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Hyperbolic phonon polaritons in hexagonal boron nitride

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Uniaxial materials whose axial and tangential permittivities have opposite signs are referred to as indefinite or hyperbolic media. While hyperbolic responses are normally achieved with metamaterials, hexagonal boron nitride (hBN) naturally possesses this property due to the anisotropic phonons in the mid-infrared. Using scattering-type scanning near-field optical microscopy, we studied polaritonic phenomena in hBN. We performed infrared nano-imaging of highly confined and low-loss hyperbolic phonon polaritons in hBN. The polariton wavelength was shown to be governed by the hBN thickness according to a linear law persisting down to few atomic layers [Science, 343, 1125–1129 (2014)]. Additionally, we carried out the modification of hyperbolic response in heterostructures comprised of a mononlayer graphene deposited on hBN. Electrostatic gating of the top graphene layer allows for the modification of wavelength and intensity of hyperbolic phonon polaritons in bulk hBN. The physics of the modification originates from the plasmon-phonon coupling in the hyperbolic medium. Furthermore, we demonstrated the "hyperlens" for subdiffractional imaging and focusing using a slab of hBN.