Single Clad Coiled Optical Fibre for High Power Lasers and Amplifiers

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High power fibre lasers are rapidly becoming a promising alternative to conventional CW solid state lasers [1,2]. In this paper we describe a new type of high power fibre laser based on single clad coiled optical fibres. The new fibre laser design employs an all-glass structure, allowing multi-point pump injection and offers a straightforward way to scale output power of a fibre laser system with the possibility of pump redundancy.

The fibre device consisted of a length of single clad silica fibre with a 12 μm, 0.07 NA core doped with Yb-ions centred within 100 μm cladding. The fibre surface was optically clean and coiled into a 4cm diameter tightly bounded ring in such a way that adjacent turns were in close optical contact. To deliver pump power two 80μm silica rods was implemented inside the laser coil. The pump delivery fibre and doped fibre interacted over a relatively long length which was comparable to the pump absorption length. This arrangement ensured efficient delivery of pump power to the doped fibre with pump insertion loss below 0.8 dB.

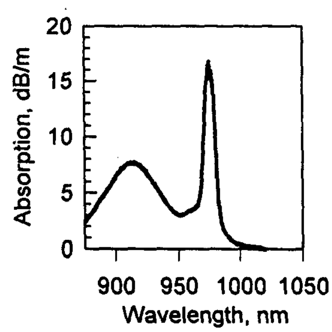

Fig.1 Absorption spectrum of coiled single-clad Yb-doped fibre

The pump absorption spectrum of the coiled fibre is shown in Fig.1. Despite the high absorption, the fibre did not exhibit any concentration quenching effects and the device length for the 915 nm pumping wavelength was just two meters – a length comparable with core-pumped devices.

A diode bar operating at 915 nm followed by a two mirror beamshaper [3] pumped the fibre laser. The use of glass-air waveguide results in a very high NA (>1) for pump and therefore allows great flexibility in choice and configuration of pump sources. In particular, the spot size of the pump beam at the focus of the focusing lens was 200 μm with NA=0.3. In order to increase the pump power delivered into the laser coil the output from the pump source was first launched into a length of 200 μm silica fibre coated with silicone rubber. The other end of the fibre was un-coated, tapered to 80 μm and then spliced to the pump fibre. This measure allows us to take full advantage of the high NA of glass-air waveguide and significantly increase pump intensity.

Measured output power as a function of input power incident on the fibre device is plotted in Fig.1.

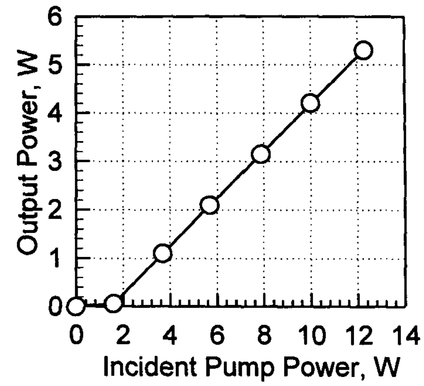

Fig.2 Output power versus absorbed power

The laser was operating at 1080 nm. The slope efficiency is 65% with respect to the absorbed power. Note that slope efficiency of the fibre pulled from the same preform and operating in conventional, double clad configuration was 77%. The most likely reason for the difference in slope efficiencies is surface quality of the coiled fibre. However we have not observed any laser performance degradation over several hours of operation.

In conclusion we have demonstrated a new concept in development of high power fibre lasers and amplifiers based on single clad coiled fibres. Combination of a highly efficient Yb-doped fibre, and glass-air waveguide for multi-point pump injection allows to reduce device length to less than 3 m with pumping at 915 nm and below 1 m for 980 nm pumping. We expect that this type of all-silica glass fibre lasers will be able to withstand the high pump powers needed for a kW fibre laser offering at the same time ready access to the pump waveguide for large scale pump multiplexing.

References

1. H.Po, J. Cao, B. Laliberte et al Electron. Let., 29, 1500, (1993)
2. M. Muendel, B. Engstrom, S.Abbey at al CLEO'99, paper CThD1, Baltimore, May 1999
3. W.A. Clarkson and D. C. Hanna, Opt. Lett., 15, 375, (1996)