Optika

Yevtushenko D.A., Odarenko E.N.
Kharkiv National University of Radioelectronics, Ukraine
V. N. Karazin Kharkiv National University , Ukraine

INTERACTION OF THE ELECTROMAGNETIC RADIATION WITH TWO-DIMENSIONAL NONLINEAR PHOTONIC CRYSTAL

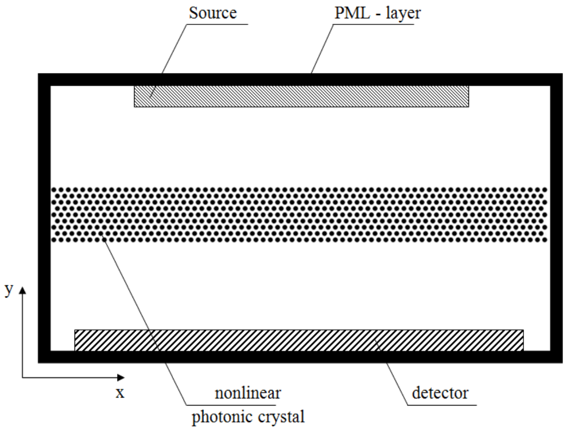
The spatial confinement of light is an important prerequisite for the excitation of interest of studying of photonic crystals and nonlinear optics. In physics, the idea of localization is generally associated with disorder that breaks translational invariance. However, researches in recent years have demonstrated that localization can occur in the absence of any disorder and solely due to nonlinearity, in the form of intrinsic localized modes [1].

From an engineering point of view an application of nonlinear effects in periodic structures leads to unusual consequences of interaction between light and photonic crystals, which could enhance their properties.

The nonlinearity of optical materials is essential if we wish to create nonlinear devices such as optical diodes, transistors, switches, and limiters [1].

Linear and nonlinear photonic crystals illuminated by plane wave are considered in this work. Kerr nonlinearity is assumed. The modeling of such structures and calculations of the dispersion diagrams and transmittance are performed in software packages MEEP and MPB [2, 3].

The photonic crystal structure that consists of infinity nonlinear cylinders is considered. This system of cylinders located in the air. Elements have radius equal to $r = 0.35a$ where a is the period of structure. The modeling structure is shown on Fig.1 and it contains source of radiation, detector for registration of the transmitted electromagnetic energy, PML-layer around the calculation domain and structure under investigation – nonlinear photonic crystal.



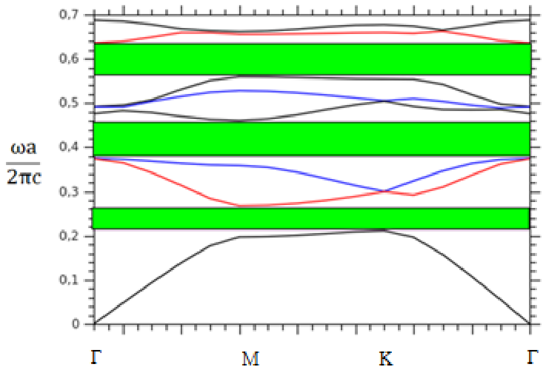


Fig. 1. Scheme of the structure for numerical

Fig. 2. Dispersion

Fig. 2 displays dispersion diagram of the dielectric photonic crystal. This diagram is calculated within the irreducible Brillouin zone. The *ordinate axis* shows the *normalized frequency*. There are some band gaps which indicated by horizontal stripes. It should be noted that the dispersion diagram of a nonlinear photonic crystal does not significantly differ from dispersion diagram of a dielectric photonic crystal.

Fig. 3 and Fig. 4 show the electric field distributions in the calculation domain for dielectric photonic crystal (Fig. 3) and nonlinear one (Fig. 4). The normalized radiation frequency is 0.57 that lies in the band gap (Fig. 2). It is clear that radiation did not pass through dielectric structure, due to the central frequency of radiation source which is located in the forbidden zone of dielectric photonic crystal (Fig. 2). In this case we can see superposition of incident and reflected waves between photonic crystal structure and radiation source. It is apparent that transmitted wave is absent because field decays exponentially in several periods of dielectric photonic crystal structure.

On Fig. 4, in contrast, the picture of field distribution of radiation for nonlinear photonic crystal shows transit of wave with the same frequency and amplitude. It should be noted that the wave transmission in the nonlinear photonic crystal is observed at high amplitude values. Also, self-focusing can be seen while radiation passes through the structure. Moreover the field concentration is realized within the nonlinear photonic crystal. This mode can be coupled with solitary waves propagation in the structure [4].

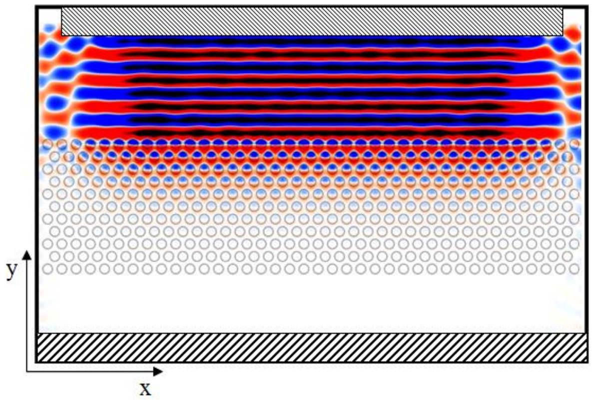


Fig.3. Field distributions for dielectric photonic crystal

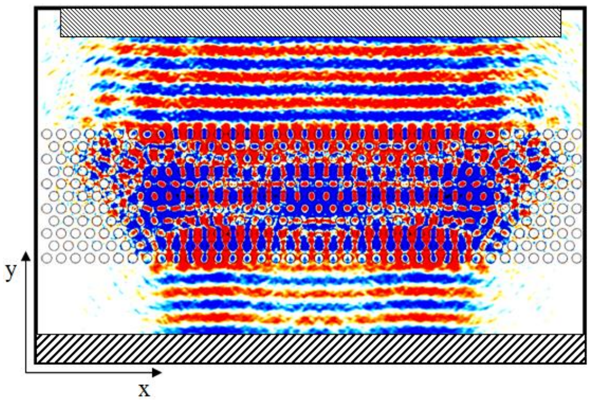


Fig.4. Field distributions for nonlinear photonic crystal

Consequently, Kerr nonlinear photonic crystal structures can be used in resonant systems and devices for dynamic control of optical radiation.

Литература:

1. Mingaleev S. F., Kivshar Yu. S., Sammut R. A., Long-range interaction and nonlinear localized modes in photonic crystal waveguides // Physical review E. –2000. – Vol. 62. – No 4
2. Oskooi A. F., Roundy D., Ibanescu M., Bermel P., Joannopoulos J. D., Johnson S. G. MEEP: A flexible free-software package for electromagnetic simulations by the FDTD method // Computer Physics Communications. – 2010. – Vol. 181. – P. 687–702.
3. Johnson S. G., Joannopoulos J. D. Block-iterative frequency-domain methods for Maxwell's equations in a planewave basis // Optics Express. – 2001, No 3. – pp. 173–190.
4. John S., Akozbek N. Nonlinear Optical Solitary Waves in a Photonic Band Gap // Physical Review Letters. – 1993. – Vol. 71. – No. 8. – pp. 1168-1171.