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Hole-Size Increasing PCFs for Blue-Extended Supercontinuum Generation

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Supercontinuum (SC) sources with spectra extending into the deep-blue region below 400 nm are highly desirable in areas such as fluorescent microscopy [1]. Tapering of photonic crystal fibers (PCFs) with high air-fill fractions has proven an effective way of extending the spectra into the deep-blue [1-4]. This facilitates the ideal combination of (1) an initial fiber section to allow a pulse break-up in the vicinity of the zero-dispersion wavelength (ZDW) and an efficient energy transfer into the visible, and (2) a subsequent fiber section with group-velocity match (GVM) from the long wavelength spectral edge to wavelengths in the deep-blue or even UV. Previous reports on blue-extended SC generation were typically achieved in tapered PCFs where the air-hole structure was preserved [1-4], i.e. the relative hole-size constant. However, such PCFs with high air-fill fractions are inevitably (highly) multi moded at the pump, which complicates coupling and interfacing. In [5] this was overcome by increasing the air-hole size in a short section of a single mode PCF using a post processing technique, but only to enhance the visible power. Here we present the first high-power SC generation into the deep-blue in a single mode PCF with varying hole-size and pitch fabricated directly at the draw-tower.

The PCFs in this work are fabricated by increasing the pressure on the air holes during the drawing. However, this process alone will lead to an undesirable structure where both the relative hole-size and pitch increase. The draw speed was therefore increased simultaneously with the increase in pressure to give the optimum structural change with an increasing relative hole-size and decreasing pitch. The resulting fiber structure is shown in Fig. 1(a) for PCF 1: the hole-to-pitch ratio is increased from 0.52 at the input to 0.85 at the output over 7 m, while the pitch is decreased from 3.3 to 2.15 µm. These parameters were chosen to ensure single mode behaviour at 1064 nm at the input and a theoretical blue edge at 365 nm at the output assuming GVM to a long wavelength edge at 2300 nm. An additional target (PCF 2) was drawn to a hole-to-pitch ratio of 0.7 and a pitch of 2.2 µm over 4 m. The SC generated in the two PCFs are shown in Fig. 1(b); both extend well-below 400 nm and PCF 2 shows a record 3 dB spectral flatness over the range 363-628 nm. The higher hole-to-pitch ratio of PCF 1 should yield a more blue shifted spectral edge compared to PCF 2 [2,4], however, a closer inspection showed that the fiber structure deviated from an ideal hexagonal structure when the air holes expand. This resulted in a too small core, which explains why the broadest SC was generated in PCF 2. The results nonetheless clearly demonstrate that deep-blue spectra can be efficiently generated in such PCFs with increasing hole-size and decreasing pitch.

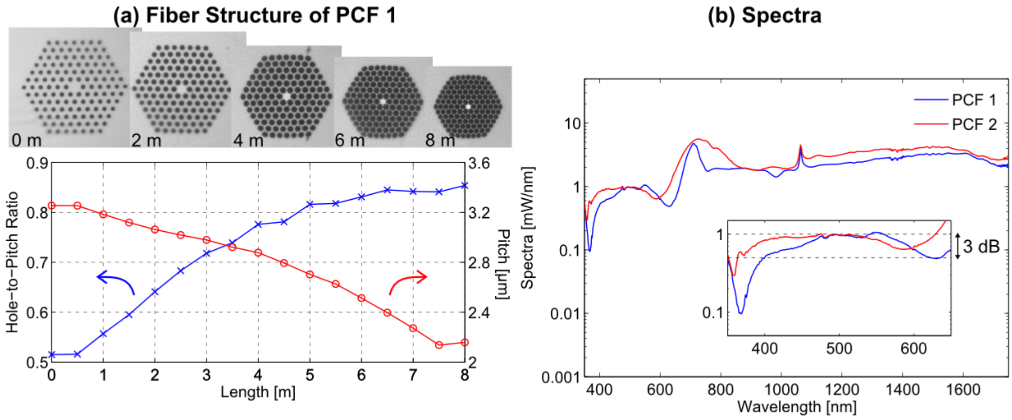

Fig. 1 (a) Characterisation of the fiber structure of PCF 1. The top row shows microscope images of the fiber structure and the plot shows the corresponding hole-to-pitch ratio and pitch as a function of length. (b) Spectra of PCF 1 and 2. The inset shows a close up of the spectral blue edge and the 3 dB bandwidth of PCF 2. The fibers were pumped at 1064 nm with 10 ps pulses at 15 W average power and 80 MHz repetition rate.

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