Highly confined epsilon-near-zero- and surface-phonon polaritons in $SrTiO_3$ membranes

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Recent theoretical studies suggest that transition metal perovskite oxide membranes can enable surface phonon polaritons in the infrared range with low loss and much stronger subwavelength confinement than bulk crystals. Such modes, however, were not experimentally confirmed so far. Using a combination of far-field Fourier-transform infrared (FTIR) spectroscopy and near-field synchrotron infrared nano spectroscopy (SINS) imaging, we study the phonon-polaritons in a 100 nm thick freestanding crystalline membrane of $SrTiO_3$ transferred on gold and Si/SiO_2 substrates. We observe a symmetric-antisymmetric mode splitting giving rise to epsilon-near-zero and Berreman modes as well as highly confined (by a factor of 10) propagating phonon polaritons, both of which result from the deep-subwavelength thickness of the membranes. We complement our study with theoretical modeling based on the analytical finite-dipole model and numerical finite-difference methods. The modelling fully corroborates the experimental results. Our work reveals the potential of oxide membranes as a promising materials for infrared photonics and polaritonics.

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