Investigation of transport property reductions in epitaxial La-doped $BaSnO_3$ films

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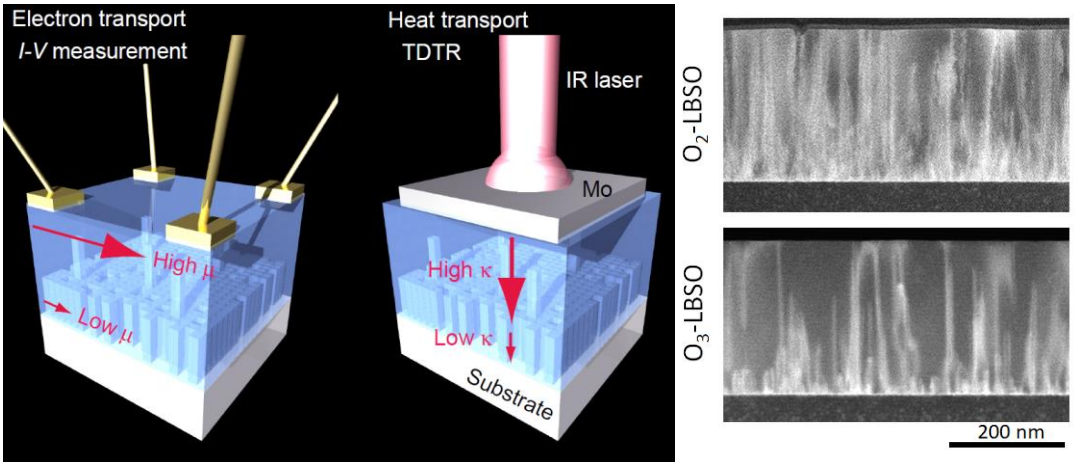
La-doped $BaSnO_3$ (LBSO) exhibits a wide bandgap (~3.5 eV) and high single crystal electron mobility (320 $cm^2\ V^{-1}\ s^{-1}$)[1], which are ideal transparent oxide semiconductor characteristics for optoelectronic applications[2]. However, the mobility observed from LBSO thin films is much lower compared to the single crystal value. Most studies attribute this phenomenon to the threading dislocations from the lattice mismatch between LBSO/substrate, but the threading dislocations do not fully explain the mobility suppression in LBSO films[3,4,5]. Another perspective for approaching this phenomenon is necessary, and this is the context of this work. A recent study found that the LBSO epitaxial film grown by pulsed laser deposition in ozone atmosphere (O_3-LBSO) exhibited higher electron mobility (115 $cm^2\ V^{-1}\ s^{-1}$) than the LBSO films grown in oxygen atmosphere (O_2-LBSO, 100 $cm^2\ V^{-1}\ s^{-1}$), suggesting that the oxygen deficiency can also be a factor. Here, we compare the electron and heat transport properties of O_2-LBSO and O_3-LBSO films at various thicknesses to investigate the LBSO thin film mobility suppression in a broad perspective. All films exhibited a strong thickness gradient. Compared to O_2-LBSO films, O_3-LBSO films showed lower oxygen deficiency, higher electron mobility, and higher thermal conductivity. In addition, the LAADF-STEM demonstrated that the lattice strain in O_3-LBSO films is much smaller than that in O_2-LBSO films. These show that the electron mobility enhancement in LBSO films is closely related to reducing the lattice strain. While threading dislocations can affect the lattice strain, they are not certainly the sole factor, and our results demonstrate that the thickness and the oxygen vacancy can also affect the lattice strain and therefore the mobility. In this work, we discuss different factors dominating the mobility of LBSO films and the limitations in aiming the single crystal mobility in LBSO films.



References

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