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The Propagation of Light in Photonic Crystal by Visualization of Photonic Band Structure

KEYWORDS: photonic band gap, Impurity, light

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ABSTRACT *In photonic band gap, light cannot enter the crystal because the band gap acts as an insulator of light and the light velocity changes from velocity of light to zero and thus light and matter interaction is controlled. The existence of photonic band gap is a forbidden gap for photons in which location of light and spontaneous emission of light can be controlled by adding controlled amount of impurities and also by artificially introduced defects which in turn finds wide applications in scientific and engineering fields.*

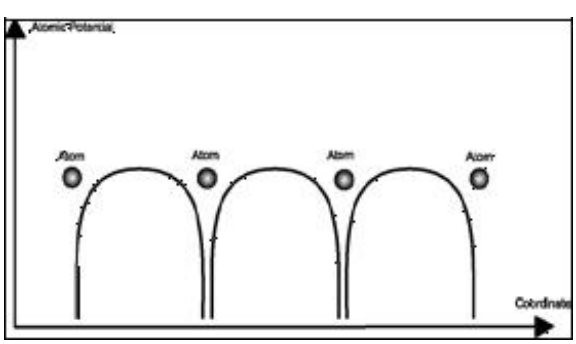
1.1.1: INTRODUCTION

Photonic Crystal:

In photonic crystals, the dielectric medium is periodically ar-ranged such that between any two dielectric regions there exist gaps (or) separations called as band gaps similar to that of periodic potential regions in a metal. The study of motion of electron is described by kronig-penney model in periodic potential regions in a metal and the study of photonic crystals [1] can be done by Bloch-Floquet theorem.

The propagation of light in photonic crystal can be studied by four Maxwell equations which are to be modified for the study of photonic crystals. Photonic crystal consists of regular arrays of materials with different dielectric constant with the period of order of optical wavelength and the spatial periodic distance of the crystal is called lattice constant 'a'.

Figure 1: Electron moves in periodic potential fields.



Sources: Wikipedia

1.1.2 : 2D & 3D photonic crystals:

Photonic Crystal can control light freely by using 2D & 3D photonic crystals. The 2D photonic band structure possess band gap near infrared region and in 3D photonic crystal, full band gap can be obtained.

The existence of photonic band gap is a forbidden gap for photons [2]. Light cannot enter this region as well as electrons cannot enter this region as well as electrons cannot emit photons, thus it acts as insulator of light [3].

2D Photonic crystals have close packed triangular lattice and 3D photonic crystal have FCC lattice and diamond like struc-ture and both have band gap in TE and TM modes.

According to classical theory and quantum theory electron moves in a constant (zero) potential field established by the positive ions but in a real substance (metal) electron moves in a periodic potential fields such that potential energy is min-imum near positive ion and maximum in between 2 positive ions. At the surface potential energy[3] is very large (or) in-finite for simplicity the periodic variation of potential energy is considered in rectangular steps which consists of potential well of barrier in which Schrodinger equation for the motion of electron is considered.

For the potential barrier strength(P) tends to zero leads to the situation of an isolated (single) atom where energy level is quantized and for P tends to infinity leads to results of clas-sical theory where electron possess only kinetic energy and electron behaves as free particle.

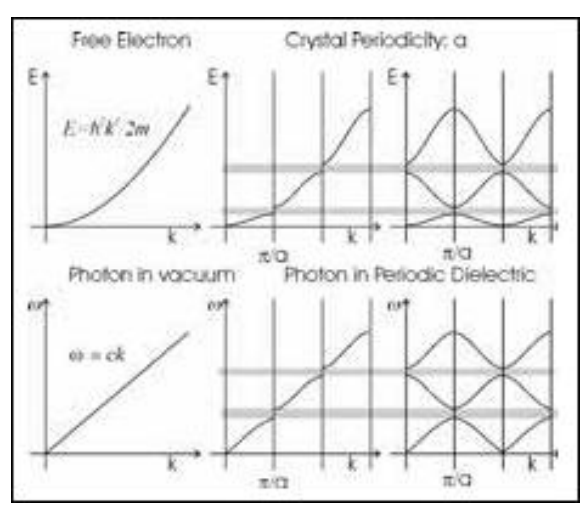


Figure 2: Band diagrams and photonic band gaps.

1.2.1: Results and Discussion: Role of photonic band gap.

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lar to that of periodic potential regions in a metal. The study of motion of electron is described by kronig-penney model and Bloch the-orem in periodic potential regions in a metal and the study of photonic crystals can be done by Bloch-Floquet theorem.

Photonic bands predict the behavior of light accurately [2]. In photonic band gap, light cannot enter the crystal be-cause and gap acts as an insulator of light and the light velocity will be changed from velocity of light to zero and thus light and matter interaction is controlled.

The existence of photonic band gap is a forbidden gap for photons. Light cannot enter this region thus it acts as insu-lator of light [3].

The basic phenomenon is based on diffraction in photonic crystals[6] and they are fabricated by the methods used in semiconductor industry of etching and photo lithography technique.

PC can control light freely by using 2D & 3D photonic crystals. The 2D photonic band structure possess band gap near infra-red region and in 3D photonic crystal, full band gap can be obtained.

2D Photonic crystals have close packed triangular lat-tice and 3D photonic crystal [1] have FCC lattice and dia-mond like structure and both have band gap in TE and TM modes.

By adding controlled amount of impurities in photonic band gaps the location of light and spontaneous emission of light can be controlled and also by artificially introduced defects PC finds wide applications in scientific and engi-neering fields.

Using PC, PCF can be fabricated such as holey fiber, pho-tonic band gap fiber and Bragg fiber.

A two dimensional photonic crystal [5] can be imagined to have material in a square lattice of dielectric columns. The columns may be considered as tall cylinders along Z direction where the material is homogeneous and periodic along the material is homogenous and periodic along X & Y directions with lattice constant 'a'

The band structure[4] of transverse – electric (TE) modes and transverse magnetic (TM) modes are completely differ-ent be-cause there may exist photonic band gap for one polarization only and photonic band gap for another po-larization may not exist at all.

CONCLUSIONS:

The main problem of a fiber optic cable is its attenuation and in order to overcome this problems photonic crystal fiber (PCF) which is based on the properties of photonic crystals can be used.

A photonic band gap (PBG) crystal is a structure that could manipulate beams of light in the same way as metal (or) sem-iconductor crystal which affects the electron motion due to the presence of allowed and unallowed zones (or) energy bands.

A semiconductor cannot support electrons of energy ly-ing in the electronic band gap. Similarly, a photonic crystal cannot support photons lying in the photonic band gap.

Photonic crystals have periodic repeating and alternately ar-ranged dielectric regions of different values of dielectric con-stant with a band gap that forbids the propagation of certain light frequency range and thus light processing can be done By preventing or allowing light to propagate through a crystal.

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