306W all-fiber based linearly polarized single-mode Ytterbium fiber laser

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Abstract: We demonstrate the first completely monolithic linearly-polarized (extinction 19dB) fiber laser producing high power (306W) diffraction-limited beam (M^2~1.1) with a stabilized, narrow-linewidth (0.57nm) spectrum at 1086nm. Laser design does not require any external polarizing components.

OCIS codes: (060.2320) Fiber optics amplifiers and oscillators; (060.2280) Fiber design and fabrication

1. Introduction.

Advances in Large-Mode Area (LMA) fiber designs [1,2] have led to high power fiber lasers with single-transverse mode output. Single-fiber, continuous wave (CW) lasers with M^2<1.5, random polarization and output power exceeding 800 W have been demonstrated recently [3,4].

Linearly-polarized high power fiber lasers with stable, narrow-line spectrum are highly desired for further high-power scaling through coherent beam combining and for a variety of applications, such as nonlinear frequency conversion. Such fiber lasers can be constructed using Polarization Maintaining (PM) LMA fibers. So far, however, linearly polarized fiber lasers with more than 100-W output have been demonstrated with either external free-space polarizing elements [5] or using complex MOPA schemes [6], thus significantly limiting the robustness and power-handling capacity of such designs.

Here we report the first completely monolithic linearly-polarized cw fiber laser operating in a diffraction-limited and a stabilized narrow-line width beam with more than 300-W output. The significant practical advantage of the demonstrated design is its ultimate simplicity: laser cavity consists only of a PM LMA fiber and a spliced-on fiber grating. Linearly polarized output is achieved due to a polarization-mode selectivity of a tightly coiled PM LMA fiber [7].

2. Experiment and results

The laser design is shown in Figure 1. The laser cavity includes 33 meters of PM-LMA-YDF, and is formed by a spliced-on fiber Bragg grating (FBG) with >99% reflectivity on one end and a flat fiber cleave providing 3.5% Fresnel reflection on the other end. The YDF is a Panda-type PM fiber, having a 20μm core, 400 micron octagonally-shaped inner cladding, a 0.06 core NA and a 0.46 cladding NA (core V# ~ 3.5). The YDF was coiled to a 9cm diameter around an aluminum mandrel, in order to eliminate both the undesired polarization-mode and higher-order transverse modes [7]. The laser was pumped from both ends by fiber-coupled, wavelength-multiplexed diode bars (915nm+940nm+976nm). The total amount of pump power coupled into the fiber laser is 496W.

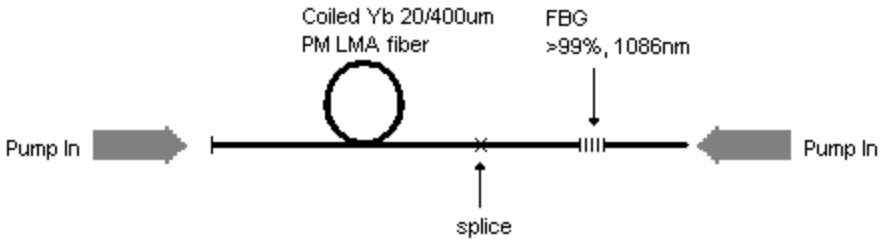

Fig. 1 Experimental setup

Figure 2 shows the 1086 nm laser output-power vs. coupled pump-power. The laser exhibited a threshold of ~3W and a 62% slope efficiency; the latter comparable to other techniques of making polarized fiber lasers. The maximum laser output power was 306W. A Polarization Extinction Ration (PER) up to 19dB has been measured at the output of this simple laser cavity. The laser produced a near diffraction-limited single mode output with M^2=1.1+/-0.1.

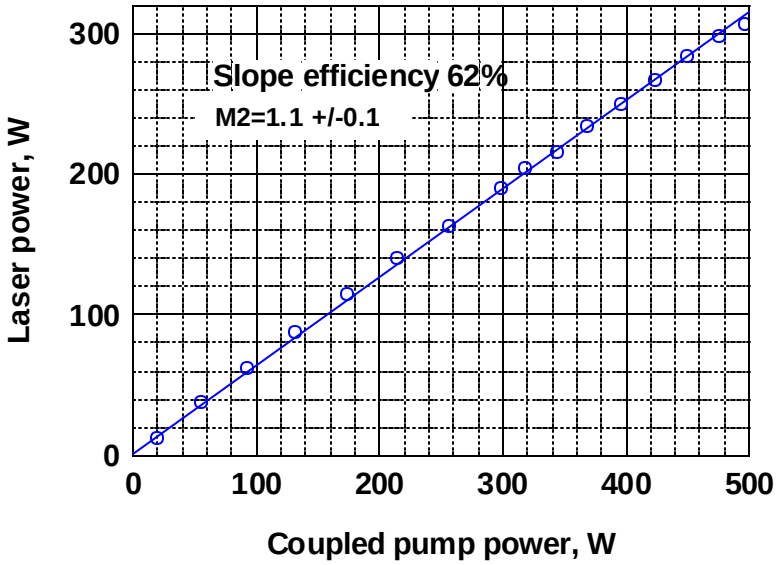

Fig. 2. Laser efficiency.

Figure 3 shows the measured laser line width. The laser had a relatively narrow line width (0.57nm), stabilized by the FBG. Note, that the spectral width was limited by the width of the FBG reflector. No sign of detrimental non-linear effects, such as Brillouin or Raman scattering typical in small-core fibers, has been observed. We believe narrower spectral widths are achievable at this power level.

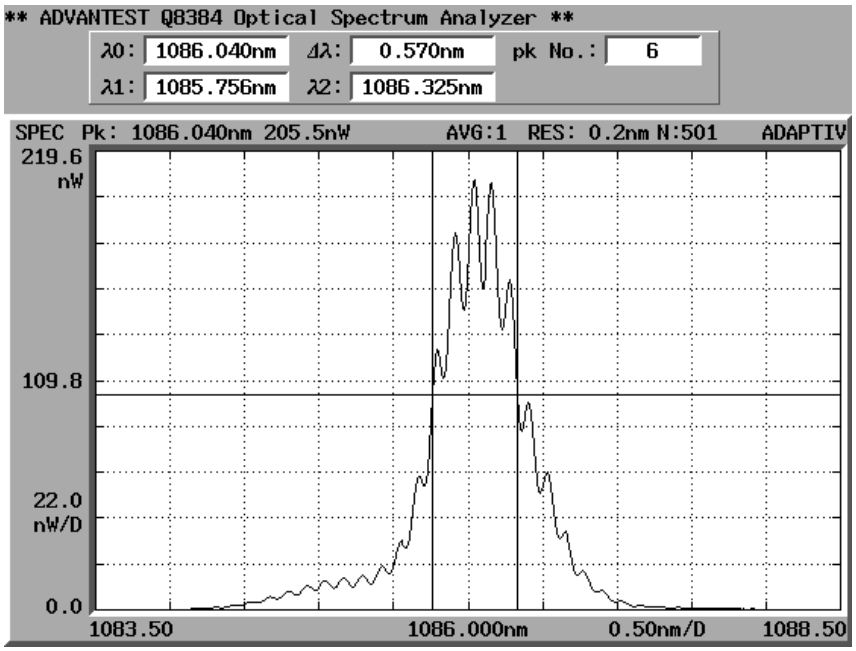

Fig. 3. Output laser spectrum

In conclusion we have demonstrated a monolithic 306-W linearly-polarized, SM fiber laser with a stabilized, narrow line width. Laser output power was limited by the available pump. Our analysis indicates that output power using this design is scalable to 1kW cw and higher. This simple and robust all-fiber design is particularly attractive for further fiber-laser power scaling to >10kW using multiple-beam combining techniques, and is promising to facilitate a broad variety of practical applications requiring high-power linearly-polarized diffraction-limited laser beams.

Authors acknowledge partial support by US Airforce DUS&T program for the development of diode pump source.

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