Nanophononics: Tailoring the Generation and Detection of Nm-Wavelength Acoustic Waves

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Through the development of high quality nanostructures displaying a controlled acoustic impedance modulation a new area is growing in nanoscience: nanophononics. This area is devoted to the study of the vibrational and thermal properties at the nanometer scale, and the interaction of engineered phonons with photons and electrons at high frequencies and reduced scales [1]. Performing pump-probe experiments, sub-THz coherent acoustic phonons (nm wavelengths) can be generated and detected in nanostructures [2]. The coherent generation of acoustic phonons in nanometric multilayers relies on the space-dependent ultrafast strain induced by a femtosecond laser pulse. A delayed probe pulse senses the time-dependent change of the optical reflectivity. In this presentation I will discuss some recent results on the control of acoustic phonon dynamics using engineered nanostructures. Superlattices operate as high reflectance phononic mirrors, acoustic nanocavities confine and amplify the hypersound field both spatially and in the spectral domain [3], and optimized aperiodic multilayers may act as tailored phononic filters [4]. I will introduce the basics of nanophononics design, including the engineering of nanostructures, selection of materials and experimental conditions. The selection of materials and their thickness allow the tuning of both the photonic and phononic operation range. Through the electron confinement in nanometric layers, it is also possible to perform a spatially selective excitation. In this way, a full optical, acoustic and electronic engineering is made on the studied systems. I will discuss some recent results on the tailoring of metallic structures to control the system response and how it can be optimized by confining the electromagnetic and acoustic fields.

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