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Brillouin spectroscopy in optophononic micropillars in the 18-350 GHz range

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Inelastic scattering of light by acoustic phonons has potential for the tailored generation of frequency combs, laser-line narrowing, and all-optical data storage. These applications require strong optical fields and a large overlap between the optical and acoustic modes to be efficient. We have designed optophononic micropillar resonators based on AlAs/GaAs superlattices, to simultaneously confine light and sound (Fig. 1(a)) [1,2]. This results in enhanced optomechanical interactions. In this work, we present two free-space filtering strategies implemented to maximize the signal to noise ratio in spontaneous Brillouin scattering measurement for the characterization of high-frequency acoustic phonons.

In the first approach we introduce a spatial mode mismatch between the incoming laser beam and the optical micropillar mode [3]. Figure 1(b) presents a Brillouin spectrum with excellent stray-light rejection at 300GHz, acquired by spatially selecting the Gaussian shaped mode at an interference minimum of resulting diffracted Airy pattern of the excitation laser from the micropillar (see inset).

In the second approach, we develop a polarization filtering technique based on the rotation of polarization induced by an elliptical micropillar. Due to the pillar ellipticity, the degeneracy of horizontally (H) and vertically (V) polarized cavity mode is lifted (Fig.1(c)), leading to polarization-dependent reflection coefficient r_H and r_V. By resonantly exciting the pillar with a mode matched beam of polarization projected on both H and V, the reflected laser undergoes a rotation of polarization and differs in polarization from the Brillouin signal. We measured elliptical pillar presenting a mode splitting of ~0.1 nm and acoustic mode at 18 GHz.

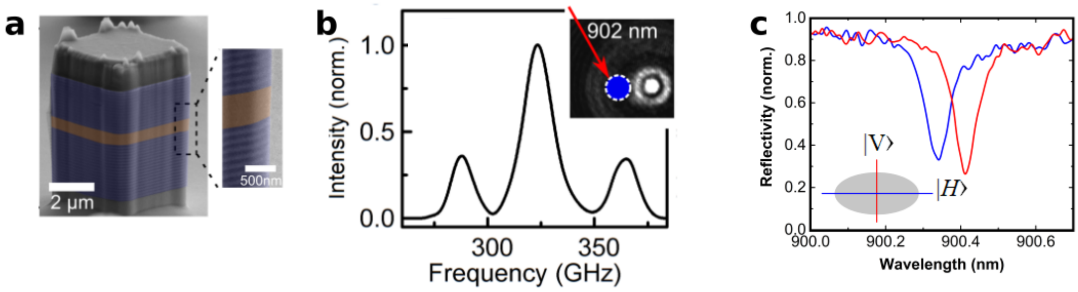

Figure 1 : (a) SEM image of a single square micropillar with a lateral extent of 4.5 µm. (b) Experimental Brillouin spectrum of the micropillar shown in (a). The blue circle indicates the position and size of the spatial filter applied for Brillouin spectroscopy. (c) Cavity reflectivity for horizontally polarized (blue) and vertically polarized (red) incident light for an elliptical micropillar.

The optophononic micropillars could be integrated into fibered and on-chip architectures [4], can be engineered to reach the stimulated Brillouin scattering regime, and are compatible with quantum dots, making them relevant for quantum communication.

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