Emergence of topological features in a periodic lattice operating at C-band

Sayan Bhattacherjee*, Somnath Ghosh
[1]Department of Physics, Indian Institute of Technology Jodhpur, Rajasthan-342037, India
E-mail: *bsayan1992@gmail.com

1. Introduction

Topological photonics has emerged as an efficient tool to mould the flow of light. Topology is the branch of science, which deals with the properties related to the geometry of the systems. These systems support robust topologically protected states, unidirectional light propagation as well as a versatile platform for various experiments related to light matter interaction [1, 2]. Already reported one-dimensional systems exhibiting these characteristics are based on Abry-André-Harper (AAH) or Su-Schrieffer-Heeger (SSH) models [3, 4]. However, in this paper, for the first time, we report a spatially modulated periodic system exhibiting non-trivial behavior at 1550nm. Non-trivial nature is claimed by virtue of the light propagation dynamics as well as photonic band-gap character of the reported lattice. Further spectrums of the lattices are calculated exhibiting promising technicality.

2. Design of the optical waveguide and results

Schematic of refractive index (r.i.) variation for a periodic photonic lattice of 150 bi-layers is shown by Fig. 1(a). The r.i. of the bulk is 1.46 on which alternate layers are grown of 6μm thickness at a distance of 7μm having r.i. of 1.5. A Gaussian beam is launched at the 76th bi-layer having a FWHM of 8μm whose dynamics is being studied using scalar beam propagation method under the paraxial approximation. The propagation dynamics is shown by Fig. 1(c). The leaky nature of the propagating beam with multiple ripples on both sides of the central maximum indicates the nature of Bloch wave. However, by reducing the thickness of the higher r.i. layer to 0.6μm this propagation dynamic is affected. The schematic of refractive index (r.i.) variation for this spatialty lattice is given by Fig. 1 (b) and the light propagation dynamics is given by Fig. 1(d). It can be seen that the waveform does not have ripples neither it is smooth but are full of kinks along the transverse width which does not resembles the Bloch nature. Thus, the light propagation is not trivial in nature through this lattice. Further, we also analyzed the photonic band-gap behavior of these lattices. The band-gap plot for the trivial lattice is shown by Fig. 1(e). It can be seen that the band-gap plot resembles a closed contour like formation. However, for the non-trivial lattice, band-gap does not resemble a closed contour like formation as can be seen from Fig. 1(f). Next, considering the fact that systems can be written in the form of Hamiltonians, we have computed the system Hamiltonians for both the lattices and calculated their spectrum. The spectrums for the trivial and non-trivial lattices are shown by Fig 1(g) and (h) respectively. The method of calculating the spectrum would be described during the presentation. The astonishing observation from these plots are that the central valley of the upper band for the trivial lattice had coinciding eigen-value with central peak of the lower band for the non-trivial lattice.

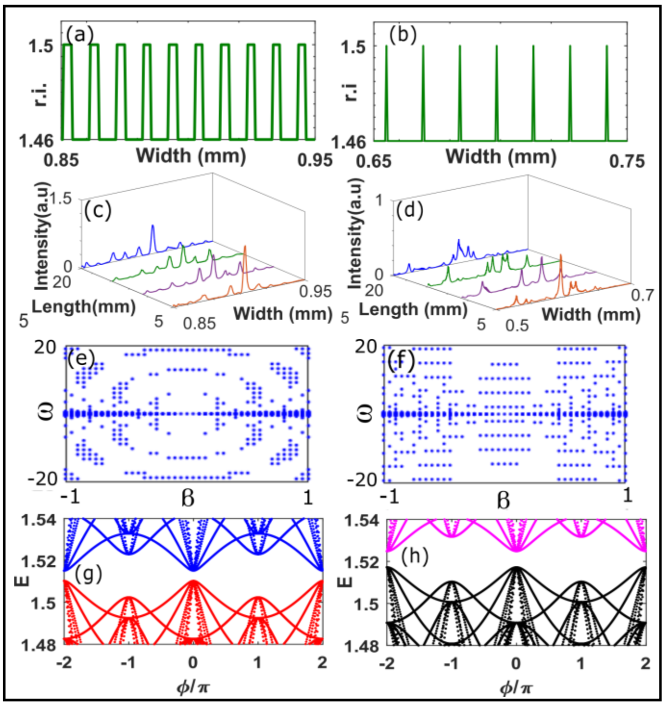

Fig. 1: Schematic of r.i. variation of (a) 1D periodic waveguide lattice over a small region consisting of 150 bi-layers and (b) spatially modulated lattice over a small region where the thickness of one of the layer is changed. The wave propagation dynamics through the (c) periodic lattice showing the trivial leaky nature along with evanescent tail and (d) spatially modulated lattice showing peculiar non-trivial behavior with multiple kinks devoid of evanescent tail. Photonic band-gap for the (e) trivial lattice showing a closed contour like plot and (f) for the spatially modulated lattice showing an open contour like plot. Spectrum of the (g) trivial lattice showing the two distinct bands with a gap and (h) of the spatially modulated non-trivial lattice showing the two distinct bands with a gap due to its purely periodic nature.

3. Conclusion

In summary, we propose the existence of a non-trivial topology in a periodic lattice working at C-band. It can be predicted that a topologically protected state would be supported at the junction of a hybrid lattice comprising of these two trivial and non-trivial lattices.

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