Photonic Crystal Resonators and Photonic Membranes as Platforms for All-Optical Signal Processing

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The conventional membranes separate particles during the process of its selective transport through the membrane channels. In photonics, the membranes are a kind of thin 2D photonic crystal resonators characterizing as thin and wide systems ordered in both transversal directions and filtering radiation along the normal to surface direction. Photonic bandgap manifestations in the reflectivity of periodically patterned systems were investigated

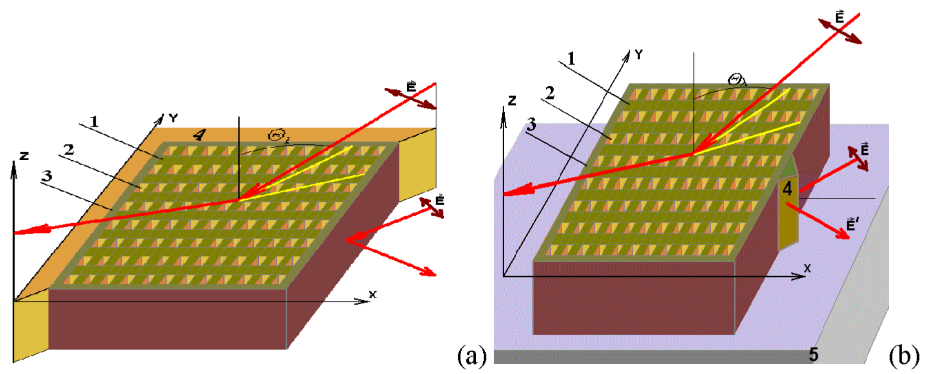

Fig. 1. Membranes and photonic crystal resonators. (a) A finite porous membrane. Out-of-plane incidence: s-polarisation, Θ_l, external polar angle of incidence, azimuth angle $\Phi_l=\pi/4$; yellow lines, sector of total internal reflection. **In-plane incidence:** p-polarisation. 1, matrix material; 2, rectangular bar/air wells in matrix; 3, covering layer (nonlinear), 4, external medium. **(b) A finite 8x12 2D photonic crystal resonator**. **Out-of-plane incidence:** s-polarisation, Θ_l, external polar angle of incidence, azimuth angle $\Phi_l=\pi/4$; yellow lines, sector of total internal reflection. **In-plane incidence:** p-polarisation. The is not shown. 1, system matrix; 2, rectangular bar/air wells in matrix; 3, covering layer, 4, input prism, 5, substrate.

experimentally and theoretically in a lot of works by the resonant coupling wave method connecting photonic bands existing for in-plane geometry of incidence with both diffractional signals in reflection and transmission.

The existing terminology distinguishes photonic crystals, photonic membranes or MPC and photonic crystal resonators (PCR). The infinite 2D structures ordered in XY plane which has also infinite size in Z direction are usually called photonic crystals. A photonic crystal resonator is a finite 2D system with perfectly smooth side walls. The latter circumstance leads to a clearly expressed angular area of total internal reflection (Fig. 1a, yellow lines) for a field closed inside the resonator. In the ideal case, the system should have infinite size in Z direction. The only way to excite intrinsic standing waves exists through the input prisms which allow the external beam to enter the total internal reflection area. Correspondingly, we will tell the difference between above mentioned pure PCR resonators and waveguide/cavity resonators embedded into a PCR. Finally, a photonic membrane may be treated as a thin photonic crystal and in this capacity it exhibits properties of a two-dimensional system. The transfer from a photonic membrane to a photonic membrane resonator makes a 3D system from the initial 2D system.

In this work, we consider some important aspects of electromagnetic field behavior in membranes photonic crystals and PCRs. We develop the approach uniting both external and intrinsic problems, in-plane and out-of-plane geometries of incidence, and resonator properties of MPCs.

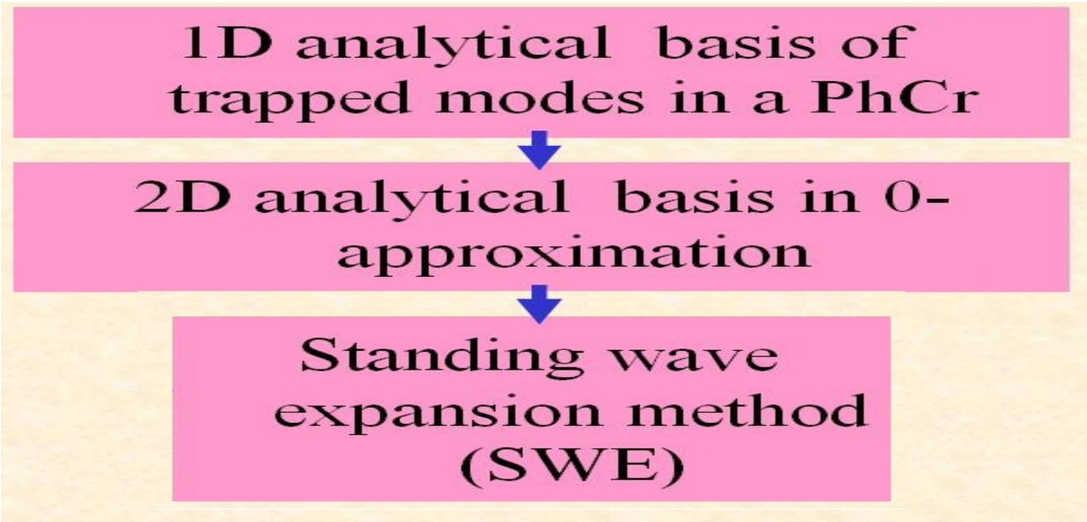

Fig. 3 A scheme of SWE method use. Two 1D bases generate the 2D analytical basis of standing waves which is a ground of SWE calculation of the eigenproblem for the electromagneric field in a resonator.

To summarise, the approach uniting both external and intrinsic problems, in-plane and out-of-plane geometries was developed to investigate resonator properties of MPC. We have considered light reflection in out-of-plane geometry for rectangular 2D photonic membrane resonators where the incident wave excites trapped standing waves. A novel analytical method SWE is developed to calculate the resonator in-plane standing modes excited by an external source. The proposed SWE method for finite resonators uses open boundary conditions and may be adapted for any symmetry of the lattice as well as for any shape of material 2 bars in matrix material. Finally, a conception of all-optical logic devices based on optical properties of PCR is developed.

1. Glushko, E.,Ya, Glushko, A., E., Evteev, V., N., Stepanyuk, A., N., "All-optical signal processing based on trapped modes of a photonic crystal resonator," Proc. SPIE 7354, 73540L (2009).