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Increasing Directional Intensity of Output Light Beam from Photonic Crystal Slab Outlet Including Micro Cavity Resonators

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Abstract**—**in this paper we modified a simple two-dimensional photonic crystal waveguide by creating micro cavity resonators in order to increase the output light emission which can be applicable to photonic integrated circuits. The micro cavity resonators are constructed by removing two tubes close to the waveguide output. Coupling emitted light from waveguide with those micro cavities, results increasing intensity of waveguide output light. Inserting a tube in last row of waveguide, we have improved directionality of output light beam.

Keywords**—**photonic crystal, waveguide, micro cavity resonators, directional emission

I. INTRODUCTION

PHOTONIC crystal (PC) has the potential to be a fundamental of future optical integrated circuits. Recently, a variety of devices such as a low loss waveguide circuit fibers, couplers and multiplexers are demonstrated on membranes of 2D PC [1]-[2], to make all optical systems. Coupling efficiency is an important subject to use the PC-based devices [3]. Coupling efficiency between PC waveguide and external optical components is low, because of difference in their refractive index and mode size [3] and diffracting the light emerging from the PC, in all directions [4].

To overcome the poor coupling efficiency of PCs, many investigations such as coupling via out-of-plane gratings, combinations of ridge waveguides and tapers, or evanescent coupling [5], micro cavity-to-waveguide side coupling system with a reflector at one end of the waveguide for the feedback [6] have been reported. But, applying these solutions to a compound semiconductor based with air cladding is very difficult [3]. In this paper we studied photonic crystals containing defects which have the ability to capture a particular light frequency around those defects.

The distinct advantage of our proposed structure is the lack of any complexity, which contains only absence of a few rods, close to the end of the waveguide. In addition, no modifications are made to the rods' radii and also there is no change in the crystal lattice constant.

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II. PROPOSED STRUCTURE

We considered a two dimensional slab PC with dielectric rod in air background. The lattice is square with r/a=0.2 with TE polarization. We calculated the dispersion diagram by means of PWE (plane wave equation). The band gap region extends from 2.267<λ/a<3.096 [7].

The simple waveguide is constructed by removing one column mediate tubes from photonic crystal slab. The input source is an adequately broadband Gaussian pulse with a frequency center at λ/a=2.503. This structure has spherical output beam intensity profile and the waveguide outlet behaves like a single source point that emits in air.

Two defects interned in regions close to the end of waveguide surface in (a,-a), (-a,-a) coordinate in x-z plan, as shown in Fig.1, that each one can act as a micro cavity resonator and drop distinct wavelength from input light. Fig. 2 shows the yield figure of each cavity.

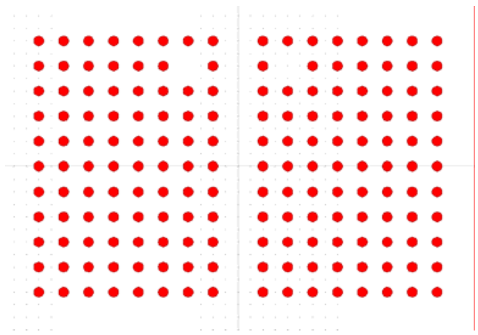

Fig.1 Schematic drawing of the square-lattice PC waveguide with 2 local micro cavity resonators at (a,-a) and (-a,-a) coordinate in x-z plan

III. RESULTS AND DISCUSSION

We have calculated the output intensity with respect to λ/a in different value of x axis at distance z=15a from PC surface, that shown in Fig. 3. The transmitted intensity has a maximum in λ/a =2.503 with transmission coefficient of 88%. In fact in this wavelength the cavities behave such as two point sources and the emitted waves interfere with transmitted wave from waveguide. The steady-state field profile evolution of the PC is showed in Fig. 4. In this figure, it can be seen the high directionality of light beam and weak transmission at two sides. In Fig. 5 we have compared intensity profile of PC waveguide without micro cavity resonator and PC waveguide with two micro cavity resonators for various x/a at z=15a from PC surface.

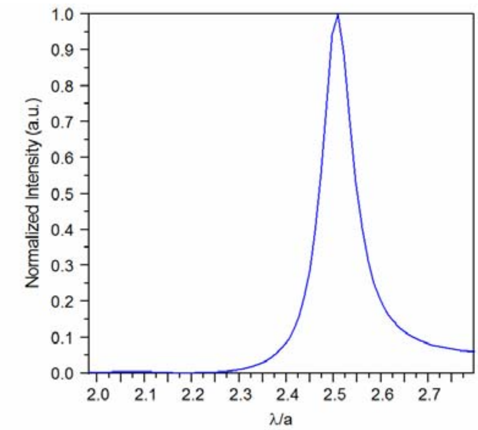

Fig. 2 Intensity profile in micro cavity resonator with respect to λ/a

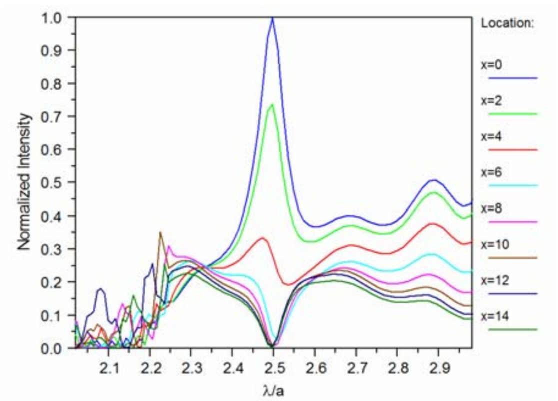

Fig. 3 Intensity profile computed in different x location at z=15a from PC surface for various λ/a

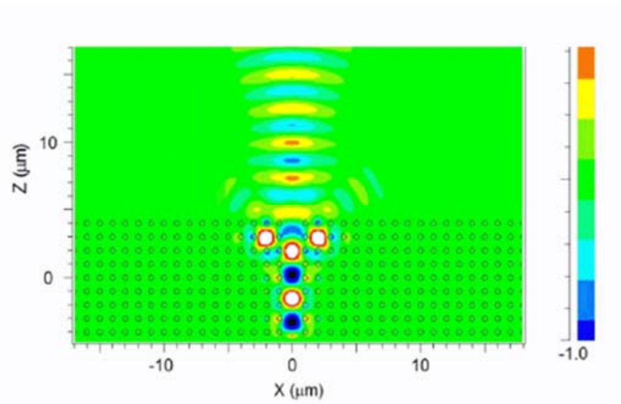

Fig. 4 Steady-state field profile evolution of the PC with 2 micro cavity resonators

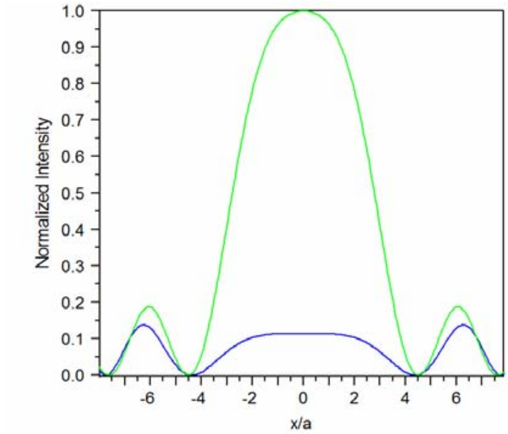

Fig. 5 Comparison of intensity profile of PC waveguide with no (blue line) and two micro cavity resonators (green line) for various x/a at z=15a

To achieve higher directional light beam, we locate one rod in last row of waveguide in our proposed structure. We have shown furrier expansion for this structure in Fig. 6. The light emitted from the waveguide in small interval wavelength and the rod at the end of the waveguide reflects the undesirable frequency and increases coupling the reflected light to micro cavity resonators.

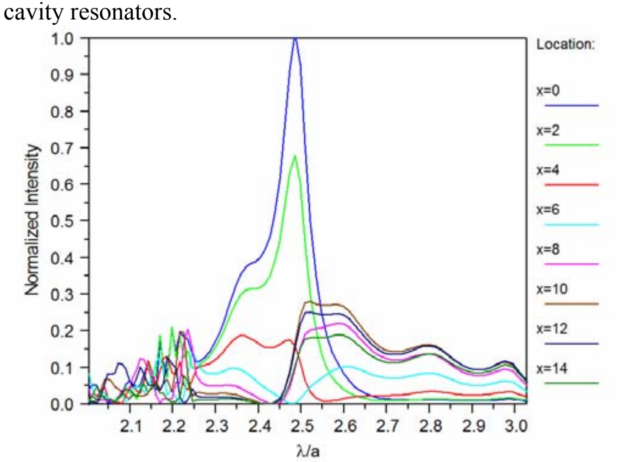

Fig. 6 Intensity profile in different x location at z=15a from PC surface for end closed PC waveguide

V. CONCLUSION

We have proposed very simple structure by creating micro cavity resonators in photonic crystal waveguide and demonstrated directional beams with 88% reduction in the beam divergence angle emerging from waveguide. High directionality of the proposed structure establishes it a good candidate for photonic integrated circuit applications.

ACKNOWLEDGMENT

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