Giant Photo-Elasticity of the Superlattice Polaritons for Detection of Coherent Phonons

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High-frequency coherent phonons in the GHz range have a potential for application in quantum technologies due to their nanometer wavelengths being comparable with the size of quantum nanodevices. Therefore, increasing strength of photon-photon coupling became of interest to the community [1,2]. In this work, we show that it is possible to reach quantum sensitivity of the phonon detection with a standard pump-probe set-up by exploiting giant photoelasticity of exciton-polariton resonance in a short period GaAs/AlAs superlattice (SL) [3].

For excitation and detection of the coherent phonon wave packet, we used a standard pump-probe experimental set-up with a mechanical delay line and a lock-in amplifier. A coherent acoustic phonon wave packet is generated by absorption of the pump laser pulse by a metal transducer at the back of the sample. Strain pulse propagates into GaAs substrate and reaches the GaAs/AlAs SL at the front, where it gets detected. By sweeping the central wavelength of the probe in the vicinity of the polariton resonance we obtained signals for several detuning values of probe photon energy. The amplitude of the measured signal depends strongly on the photon energy of the probe.

Our experiments reveal giant photo-elasticity of polaritons and extremely high sensitivity to propagating coherent phonons. The strong dispersion of the dielectric permittivity in the vicinity of the polariton resonance results in a strong ultrafast response of the optical properties to dynamical strain which accompanies the coherent phonons. This discovery opens new possibilities of ultrasensitive measurements of extremely low-density phonon fluxes.

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