2626
doi:10.1017/S1431927620022230

Microsc. Microanal. 26 (Suppl 2), 2020

Atomic-scale Considerations on $LaNiO_3$-La_2CuO_4 Heterostructures: Interface—thermoelectricity Relationship

Pinar Kaya, Y. Eren Suyolcu, Federico Baiutti, Petar Yordanov, Georg Christiani, Friederike Wrobel, Eva Benckiser, Bernhard Keimer, Hanns-Ulrich Habermeier, Giuliano Gregori, Gennady Logvenov, Peter van Aken and Joachim Maier

Max Planck Institute for Solid State Research, Stuttgart, Baden-Wurttemberg, Germany

It is well-known that the electrical transport along interfaces [1] and boundaries [2] can be modified by several orders of magnitudes, and various examples such as $LaAlO_3$/$SrTiO_3$ [3] and La_2CuO_4-based interfaces [4], were extensively studied. Moreover oxygen stoichiometry and exchange dynamics [5] play an important role as well. Hence, the utilization of interface engineering and linking it with defect chemistry can be a powerful tool to tailor the electrical transport properties of oxides.

In this study, by means of the atomic-layer-by-layer oxide molecular beam epitaxy technique, we designed oxide heterostructures consisting of tetragonal K_2NiF_4-type La_2CuO_4 (LCO) and perovskite-type $LaNiO_3$ (LNO) layers with different thicknesses to assess the heterostructure–thermoelectric property–relationship. The temperature dependence of the Seebeck coefficient S(T) and the electrical conductivity σ(T) were measured simultaneously under 1 bar oxygen between 300 K and 800 K, using ULVAC ZEM3 system. For the investigations, a JEOL JEM-ARM200F STEM equipped with a cold field-emission electron source, a probe Cs-corrector (DCOR, CEOS GmbH), a large solid-angle JEOL Centurio SDD-type energy-dispersive X-ray spectroscopy (EDXS) detector, and a Gatan GIF Quantum ERS spectrometer was used.

We observed the dependency of transport properties on the individual layer thickness, interface intermixing, and oxygen exchange dynamics in LCO layers that occurs at high temperatures. In particular, as the thickness of the individual layers was reduced, the σ(T) decreased and the sign of the S(T) changed (Figure 1), revealing the contribution of the individual layers, where the possible interfacial contributions cannot be ruled out. High-resolution scanning transmission electron microscopy (HR-STEM) investigations showed that a substitutional solid solution of $La_2(CuNi)O_4$ was formed, when the thickness of the constituent layers was decreased. Moreover, in such LNO-LCO heterostructures with relatively thick LNO and LCO layers (8 u.c. and 6 u.c. thick) the thermoelectric properties are determined by the more conducting LNO layers and can be described by the parallel slab model [6, 7].

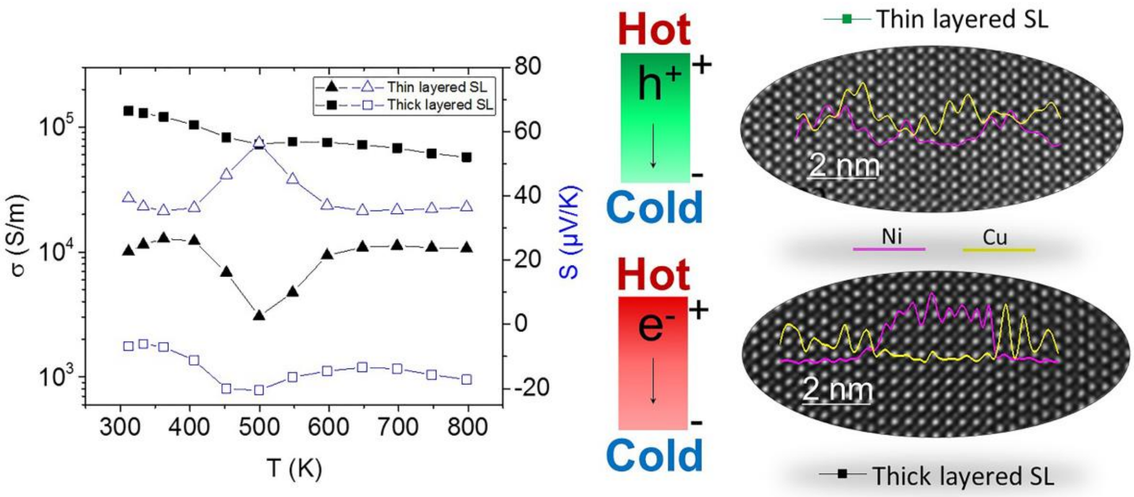

Figure 1. Seebeck coefficient S(T) and electrical conductivity σ(T) of thin & thick layered superlattices (SLs) and HR-STEM images with Cu & Ni elemental profiles[5]

References

[1] J. Maier, Progress in Solid State Chemistry 1995, 23, 171.
[2] P. Kaya, G. Gregori, P. Yordanov, E. Ayas, H.-U. Habermeier, J. Maier, S. Turan, Journal of the European Ceramic Society 2017, 37, 3367.
[3] A. Ohtomo, H. Y. Hwang, Nature 2004, 427, 423.
[4] Y. E. Suyolcu, G. Christiani, P. A. van Aken, G. Logvenov, Journal of Superconductivity and Novel Magnetism 2020, 33, 107.
[5] P. Kaya, G. Gregori, F. Baiutti, P. Yordanov, Y. E. Suyolcu, G. Cristiani, F. Wrobel, E. Benckiser, B. Keimer, P. A. van Aken, H.-U. Habermeier, G. Logvenov, J. Maier, ACS Appl. Mater. Interfaces 2018, 10, 22786.
[6] K. Fischer, C. Stoiber, A. Kyarad, H. Lengfellner, Appl. Phys. A 2004, 78, 323.
[7] This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 823717 – ESTEEM3.