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PROSPECTS OF PHOTONIC CRYSTALS APPLICATION IN MODERN DATA PROCESSING SYSTEMS

Nowadays the increase of data processing rate using the latest achievements in the sphere of nanotechnology and optoelectronics is the problem of paramount importance. Photonic crystals have all the necessary features, enabling to provide complete or partial replacement of existing processing systems. But in spite of many advantages of such systems the problem of matching new elements with the existing ones has to be solved.

Key words: *photonic crystals, data processing, nanotechnology, optoelectronics.*

Topicality

Modern trends in the development of information processing systems with every passing e year require the increase of the rate and quality of the calculations performed by modern computers. Traditionally, this problem was solved by the increase of the clock frequency performance, increased memory, the development of new mathematical methods for processing and analysis. But to date, the growth of the quantitative characteristics does not meet the needs. Profound qualitative changes are to be realized for creation of basically new data processing systems .

Authors propose to solve the given problem in the following manner :

a) introduction at all stages of information processing optoelectronic component base;

b) synthesis of optical components based on photonic crystals, analogues of existing electric components.

Nowadays , there are no fundamental research that would integrate all the advances in optoelectronic circuit technology and nanotechnology. That is why, proceeding from these considerations, the article, devoted to the solution of this problem is relevant.

Purpose of research – analysis of existing data processing systems and search of the ways to integrate optoelectronic component base on photonic crystals into these systems.

Research problems:

1. To inspect and show the basic properties of photonic crystals.
2. Analyze the possibility of the introduction of elements based on photonic crystals in modern systems of data processing and analysis.

Solution of the problem

To date, the development of computer technology is impossible without the simultaneous development of computer components. Photonic crystals will become the core of the future computer components base, as they are the most successful solution for the implementation of optical integrated circuits.

Photonic crystals (PC) – are artificial periodic dielectric or semiconductor structures (materials) with band gap, which prevents the propagation of light in a certain frequency range [1, 2]. Creating point defects in such structures so-called "photon traps" can be realized, in which the propagation of light is not be possible outside their boundaries . Making up a combination of point defects basic elements of modern electrical circuits in photonic crystals can be realized, that will greatly improve the performance and quality of computations [2].

Depending on the number of non uniformity directions FC are divided into one-, two-and three-dimensional photonic crystals.

One-dimensional photonic crystal can be obtained by successive application of dielectric layers with different refractive indices, the so-called Bragg mirror. For example, a pair of dielectrics SiO_2 / TiO_2 while appllying five sandwiched layers, gives the reflection factor close to 99%.

Two-dimensional FC is obtained, forming a periodic structure of the vertical rods of silicon

(*Si*), planted on a substrate of silicon dioxide (*SiO_2*), or using macroporous silicon, in the structure of which "extra" macropores are removed.

Three-dimensional photonic crystals are regular symmetrical structure consisting of cubes or spheres arranged in cubic order.

Fig. 1 shows schematic representation of photonic crystals.

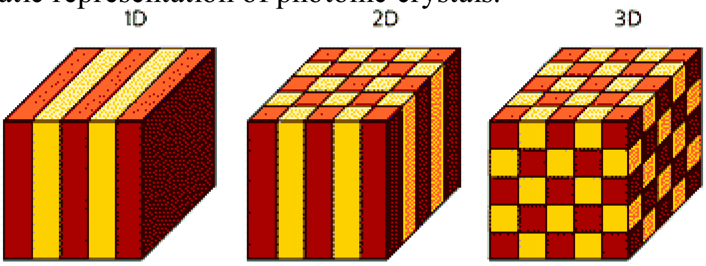

Fig. 1. Types of photonic crystals

Photonic crystals can be used to solve global problems, such as the creation of super-computers, based on photonic integrated circuits (PIC), as well as for solution of a number of complex functional tasks: turning the beam by 90 °, intersection of two waveguides, separate filtering of separate light wave from the total flow, and many others [3].

Let us consider the problem that occurs when routing fiber links – turn of fibers. Turning of the optical waveguide at which the losses are minimal, is possible if the radius is much larger than the wavelength. To meet this condition in integrated optics is rather difficult task, especially for wavelength of 1550 nm. It is better to consider the beam turn in this case in the plane of two-dimensional photonic crystal (Fig. 2).

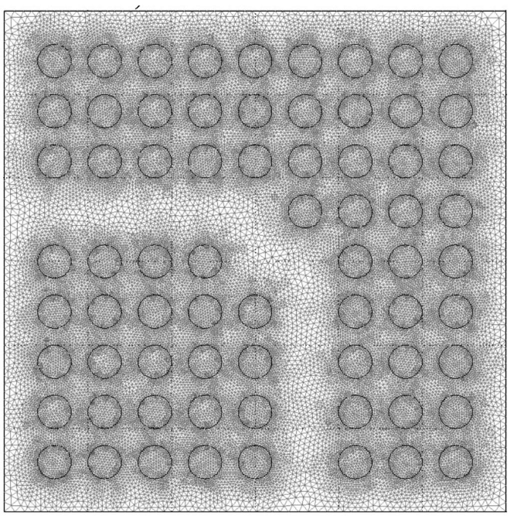

Fig. 2. Turning scheme in FC

The idea of rotation is reduced to removal of a number of rods in the direction of beam running, thus creating a linear defect. Materials for the manufacturing are taken depending on the wavelength, which will be distributed in the given channel, in particular, for visible range opal $SiO_2 \cdot nH_2O$ is used, for infrared range macroporous silicon is used. In this case, the radius of turn is $2a$, where a – is the lattice spacing [4]. The problem, dealing with the connection of fiber channel to FC is realized as direct contact between channel and crystal, bounded by integral implementation (Fig. 3).

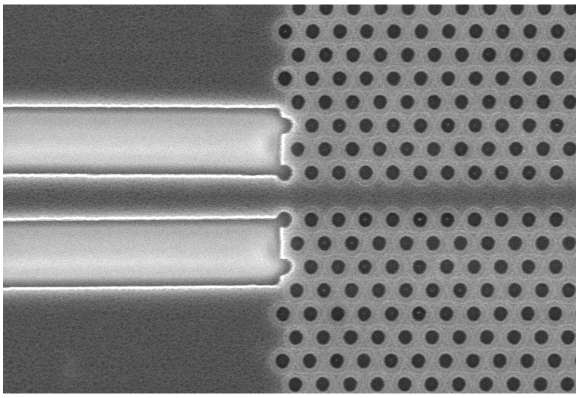

Fig. 3. Connecting of integral waveguide to FC

Such realization of the turn allows you to save on resources, using instead fiber FC, reduces several times the size of the circuit and minimizes the probability of signal loss or its attenuation.

Prerequisite for creating of the filter based on photonic crystals were DWDM and HDWDM technologies. It is based on the task of allocation of the total flow of carrier waves separately specified wave for its processing, routing, etc. Conventional band-pass filters are not suitable for these tasks, as they have high bandwidth and low quality, which results in unnecessary losses. [2] One of the known properties of the photonic crystal is selectivity in transmission of light waves, which is achieved by creating resonant defects in crystal structure, as it is shown in Fig. 4.

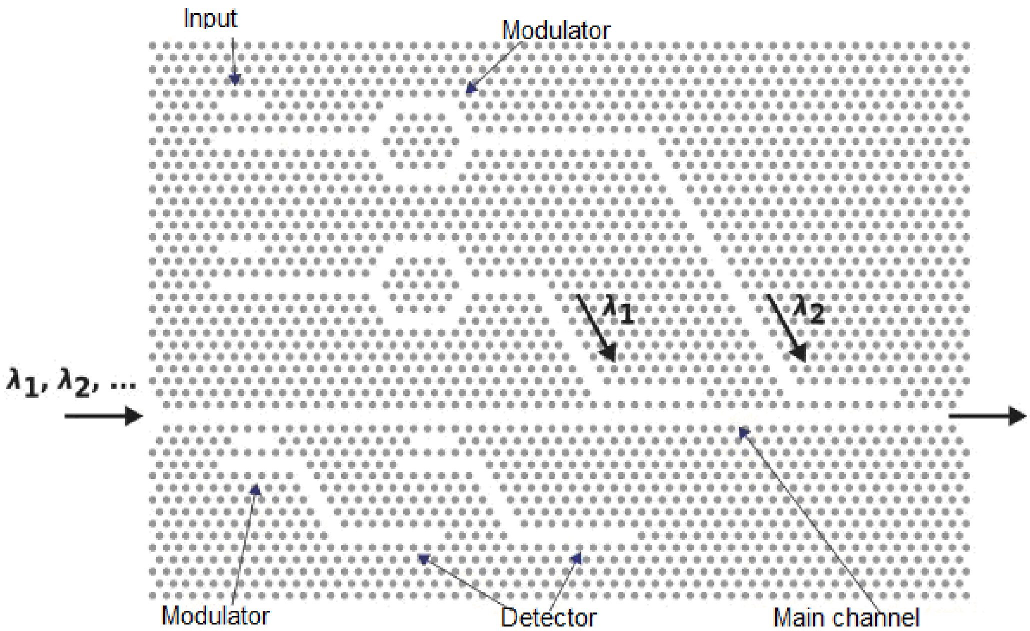

Fig. 4. Wave filtration by photonic crystal based structure

This approach allows to output the signal with a certain wavelength from the main channel , without creating disturbances for the rest of the waves, which are propagating in it. Also, it allows to realize the introduction of the signal into the main channel , provided that its propagation is allowed.

In modern information systems data are processed in electric format, i.e., on classic circuits using electric microprocessors, limited by operation rate and architectural implementation, the exchange between the structural elements of these systems is performed using optical technologies, including fibers. In this case the information is first processed, encoded into an optical signal, transmitted, decoded and then is processed in an electric format.

Double conversion of information from optical into electrical and vice versa is a major problem, and for its solution the authors propose to use photonic crystals, in future structures based on these crystals will replace the current processors.

For the manufacture of the crystals, there exist all the necessary technologies and methods: from the epitaxial growth, ending by photolithography. Most suitable for crystal creation, oriented on PIC, is a method of biphotonic polymerization, the essence of which is etching using lasers of irregularities with dimensions of a few nanometers [3]. Also, use of this method allows to build channels of arbitrary length and complex topology (example is shown in Fig. 5).

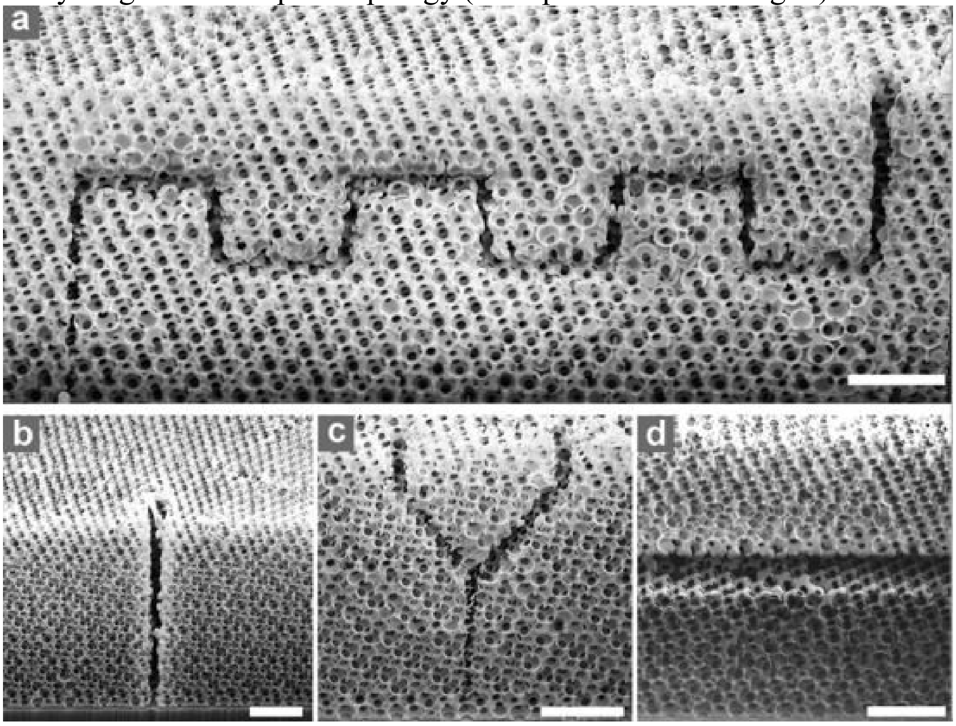

Fig. 5. FC channels etched by biphotonic polymerization

Conclusion

The analysis of the properties of photonic crystals suggests that the construction of optical elements and their integration into computer systems is attainable goal for which all the prerequisites are created.

The simplicity and accuracy of crystals manufacturing can significantly reduce losses in the process of data transmission and processing.

Exclusion from the cycle of active systems of signal conversion significantly reduces energy consumption, photonic crystal will become their analogue , which is based on the passive processing of data using the selective properties of the crystal itself.

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