Mid-Infrared Polarization-Maintaining Photonic Crystal Fiber

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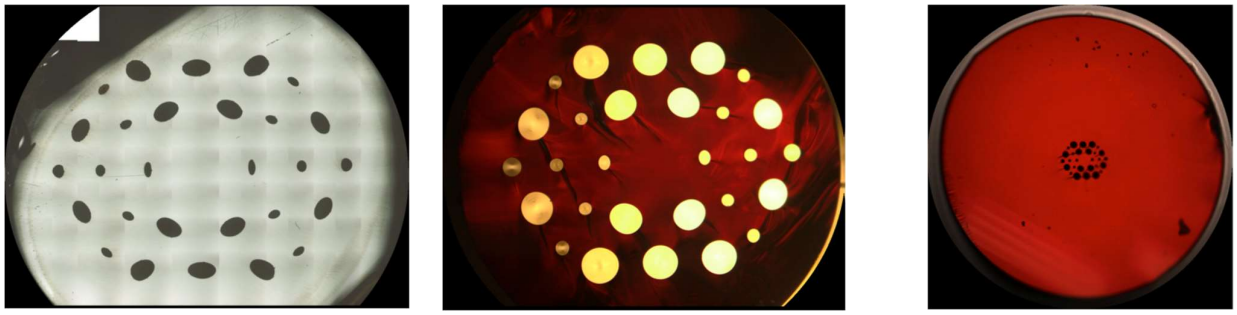
A novel polarization-maintaining photonic crystal fiber (PM-PCF) made of chalcogenide glass is presented. The endlessly single-mode PM-PCF has a solid core surrounded by an asymmetric orthogonal pattern of longitudinal holes having different periods and diameters. High-purity chalcogenide glasses (As_2S_3) were made to extrude the PM-PCF preforms through custom-made dies (Figure 1(a)). The dies are made of titanium by CNC milling. The die design consists of an array of pins corresponding to the desired holes in the preform, and feed through holes to push the glass forming the preform. The extruded preforms were pulled into ~2mm canes, with the canes drawn under positive pressure (~10mbar) to start the hole inflation process and improve the hole circularity (Figure 1(b)). The canes were inserted into a chalcogenide tube, with an inner diameter of 2.5mm and outer diameter of 12mm to produce the PM-PCF preform. The preform was pulled into the PM-PCF using pressurization on the cane for fine control over the hole sizes in the PM-PCF (Figure 1(c)).



(a) (b) (c)

Figure 1: (a) Extruded preform 13.5 mm, (b) pulled cane 2.3 mm, (c) PM-PCF 260 µm.

The simulations of the new PM-PCF design show transmission in the mid-infrared (2-6µm) with high birefringence ~10^{-4}. The confinement (light in the core) is >97% resulting in strong guiding and low transmission loss <2.3 dB/km (assuming no material loss). Also, the induced bending loss under a bend radius of 15 mm is negligible. Most importantly, the guided mode is circular (circularity >99%) to improve the coupling efficiency and to collimate the output beam with a single lens. The estimated coupling loss for a focused circular Gaussian beam is ~2.1% (<0.1dB).

Several PM-PCFs were drawn and characterized. The PM-PCF loss, mode field diameter, polarization extinction ratio (cross talk), birefringence and beam quality (M^2) were measured and will be presented.