Design of photonic crystal functional elements by a plane-wave-based transfer-matrix method

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Recently we have developed a plane-wave-based transfer-matrix method (PWTMM) to investigate the optical properties of photonic crystals (PCs) [1-3]. We have successfully advanced this formulation from its standard area of application to solve band structure, transmission and reflection spectra to handle Bloch-mode scattering problems [4]. We have used the method to examine coupling problem of 2D PC waveguides [4-6], 2D PC filters [4], modal coupling and conversion in multimode PC waveguides [7], and semiconductor nanowire laser arrays [8]. In this talk we will report our recent progress in using the PWTMM to design high-performance PC functional elements. In the first example, we discuss the discovery of wideband continuous tunability of high-performance PC channel-drop filters that are realized by simply changing the radius of cavity rods [9]. As the second example, we discuss the optical performance of filters made from coupling waveguide-cavity structures in a semiconductor 2D PC slab [10]. The transmission, reflection, and radiation loss spectra of guided waves through this filter are accurately determined. From this information we can find out the filter of optimum performance. In the final example, we examine a T-shape beam splitter built on a 2D PC slab. Similarly, based on the information of the transmission and radiation loss spectra, we can yield an optimal design of the beam splitter. These examples indicate that the PWTMM is an accurate, convenient, and efficient numerical tool for exploring and designing PC functional elements and integrated circuits.

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