Glass-like Through-Plane Thermal Conductivity Induced by Oxygen Vacancies in Nanoscale Epitaxial $La_{0.5}Sr_{0.5}CoO_{3-\delta}$

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Ultrafast time-domain thermoreflectance (TDTR) is utilized to extract the through-plane thermal conductivity (L_{LSCO}) of epitaxial $La_{0.5}Sr_{0.5}CoO_{3-d}$ (LSCO) of varying thickness (<20 nm) on $LaAlO_3$ and $SrTiO_3$ substrates. These LSCO films possess ordered oxygen vacancies as the primary means of lattice mismatch accommodation with the substrate, which induces compressive/tensile strain and thus controls the orientation of the oxygen vacancy ordering (OVO). TDTR results demonstrate that the room-temperature L_{LSCO} of LSCO on both substrates (1.7 W m^{-1} K^{-1}) are nearly a factor of four lower than that of bulk single-crystal LSCO (6.2 W m^{-1} K^{-1}). Remarkably, this approaches the lower limit of amorphous oxides (*e.g.*, 1.3 W m^{-1} K^{-1} for glass), with no dependence on the OVO orientation. Through theoretical simulations, origins of the glass-like thermal conductivity of LSCO are revealed as a combined effect resulting from oxygen vacancies (the dominant factor), Sr substitution, size effects, and the weak electron/phonon coupling within the LSCO film. The absence of OVO dependence in the measured L_{LSCO} is rationalized by two main effects: (1) the nearly isotropic phononic thermal conductivity resulting from the imperfect OVO planes when *d* is small; (2) the missing electronic contribution to L_{LSCO} along the through-plane direction for these ultrathin LSCO films on insulating substrates.