

# Gap maps, waveguides and resonators in photonic crystal slabs with a triangular lattice of triangular holes

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We report on a systematic study of the photonic crystal (PC) membrane structure with a triangular lattice of triangular air holes [1]. Guided and quasi-guided PC slab modes are calculated by using a guided-mode expansion method, and intrinsic losses by perturbation theory via coupling to radiative modes of the effective planar waveguide [2]. This approach allows us to calculate reliable photonic band gaps in the whole spectral range, also considering modes above the light line.

The lattice supports a complete photonic gap common to TE-like and TM-like polarizations for the lowest-order guided mode, as reported in [1], but the gap is actually closed by higher-order guided modes of the slab. We have calculated gap maps as a function of the air fraction and for different slab thicknesses. We found a range of parameters (air fraction, slab thickness, dielectric constant) for which this system displays simultaneous photonic band gaps around fundamental ( $\omega_{\text{pump}}$ ) and second-harmonic ( $\omega_{\text{SH}}$ ) frequencies [2], which precludes to the interest of such a lattice for integrated non-linear optics in photonic circuits.

Based on these findings, we studied possible line- and point-defect engineering in the present structure, and compared the relative propagation losses (waveguides) and Q-factors (PC microresonators) between the lattices of triangular and circular holes. We found that intrinsic losses are only slightly increased in the triangular hole-based lattice. Finally, we propose an efficient scheme for in-plane second-harmonic generation in a properly designed structure with triangular holes, based on the conversion of a high-Q cavity mode at  $\omega_{\text{pump}}$  into a propagating SH mode at  $\omega_{\text{SH}}$  [3].

[1] S. Takayama *et al.*, *Appl. Phys. Lett.* **87**, 61107 (2005).

[2] L.C. Andreani and D. Gerace, *Phys. Rev. B* **73**, 235114 (2006).

[3] D. Gerace and L.C. Andreani, in preparation.