3000 S cm^{-1}を超える高導電性深紫外透明酸化物半導体 La ドープ $SrSnO_3$

High Electrical Conducting Deep-Ultraviolet-Transparent Oxide Semiconductor La-Doped $SrSnO_3$ Exceeding ~3000 S cm^{-1}

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La-doped $SrSnO_3$ (LSSO) is known as one of deep-ultraviolet (DUV)-transparent conducting oxides with an energy bandgap of 4.2 eV. Since LSSO can be heteroepitaxially grown on the substrates, LSSO is considered to be a promising candidate as the DUV-transparent electrode. However, due to difficulties in growing high-quality LSSO films, their electron transport properties have not been extensively studied compared to the optical properties and electronic structures. The electrical conductivity of LSSO films are below 1000 S cm^{-1}, still lower than that of commercially available transparent conducting oxide ITO (~7000 S cm^{-1}), most likely due to the low solubility of La ion in the LSSO lattice.[1,2] Here we report that high electrically conducting (>3000 S cm^{-1}) LSSO thin films with an energy bandgap of 4.2 eV were fabricated by pulsed laser deposition technique on (001) MgO single crystal substrate followed by the simple annealing in vacuum. From the X-ray diffraction and the scanning transmission microscopy analyses, we found that lateral grain growth occurred during the annealing (**FIG. 1**), which improved the activation rate of La ion, leading to the significant improvement of carrier concentration (3.26×10^{20} cm^{-3}) and Hall mobility (55.8 cm^2 V^{-1} s^{-1}) (**FIG. 2 left**). The carrier effective mass (m*) of LSSO epitaxial film was also clarified by the thermopower measurements, which turned out to be 0.23 m_0 (**FIG. 2 right**), similar with that of $Ba_{0.5}Sr_{0.5}SnO_3$.[3] The present DUV-transparent oxide semiconductor would be useful as the transparent electrode to develop optoelectronic devices which transmit and/or emit DUV-light.

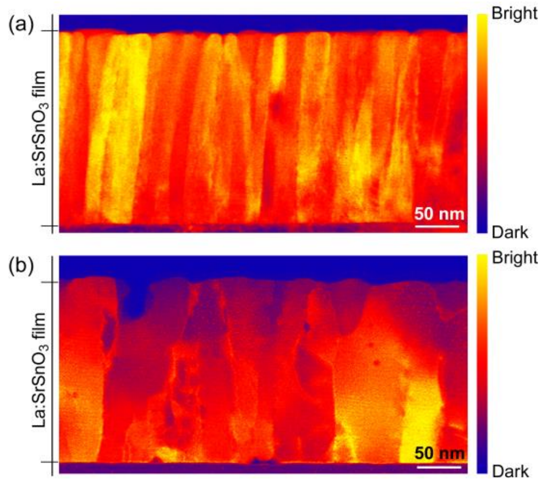

FIG. 1 | Cross-sectional LAADF-STEM images for (a) as-deposited and (b) annealed LSSO films.

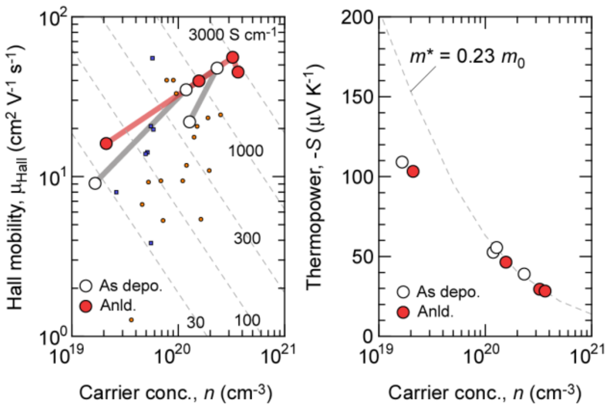

FIG. 2 | (Left) Hall mobility and (right) thermopower of the LSSO films as a function of the carrier concentration.

[1] Handbook of Transparent Conductors, Ed. D. Ginley (Springer, 2011).
[2] E. Baba *et al.*, *J. Phys. D. Appl. Phys.* **48**, 455106 (2015).
[3] A.V. Sanchela *et al.*, *Small* **15**, 1805394 (2019).