Superconductivity in infinite-layer nickelates – The role of the capping layer

DIRECTEURS DE THESE : Nathalie VIART (HDR) et Daniele PREZIOSI
INSTITUT DE PHYSIQUE ET CHIMIE DES MATERIAUX DE STRASBOURG, UNIVERSITE DE STRASBOURG (IPCMS) – CNRS UMR 7504, 23, RUE DU LOESS, 67034 STRASBOURG
E-MAIL : nathalie.viart@ipcms.unistra.fr ; daniele.preziosi@ipcms.unistra.fr
TEL : 03 88 10 72 59

The quest for a Ni-based analogous of cuprate high-Tc superconductors has reached a first success: $Nd_{0.8}Sr_{0.2}NiO_2$ thin films obtained after topotactic reduction of the perovskite $Nd_{0.8}Sr_{0.2}NiO_3$ have been found to host superconductivity below 15 K[1]. From the preparation standpoint, an $SrTiO_3$ (STO) layer was firstly used as capping layer to obtain the superconducting state in $Nd_{0.8}Sr_{0.2}NiO_2$ films[1], and beyond the assumption that it could allow for a better stabilization of the infinite-layer phase during topotactic reduction, its role is still unclear. Indeed, superconductivity was reported also for non-capped films, suggesting that it is not due to the presence of the capping layer[2].
On the other hand, some properties of capped and un-capped samples are different, in particular the low energy excitation spectra. Indeed, while magnetic excitations (of about 200 meV energy loss) were observed for STO-capped samples of different Sr-content[3], a charge ordering phenomenon was observed for the uncapped ones[4]. The actual state-of-the-art imposes a thorough study of the role of the capping layer on the properties of the infinite-layer nickelates. Even the Stanford group, which started the field, did not yet perform a systematic study of the role of the capping. From an experimental perspective, this is certainly an issue that deserves further investigations.
The successful candidate will grow $(R,Sr)NiO_3$ (R=La,Nd,Pr) nickelate thin films by pulsed-laser-deposition and produce infinite-layer $(R,Sr)NiO_2$ thin films by topotactic reduction. Several capping layers will be used such as insulating $(LaAlO_3)_{0,3}(Sr_2TaAlO_6)_{0,7}$ (LSAT) and/or STO, metallic Pt and/or Cu, and also polar like $PbTiO_3$. X-ray diffraction and atomic-force-microscopy techniques will be used to attest the quality of the as-grown and reduced thin films. Transport measurements will be performed with a Dynacool (Quantum Design) and synchrotron radiation will be used to obtain the requested information about the electronic structure of the differently capped infinite-layer thin films.

[1] D. Li, K. Lee, B. Y. Wang, M. Osada, S. Crossley, H. R. Lee, Y. Cui, Y. Hikita, H. Y. Hwang, *Nature* **2019**, *572*, 624.
[2] S. Zeng, C. S. Tang, X. Yin, C. Li, M. Li, Z. Huang, J. Hu, W. Liu, G. J. Omar, H. Jani, Z. S. Lim, K. Han, D. Wan, P. Yang, S. J. Pennycook, A. T. S. Wee, A. Ariando, *Phys. Rev. Lett.* **2020**, *125*, 147003.
[3] H. Lu, M. Rossi, A. Nag, M. Osada, D. F. Li, K. Lee, B. Y. Wang, M. Garcia-Fernandez, S. Agrestini, Z. X. Shen, E. M. Been, B. Moritz, T. P. Devereaux, J. Zaanen, H. Y. Hwang, K.-J. Zhou, W. S. Lee, *Science* **2021**, *373*, 213.
[4] G. Krieger, L. Martinelli, S. Zeng, L. E. Chow, K. Kummer, R. Arpaia, M. M. Sala, N. B. Brookes, A. Ariando, N. Viart, M. Salluzzo, G. Ghiringhelli, D. Preziosi, *arXiv* **2021**, *2112.03341*.