Ring Resonator-Based Optical Filter and Splitter for Integrated Photonics

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Abstract

This work presents a novel metadevice integrated onto an optical platform that simultaneously functions as both an optical filter and an optical splitter, leveraging a dropped cavity-ring resonator configuration within a two-dimensional square photonic crystal (2D-PC). The device structure consists of two waveguides coupled via a ring resonator embedded in a defect cavity. For filtering, the PC is composed of silicon rods (ε=12), while for splitting, it utilizes alumina rods (ε=8.9). By precisely engineering the geometrical parameters, the waveguide width (*w*) and, critically, the ring resonator thickness (*g*), the transmission characteristics are dynamically controlled. Simulation results using the Finite Difference Time Domain (FDTD) method demonstrate that for specific *g* values, the structure acts as a high-efficiency filter, selectively transmitting one resonant mode while strongly attenuating another. Furthermore, by tuning *g*, the same core structure transitions into a highly efficient 1×3 optical splitter, directing nearly 99% of the incident light to a single output port or equally distributing it among all three output ports, depending on the chosen *g*. This dual-functionality, achieved through simple geometric tuning without altering the fundamental architecture, offers a promising route for compact, multi-functional components in integrated photonic circuits for applications such as wavelength division multiplexing and signal routing.

Keywords

Photonic Crystal, Ring Resonator, Optical Filter, Optical Splitter, Dropped Cavity, FDTD, Integrated Photonics.