Thermal and electrostatic tuning of surface phonon-polaritons in STO and LAO/STO interfaces

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Phonon polaritons (PhPs), half-light-half-matter quasiparticles, have been explored for a wide range of nanophotonic applications by enabling low-loss propagation of electromagnetic energy at the deep-subwavelength scale. However, the lack of tunability of the material-specific narrow PhP spectral windows mainly limits the operating frequencies of current PhPs to the mid-infrared range, thus hindering their technological implementation in long-wave infrared range. In this work, we demonstrate, by applying cryogenic infrared nanospectroscopy, the thermal and electrostatic tunability of surface PhPs (SPhPs) in $SrTiO_3$ (STO) in the far-infrared. At low temperatures, the decay length of SPhPs increases as compared to the value at room temperature. Furthermore, by depositing a thin layer of $LaAlO_3$ (LAO), we realize broader thermal tuning of the upper spectral limit of the SPhPs band than pure STO with the help of a two-dimensional electron gas (2DEG) at the LAO/STO interface. More interestingly, by applying electrostatic gating to the 2DEG, we successfully tune the spectral features of SPhPs. Our results identify perovskite oxides as potentially interesting PhP materials bridging oxide electronics and long-wave nano-photonics.