

Hydrogen Induced Colossal Resistance Switching in Perovskite Nickelates

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Interactions between hydrogen and correlated oxide materials arouse resurgence interests since last century from both scientific and technological perspectives. Unlike the hydrogen induced passivation of dangling bonds or forming the gas anneals for the case of conventional semiconductors, more complex effects have been observed in interactions between hydrogen and correlated oxides materials, i.e., electron doping, structural distortions, or valence reductions. Utilizing hydrogen interactions and the respective electron doping to modify the electrical transportation properties of correlated oxide materials is a promising way to realize the reduction in resistivity, which has been observed in materials systems such as ZnO, WO₃ and VO₂. In those cases, hydrogen is considered to diffuse into the oxides and directly donate electrons to the conducting band that modify the conductivity.

Herein, we represent a recent progress for hydrogen interactions with the perovskite structured rare earth nickelates (*Re*NiO₃), where a sharp increase in resistivity has been observed when the *Re*NiO₃ with the patterned platinum as catalysts was simply exposed under hydrogen atmospheres at room temperature [1,2]. This process is expected to be associated to a gas-induced phase transition, in which case the resistivity of SmNiO₃ increased for nearly four or eight orders of magnitudes when performing the hydrogenation process at room temperature [2] or 200 °C, respectively [1,2]. The sharp changes in resistivity induced by hydrogen doping may open up a new direction in the exploration of the emerging electronic devices with correlated oxide systems from the application aspect. A solid-state room temperature nonvolatile proton-gated phase-change transistor has been demonstrated. From the fundamental research aspect, the generation of the insulating phase has been preliminarily attributed to the electron doping of the diffused hydrogen, which modifies the electron configuration of *e_g* orbital of Ni³⁺*t_{2g}*⁶ *e_g*¹ in SmNiO₃ into strongly correlated Ni²⁺*t_{2g}*⁶ *e_g*². However, open questions still remain and will be also comment in the present presentation.

References:

- [1] J. Shi *et al*, Nature Commun. **5**, 4860 (2014).
[2] J. Chen *et al*, Appl. Phys. Lett. **107**, 031905 (2015).

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(a) Time-dependent variation in resistance during the hydrogen and de-hydrogenation processes for Pt patterned SmNiO₃ at room temperature (the blue region represent exposure under 5% H₂ atmosphere, while the white region represents air atmosphere); (b) The saturated resistance change ratio during the hydrogenation process at room temperature for various rare-earth nickelates (*Re*NiO₃).

