NAME OF THE THEME: Physical & Mathematical Sciences

Tuning of Photonic Bandgap for Switching Applications

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Introduction:

Photonic crystals are the result of periodic arrangement of refractive index. Due to continuous variations in the refractive index, they form a bandgap called photonic bandgap and allow certain frequencies often referred as eigen frequencies [1]. These eigen frequencies depend on the geometry of structure and the material used. In the proposed system, a continuous variation in photonic bandgap is achieved, by varying refractive index of the material due to applied electric field. This technique resulted with sizeable changes in photonic bandgap, altering neither geometry nor material.

In this work a triangular lattice based photonic crystal with air holes is chosen as this is the prominent structure for observing real and large bandgap [2]. An electric field varying between 5 kV/cm and 100 kV/cm is considered and the corresponding refractive indices are calculated using quadratic electro-optic effect. The proposed design can have the applications in optical switching and routing devices.

Methods:

The refractive index of an electro optic medium is a function of applied electric field [3] and the effect is referred as electro optic effect. For the quadratic electro optic effect, the refractive index takes the form as,

$$n(E) = n - \frac{1}{2}\beta n^3 E^2 \qquad (1)$$

where 'β' is called as quadratic electro optic coefficient or Kerr coefficient. Its value depends on the medium chosen and ranges between 10^{-18} and 10^{-14}. For simulating the system, air holes arranged in a triangular lattice is considered in the GaAs substrate. And it is assumed that the structure is placed in an electric field. The refractive index of GaAs at these field values is calculated using equation (1) and [4]. MPB software is used for simulation and the corresponding band diagrams were obtained.

Results and Conclusions:

The initial observations indicate that there is a shift in the photonic bandgap. To find this, for TE modes 1, 2 band positions and for TM modes 2, 3 band positions are plotted against the applied electric field. These bands are chosen because of the clear bandgap. The plots show that the bands are shifting with the applied electric field. As a result, eigen frequency of the system will be changed. The shift in bandgap is calculated and it is of the order of 10^{-4}. Even though this value is small, higher shifts can be attained by introducing defects in the structure. The proposed system can be used in optical switching, and routing in photonic networks.

Quadratic elctro optic effect based photonic crystals with triangular lattice are proposed and the effect of applied electric field on bandgap is simulated. The results reveal that there is a clear change in the bandgap with applied filed.

References:

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