

Strain Tuning of Proton-Induced Resistance Modulation in NdNiO₃ Thin Film

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Proton doping via gas-phase-chemical reaction (hydrogenation) in strongly correlated RNiO₃ (R = rare earth) thin film has the potential to enable colossal resistance modulation for emerging neuromorphic computing applications. Recently, the high resistance change owing to phase transition has been demonstrated to be directly related to the proton doping concentration within the perovskite lattice of NdNiO₃ (NNO) [1]. However, the microscopic understanding of how protons behave under lattice strain effects in RNiO₃ film has not been clearly revealed.

In this work, hydrogenation and corresponding resistance modulation were systematically studied as a function of strain in NNO thin films. KTaO₃ (KTO), SrTiO₃ (STO), (LaAlO₃)_{0.3}(Sr₂AlTaO₆)_{0.7} (LSAT), and LaAlO₃ (LAO) substrates were used to regulate distinct strain conditions within NNO films (pseudocubic, $a_{pc} = 3.807$ Å). Catalytic Pt pads on top of NNO film serve as triple phase boundaries for hydrogenation. Figure 1(a) shows that the resistance modulation of NNO during hydrogenation (R_t) varies with substrate dependence in which R_t increases from NNO deposited on KTO to that on STO, on LSAT, and finally on LAO. The inset of Figure 1(b) depicts the color change of the films after hydrogenation (“HNNO” area), which indicates the proton incorporation into the films. As plotted in Figure 1(b), the HNNO area shows an identical trend with R_t , where both increase from film with tensile strain to that with compressive strain. This demonstrates a fine tuning of proton doping is possible by regulating the strain. In the presentation, a reciprocal space mapping analysis will also be presented,

delivering an understanding of the effect of strain-controlled perovskite structure on proton doping. In addition, we will show how the compressive strain can effectively enhance the proton diffusion by reducing the activation energy via the first principles calculations.

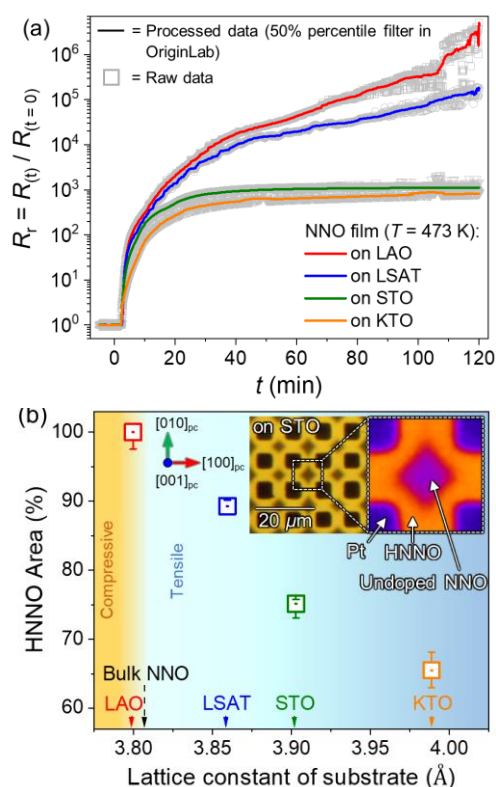


Fig. 1. NNO thin film deposited on various substrates. (a) Time-evolution of resistance modulation (R_t) during hydrogenation. (b) Hydrogenated NNO (HNNO) area as a function of lattice constant of the substrates. The inset shows optical microscopy image after hydrogenation at 473 K for 120 min.

Reference: 1) U. Sidik et al., ACS Appl. Mater. Interfaces **12**, 54955 (2020).