Experimental demonstration of single-mode large mode area multi-trench fiber for UV-VIS light transmission

Deepak Jain*, Yongmin Jung, Pranabesh Barua, and Jayanta K. Sahu
**dj3g11@orc.soton.ac.uk*
Optoelectronics Research Centre, University of Southampton, UK

Step-index optical fibers are widely used waveguides for light transmission. However, non-linear effects are always a severe challenge for optical fibers with increasing power level. This challenge is more severe at shorter wavelengths, where core size has to be much smaller in order to maintain a single mode operation. For an example, for 0.005 core refractive index with respect to cladding, a 10μm core diameter can ensure single mode operation at 1550nm. On other hand, core diameter has to be ~4μm and ~2μm at λ=632nm and 300nm respectively for single mode operation. At these shorter wavelengths, photonic crystal fiber (PCF) and hollow core photonic bandgap fiber (HC-PBGF) have been proposed to address non-linear effects by offering large core diameter and air-core respectively [1-2]. However, such fibers are relatively difficult to fabricate. Moreover, presence of air-holes causes considerable difficulties in cleaving and splicing.

Recently, we proposed an all-solid fiber design known as multi-trench fiber (MTF) as shown in Fig. 1(a) [3]. In this paper, we demonstrated their mode area scaling capability for UV-VIS wavelengths. Numerical simulations show the potential of achieving an effective single mode for 10μm and 20μm core diameter MTF by ensuring high loss to the higher order modes (HOMs) at ~300nm and ~632nm respectively. Fig. 1(b) shows numerically computed bending loss of a 20μm core MTF with trench thickness (t)=1.34μm, refractive index difference between core and cladding (Δn)=0.005, and resonant ring thickness (d)=6μm at 632nm. It is important to note that MTF ensures similar level of loss (as shown in Fig. 1(b)) to the HOMs even in an unbent case thanks to the resonant coupling between modes of core and resonant ring, which ensures suitability for beam delivery applications. Fig. 1(c) shows the RIP and microscope image of a 20μm core MTF fabricated by MCVD process in conjunction with rod-in-tube technique. Fig. 1(d) shows the measured bending loss of fiber. The loss remains lower than 0.2dB/m and 0.5dB/m at ~30cm and ~15cm bend radius respectively at ~632nm. This loss can even be reduced down with further refinement in fabrication process. We investigated the output profile of a 2m long MTF using the experimental set-up shown in Fig. 1(e) with respect to the multi-mode input beam as shown in Fig. 1(g). Fig. 1(f) shows the output for different offset launching, while fiber is coiled at ~20cm bend radius. On the other hand, Fig. 1(h) shows the output at different coil radii for optimum launching. In this paper, for the first time, to the best of our knowledge, an effective-single-mode behaviour of an all-solid and cylindrical symmetrical fiber of a large core (~20μm) fiber at ~632nm has been demonstrated. All-solid design and cylindrical symmetry ensure suitability for mass-scale production and easy cleaving and splicing. Further, with these advantages, a large core (~10μm) MTF at ~300nm as confirmed by our simulations can also be achieved and details will be presented at conference.

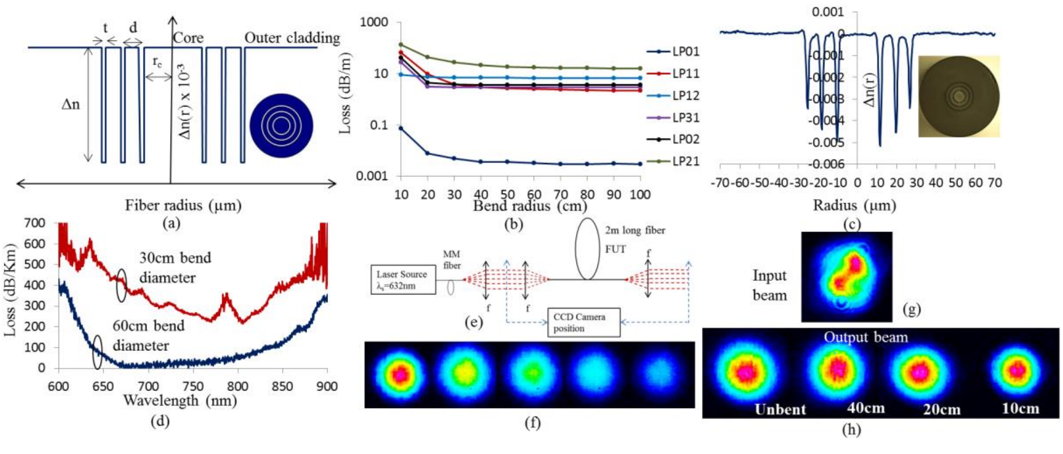

Fig. 1 (a) Schematic of multi-trench fiber (MTF), (b) computed loss of different modes for 20μm core fiber at 632nm wavelength, (c) RIP and 2D-cross sectional image of fabricated MTF, (d) measured bending loss of fiber, (e) experimental set-up for verification of single-mode behaviour, (f) profile of output beam for offset launching of input beam, (g) profile of input multi-moded beam, and (h) profile of output beam at different bend radius.

References

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