2D Photonic Crystal Resonators with Time-Reversal Broken Symmetry and Nonreciprocal Components on Their Basis

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Nonreciprocal devices are important elements in integrated optics. They permit to mitigate the influence of parasitic reflections of electromagnetic signals from non-ideally matched components because the reflected light causes instabilities of lasers and amplifiers.

However, the traditional optical isolators and circulators have rather large dimensions, for example, the ferrite isolators based on Faraday effect have the length of several millimeters [1]. Besides they do not permit integration with other optical elements.

Our aim is a theoretical investigation of new compact non-reciprocal components based on 2D photonic crystal. The non-reciprocity of such components is defined by Time-reversal asymmetry of gyrotropic media, for example, the tensor of permeability of magnetized ferrites and the tensor of permittivity of semiconductors [1]. It is known that magneto-optic activity of the ferrites and magnetized semiconductors is very small. One of the ways to overcome this difficulty is the use of some resonant effects.

We present in our work some theoretical results of three-port optical circulator and non-reciprocal optical divisor based on a magneto-optical resonator on a 2D photonic crystal. The resonator is constructed by substituting an air hole by a post of Bismuth Iron Garnet (BIG) material. For theoretical simulations, the commercial software COMSOL MULTIPHYSICS was employed.

The components presented in our work (Fig. 1 and 2) are very compact because the physical principle of its functioning is a magneto-optical cavity. This cavity reduces the region of interaction necessary to a sub-wavelength scale due to the strong field concentration in the cavity which increases the gyrotropy effect.

In the following, we showed the simulation results of three-port optical circulator and non-reciprocal optical divisor. The first component allows to protect the source from the harmful reflections in the optical circuits connected to the source (isolation) and the second, fulfills simultaneously two functions: division and isolation of optical signals.

For the non-reciprocal optical divisor, the minimum number of ports is four: the input port (1), two output ports (2 and 4), where the input signal is divided, and an extra port (3), where the signals due to undesired reflections in ports 2 and 4 are collected so that the port 1 is isolated from ports 2 and 4.

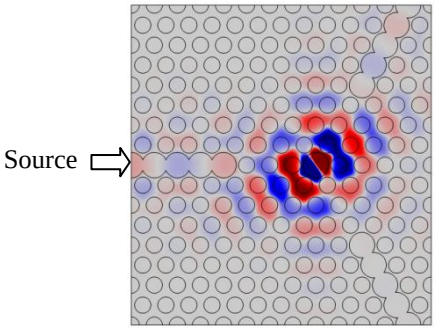

Fig. 1. Three-port optical circulator.

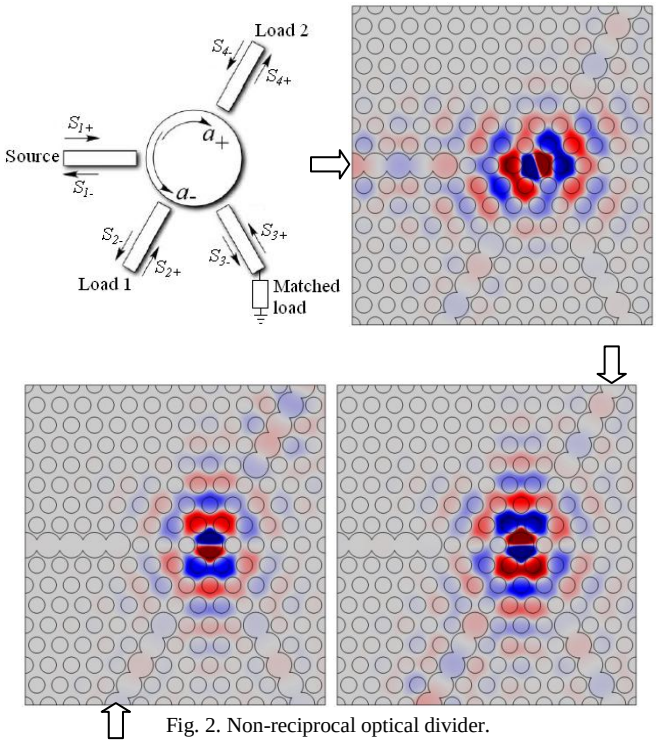

Fig. 2. Non-reciprocal optical divider.

REFERENCES

[1] A. Zvezdin and V. Kotov, Modern Magnetooptics and Magnetooptical Materials, Institute of Physics Publishing, Bristol and Philadelphia, 1997.

[2] Z. Wang and S. Fan, "Optical circulators in two-dimensional magneto-optical photonic crystal", Optics Letter., vol. 30, No 15, pp.1989-1991, 2005.