

## **Phonon-polaritons in the deep-strong coupling regime**

Andrey Baydin, Manukumara Manjappa, Mishra Sobhan Subhra, Hongjing Xu, Fuyang Tay, Dasom Kim, Felix G. G. Hernandez, Paulo H. O. Rappl, Eduardo Abramof, Ranjan Singh, and Junichiro Kono.

Formation of polaritons in the ultrastrong (USC) and deep-strong (DSC) coupling regimes provides opportunities for exploring novel phases of light-matter hybrids as well as for applications in quantum information processing and technology. Phonon-polaritons are particularly interesting as they are expected to be able to modify and control chemical reactions and superconductivity; they are also predicted to induce a new type of ferroelectric phase transitions. Here, we investigate coupling between vacuum photons and phonons in lead telluride in small-mode-volume terahertz cavities. Using metamaterial cavities to enhance vacuum fluctuation fields in the terahertz range, we observed a Rabi splitting whose value exceeded the cavity-phonon frequency, placing us in the DSC regime. We systematically studied the coupling strength as a function of sample thickness, temperature, and cavity length. These experimental results will be discussed in comparison with results of electromagnetic simulations we conducted.