

Beam Deflection with Unidirectionality Due to Zeroth Order and Evanescent Wave Coupling in a Photonic Crystal with a Defect Layer without Corrugations under Oblique Incidence

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Abstract : Single beam deflection and unidirectional transmission are examined for oblique incidence in a Photonic Crystal (PC) structure which employs defect layer instead of surface corrugations at the interfaces. In all of the studied cases, the defect layer is placed such that the symmetry is broken. Two types of deflection are observed depending on whether the zeroth order is coupled or not. These two scenarios can be distinguished from each other by considering the simulated field distribution in PC. In the first deflection type, Floquet-Bloch mode enables zeroth order coupling. The energy of the zeroth order is redistributed between the diffraction orders at the defect layer, providing deflection. In the second type, when zeroth order is not coupled, strong diffractions cause blazing and the evanescent waves deliver energy to higher order diffraction modes. Simulated isofrequency contours can be utilized to estimate the coupling behavior. The defect layer is placed at varying rows, preserving the asymmetry of PC while evanescent waves can still couple to higher order modes. Even for deeply buried defect layer, asymmetric transmission and beam deflection are still encountered when the zeroth order is not coupled. We assume $\epsilon=11.4$ (refractive index close to that of GaAs and Si) for the PC rods. A possible operation wavelength can be within microwave and infrared range. Since the suggested material is low loss, the structure can be scaled down to operate higher frequencies. Thus, a sample operation wavelength is selected as $1.5\mu\text{m}$. Although the structure employs no surface corrugations transmission value $T\approx 0.97$ can be achieved by means of diffraction order $m=-1$. Moreover, utilizing an extra line defect, T value can be increased upto 0.99, under oblique incidence even if the line defect layer is deeply embedded in the photonic crystal. The latter configuration can be used to obtain deflection in one frequency range and can also be utilized for the realization of another functionality like defect-mode wave guiding in another frequency range but still using the same structure.

Keywords : asymmetric transmission, beam deflection, blazing, bi-directional splitting, defect layer, dual beam splitting, Floquet-Bloch modes, isofrequency contours, line defect, oblique incidence, photonic crystal, unidirectionality

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