J Biotech and Phyto 2017

Soft based hypersonic phononics

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Phononic structures (composite materials in which a periodic distribution of elastic parameters facilitates control of the propagation of phonons, hold the promise to enable transformative material technologies in areas ranging from acoustic and thermal cloaking to thermoelectric devices. This requires strategies to deliberately 'engineer' the phononic band structure of materials in the frequency range of interest. Phononics, the acoustic equivalents of the photonics, are controlled by a larger number of material parameters, as phonon cannot propagate in vacuum. The study of hypersonic phononics (hPnC) imposes substantial demand on fabrication and characterization techniques. Colloid and polymer science offer methods to create novel materials that possess periodic variations of density and elastic properties at length scales commensurate with the wave length of hypersonic phonons and hence visible photons. The key quantity is the dispersion ω(q) of high frequency (GHz) acoustic excitations with wave vector q which is measured by the noninvasive high-resolution Brillouin light scattering. The approach involves the exploitation of Bragg-type bandgaps (BGs) that result from the destructive interference of waves in periodic media. However, the sensitivity of BG formation to structural disorder limits the application of self-assembly methods that are susceptible to defect formation. Hybridization gaps (HG), originating from the anti-crossing between local resonant and propagating modes, are robust to structural disorder and occur at wavelengths much larger than the size of the resonant unit. Here, examples based on hierarchical structures will be highlighted: (i) 1D-hPnC to acquire comprehensive understanding, while the incorporation of defects holds a wealth of opportunities to engineer ω(q). (ii) In colloid based phononics, ω(q) has revealed both types of band gabs. (iii) particle brush materials with controlled architecture of the grafted chains enable a new strategy to realize HG's (iv) Hierarchically nanostructured matter can involve unprecedented phonon phono propagation mechanisms.

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