Ultra-wide acoustic band gaps in pillar based phononic crystal strips

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Phononic Crystals are periodic structures that exhibit special properties for the propagation of elastic waves. Indeed, for specific frequencies called phononic band gap, the propagation of waves is forbidden, whatever the polarization. This phenomenon can be used in a broad range of technologies such as wave filtering, wave guiding, insulation etc. As wider band gaps generally mean better performances for devices, many studies have focused their interests on the opening and the widening of band gaps. The focus of our work has been on designing phononic strips with wide band gaps using a method allowing the flattening and the deletion of modes thanks to the study of their energy confinement on unit-cells.

The structure obtained consists of cylindrical tungsten pillars periodically deposited on a tailored silicon strip as showed in Figure 1. Calculations are done using the finite element method with the commercial software Comsol Multiphysics. Figure 2a represents the band diagram - normalized frequency ($F \times a$ [Hz.m]) as a function of reduced wavevector ï of the infinite PC strip. Several absolute band gaps can be noticed, the widest one has a mid frequency of 1500 Hz.m and a gap-to-midgap ratio of 89.7%. Figure 2b shows the transmission coefficient of the phononic strip with five periods for a mixed and a *y* polarized source. The structure exhibits an attenuation close to -115 dB for the mixed source at the mid frequency. As the mode 6 has no *y* polarization as shown in the insert, the structure has two *y* band gaps leading to an attenuation of -50 dB for the y polarized wave in these frequency ranges.

Figure 1: Schematics of the PC strip. unit-cell with geometric parameters (blue: tungsten, red: silicon).

The strong attenuation reached with this structure could be used to spatially confine waves in a resonator for example. The processes for manufacturing tailored silicon are well-known and widely used in clean-room industry. Pillars could be grafted or, for other materials as nickel or copper, electroformed. Such phononic strips could be mass produced and used as micro-resonator anchors or as force-modulation microscope tips for the improvement of the quality factor.

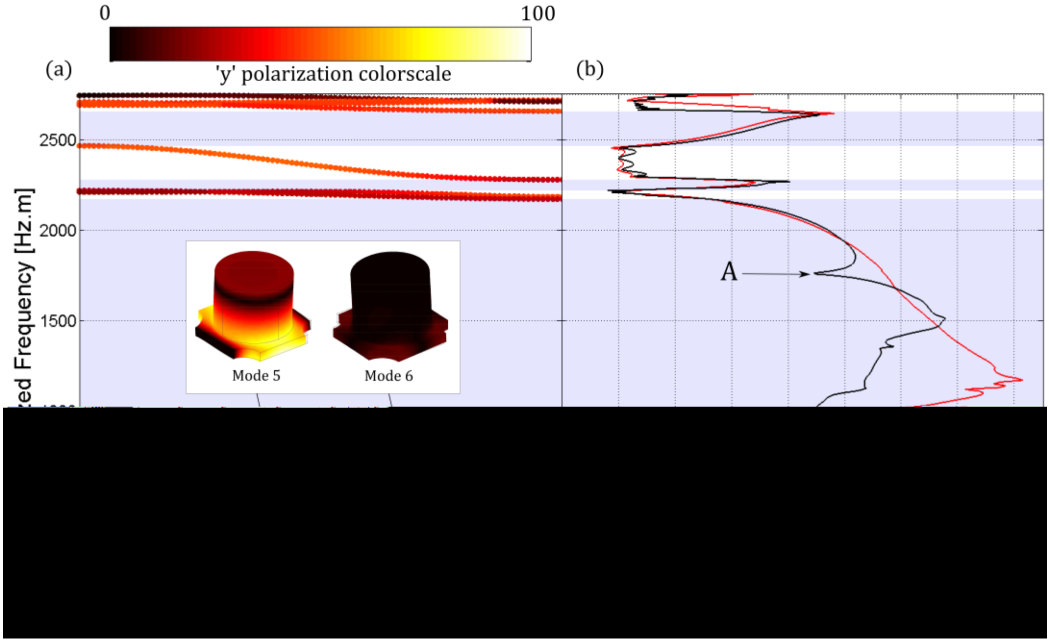

Figure 2: (a) Band diagram of the PC strip. The color indicates in percentage the y axis polarization normalized with the total displacement. Insert: Displacement along y of a unit cell for modes 5 and 6. (b) Transmission spectra of y polarized elastic (red) and mixed polarized (black) waves through a structure with 5 unit cells.