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Metamaterial based photonic crystal fiber memory for optical computer

G. Palai[a,*], B. Nayak[a], Santosh Kumar Sahoo[b], Soumya Ranjan Nayak[c], S.K. Tripathy[d]

[a] Department of Electronics and Communication Engineering, Gandhi Institute for Technological Advancement (GITA), Bhubaneswar, 752054, India
[b] CVR college of Engineering, Hyderabad, India
[c] Department of CSE, K L University, Vaddeswaram, Guntur, Andhra Pradesh, 522502, India
[d] Department of Electronics and Communication Engineering, National Institute of Technology, Silchar, 788 010, India

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ABSTRACT

Photonic crystal fiber (PCF) based optical memory is discussed in this communication, which will be useful for optical computer. The proposed PCF is designed by using metamaterial structure, which bestows implausible upshot for envisaging optical memory in computer system. Present report uses two IR signals of 1300 nm and 1575 nm wavelengths to realize the aforementioned memory application, where 1300 nm acts as input signal and 1575 is used as excited signal. Moreover plane wave expansion technique is employed to study the modal analysis of electric-field distribution in the proposed photonic crystal fiber, where the variation of peak electricfield in the fiber is the basic operational principle of present discussion. Finally, this work avows that photonic crystal fiber with apt intrinsic parameters can be a suitable element for optical computer.

1. Introduction

The English proverb “slow and steady wins the race” is factual pertaining to tortoise and hare story from Aesop’s fable is going to be notional with respect to worldwide research in technology owing to the todays know-how is burgeoning as swift mode in such way that “fast and steady wins the race” [1]. The same can be acknowledged with respect to Moore’s law which vis-à-vis to ministration of optoelectronic devices [2]. Similarly research on information technology is hastily time to time with the help of nanotechnology. Furthermore the combination of information and nanotechnology bestows a fast communication using computer network. To achieve high speed computer network, each element or component of computer system should be emphasized for the same efficiency. To realize a speedily communication, researchers are speculating that light based computer would fetched an adequate efficiency as the desire of today’s generation as compared to current days electronic computer [3]. Moreover researchers are also considering that photonic based computer is an upcoming entrant to the world. However it takes delay to arrive in market due to fabrication feasibility and trapping of photons [4]. It is a device that uses photon in lieu of electron or electric current that performs a digital computation. As far as the limitation of today’s computer is concerned, electric current generates heat during digital computation in computer system [5]. Also the amount of heat increases due the increasing of speed of computer which leads to the generation of massive heat loss and as a result of which it damages the hardware component. However quantum of light (photon particle) creates insignificant amount of heat regardless of how much is used. Moreover with the help of the advantages of visible and infrared (IR) networks at the device or components of scale, this future computer could be pretended 10 or more times speed than that of a conventional electric

* Corresponding author. Tel.: +91 9439045946.
E-mail addresses: gpalai28@gmail.com, g_pallai@yahoo.co.uk (G. Palai).

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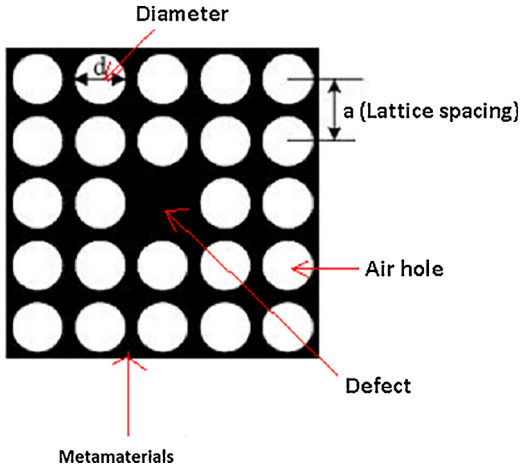

Fig. 1. Schematic diagram of metamaterial based photonic crystal fiber.

computer. Another, advantage of optical computer is due to non-effect of photon beams, but the interaction of electron beams creates predicament in the system.Therefore now a day's most research projects are being focused on the replacing of current computer components with optical elements. Resulting photonic digital computation system processing would be faster [6]. Though this paper states about the speed of the computer or optical computer,each component of the same plays vital role to make high speed computer.Out of different element of optical computer, optical memory is a key element of the same, which is discussed in this article using metamaterial structure. Again considering today's electric memory, semiconductor grating have widely been used now-a-days which relay on magnetic memory of molecular scale. Because of tiny molecules, it is '0′ when beam is magnetized and '1′ with respect to demagnetization which is equivalent to 0,1 bits. The principle of optical memory is similar to the same. However the intrinsic material is different from existing semiconducting magnetic materials. Because, this article uses metamaterial based photonic crystal fiber, that is the combination of PCF and metamaterial which belongs to the application of optical metamaterials. As far as literature survey on metamaterial isconcerned, though many works have been carrying out using the same, few works with respect to flabbergast upshot have been divulged in international journal of light and electron optics (OPTIK) [7–9].Also although few works related to sensing and communication have been realised using similar structure, the proposed structure in this paper discloses new type of application embedded with metamaterial structure [10,11].

This manuscript is organized as follows; Section 2 discusses the operational principle including the intrinsic structure of proposed PCF using metamaterial and results and simulation is discussed in Section 3. Finally conclusion is drawn in Section 4.

2. Structure and operational principle

Before going to discuss the principle of operation, lets us concentrate on metamaterial based photonic crystal fiber structure which is shown in Fig. 1 and it is represented as the cross sectional view of two dimensional square type photonic crystal fiber.

From Fig. 1, it is seen that 5 × 5 air holes are etched on metamaterial substrate in such way that defect is made at center (no etching of air hole). To get several memory applications, this article choose a specific values of lattice spacing and diameter of 10 nm and 8.4 nm respectively. The reason for selecting such structure and dimension is that to realize photonic based memory application. As far as operational principle of memory is concerned, it deals with the storing of signal and retrieving the same at the time of requirement. Since this work deals with optical memory, two different wavelengths are manipulated with aforementionedstructure, where first wavelength is represented as storing signals and second wavelength can be considered as retrieving the same input from the structure. Moreover the following schematic diagrams explain lucidly to envisage the same.

Fig. 2(a) represents, signal 1300 nm is incident to photonic crystal fiber (structure of Fig. 1), where Fig. 2(b) explains, the storing of signal 1300 nm with same and the storing of signal can be understood from R = 0, A = 1, T = 0 (zero reflection and transmission and 100% absorption). It indicates, the aforementioned photonic structure, does not reflect and transmit any signal, whereas all signals are absorbed by it.So it is affirmed that the applied signal is completely absorbed by said PCF. Similarly Fig. 2(c) shows the retrieves of same signal from same photonic crystal fiber. For example, the wavelength of 1575 nm acts as supply signal which is applied to metamaterial based PCF to retrieve of the signal1300 nm. The same can be realized by considering A = 0, R = 0 and T = 1. It indicates that absorbing or storing signal corresponding to the wavelength of 1300 nm is getting transmitted rather reflected or absorbed. Moreover an interestingly, it is revealed that the nature of the structure and dimension of PCF for step-1, 2 and 3 remains stationary.

The reason for above said interesting result is due to the nature of materials(metamaterial) along with structure diameter. Metamaterial is an extraordinary material which exhibits superior properties and bestows unbelievable application pertaining to current research scenario. Again, this interesting application of metamaterials lies with size of device with respect to incident signal (wavelength of signal). It is observed that size of the device is less than wavelength of signaland it is represented as metamaterial