Silicon nanomembrane-based phononics

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Abstract
Engineering of the phonon dispersion relation provides a means to impact on related properties of materials such as group velocity in a controlled manner and, therefore, the propagation of phonons. Phonon confinement is an important component of phonon engineering as the density of states, frequency and symmetry of confined phonons depend on the geometrical shape of the cavity, as well on the acoustic characteristics of the cavity constituents. In this context, nanomebranes, which are component parts in integrated photonic and mechanical devices, appear as an excellent example to study the effect of the reduction of the characteristic size on the phonon dispersion relation[1]. The introduction of a controlled stress on the membrane presents an additional degree of freedom to tailor the phonon dispersion relation [2]. A step further in geometrical complexity and, therefore, in increasing the control and manipulation of phonons is achieved by introducing a periodicity in the elastic properties of the nanomembrane to form phononic crystals. Alternatively, by placing a periodical arrangement of a set of cylindrical resonators on top of the membrane can result in the appearance of hybrid slow phonons[3]. In this work, we present an experimental study of the dynamics of hypersonic phonons in the above mentioned approaches for phonon engineering by means of Brillouin light scattering. Our theoretical results based on the elastic continuum approximation are in good agreement with the measured dispersion relations.

References
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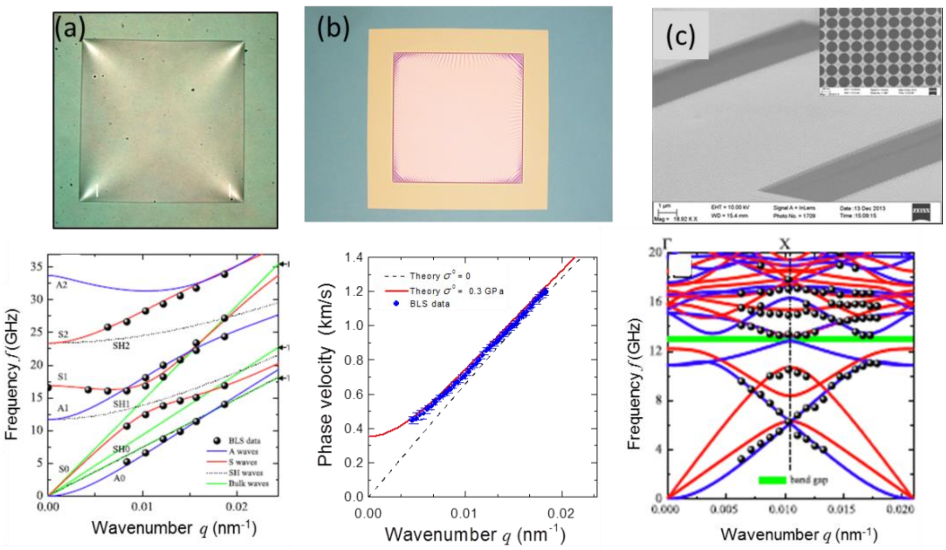

Figure: Examples of strategies used to tailor the phonon dispersion relations: Phonon confinement (a) stress control (b) and phononic crystal Si membrane. Top: Optical microscope (a) and (b) and SEM images (c) of the Si membranes without and with stress control, and Si membrane based phononic crystal. Bottom: Calculated and experimental phonon dispersion relations.