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Realization of efficient transmitter and absorber using X structure at nano scale

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ABSTRACT

High transmittance and absorbance of X photonic structure at 193.5 THZ frequency pertaining to nano scale is reported in this research. Finite element method (FEM) manipulates with said structure forrealizing an efficient transmitter and absorber. The outcomes of the simulation work divulge that X structure can be good candidate for both transmitter and absorber and it relies on the nature and configuration of both substrate and introducing materials.

1. Introduction

Research on nano-devices is burgeoning time to time now a days owing to its exciting behavior pertaining to efficient performance and robust application. So recently, people from academic institution, industry, scientist from R & D sector taking interest towards miniaturization devices rather than conventional bulky devices. Moreover currently nano devices are being investigated with respect to various applications including sensing, communication, and networking and computing. Keeping the importance of nano devices for different application, we in this work design a new kind of structure realizing both transmitter as well as absorber. The reason for choosing such miniature structure is that such proposed devices explores high transmittance and absorbance at 193.5 THz frequency. The above said frequency is widely used for various communication purposes and also it belongs to third optical communication windows. Moreover the investigation of transmittance and absorbance pertaining to aforementioned devices is realized by the manipulation of finite element method with the same. Though the present research claims new structure and novel application, few works similar to the same have appeared in literature. For example in reference [1], authors discuss high transmittance devices using 1 D grating SOI structure for 1000 nm and 1250 nm signal. Though this upshot explores an efficiency of more than 99% it has couple of limitations including size of devices (mm) and operating signal (which are not belong to any communication window). Similarly in reference [2], one dimensional nano scale polymer device is considered to realize high transmittance at 1550 nm. Though it operates at third window but defect has been incorporated with it which leads to hard to fabricate and design. Recently [3,4] explores high transmittance devices using similar fashion using polymers and semiconductor materials respectively at different optical windows. Further moving to proposed structure here the article deals with X structure for aforementioned application. As far as X structure is concerned a few application have seen in literature. For example in reference [5], optical logic gate is designed using X type photonic structure Also communication based application is made in reference [6].

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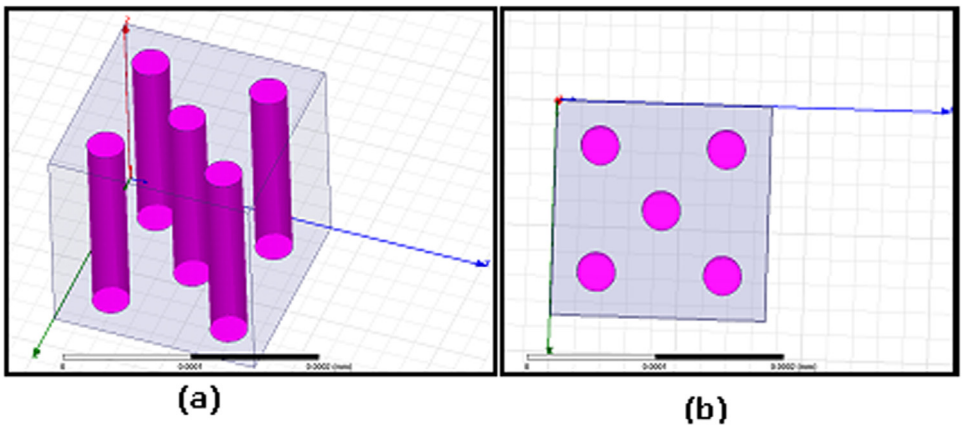

Fig. 1. Schematic diagram of proposed X structure 3D (Fig. 1(a)) and 2D (figure (b)).

Though aforementioned work explores different upshot, reference [1–4] employs 1D grating structure for investigating high transmittance only, where reference [5,6] use X structure for revealing single type of application but the present work proposes X structure for examining double applications of transmitter and absorber at signal 1550 nm wavelength.

2. Proposed structure and principle of operation

The high transmittance and absorbance structure which has considered in this paper is simple and similar to the X structure is shown in Fig. 1.

Fig. 1(a) and (b) represent 3D and 2D view of the proposed X photonic structure respectively. As far as intrinsic material is concerned it is based on silicon as background material and subsequently five holes have been etched on it. Then nanometer size of ferrite rods have been arranged in the shape of an English alphabet X. As far as dimension of concerned, this work deals with 30 × 30 nm substrate with 6 nm is the diameter of ferrite rods. However the height of the ferrite rod is differed from different applications. For example, high transmittance application can be realized by considering the height of ferrite rod is taken of 25 nm. Further decrease the height of rod and keeping static to other parameter (diameter of substrate rod and dimension of silicon substrate) it is accomplishing as good absorber. As far as principle of operation is concerned, it is based on the interaction of IR signal of 193.5 THz with above said silicon with ferrite structure which divulges both transmitter and absorber application. Further the said application relies on nature, position and configuration of the proposed structure. For example the height of ferrite rod in the Fig. 1 decides the control of signal pertaining to either transmitter or absorber.

3. Simulation result and discussion

Finite element method based high frequency structure software (HFSS) is used to make simulation of proposed structure to envisage both transmitter and absorber. To accomplish the same, suggested photonic X structure is a function of nature of material, position and configuration of the structure including the dimension of the substrate and infiltrating material. The above said application can be accomplished by computing S_{11} and S_{12} parameter, where S_{11} represents input and output can be measured at port 1 (same end) and S_{12} represents as input at port one and output at port 2. Since this paper deals with both transmitter and absorber, we discuss two application using X structure with the help of S_{11} and S_{12} parameter. In this case signal of 193.5 THz interact with X structure Fig. 1 where dimension of silicon substrate is taken of 30 nm × 30 nm, height and diameter of the ferrite rod is taken of 25 nm and 6 nm respectively.Under this condition, the simulation result for S_{11} and S_{12} is mentioned in the Fig. 2(a) and (b) respectively.

Fig. 2(a) and (b) represent $S_{11\text{ and }}S_{12}$ parameter of silicon based X structure (30 nm × 30 nm) with the infiltration of ferrite rod having height 25 nm. Technical interpretation indicates the reflection and transmission of a signal is nothing but S_{11} and S_{12} parameter respectively. In Fig. 2, loss parameter in dB is taken along vertical axis, where frequency in THz is taken along horizontal axis. Though above graphs compute the loss parameter corresponding to many frequencies, we concentrate on 193.5 THz frequency because structure have been set for above said frequency as it belongs to third communication windows. Further it is also being widely used for communication purposes. From Fig. 2(a) it is seen that loss parameter is about −53.23 dB, which indicates 0.0075% of signal is reflected using formula L (dB) = −10 log (P_{in}/P_{out})., however from Fig. 2(b) the same (S_{12})is −2.3 dB, furthermore it shows 99.999% is transmitted through aforementioned X structure.

From above expansion, it is reveal that if height of the ferrite material is comparable with substrate dimension, then proposed structure can be a good transmitter. Again moving to realize absorber, All parameters of said structure is invariant except the height of the rod. For example, we intentionally drop the height of the rod to 5 nm, which is very less as compared