Experimental demonstration of photonic confinement suspended square-lattice silicon photonic crystal cavities

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It has been shown that the square lattice is one the most suitable ones to produce simultaneous photonic and phononic band gaps on suspended silicon slabs [1]. The introduction of point defects on such "phoxonic" crystals should lead to an enhanced interaction between confined light and sound at the nanoscale. In this work we report on the experimental measurements of light confinement in cavities created on two-dimensional square-lattice silicon photonic crystal membranes. The dimensions of the fabricated structures are chosen to provide a "phoxonic" bandgap, where the photonic bandgap (PBG) for even modes occurs at wavelengths around 1550 nm. To obtain the "phoxonic" bandgap, the silicon layer is a thicker that in conventional triangular-lattice photonic crystals (around 220 nm): around 325 nm for the square lattice. The radius of the holes is *r*=230 nm and the lattice period is a=540 nm. We fabricated the "phoxonic" crystal structures by using a direct writing photolithography process carried out with standard nanofabrication tools. Cavities are created by removing N holes in the transversal direction. Figure 1 shows scanning electron micrographs images of the released regions in a fabricated sample with two cavities (N=3 and N=11). Transmission spectra were taken in the 1260-1630 nm wavelength range by using a conventional end-fire technique. Transmission results of a fabricated sample are shown in figure 2, where it can be seen the appearance of transmission peak inside the PBG corresponding to the excitation of cavity modes. Computations of the N=3 cavity using the Finite Element Method show the existence of three localized photonic modes around 1550 nm and four localized phononic modes around 6 GHz. Moreover, computations using the 3D-FDTD method permit us to observe a great agreement between experimental and theoretical results. Our results lead us to conclude that cavities implemented in square lattice "phoxonic" (or optomechanical) crystals are a very suitable platform to observe an enhanced interaction between propagating photons and phonons.

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References

[1] Y. Pennec et al., "Simultaneous existence of phononic and photonic band gaps in periodic crystal slabs," Opt. Express 18, 14301-14310 (2010).

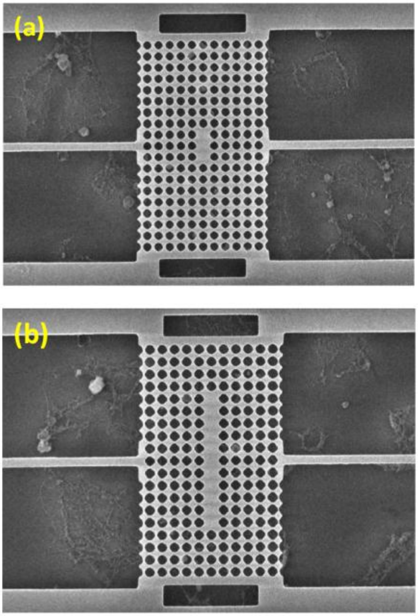

Figure 1: SEM images of a suspended square lattice silicon phoxonic crystals with cavities created by removing N holes in the transversal direction. (a) N=3 and (b) N=11.

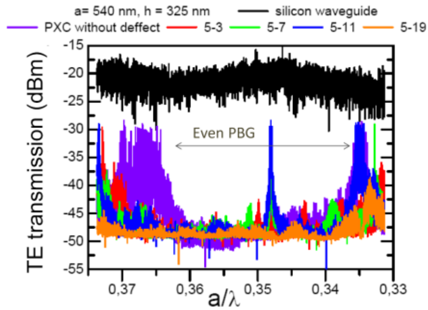

Figure 2: Measured spectra of a fabricated sample. The calculated PBG for even modes is shown. The peaks appearing in the PBG correspond to modes localized in the cavities.