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Functional Devices based on Photonic Crystal Waveguides

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Photonic crystals have drawn a lot of attention due to their potential in guiding, controlling, and manipulating photons. This paper reports our recent research on the functional devices based on photonic crystal waveguides (PCWs).

A double-slot PCW with an air-bridge structure on silicon-on-insulator (SOI) substrate is proposed and fabricated [1], where coupling between the defect modes is tuned to lie below the air-lightline and an enhanced transmission-dip with extinction ratio of 22 dB is achieved. Based on the coupling of the defect modes in PCW, a novel principle of optical switch is proposed and demonstrated by integrating a titanium/aluminum microheater on the top of the PCW [2]. Switching functionality with bandwidth up to 24 nm and extinction ratio in excess of 15 dB over the entire bandwidth is achieved with footprint of only 8 μm×17.6 μm [3], which is the most compact broadband optical switch and thus promising for wavelength division multiplexing (WDM) optical links in optical interconnect.

For InP-based active PCW, etching depth up to 3.5 μm and 1.8 μm for 200 nm-diameter holes and 40 nm-width slots are achieved [4], respectively. This is the record-high aspect-ratio of etching in InP heterostructure, and paves the way for ultra-compact InP-based and electrically-pumped optical devices for future mono-/hetero-integrated photonic circuits. Moreover, PC nanobeam cavity with stagger holes for direct modulation of nanocavity light emitting diodes (LEDs) is proposed. Quality factor of the proposed cavity can be widely engineered while keeping a small mode volume. Simulation result shows that the direct modulation bandwidth can be wider than 60 GHz [5].

An optomechanical cavity is proposed based on optomechanical crystals in a nanobeam [6]. Only by adjusting the radius of air holes, an optomechanical coupling rate as high as 1.24 MHz is obtained. Moreover, the nanobeam cavity exhibits a high mechanical frequency of 4.58 GHz with a small effective mass of 96 fg. The transmission spectrum of the nanobeam cavity is measured and demonstrates a single optical resonance at 1502 nm and a quality factor over 20000.

To further enhance the optomechanical coupling, a hetero optomechanical crystal nanobeam cavity is proposed [7]. The proposed hetero nanobeam structure confines the optical and mechanical mode with two periodic structures and possesses resonant optical and mechanical mode of 194 THz (corresponding to wavelength of 1.55 μm) and 5.88 GHz with *Q*-factor of 2.0×10^4 and 4.9×10^5, respectively. By concentrating and enhancing overlap of optical field and strain field, the simulated optomechanical coupling rate of the cavity is as high as 1.31 MHz, which, as far as we know, is the highest optomechanical coupling rate reported.

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