Low Loss Antiresonant Hollow Core Fibres

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Abstract: We study the loss mechanisms in novel antiresonant hollow-core fibres and demonstrate the importance of optimising the air-cladding thickness and reducing the node size. Based on these rules we fabricate fibres with wide-bandwidth and low-loss.

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1. Introduction

Fibres that guide light in a large hollow core and in a few spatial modes are becoming increasingly important in the delivery of multi-MW peak power beams and to exploit nonlinear dynamics in gases. For high peak power beam delivery, a large air core is required to prevent fibre damage and catastrophic self-focusing effects. Hollow core Kagome'-type fibres are ideally suited for these applications but they do present an extended complex-to-make cladding [1]. Simplified hollow core fibre types guiding by antiresonance, made of a single ring of holes around the core and presenting low loss for device applications were recently reported [2-4]. Here we study loss mechanisms in these fibres and present an improved fibre design with a minimum loss below 1 dB/m in the near infrared.

2. Fibre design, fabrication and characterisation

Studying the loss of circularly symmetric air-glass Bragg fibres provides good insights into the guidance of more realistic structures. It can be shown that an annular glass ring contained within a larger solid cladding has a λ^4/r^5 loss dependence, as compared to the λ^2/r^3 of more conventional circular hollow core fibres, and therefore can achieve the same loss in a smaller core structure, less prone to intermodal effects and bending losses. The overall loss can be minimised by imposing a quarter wave stack condition to the outer air layer, which requires its thickness to be 65% of the core radius. Besides *radial resonances* resulting in strong loss peaks at those wavelengths where resonance occurs in the glass core ring surround, unavoidable *azimuthal resonances*, lower in magnitude but denser in the spectrum, also occur in any real structure. We conducted a thorough analysis of several realistic fibres with the same core size and found that one particular design, corresponding to a hexagram or Star-of-David (SoD) shape provided consistently lower losses than any other structure studied (Fig.1a). A number of hexagram fibres were fabricated and characterised, which highlighted the importance of reducing the node size (Fig1b and 1c).

The best fibre fabricated to date has a core of 38 μm, average losses of around 4 dB/m in the 800-1600nm range and minimum loss below 1 dB/m (Fig.1d). Ongoing work focuses on the understanding of the improved low-loss performance of the SoD fibre, and on means to practically reducing further the node sizes in fabricated fibres.

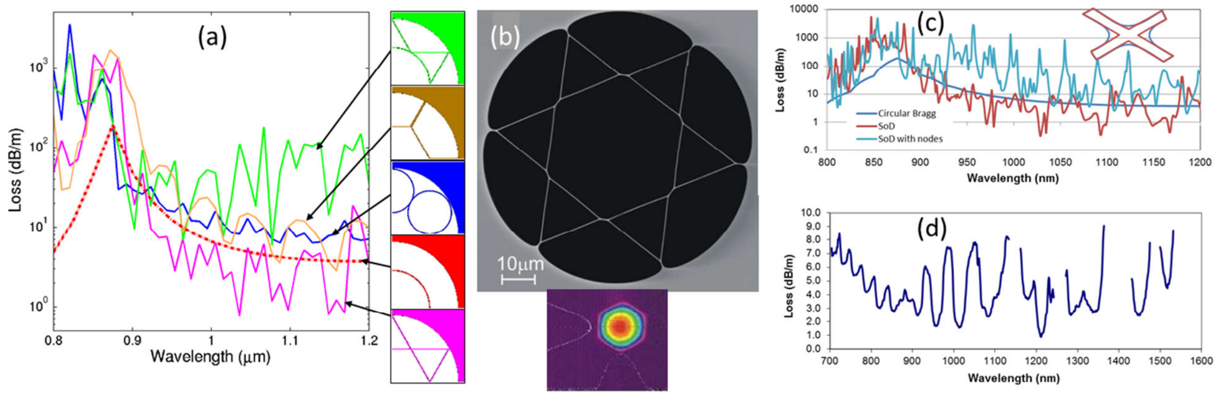

Fig. 1: (a) Simulated loss of various hollow core fibres (r = 15μm, th = 420nm); Fabricated SoD (r = 19.8μm, th = 300nm); (c) calculated loss of the SoD with (blue) and without (red) nodes; (d) measured loss for the fibre in (b).

6. References

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