3D printed Er-doped silica fibre by Direct Ink Writing

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Over the past decades, many new types of optical fibres have been developed to cope with the ever-increasing demand for bandwidth in optical communications, and to extend the use of optical fibers in other fields. Some of the features of these optical fibres are complex geometries and multiples materials such as photonics crystal fibres (PCFs), anti-resonant fibers (ARFs) and multicore fibres (MCFs), among others. The current fabrication methods often require a lengthy and complex preform fabrication processing that compromise the mechanical integrity of the preform, Additive manufacturing processes have been explored to tackle the current drawbacks of optical fibres fabrication. In recent years, direct ink writing (DIW)[1], Stereolithography (SLA)[2], digital light processing (DPL)[3], and laser powder bed fusion (LPBF)[4] have been used to 3D print glasses. Moreover, 3D printed silica optical fibres with complex structures[5] and multiple materials[6] were reported using laser printing method[5,6]. In this work, we present the fabrication of a 3D printed Er-doped silica optical fibre by DIW method.

The 3D printed preform was fabricated using a composite mixture of 12wt% hydrophobic fumed SiO_2; 2wt% Polydimethylsiloxane (PDMS); 85wt% of tetraethylene glycol dimethyl ether (Tetraglyme), and 1wt% of erbium chloride. A 3D printer, Ultimaker[+2], was used to deposit the composite mixture in uniform layers of 500µm thickness and a constant printing speed of 40mm/s at room temperature. A printed green body was produced, which is subsequently heat treated to a transparent glass as described in Fig 1. The 3D printed Er-doped preform was placed inside a fluorinated tube that was used to provide the refractive index contrast to the fibre. A multimode Er-doped optical fibre was drawn with an OD of 100µm and core diameter of ~40µm. The compositional analysis using energy-dispersive X-ray spectroscopy (EDX) on the fibre confirmed the incorporation of erbium ions into the silica glass. A white light source (WLS) was used to evaluate the Er^{3+} absorption in the core region. The produced 3D printed optical fibre presents an absorption of 62.98dB/m at 980nm and 151.49dB/m at 1535nm, as shown in Fig 2. More optical characterisation results will be presented at the conference.

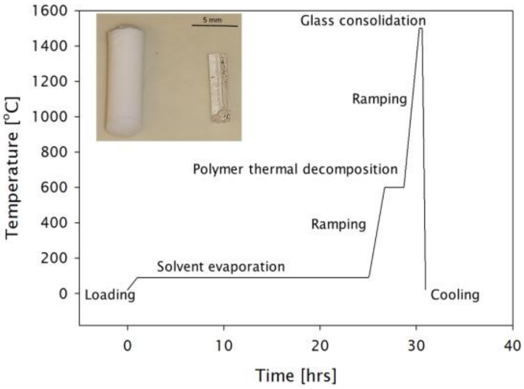

Fig. 1 Heat treatment stages of 3D printed Er-doped silica green body. (inset, 3D printed preform is shown after drying and after consolidation into transparent glass).

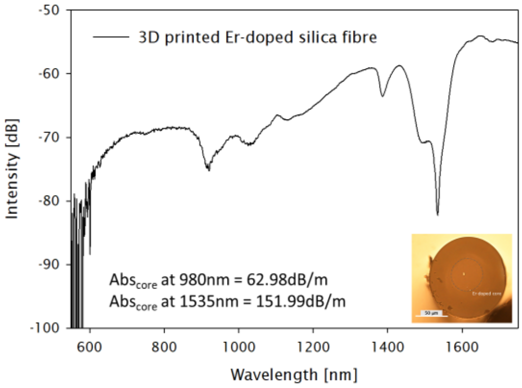

Fig. 2 Absorption spectrum of 3D printed Er-doped silica optical fibre by DIW.

In summary, we have demonstrated the DIW process for fabricating RE-doped 3D printed silica optical preforms. The reported optical fibre presents additional absorption peaks at wavelengths ~1380nm and ~1030nm, which are likely to be the contribution of residual OH, PDMS and impurities from the starting materials. A refinement of the fabrication process is needed for elimination of residual polymer and OH.

The authors would like to acknowledge the contributions from the UK Engineering and Physical Sciences Research Council award: EP/M020916/1; and CONACyT-Mexico awards: CVU607008 and CVU377962. All data supporting this study is available at https://doi.org/10.5258/SOTON/D1418.

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