Multicore optical fibres for astrophotonics

***T. A. Birks*[1], *B. J. Mangan*[1], *A. Diez*[2], *J. L. Cruz*[2], *S. G. Leon-Saval*[1,3], *J. Bland-Hawthorn*[3], *D. F. Murphy*[4]**

[1]*Department of Physics, University of Bath, Claverton Down, Bath, BA2 7AY, UK.*
[2]*Departamento de Física Aplicada, Universidad de Valencia, Dr Moliner 50, 46100 Burjasot, Spain*
[3]*Institute of Photonics and Optical Sciences, School of Physics, University of Sydney, Sydney, Australia*
[4]*Waterford Institute of Technology, Waterford, Ireland*

We report progress towards multimode (MM) fibre filters for suppressing the OH emission that hinders ground-based observation of the early Universe. Fibre Bragg gratings (FBGs) can filter these narrow spectral lines in single-mode (SM) fibres [1]. Implementing them in MM fibres well-matched to astronomical instruments requires transitions between the MM fibre and several SM fibres [2]. Such hand-crafted "photonic lanterns" require many identical FBGs to be made and spliced in place. Instead we are pursuing the idea in multicore (MC) fibres, Fig. 1(a). The FBG is written at once in all the SM cores. The fibre is jacketed with low-index glass and tapered to form the core and cladding of a MM fibre, giving a monolithic FBG filter with conventional MM ports. Such a device can stand alone, or be incorporated into more elaborate instruments [3, 4].

We made a fibre with 120 SM cores, Fig. 1(c). Its outer diameter, core pitch, core diameter and NA were 230 µm, 17.5 µm, 4 µm and 0.22 respectively. Simple single-notch FBGs were written across the fibre using a UV laser beam and phase mask. The spectrum of each core was measured, Fig. 1(b), and maps of FBG notch depth and wavelength are plotted in Fig. 1(d) and (e). FBGs were successfully written right across the fibre's cross-section. However, focusing of the FBG-writing beam by the curved surface of the fibre caused an uneven distribution of notch depth, which was correlated to an undesirable spread in notch wavelength.

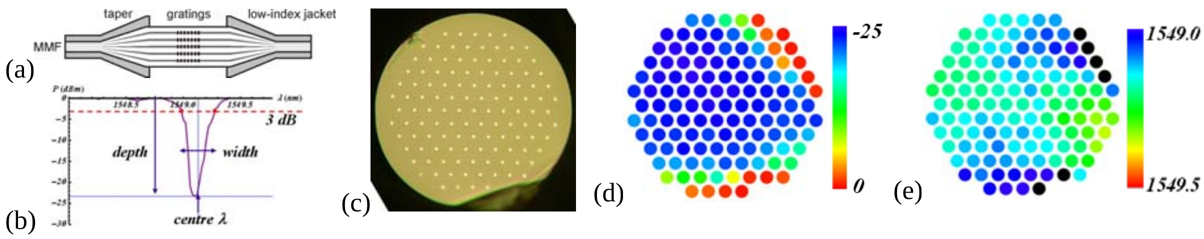

Fig. 1. (a) Sketch of the tapered MC fibre photonic lantern. (b) Transmission spectrum of a typical core of the fibre, with the FBG notch characteristics defined. (c) Micrograph of the MC fibre. Map across the MC fibre of (d) notch depth in dB and (e) centre wavelength in nm.

The fibre was jacketed with depressed-index F-doped silica and drawn down 4.6× on a taper rig. The original MC fibre now acts as the 50 µm core of an NA = 0.22 MM fibre, Fig. 2(a). The structure was designed to have the same number of spatial modes at 1550 nm as the number of cores in the MC fibre, as required for a low-loss device [2]. Two such tapers either side of the FBG yielded a proof-of-principle filter with a transmission spectrum matching the average of the spectra of the individual SM cores, Fig. 2(b) and (c).

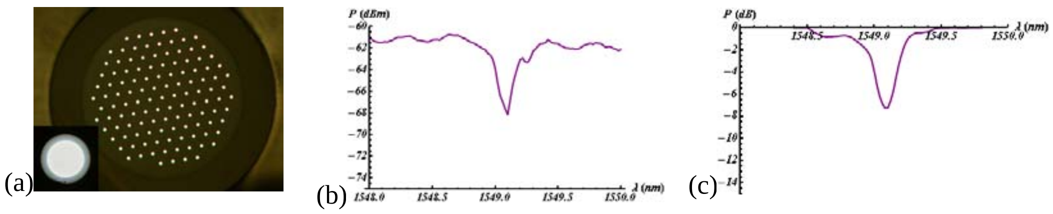

Fig. 2. (a) Micrographs of the jacketed MC fibre before and (inset) after tapering, to the same scale. (b) Measured transmission spectrum of the filter between MM ports. (c) The average of the measured FBG spectra of each SM core.

Our next step is to eliminate the focusing of the FBG-writing beam, to improve FBG uniformity across the SM cores and yield a MM response more like that of a single SM core. Then we can assess the core-to-core uniformity of the fibre itself, and consider inscription of the complex FBGs needed for OH suppression. The long-term aim is to demonstrate mass-producible OH suppression filters.

The authors thank the Astrophysikalisches Institut Potsdam for providing glass for fibre fabrication and R. R. Thomson for stimulating discussions. TAB thanks the Leverhulme Trust for a Research Fellowship.

References

[1] J. Bland-Hawthorn et al "New approach to atmospheric OH suppression using an aperiodic fibre Bragg grating" Opt. Express **12**, 5902 (2004).
[2] S. G. Leon-Saval et al "Multimode fiber devices with single-mode performance" Opt. Lett. **30**, 2545 (2005)
[3] J. Bland-Hawthorn et al "PIMMS: photonic integrated multimode microspectrograph" Proc. SPIE **7735**, 77350N (2010)
[4] R. R. Thomson et al "An Integrated Fan-Out Device for Astrophotonics" Frontiers in Optics, paper PDPA3 (2010).