Low Loss Kagome Fiber in the 1 µm Wavelength Region

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Abstract: We present a Kagome hollow core fiber with record low loss (12.3dB/km at 1010nm), a wide 3dB bandwidth (150nm), low bend sensitivity and large mode field diameter (~30µm), tailored for high power delivery applications.
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1. Introduction

Kagome hollow core fibers (K-HCFs) are a type of hollow core-photonic crystal fiber (HC-PCF) which provide low loss transmission through an anti-resonance guidance mechanism. In recent years, substantial loss reduction has been achieved in these fibers through optimization of the core curvature [1,2]. This progress, combined with a wide operating bandwidth, ultralow nonlinearity and large mode field diameter make K-HCFs very attractive for high power beam delivery (e.g., for machining). The state-of-the-art in terms of minimum loss for K-HCF is 17 dB/km over a narrow bandwidth (~10nm) and ~40 dB/km over a wide bandwidth [2] showing that K-HCF losses now compete with hollow core-photonic bandgap fibers (HC-PBGFs) over certain wavelength ranges, albeit in exchange for higher bend loss. Here we report a new record low loss (12.3 dB/km), wide bandwidth K-HCF operating around 1 µm, a critical wavelength for power delivery, which also demonstrates record low bend loss for this geometry.

2. Fiber fabrication and characterization

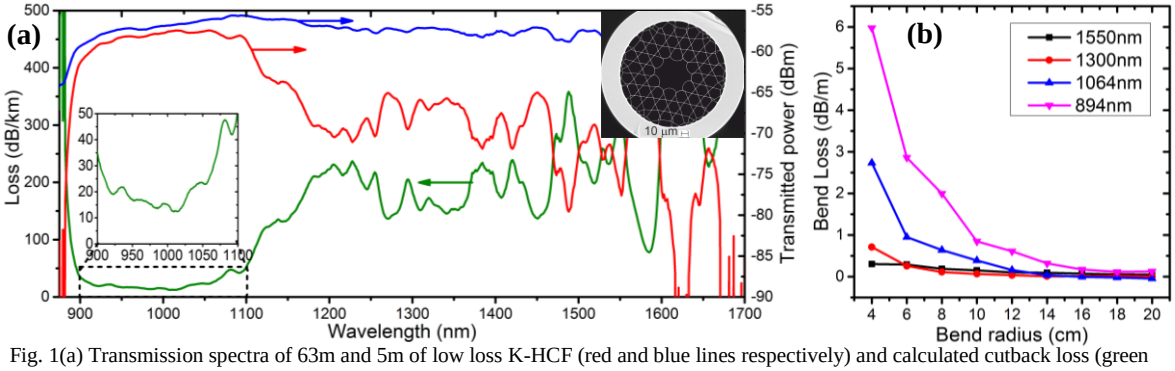

Fig. 1(a) Transmission spectra of 63m and 5m of low loss K-HCF (red and blue lines respectively) and calculated cutback loss (green line). Scanning electron microscope image of the fiber is inset. (b) Bend loss measurements on our low loss fiber.

We fabricated our K-HCFs using the stack-and-draw technique. A scanning electron micrograph of our 7-cell core fiber is shown in Fig. 1a; the core diameter is 43 µm and the average core wall thickness is ~375 nm. The fiber loss was measured via the cutback technique (Fig. 1a); the minimum loss is 12.3 dB/km at 1010 nm and the 3 dB bandwidth is 150 nm. To the best of our knowledge, this represents the lowest reported loss for any anti-resonant HC-PCF and also is equal in loss with the best HC-PBGF reported at this wavelength [3] while providing wider bandwidth and a larger mode field diameter. The low loss achieved in the previous record loss K-HCF was attributed to a large core curvature (defined by a geometric parameter 'b' =1 [2]). Here it is interesting to note that for our fiber b ~0.5, significantly lower than in the previous record fiber, which may indicate that further loss reduction is possible through curvature optimization. At longer wavelengths, higher loss resonances are observed; we believe that these may be due to the elongated nodes at the core boundary and further investigation of this and the loss reduction is underway. To investigate the practicality of our fiber for power delivery we measured the fiber sensitivity to macro-bend (Fig. 1b). At longer wavelengths (1300 nm and 1550 nm) the fibre suffers negligible bend loss above bend radii of 5 cm; this is considerably lower than the 2 dB/m bend loss of the state-of-the-art fiber [4]. At 1064nm, the bend loss is higher, as expected, but still remains negligible for radii ≥12cm and is perfectly compatible with a power delivery application. Initial measurements of modal content using an S^2 technique at ~1550 nm (not shown here) show a higher order mode suppression of >30 dB over a 43m length.

3. References

[1] Wang, Y.Y. et al. *Optics Letters* 36(5), 669-671 (2011).
[2] Debord, B. et al. *Optics Express* 21(23) 28597-28608 (2013)
[3] Chen, Y. et al. to be presented at *CLEO 2016* (2016).
[4] Alharbi, M. et al., *Optics Express* 21(23) 28609- 28616 (2013).