600 Watt-Level All-Fiber Polarization-Maintained Fiber Amplifier with <0.5GHz Linewidth and Near-Diffraction-Limited Beam Quality

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Abstract—We demonstrate a 600 watt-level all-fiber polarization maintained fiber amplifier with narrow linewidth and near-diffraction-limited beam quality. At maximum output power, the optical to optical conversion efficiency of the laser is 82.6% and the polarization extinction ratio (PER) of the configuration is higher than 93%. The linewidth is narrowed approximately an order than reported high power (>500 W) polarization maintained amplifiers.

Keywords—narrow-linewidth, all-fiber, polarization-maintained

Many applications, such as coherent lidar system, nonlinear frequency conversion, require high power narrow linewidth lasers/amplifiers with near-diffraction-limited beam quality. The output power is limited by nonlinear effects, especially SBS effect. Kilowatt-level output power had been reported by broadening the seed laser to several GHz or using large modal area and highly doped active fiber in non-polarization maintained (non-PM) amplifiers [1-3]. In many applications aforementioned, polarization maintained (PM) sources are strongly desired [3-5]. The SBS gain is higher in PM fiber, power scaling is even more challenging [5]. Recently, high power (>500 W) PM amplifiers had been achieved with a linewidth of ~ 10 GHz level [3, 4].

In this manuscript, a 600 watt-level all-fiber narrow-linewidth and single-polarization laser with near diffraction limited beam quality is presented. SBS free operation is attained with a bandwidth within 500 MHz, which is well narrower than previously reported high power (>500 W) polarization maintained amplifiers. The master oscillator (MO) in the experiment is a 50 mW single frequency and polarization-maintained laser. The seed laser is modulated by a phase modulator before power scaling and boosted to 10 W before sending into the main-amplifier. A PM-tapper is employed to measure the backward light of the main amplifier, which acts as the SBS monitor. The core/inner cladding diameter of the active fiber is 30/250 μm, and 3 m Yb-doped PM-LMA double clad fiber is used. Approximately 0.2 m long passive fiber is spliced to the active fiber for power delivery. The spliced region is covered in high-index gel to strip out the residual pump laser. In the experiment, the modulation frequency and depth (peak-to-peak value) of the sine signal is set to be 20 MHz and 8 V, which corresponds to the linewidth of seed laser below 500 MHz. The power scaling characteristics of the laser, the backward power, and the beam quality (M² factor) measurement results are shown in Fig. 1. Pump-limited maximum power is 585 W with 82.6% optical-to-optical efficiency. SBS-induced nonlinear increase in backward power is not observed at the maximum output power (shown in the inset1 in Fig. 1). The beam quality of the output laser beam is measured to be M²x=1.5 and M²y=1.4. The PER of the MOPA system is measured to be higher than 93% in all the power scaling process.

Fig.1 Output laser power versus final stage injected pump power. Inset1, backward signal power versus output laser power. Inset2, M² measurement results of the output laser beam.

REFERENCES


