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LARGE MODE AREA TAPERED FIBERS FOR GENERATION OF HIGH ENERGY ULTRASHORT PULSES FROM NONLINEAR COMPRESSION

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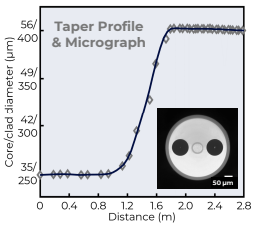
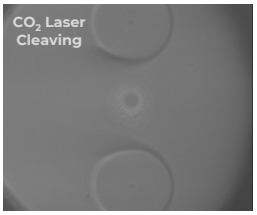
SUMMARY

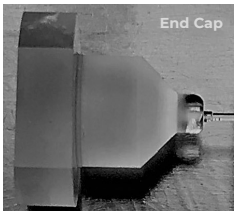
Nonlinear compression for generation of high energy ultrashort pulses [1] using an Yb-doped large mode area tapered fiber [2] is reported. Suppression of higher-order modes is enhanced compared with large mode area step-index fibers owing to the depressed-index inner cladding and confined doping [3]. Average power and pulse energy exceeding respectively 90 W and 50 µJ were achieved after multipart fiber amplifier stages, with final-stage amplifier gain larger than 40 dB. Pulse compression using a chirped volume Bragg grating [4] later yields durations as short as 1 ps and peak powers exceeding 10 MW, with near diffraction-limited output. Pulse-on-demand and burst modes are straightforward, given the master oscillator / power amplifier scheme, with pulse generation first initiated from direct current modulation of a seed laser diode while subsequent external phase modulation and spectral selection yield pulse trains/bursts following digitized arbitrary waveforms [5]. The proposed scheme is considered to be relevant for laser materials processing.

LMA TAPERED FIBER

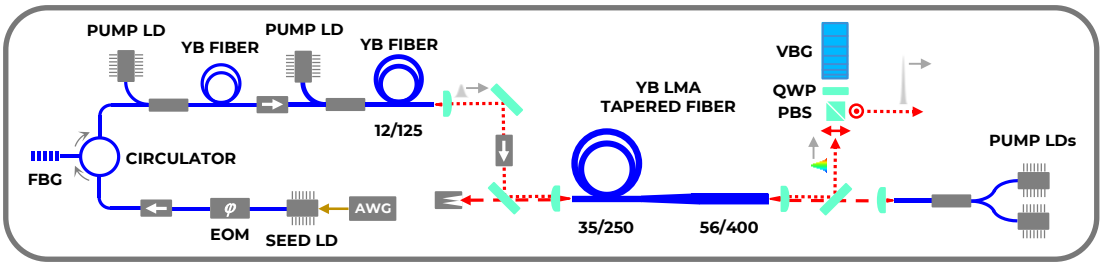
Optical Properties		Data
Core numerical aperture		0.07
Cladding numerical aperture		0.50
Cladding absorption / 915 nm	[dB/m]	2.7
Cladding absorption / 975 nm	[dB/m]	10.8
Birefringence		$1.8 \cdot 10^{-4}$
Physical Characteristics		**Data**
Small core diameter	[µm]	35
Small cladding diameter	[µm]	250
Large core diameter	[µm]	56
Large cladding diameter	[µm]	400
Coating diameter	[µm]	525







MASTER OSCILLATOR / POWER AMPLIFIER

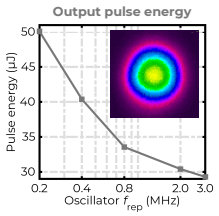


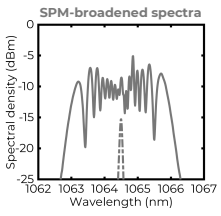
NONLINEAR PULSE COMPRESSION

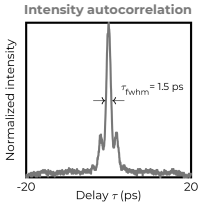
Optical pulses undergo significant nonlinear spectral broadening in the large mode area tapered amplifier fiber. Pulse compression was performed using a chirped volume Bragg grating (D = 5.9 ps/nm). Transmission of the pulse compressor was 85%. The VBG makes the compressor stage both compact and reliable. Some energy is shed away from the central peak due to the VBG which only compensates for the linear part of SPM-induced frequency chirp. The pedestal below the main peak was seen to carry about half of the total pulse energy.

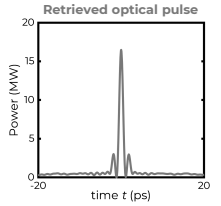
HIGHLIGHTS:

- Amplifier gain > 40 dB
- Oscillator f_{rep} up to 10 MHz
- Pulse energy ~ 30-50 µJ
- Beam quality M^2 < 1.3
- Compression factor > 30
- Pulse duration ~ 1 ps
- Peak power > 10 MW



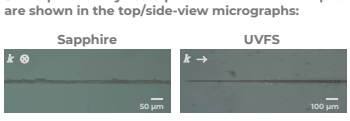






APPLICATIONS

Laser filamentation in transparent dielectrics and other brittle materials for kerfless cutting/scribing using conventional low-NA loose focusing optics. Some preliminary tests performed on few samples are shown in the top/side-view micrographs:



REFERENCES

[1] A. Steinmetz et al., "Nonlinear compression of Q-switched laser pulses to the realm of ultrashort durations," Opt. Express 19(4), pp. 3758-3764 (2011).
[2] A. Fedotov et al., "Ultra-large core birefringent Yb-doped tapered double clad fiber for high power amplifiers," Opt. Express 26(6), pp. 6581-6592 (2018).
[3] V. Roy et al., "Yb-Doped large mode area tapered fiber with depressed cladding and dopant confinement," Proc. of SPIE 10083, 1008314 (2017).
[4] L. Glebov et al., "Volume-chirped Bragg gratings: monolithic components for stretching and compression of ultrashort laser pulses," Opt. Eng. 53(5), 051514 (2014).
[5] P. V. Mamyshev, "Dual-wavelength source of high-repetition-rate, transform-limited optical pulses for soliton transmission," Opt. Lett. 19(24), pp. 2074-2076 (1994).

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