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Design of dual ring wavelength filters for WDM applications

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ABSTRACT

Wavelength division multiplexing plays a prime role in an optical communication due to its advantages such as easy network expansion, longer span lengths etc. In this work, photonic crystal based filters with the dual rings are proposed which act as band pass filters (BPF) and channel drop filter (CDF) that has found a massive applications in C and L-bands used for wavelength selection and noise filtering at erbium doped fiber amplifiers and dense wavelength division multiplexing operation. These filters are formulated on the square lattice with crystal rods of silicon material of refractive index 3.4 which are perforated on an air of refractive index 1. Dual ring double filters (band pass filter and channel drop filter) on single layout possess passing and dropping band of wavelengths in two distinct arrangements with entire band quality factors of 92.09523 & 505.263 and 124.85019 & 456.8633 for the pass and drop filters of initial setup and amended setup respectively. These filters have the high-quality factor with broad and narrow bandwidths of 16.8 nm & 3.04 nm and 12.85 nm & 3.3927 nm. Transmission spectra and band gap of the desired filters is analyzed using Optiwave software suite. Two dual ring filters incorporated on a single layout comprises the size of 15×11 μm which can also be used in the integrated photonic chips for the ultra-compact unification of devices.

1. Introduction

Photonic Crystals are the sporadic configuration possessing multitudinous applications in the discipline of optical communication and optical signal processing due to its habitual manifesto to fabricate a tremendous number of optical components on a single chip. Among these cardinal optical components for integrated optics are linear waveguides, waveguide bends, and Y-splitters. Waveguides are the frameworks which successfully escort the initial waveform from starting to output end with low losses. In such arrangements, propagation may be unauthorized in any direction for the conclusive range of frequencies called photonic band gaps (PBGs). Based on photonic band gap attribute, the waveguides are progressed in the photonic crystal. By wielding these waveguides the optical devices thrive for many demands. Here the waveguides are utilized to outline photonic crystal ring resonator to drop the signal as a function of a filter which can be used for WDM applications. Better selectivity and scalability can be obtained by instigating point defects and/or line defects in the plotted composition. Photonic crystal grounded bandstop filter is coined with single ring resonator coupled with the coupler and 93% efficiency is realized [1].The desired L-shaped bend ring resonator with high-level transference was procured. The normalized transferal of above 90% was achieved [2], current optical add–drop filter (OADF) constructed on two-dimensional photonic crystal ring resonator (2D PCRR) filter is drafted with a hexagonal system of silicon rods in air. Using the finite- difference - time-domain (FDTD) technique, 100% forward dropping efficiency can be fulfilled at the operating wavelength of 1550 nm. Moreover, the footprints of customizing the dielectric constant of entire rods and coupling rods of the constitution as well as the radius of rods and coupling rods are discussed. The device could be used as an optical add–drop filter (OADF) and has the ability to be highly suitable for integration [3]. There are some other types of photonic crystal band-pass filters which are utilized and optimized using the two-dimensional finite-difference-time-domain (FDTD) technique [4]. The Add-drop filter based on photonic crystal structures using nested rectangular resonator befitting for optical communication demands which have dropping efficiency of 100% and the quality factor of 258. Such assembly may propound emboldening significances for photonic integrated circuits based on photonic crystals and other Nanophotonics structures [5]. The diamond shaped ring with circular pillar has been formulated and the QF of 377.5 is achieved [6]. Thus, the change of the rods radius and the ring shape may also promote to the change in the resonance identity of the depiction, non-identical types of pillars and rings have been sketched and Q factor about 400 is hooked which is

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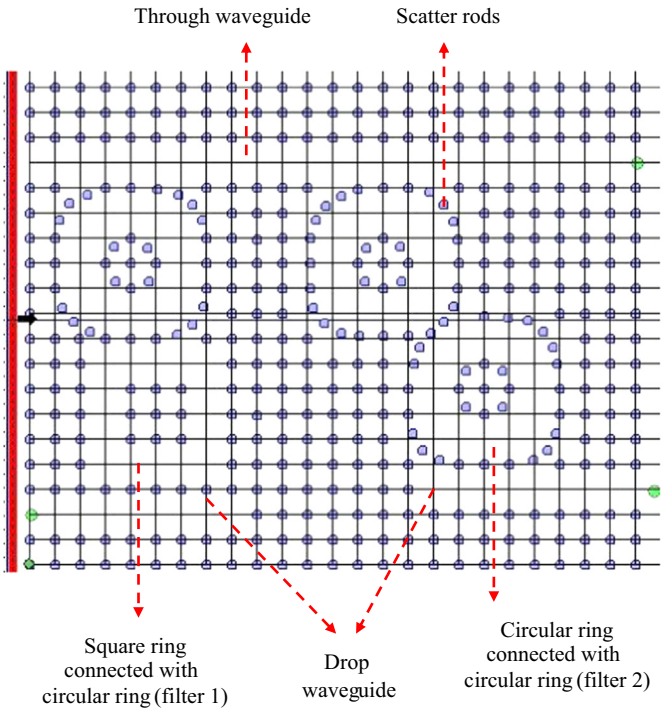

Fig. 1. Proposed dual ring filter.

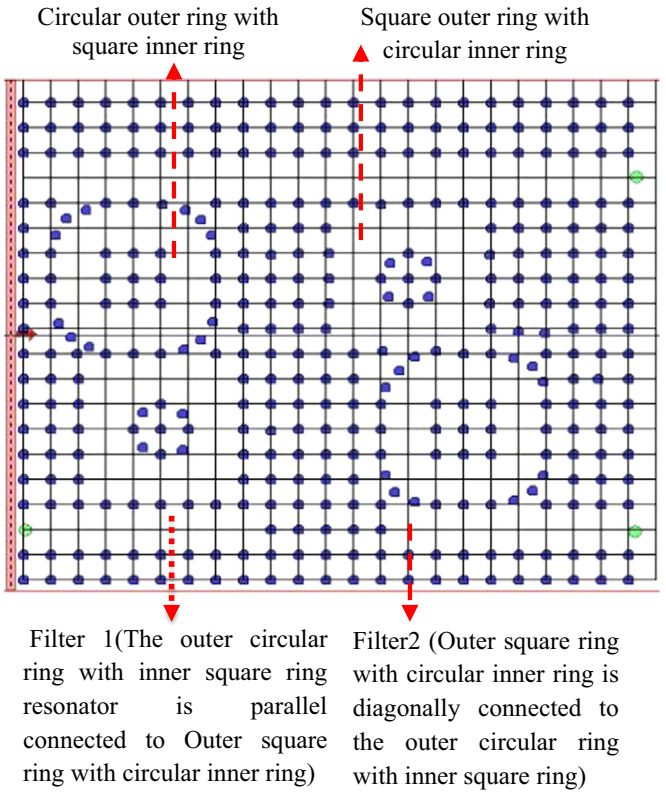

Fig. 2. Modified dual ring filter. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

satisfactory for integrated photonics applications [7–11] A new photonic crystal filter of X-shaped ring has been designed and investigated its performance for different configurations of

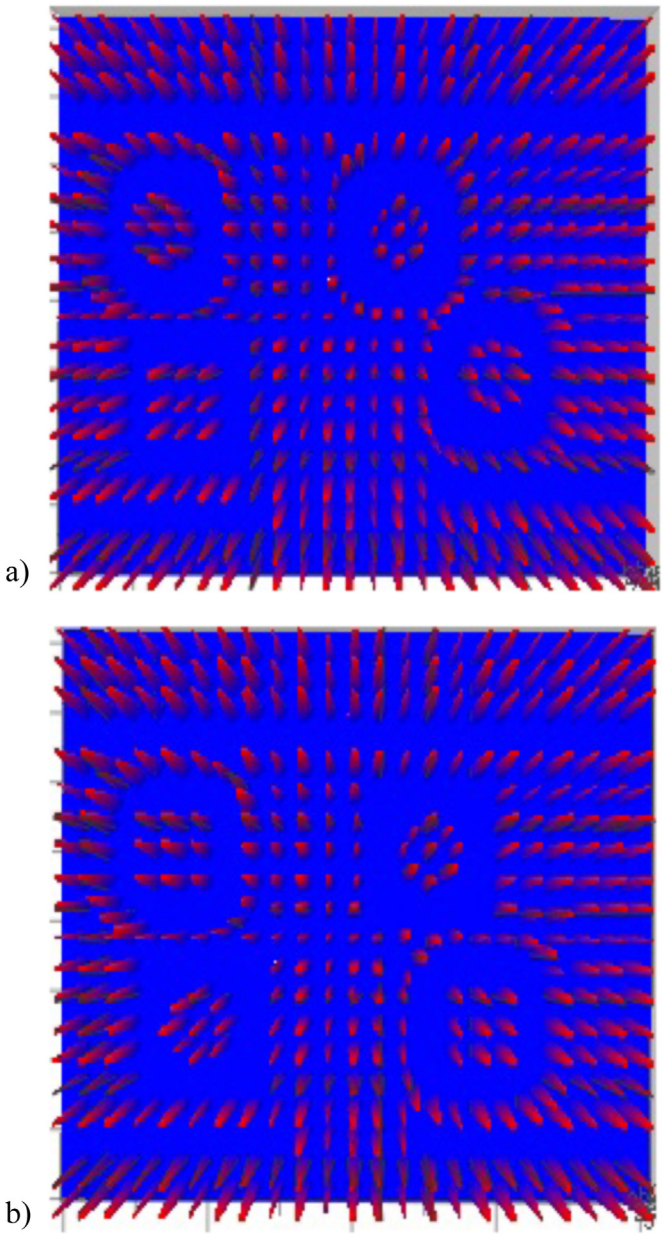

Fig. 3. Index distribution of the dual ring filters (a) Initial and (b) modified structures.

the ring position like single ring with multiple configurations [12] i.e. single ring at the center and dual ring connected in parallel and serial. Such structure has been acting as channel drop filter at the 1550 nm window useful for the future photonic devices. The filter is designed as a square ring with elliptical inner ring rods which act as band pass filter [13] at the C-band with the quality factor of 164 for circular rods at the inner square ring and 155 for elliptical rods at the inner square ring. H shaped ring type filters are designed and working as Channel drop filters whereas they have the transmission efficiency at the range of 210–250 [14]. So there are different ring filters which are single input single output band pass filter [15], X shaped [16], tunable optical CDF of square ring filter [17], T shaped channel drop filter [18–20]. From these references, the band pass photonic crystal filter has been designed as a single filter with same dual-ring configuration.