Photonic Band Structure Formed By Moirè Patterns For Terahertz Applications

R. Rachel Darthy[1], C. Venkateswaran[1], N. Yogesh[1]

[1]University of madras (Guindy Campus), Chennai, Tamil Nadu, India

Abstract

Photonic crystals (PhCs) are the periodic arrangement of dielectric structures in one, two and three dimensions offer unprecedented control of light including inhibition of spontaneous emission, negative refraction, self-collimation and confinement. Due to the advent of three-dimensional printing technique, one can explore variety of geometrical structures for novel control of light. In this work, we have realized a photonic crystal formed by Moirè patterns. Moirè patterns are the contours of trigonometric functions which is represented by the equation (Fig.1(a)),

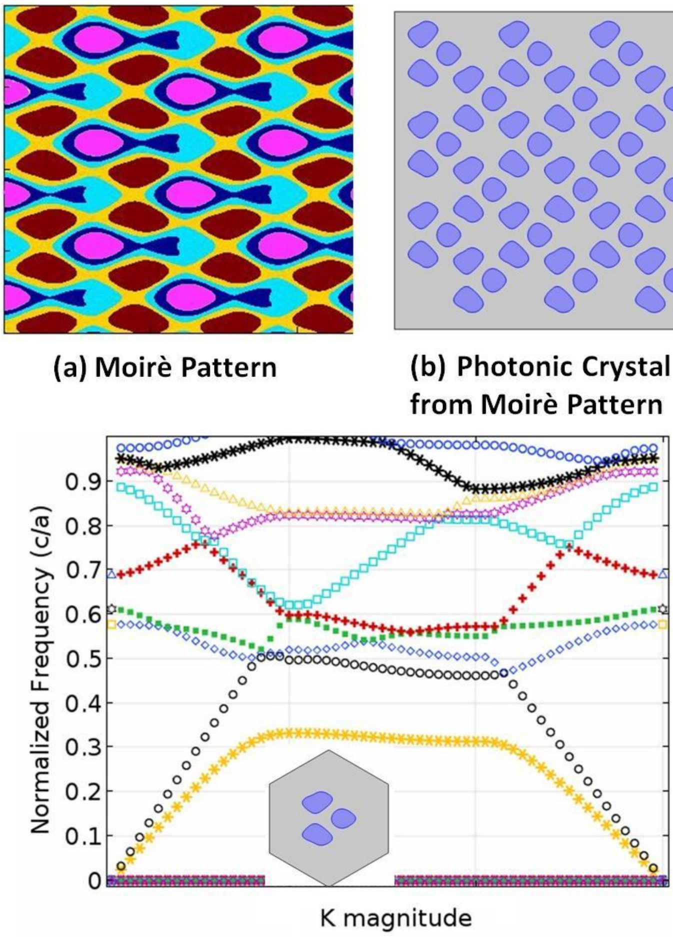
$$z = \alpha \sin(x_1) + \beta \cos(y_1) \begin{cases} x_1 = a \sin(Ix) + b \cos(Jy) \\ y_1 = c \cos(Kx) + D \sin(Ly) \end{cases}$$

, which gives additional degrees of freedom to mould light radiation. Band structure of the proposed PhC, derived out of the Moirè pattern (Fig. 1(b) and Fig. 1(c)) is obtained using Finite-element methodology based electromagnetic solver COMSOL RF module accompanied with Matlab. The material geometry is implemented through Matlab and imported to COMSOL RF module for eigenfrequency analysis to get the photonic bandstructure. The computational domain involves a unit cell of PhC and Bloch's wavevectors corresponding to irreducible Brillouine zone is used for eigenvalue search. Before computing the bandstructure of proposed PhC, benchmark has been done with well known open source bandstructure solver MPB. It's is calculated that the first bandgap for proposed structure for transverse electric (TE) polarization spans from 0.3274 (c/a) to 0.5022 (c/a). This corresponds to 9.8 GHz to 15 GHz for lattice constant of 1 cm. The properties of proposed Phcs are explored for realizing Terahertz optical devices such as cavity resonators and waveguide channels for which we have optimized the structure for THz range with the lattice constant of 10 µm with the filling fraction of 25%. The dielectric constant of THz PhC is taken to be 12. For normal incidence, the primary bandgap has been obtained from the range of 7.92 THz to 9.25 THz and secondary bandgap with a narrow steep is witnessed from 12.88 THz to 17.12 THz. The present work suggests that obtaining photonic bandstructure for complex dielectric profiles such as Moire pattern is possible and with this feature, one can explore wave controlling devices at any possible electromagnetic

spectrum, especially THz frequencies. We thank DST- INSPIRE Faculty Fellowship (**DST/INSPIRE/04/2015/002420**) for the research support.

Figures used in the abstract

Figure 1



(a) Moirè Pattern

(b) Photonic Crystal from Moirè Pattern

(c) Photonic band structure of Moirè PhC. Unit cell is given in inset.