Variable-temperature and gate-tunable SNOM imaging of phonon-polaritons in STO and LAO/STO interfaces

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Surface phonon polaritons (SPhPs)-light waves coupled to lattice vibrations-in polar crystals offer unprecedented opportunities to achieve enhanced light-matter interactions in a broadband frequency range, spanning from mid-infrared to terahertz frequencies\cite{1}. Such low-loss polariton modes are of great importance for the applications in biosensing, optical imaging and data storage. We performed cryogenic hyperspectral imaging of the propagating SPhP mode in SrTiO3 (STO) and LaAlO3/SrTiO3 (LAO/STO) \cite{2,3,4} system. In the LAO/STO, where the SPhPs electromagnetically couple with the plasmonic modes in the two-dimensional electron system (2DES), we observe a stronger temperature dependence of the SPhP band as compared to the pristine STO, which is related to the enhanced electron-phonon interaction in the doped STO layer. Furthermore, by applying electrostatic gating to the 2DES, we achieve a dynamic spectral tunability of the SPhP band. Our experimental results are supported by analytic calculations. Overall, our findings suggest SrTiO3 as to be a new promising platform for nanophotonic applications, according to recent theoretical predictions \cite{5}, in the meanwhile, providing more tractable approaches for effective spectral shift of SPhPs taking the benefit of 2DES.

\cite{1} J. D. Caldwell, L. Lindsay, V. Giannini, I. Vurgaftman, T. L. Reinecke, S. A. Maier and O.J. Glembocki, Nanophotonics 4: 44 (2015).
\cite{2} A. Ohtomo and H.Y. Hwang, Nature 427, 423 (2004).
\cite{3} S. Thiel, G. Hammerl, A. Schmehl, C.W. Schneider, and J. Mannhart 313, 1942 (2006).
\cite{4} A.D. Caviglia, S. Gariglio, N. Reyren, D. Jaccard, T. Schneider, M. Gabay, S. Thiel, G.