Efficient modeling of light propagation in three-dimensional photonic crystals

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Here, we have developed an efficient approximate technique to study the beam propagation through three-dimensional photonic crystals. We show that the beam diffraction in these structures can be analyzed by a two-component diffractive index model. This model simplifies the study of beam diffraction in these structures by reducing the computation time considerably and by drawing analogies with ordinary diffraction effects. Also, we compare the beam profile obtained in this model to that of a conventional modal approach to emphasize its excellent accuracy in simulating the diffraction properties of photonic crystals.

Using this model we can engineer the band structure to exploit appropriate diffraction properties in addition to the desirable refraction and superprism effects. We report on negative diffraction to focus the light beam at the output plane in addition to negative refraction to separate the desired signal from the unwanted input waves. We demonstrate that by exploiting these two effects along with the superprism effect we can properly engineer the propagation of light for applications such as wavelength demultiplexing and multiplex spectroscopy.