

Femtosecond laser inscribed parallel long-period fiber gratings for multi-channel core mode conversion: supplement

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Femtosecond laser inscribed parallel long-period fiber gratings for multi-channel core mode conversion

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The polarization-dependent loss (PDL) of the gratings for mode conversion between LP₀₁-LP₁₁ modes, LP₀₁-LP₂₁ modes, LP₀₁-LP₀₂ modes, LP₀₁-LP₃₁ modes, and LP₀₁-LP₁₂ modes were measured by using an optical vector analyzer (OVA 5000, Luna) with a resolution of 0.15 pm. The PDL of the five mode converters is measured to be 23.1, 39.3, 22.1, 23.9, and 34.2 dB, respectively. Figure S1 (a) shows the measured PDL, maximum, and minimum loss spectra of the LPG with mode conversion between LP₀₁ and LP₃₁. The high PDL could be attributed to the local asymmetric refractive index modulation in the fiber core. Figure S1 (b) shows the schematic diagram of a fiber cross-section of the LPG illustrating the refractive index modulation of the fiber core. The X⁺ is the laser irradiation direction, and Z-axis is perpendicular to the refractive index modulation plane. Figure S1(c) are the microscope images of the refractive index modulation in the X-Y and X-Z planes observed via microscope with a 40x oil objective. We can observe a significant refractive index modulation region along with the Y-direction of the fiber core. The height of the refractive index region is about 3.0 μm (See in the bottom image in Fig. S1 (c)), and the depth of the refractive index region is about 8.7 μm (See in the top image in Fig. S1 (c)), suggesting that the cross-section of the modulation region induced by the laser in the fiber core resembles an ellipse shape. This explains the high PDL of the gratings. The depth of the refractive index region can be reduced with decreased pulse energy, and reduce the asymmetry of the modulation area.

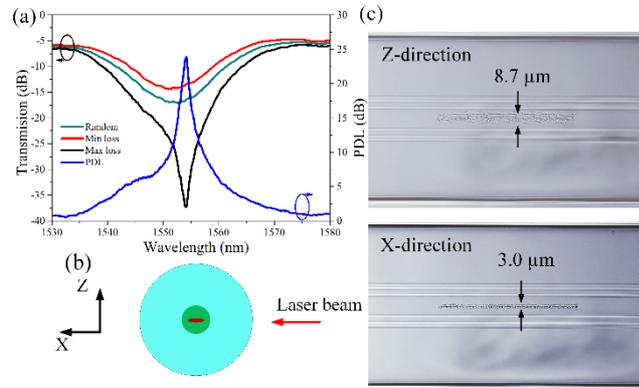


Figure S1 (a) The measured transmission spectrum and PDL spectrum of the LPG with mode conversion between LP_{01} and LP_{31} modes. (b) Schematic diagram of the refractive index modulation of the fiber grating cross-section. (c) Microscope images of the refractive index modulation regions were viewed in X- and Z- directions.

Figure S2 shows the microscope image of part of the refractive index modulation regions of the parallel LPG includes three gratings viewed in the X-direction.

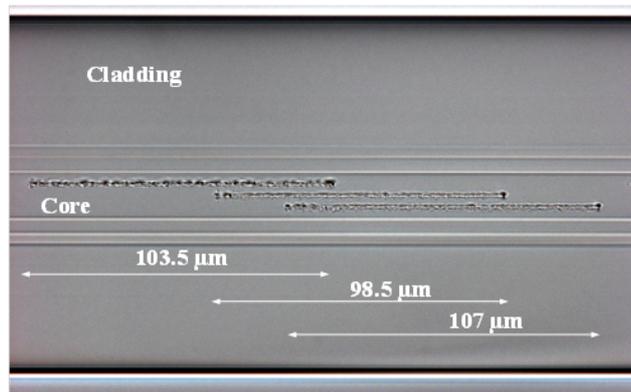


Figure S2 Microscope images of the modified regions by the femtosecond laser for the three parallel LPGs with different periods viewed in X-direction.