Holmium doped fibre optimised for resonant cladding pumping

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Two-micron lasers are of great interest in a range of applications, from spectroscopy and free space communications, to polymer machining and laser surgery. They also provide an important stepping-stone for wavelength generation further into the mid-infrared via nonlinear frequency conversion. Holmium doped fibre laser systems offer particularly attractive properties as they allow access to the atmospheric transmission window between 2.1 and 2.25 µm. Recently, operational efficiencies for resonantly pumped Ho:silica fibre close to the quantum limit have been demonstrated for core pumped lasers [1]. To further power scale Ho:fibre lasers, development of cladding-pumped fibre configuration is necessary and indeed has enabled scaling of such fibres to >400 W cw average power [2]. Conventional polymer-coated double-clad fibres have high inner-cladding propagation loss at the ~1.95 µm pump wavelength, resulting from the presence of OH^- contamination and absorption in the polymer outer-cladding [3]. Here we report on optimisation of holmium all glass double-clad optical fibre in order to provide efficient operation for cladding pumping at 1.95µm.

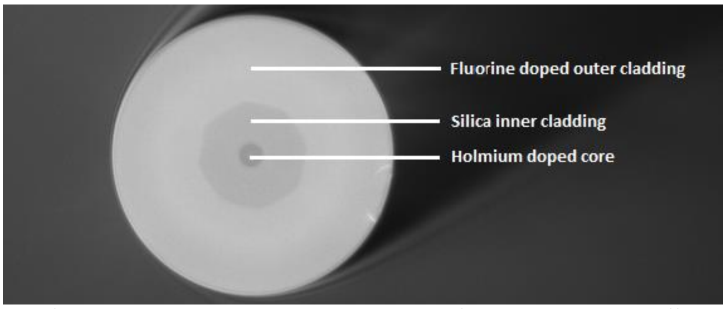

Fig. 1 End view of the in-house, all-glass, double-clad Ho-doped fibre, highlighting the different glass layers.

The Ho:fibres reported here are fabricated in house via solution doped MCVD (Modified Chemical Vapour Deposition) with particular emphasis on reducing OH^- contamination within the core material, which is minimised to below 0.1 ppm – one of the lowest reported for a holmium-doped fibre [4]. This yields Ho:doped silica core material that can operate with 74% slope efficiency with respect to absorbed pump power at 1.95µm.

The optimised composition is included in an all-glass double-clad structure with a pure silica inner-cladding and a fluorine-doped outer jacket, as shown in Fig. 1. A laser machining technique is used to shape the inner-cladding prior to overjacketing in order to maximise pump overlap with the core and minimise OH^- contamination in the cladding. In this process, a pulsed CO_2 laser is raster scanned over the preform outer surface in order to ablate cladding material, resulting in an octagonal shaped surface [5]. This process provides a shaped glass cladding with much better surface quality than conventionally milled surfaces such that there is no requirement to fire polish prior to overjacketing with the fluorine doped glass cladding. This dramatically reduces the level of unwanted OH^- ions incorporated from the hydrogen torch and leads to an optical cladding with an average of <0.1ppm OH^- contamination. This feature, in combination with the all-glass pump guidance, leads to low parasitic pump light loss and hence only a small reduction in efficiency over core pumping.

Laser demonstration of up to 70 W of output power at 2100 – 2110 nm, when pumped with a 1950 nm Tm doped fibre laser is also reported. The corresponding slope efficiency with respect to absorbed pump power was 67%, which, to the best of our knowledge, represents the highest reported efficiency for a cladding pumped Holmium doped fibre laser [2,3,6].

References

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