Supporting Information

Metal-insulator transition of $LaNiO_3$ films in $LaNiO_3/SrIrO_3$ heterostructures

Yao Li,[†, ‡, §] *Jian Zhou,*[†, ‡, §] *and Di Wu*[†, ‡, §, *]

† National Laboratory of Solid State Microstructures and Department of Materials Science and Engineering, Nanjing University, Nanjing 210093, China

‡ Jiangsu Key Laboratory for Artificial Functional Materials, Nanjing University, Nanjing 210093, China

§ Collaborative Innovation Center of Advanced Microstructures, Nanjing University, Nanjing 210093, China

* Please address correspondence to Di Wu (diwu@nju.edu.cn).

1. Structure and surface morphology of the heterostructure

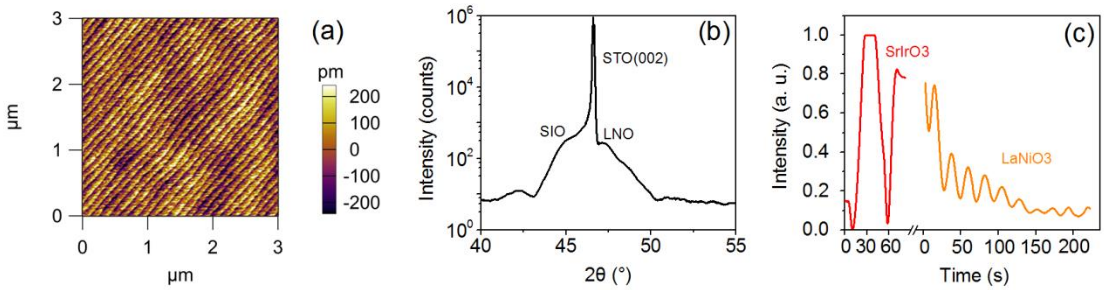

Fig. S1 (a) Atomic force microscope image of the surface of the $(LNO)_{10}/(SIO)_2$ heterostructure; (b) θ-2θ X-ray diffraction pattern of the $(LNO)_{10}/(SIO)_{10}$ heterostructure; and (c) RHEED oscillations recorded *in situ* during the deposition of the $(LNO)_{10}/(SIO)_2$ heterostructure.

Fig. S1 (a) shows a clear step-terrace surface of the $(LNO)_{10}/(SIO)_2$ heterostructure. Fig. S1 (b) shows the XRD pattern of the $(LNO)_{10}/(SIO)_{10}$ heterostructure. Diffraction peaks from LNO and SIO observed indicate the high crystallization quality. Clear RHEED oscillations recorded during the deposition of the $(LNO)_{10}/(SIO)_2$ heterostructure, as shown in Fig. S1 (c), indicate the layer-by-layer growth of the sample.

2. Schematic diagrams of electrode connection for electrical measurements

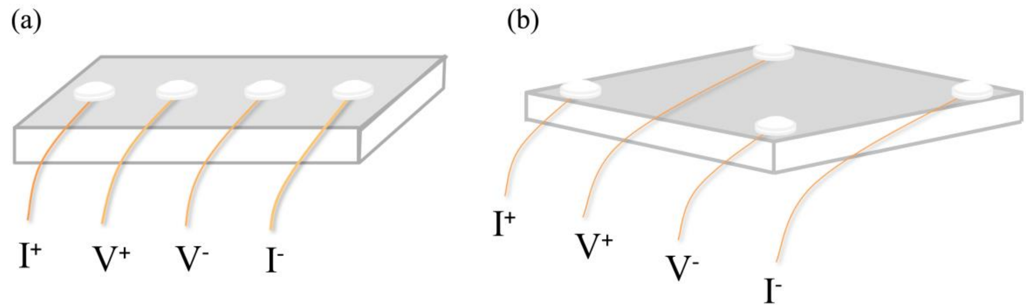

Fig. S2 Schematic diagrams of electrode connection for (a) sheet resistance and magnetoresistance measurements, and (b) hall transport measurements.

3. Transport characteristics of LNO and SIO single layer films

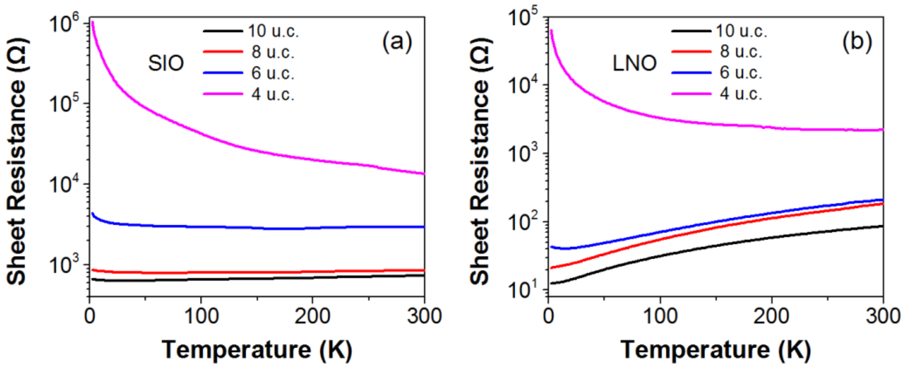

Fig. S3 Temperature-dependent sheet resistances of (a) SIO, (b) LNO single layer films as functions of film thickness.

4. MR curves of LNO and SIO single layer films

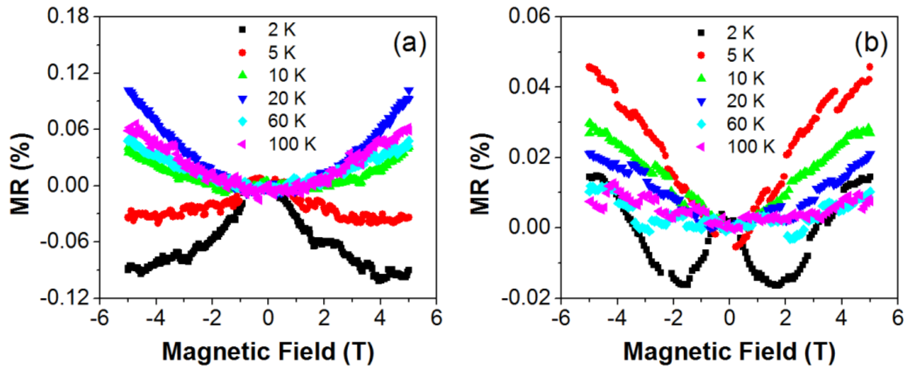

Fig. S4 Magnetoresistance of (a) 10 u.c. LNO and (b) 10 u.c. SIO films at different temperatures.

As observed, MR of 10 u.c. LNO films are positive above 10 K, as expected for a paramagnetic metal. The negative MR of LNO below 10 K is probably due to random scattering by defects, as often observed in LNO thin films.[1] However, since no M-I transition is observed in 10 u.c. LNO films and the negative MR is very small, this random scattering is considered weak enough in LNO films and also in $(LNO)_{10}/(SIO)_2$ heterostructures. MR of the 10 u.c. SIO films, as shown in Fig. S4 (b), is small. And MR values at high field are positive at all temperatures measured, in agreement with previous reports.[2] The MR of SIO should not affect the interpretation of MR data of the heterostructures.

5. Temperature-dependent magnetization of LNO and SIO single layer films

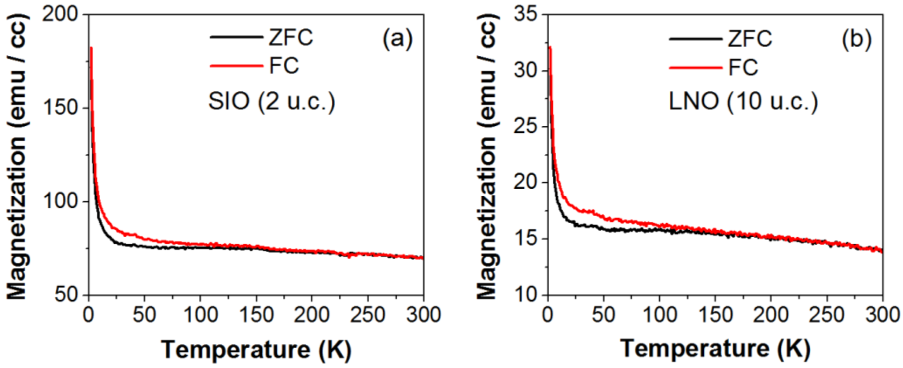

Fig. S5 Temperature-dependent magnetization of (a) 2 u.c. thick SIO film and (b) 10 u.c. thick LNO film, measured with 1000 Oe after cooling with and without a 2.0 T magnetic field applied parallel to the film surface.

The temperature-dependent magnetization curves shown in Fig. S5 reflects the paramagnetic nature of LNO and SIO. The small discrepancy in field cooling and zero field cooling curves may be ascribed to oxygen vacancies that are inevitable in perovskite oxides.[3]

REFERENCES

(1) Gayathri, N.; Raychaudhuri, A. K.; Xu, X. Q.; Peng, J. L.; Greene, R. L. Magnetoresistance of Metallic Perovskite Oxide $LaNiO_{3-\delta}$. *J. Phys.: Condens. Matter* **1999**, *11*, 2901–2907.

(2) Fujioka, J.; Okawa, T.; Yamamoto, A.; Tokura, Y. Correlated Dirac Semimetallic State with Unusual Positive Magnetoresistance in Strain-Free Perovskite $SrIrO_3$. *Phys. Rev. B* **2017**, *95*, 121102.

(3) Sánchez, R. D.; Causa, M. T.; Caneiro, A.; and Butera, A. Metal-Insulator Transition in Oxygen-Deficient $LaNiO_{3-x}$ Perovskites. *Phys. Rev. B* **1996**, *54*, 16574.