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Novel low-loss 60° bends in photonic crystal waveguides

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Abstract: A novel type of 60 degree photonic crystal waveguide bend has been designed, simulated and fabricated in silicon-on-insulator material utilizing deep ultraviolet lithography. Loss-free bending has been observed in certain wavelength regions.

OCIS codes: (130.3120) Integrated optics devices; (130.3130) Integrated optics materials; (220.4610) Optical fabrication; (220.4830) Optical systems design; (230.3990) Microstructure devices; (230.7390) Planar waveguides; (999.9999) Photonic crystals

Experimental and theoretical investigations are reported for a novel type of 60° photonic crystal waveguide (PhCW) bends, which display extremely low bend losses for TE-polarized light. The bends are designed with sufficient tolerances for fabrication with standard deep UV lithography and they may therefore readily be utilized in future PhCW components.

The investigated PhCWs are defined by removing one row of nearest neighbor holes in a triangular array of air holes. The lattice constant is Λ=435nm and the bulk hole diameter is D=249nm. The material is silicon-on-insulator, consisting of a 220nm layer of silicon on top of a 1μm layer of silica. 248-nm deep UV lithography was used to define the patterns. The structures were transferred to the silicon layer using a reactive ion etching process. The fabrication procedure is described in detail in Ref. [1]. The fabricated PhCW containing two consecutive novel 60° bends is shown in Fig. 1.

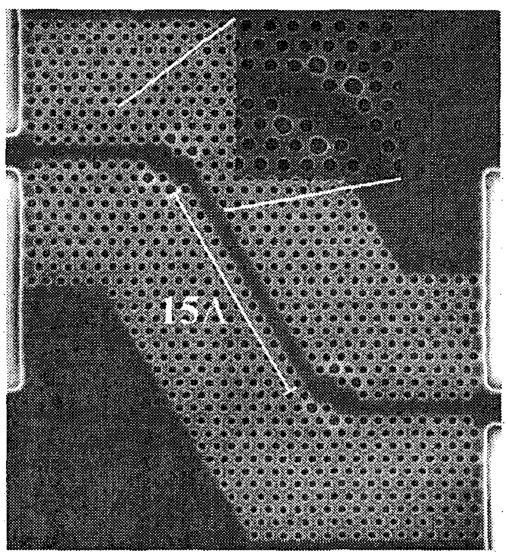

Fig. 1: Scanning electron micrograph of the fabricated structure containing the novel bends. Also shown is a zoom-in on one of the bends. The diameter of the large holes is 320nm.

Ridge waveguides, gradually tapered from 4μm at the facet of the sample to 1μm at the PhCW interface, are used to route light to and from the structure. The transmission spectra for the investigated component are normalized to a straight PhCW of equivalent propagation length. The fabricated component was characterized utilizing a previously described setup [2].

The measured spectra are compared to 3D FDTD simulations [3] performed on components identical to the fabricated ones. In order to extract the bend losses the calculated spectra were normalized to spectra for straight PhCWs of equivalent length calculated using the same scheme.

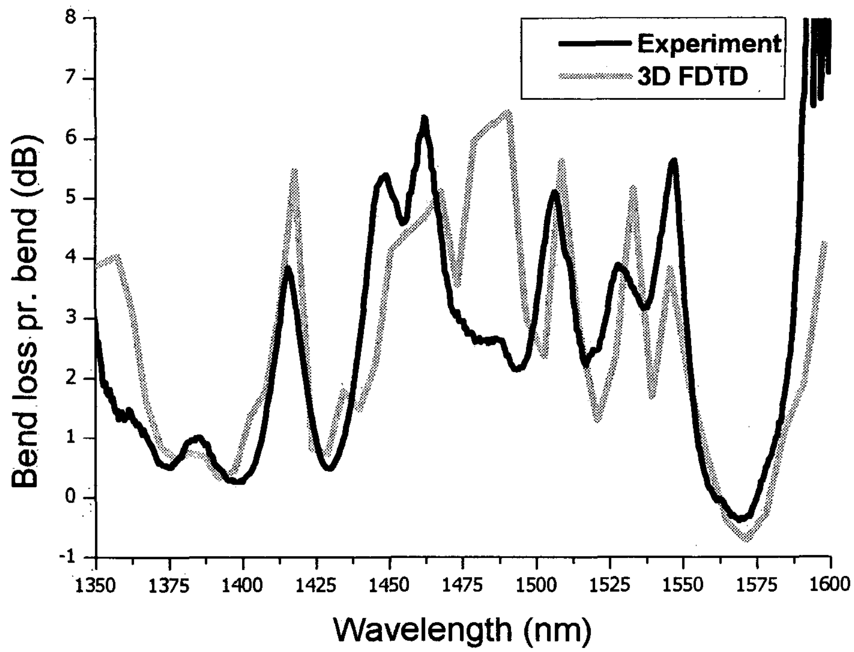

Fig. 2: Measured and calculated bend losses for TE-polarized light.

The results obtained from experimental measurements and numerical calculations are displayed in Fig. 2. A noteworthy feature is the remarkable similarity between the measured and the calculated spectra. This clearly demonstrates our ability to fabricate devices behaving in accordance with design guidelines. Two bandwidth ranges distinguish themselves: In the range 1550-1575nm a loss up to –0.5dB is observed per bend. Hence, in this region the bends may transmit light better than an equivalent length of straight PhCW. This is believed to be due to resonance effects in the bends. In the wavelength range 1370-1410nm the loss is found to be in the range 0.25-1dB per bend.

In conclusion, we have shown that our novel bends show extremely low bend losses when compared to a straight PhCW for certain bandwidth ranges. The low loss bandwidth may be further extended by careful optimization of the bends.

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