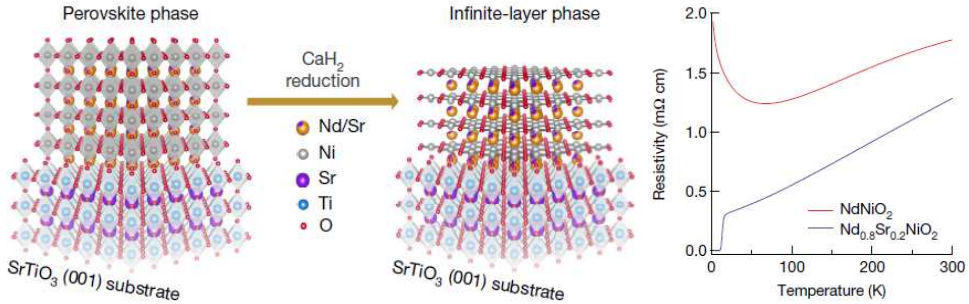

Fig. 1. *Schematic of topotactic reduction of the $(Nd_{1-x}Sr_x)NiO_3$ films epitaxially grown on a $SrTiO_3$ substrate (left) and electrical resistivity of reduced $NdNiO_2$ and superconducting (T_c=9-15K) $Nd_{0.8}Sr_{0.2}NiO_2$ films (right), from Hwang et al. Nature 572 (2019) 624–627. [1].*

Research topic and facilities available:
At the present time the discovery of the Stanford group has been confirmed by two other groups (Singapore and China) working on thin films. At Néel Institute we search for similar layered Ni-based oxides, but in bulk form, where superconductivity could occurs. The related internship will include the synthesis of the samples with one step using an original method, the high pressure – high temperature elaboration. It will also include the study of the structural, magnetic and electronic properties of the synthesized nickelates, thanks to the various experimental setups available in our laboratory. Measurements under very high pressure, in particular x-ray diffraction or transport measurements will be envisaged. Complementary structural characterisation by transmission electron microscopy can be carried out if necessary.

Possible collaboration and networking:
Our laboratory has started a joint research work on this subject with CRISMAT laboratory in Caen where nickelates thin films are grown and studied. With our colleagues and three other french laboratories an ANR project has been submitted and is currently under reviewing.

Possible extension as a PhD: yes, possibly. In particular, it will involves measurements using large scale facilities (neutrons and synchrotron sources) to probe in details the changes of the properties with temperature or pressure.

Required skills: A good background in material science and condensed matter physics is required.

Starting date: March/April 2021

Contact: TOULEMONDE Pierre and LEPOITTEVIN Christophe
Institut Néel - CNRS : 04 76 88 74 21, pierre.toulemonde@neel.cnrs.fr;
04 56 38 71 92, christophe.lepoittevin@neel.cnrs.fr
More information: http://neel.cnrs.fr