High-power single-frequency thulium-doped fiber master-oscillator power-amplifier at 1943nm

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Abstract: A Tm-doped fiber master-oscillator power-amplifier system that generates over 100W of single frequency output in a near-diffraction-limited beam with an M^2 parameter of 1.25 is described. The prospects for further increase in power are considered.

OCIS codes: (140.3510) Lasers, fiber; (060, 21320) Fiber optics amplifiers and oscillators.

1. Introduction

Narrow linewidth, high power laser sources operating in the eyesafe wavelength regime around two-microns have numerous applications, for example, in areas such as remote sensing and LIDAR, and provide the ideal starting point for nonlinear frequency conversion to the mid-infrared wavelength regime. One promising route to the required output characteristics is via the use of master-oscillator power-amplifier (MOPA) configuration based on Tm-doped silica fiber as the gain medium. In recent work reported in [1], the output from a single-frequency, Tm-doped distributed-feedback (DFB) fiber laser operating at 1932 nm was amplified to 20 W using two Tm-doped fiber amplification stages pumped by Er,Yb cop-doped fiber lasers at 1567 nm. In this paper, we report on a single-frequency Tm-doped fiber MOPA with 100 W of single-frequency output at 1943 nm in a linearly-polarised beam with $M^2 \approx 1.25$.

2. Experiments and Results

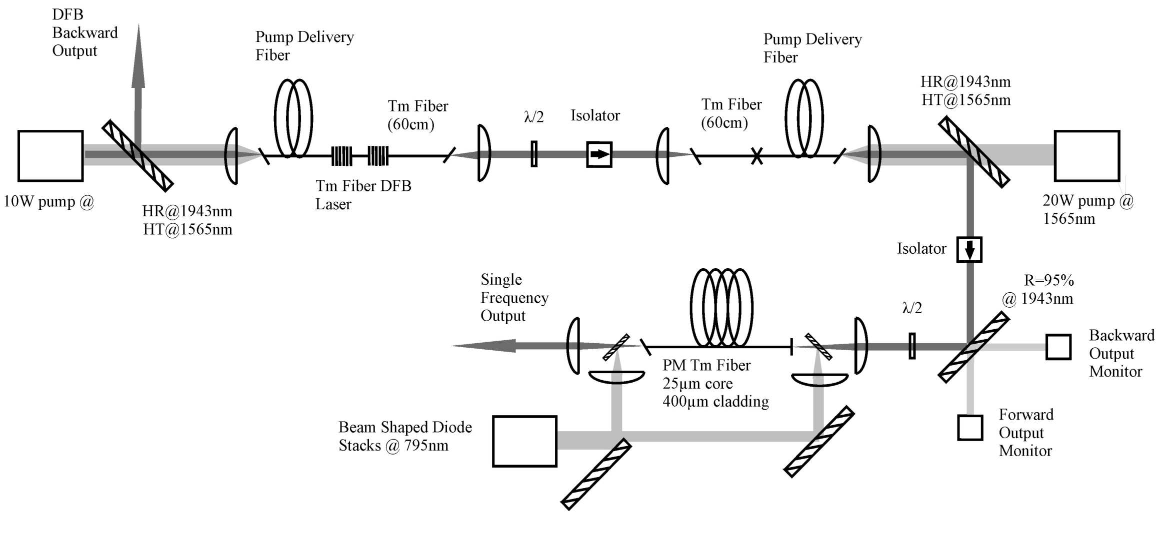

Fig. 1. Schematic diagram of MOPA configuration.

A schematic diagram of the MOPA system used in our experiments is shown in Fig. 1. The master-oscillator was a Tm-doped fiber DFB laser operating at 1943 nm based on a highly-efficient Tm-doped photosensitive silica fiber in-band pumped by an Er,Yb fiber laser with 10W of output at 1565nm. The DFB laser had a maximum output power of 875 mW, limited only by the absorbed pump power. This was amplified to >3W using a simple Tm-doped fiber pre-amplifier stage spliced directly to the DFB fiber without an intermediate isolator [2]. The pump power for the pre-amplifier stage was provided by the unabsorbed pump from the DFB laser. The amplified signal beam exiting the pre-amplifier stage had an M^2 parameter of <1.1. The latter was then amplified to ~10 W using a second amplifier stage pumped by an Er,Yb co-doped fiber laser with a maximum output power of 20 W at 1565nm.

The final amplifier stage employed a Tm-doped polarization-maintaining (PM) double-clad fiber with a core of 25um diameter and 0.1 NA surrounded by a silica inner-cladding cladding with a diameter of 400 µm. Pump light was provided by two spatially-combined diode-stacks with a combined output power of 240W at 795 nm. The pump beam was split into two beams of roughly equal power by a knife-edged mirror and was launched into both ends of the fiber with a launching efficiency of >83%. The effective absorption coefficient for pump light at 795 nm in this fiber was measured to be ~4.5 dB/m, and hence a fiber of ~4m length was used for our experiment. Both facets of the PM fiber were angle-polished at approximately 10 degrees to suppress parasitic lasing.

The output from the second stage amplifier was launched into the final stage amplifier via an arrangement of two beam steering mirrors, a free-space isolator and a half-wave plate. The latter was used to align the polarisation direction to be parallel to the slow-axis of the PM fiber. In order to avoid beam quality degradation due to the isolator and also damage to the isolator, the pump power to the second amplifier was reduced to produce a maximum amplified signal power of 5W. One of the beam steering mirrors (see Fig. 1) had a transmittance of 5% at the signal wavelength to allow monitoring of any backward-propagating beam caused by the onset of parasitic lasing or Stimulated Brillouin Scattering (SBS). The launched seed power into the fiber core was measured to be ~3 W.

Under these operating conditions, we obtained 100 W of single-frequency output for a launched pump power of 190W with a slope efficiency with respect to launched pump power into the final amplifier stage of 59% (see Fig. 2). There was negligible power propagating in the backward direction, confirming the absence of parasitic lasing and SBS. Single frequency operation was confirmed with the aid of a scanning Fabry-Perot interferometer (see inset of Fig. 2). The beam propagation factor (M^2) for the output beam was measured to be 1.25 at the maximum output power and the polarisation extinction ratio (PER) was 94%.

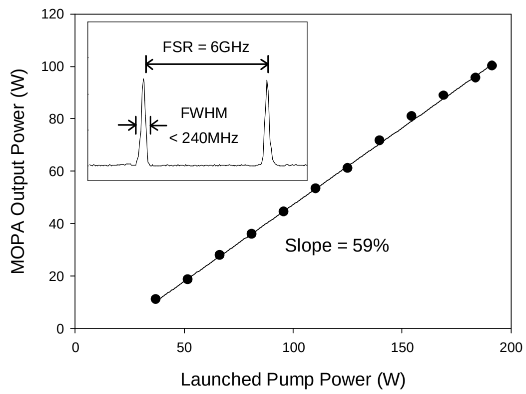

Fig. 2. The MOPA output power as a function of launched pump power (Inset: Oscilloscope trace for scanning Fabry-Perot Interferometer).

3. Conclusions

We have demonstrated a high-power Tm-doped fiber MOPA with up to 100 W of single frequency output at 1943nm. The maximum output power was limited only by the available pump power. Hence, scaling to much higher powers in the multi-hundred-watt regime should be possible from this Tm doped fibre MOPA system with a higher pump power source for the final stage power amplifier.

4. Acknowledgements

This work was supported by the European Commission under the Information Society Technologies priority of the Sixth Framework Program through contract FP6/IST/34010 and by the Engineering and Physical Sciences Research Council.

4. References

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