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ORIGINAL PAPER

Multichannel Filtering Properties of a One Dimensional Photonic Crystal Composed of Semiconductor Photonic Quantum Well Defect

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Abstract
Multichannel filtering properties of a one dimensional photonic crystal containing semiconductor photonic quantum well defect were theoretically investigated in the infrared region. We have considered two possible structures of photonic quantum well, symmetric $((AB)^P(C_1C_2)^Q(BA)^P)$ and asymmetric $((AB)^P(C_1C_2)^Q(AB)^P)$. It was found that, for a symmetric structure number of channels equal to $Q+1$ whereas for asymmetric structure channel number is Q. Further it was observed that the position of channels can be tuned by means of temperature variations in semiconductor material. In addition, more channels can be generated by the use of a double photonic quantum well defect.

Keywords Multichannel filter · Photonic quantum well · Defect mode

1 Introduction

Photonic crystal (PCs) are artificial materials with periodic multilayer structure. One of the most significant optical characteristics of a PC is the existence of photonic band gap (PBG) in their transmittance spectra within which electromagnetic waves of certain frequencies are forbidden [1–6]. Engineering of PBG can be useful for realising various photonic devices. Among them, widely applied optical components are narrow band transmission filters. Usually a transmission filter will be achieved by inserting a defect layer in to PC structure in order to break the translational symmetry. In such structure the transmission peak is designed to locate within the PBG of PC. This transmission peak is usually referred as channel of the filter.

As a design for a multichannel filter based an all optical components, a PC containing PQW is more attractive. To obtain a multichannel filter, the single defect in the PC has to be replaced by so called photonic quantum well (PQW) $(C_1C_2)^Q$ as shown in Fig. 1. The design principle of PC containing PQW is that the pass band structure (PBS) of PQW $(C_1C_2)^Q$ must be completely inside the PBG of $(AB)^P$[7]. Thus, when $(AB)^P(C_1C_2)^Q(BA)^P$ or $(AB)^P(C_1C_2)^Q(AB)^P$ (with $Q < P$) structures are formed, due to photonic confinement effect the continuous pass bands will be quantised. Hence, within the PBG discrete multiple defect modes are generated. Moreover, the numbers of resonant peaks or defect modes in the transmission spectra can be determined by stack number (Q) of PQW . The features of PQW defect in PC structure is useful in designing optical filters [7–17]. Beside above referred theoretical works, experimental study also has been reported [18].

Recently tunable filter has generated great deal of interest. The external tuning can be done by means of electric field (E-tuning) [19, 20], magnetic field (M-tuning)[21, 22], temperature (T-tuning) [23, 24] and doping concentration (N-tuning) [25, 26]. B. Suthar et al. [13] has investigated the temperature tunable channel filter based on semiconductor PQW. Hung et al. [14] studied the tunable multichannel PC filter composed of extrinsic semiconductor PQW.

Motivated from above theoretical studies, in the present communication we intend to examine the multichannel filtering properties of a one dimensional PC containing semiconductor PQW. The analysis has been extended to design a multichannel filter which can be tuned by temperature variation in semiconductor material.

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