Supplemental Document

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Large mode area double-clad ytterbium-doped spun tapered fiber: supplement

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Polarization eigenstates and birefringence measurements

The polarization eigenstates of three sT-DCF with 7.5, 15, and 30 mm pitch were measured using the Jones method [1], similarly to how it was done in [2,3]. The Jones transfer matrix of an optical device can be found by measuring output polarization states in response to known launched polarization states. It is most convenient to launch three linear polarizations oriented at 0°, 90°, and 45°. The igenvectors of a Jones matrix are polarization eigenstates of an optical device. The measurements were carried out in a passive regime without pumping. For all spun tapered fibers, their polarization eigenstates were elliptical, close to circular (Fig. S1).

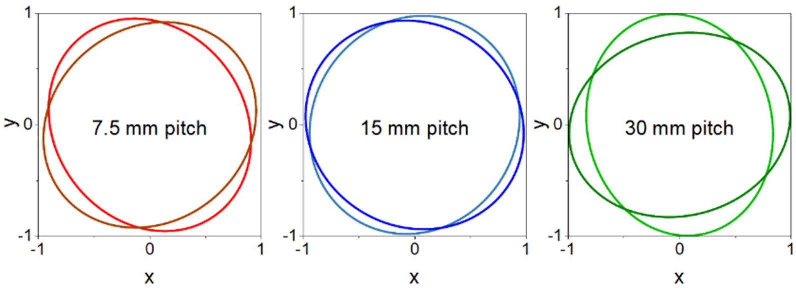

Fig. S1. Polarization eigenstates of sT-DCF with three different pitches: 7.5, 15, and 30 mm.

The sT-DCF had a large bend radius of 75 cm. As the radius of a tapered fiber changes with length, we calculated the linear birefringence as a function of fiber length and used the mean value for further calculations. In addition, the ratio of linear and circular birefringence can be found from Jones matrix. Thus, eigenstates and birefringence values for all three sT-DCF were calculated and presented in Table S1.

Table S1. Measured eigenstates and birefringence for sT-DCFs.

Pitch, mm	DOP, %	Ellipticity of eigenstates, degrees	Azimuth of eigenstates, degrees	Circular birefringence	Linear birefringence
7.5	92.8	-41.0/40.5	37.7/-53.9	4.12×10^{-8}	6.16×10^{-9}
15	99.0	42.3/-42.5	-30.5/57.6	7.59×10^{-8}	6.83×10^{-9}
30	98.7	-39.2/39.6	14.0/-77.1	3.36×10^{-8}	6.67×10^{-9}

Green picosecond laser

The green laser was made by using frequency doubling of 1064 nm MOPA system based on sT-DCF with 15 mm pitch. The MOPA was seeded by commercially available 1064 nm gain-switched laser diode emitting linearly polarized 95 ps pulses at 10 or 100 MHz repetition rates. For effective amplification in sT-DCF, the seed signal was pre-amplifier up to an average power of 15 and 26 mW, respectively. We used an active sT-DCF as the main amplifier. 100 W of 976 nm pump was launched through the wide end in a counter-pumping scheme. The maximum output average power was 49 W at 10 MHz and 64 W at 100 MHz at a central wavelength of 1064 nm. A green light was generated in a 3×3×20 mm LBO crystal using a non-critical phase-matching scheme. At 10 MHz, the maximum output power of green at 532 nm was 17 W with an efficiency of 48% (Fig. S2a). For 100 MHz, we managed to reach 14 W of green with 27% efficiency (Fig. S2b).

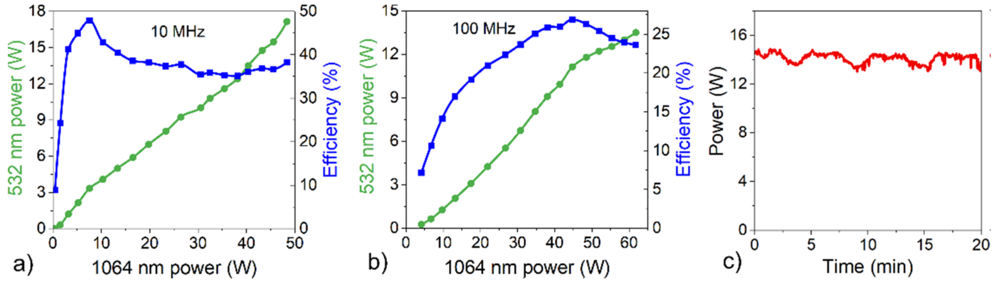

Fig. S2. Power of green light and conversion efficiency vs. 1064 nm pump power for a) 10 MHz and b) 100 MHz. c) Fluctuations of 532 nm output power.

Power output stability was measured over 20 minutes at 85% of the maximum output power. Although the temperature of the nonlinear crystal was electronically controlled during the experiment, it varied within the range of 0.4°C. Accordingly, the power of green radiation changed periodically with an amplitude of 13% (Fig. S2c). These power fluctuations are mainly associated with temperature variation of the nonlinear crystal oven. The linewidth of the green laser was 0.08 and 0.05 nm for 10 and 100 MHz, respectively (Fig. S3a), measured with the resolution of an optical spectrum analyzer of 0.05 nm.

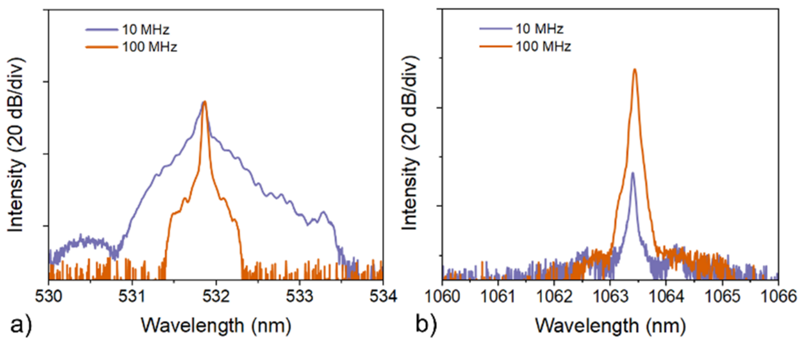

Fig. S3. a) Green laser spectra at 10 and 100 MHz, b) 1064 nm spectra at 10 and 100 MHz.

References

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