Topological interface mode by simultaneous optical and nanophononic band inversion

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Nanophononics, the control of acoustic phonons at ultrahigh frequencies, appears as a suitable platform for single-particle quantum simulations and to study general wave phenomena. Band inversion in one-dimensional superlattices is a strategy to generate topological interface modes in electronics, optics, acoustics, and nanophononics [1-4]. Despite their potential for the control of topologically robust interactions, most realizations of these states have so far explored only a single kind of excitation. Here, we construct an optical and phononic interface mode by simultaneous band inversion for photons and phonons. [5] We rely on GaAs/AlAs heterostructures that exhibit a naturally occurring colocalization of the optical and acoustic fields, resulting in enhanced optomechanical interactions. We designed and fabricated a heterostructure presenting a topological interface mode for photons at 1.34 eV and phonons at 18 GHz. We experimentally observe colocalized interface modes for NIR photons by optical reflectivity and 18 GHz phonons by coherent phonon generation and detection.
Through numerical simulations, we demonstrate the ensuing robustness of the Brillouin interaction between them with respect to a specific type of disorder. Furthermore, we theoretically deduce a set of engineering rules in different topological designs presenting colocalized states. Potential future applications include the engineering of robust optomechanical resonators in a material system compatible with quantum wells and quantum dots.

References

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Figures

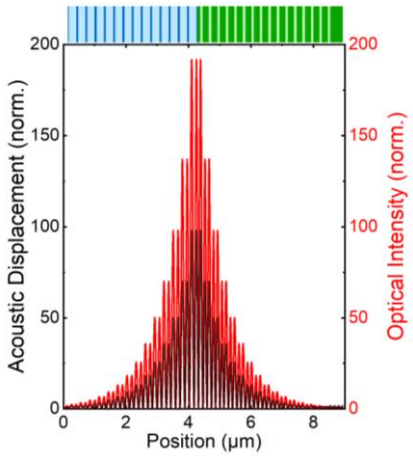

Figure 1: Schematic of multilayered structure formed by two concatenated GaAs/AlAs superlattices presenting band inversion (top). Acoustic and optical field distributions corresponding to the simultaneous confined interface mode (botom) [5].