Contribution ID: **87** Type: **Oral**

Understanding the role of hydrogen in the phase transitions of nickelate systems

Tuesday, 16 July 2024 17:30 (20 minutes)

The modification of epitaxial layers through hydrogenation is a thriving field of research that offers diverse opportunities to tune the physical properties of different systems. Recent research has been extended to correlated oxide interfaces, where hydrogen induced, reversible metal-to-insulator transitions have been uncovered in material systems such as rare-earth nickelates [1-2]. The combination of neutron and x-ray scattering methods are without doubt one of the best way to study these systems. In this talk we will show the reentrant phase transformation observed at room temperature for $LaNiO_3$ upon exposure to hydrogen gas. Electrical transport shows a metal-insulator-metal transition which was never observed before. We will present the results of in situ neutron reflectometry (NR), which allowed us to distinguish and quantify oxygen depletion and hydrogen incorporation, which are two possible mechanisms to explain the electronic modification of the host layer. In addition to the neutron measurements, we will present complementary results from in situ synchrotron x-ray diffraction and x-ray absorption, which helped to uncover the hydrogenation mechanism and electronic modification of the Ni valence. This work clearly shows the need of combining both neutron and x-ray scattering techniques to correctly identify the source of modifications induced by gas exposure in complex systems such as transition metal oxides.

References
[1] J. Shi, Y. Zhou, S. Ramanathan, Nat. Commun. 2014, 5, 4860.
[2] Haowen Chen, et al. Nano Letters 2022 22 (22), 8983-8990

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Dynamics of surfaces, interfaces, and nanostructures

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Session Classification: Dynamics of surfaces, interfaces, and nanostructures