High Spectral Brightness, Actively-Triggered, ns-Pulse, MW-Peak-Power Fiber-Based Laser Transmitter for Space-Based Terrain Mapping

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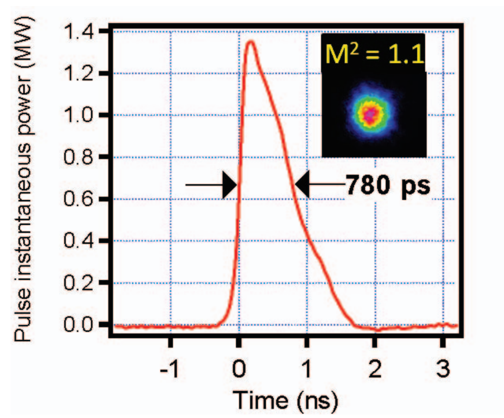
Space-based 3-D imaging/altimetry ladar missions require or strongly benefit from ns-pulse laser transmitters operating at pulse repetition frequencies (PRF) in the multi-kHz range. Additional laser requirements include near diffraction-limited beam quality, excellent wavelength stability and spectral brightness, mJ-level pulse energy (MW-level peak power), and high wall-plug efficiency.

The high efficiency requirement singles out diode-pumped Yb-doped pulse fiber-based lasers as a very promising solution for these missions. These optical sources, in fact, can offer approximately 2X higher optical-to-optical efficiency compared to traditional diode-pumped bulk solid-state lasers while providing simpler thermal management as well as higher and more stable beam quality and beam pointing (thanks to single-mode waveguiding). They are also naturally amenable to compact and rugged packaging. Traditionally, however, fiber lasers have been unable to generate pulse energies and peak powers in line with the requirement of long range ladar missions due to the onset of in-fiber nonlinear optical effects (NLEs) that significantly degrade the spectral brightness.

(a)



(b)

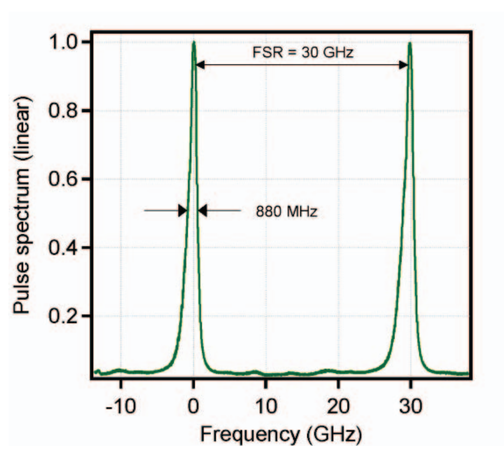


Fig. 1: Example performance of our fiber-based MOPA (see Text). (a): MOPA-emitted pulse temporal profile corresponding to PRF = 50kHz and pulse energy >1.1mJ. The peak power was >1.3MW; inset: Near-field image of the output beam. (b) Pulse spectrum (recorded using an scanning Fabry-Perot spectrometer of ~30GHz free-spectral range).

We have bridged this performance gap by resorting to very large core, single-transverse-mode Yb-doped photonic crystal fibers (PCF), which retain excellent beam quality while significantly raising the threshold peak power for NLE [1-4].

In this paper, we will first detail the performance of our actively-pulse-controlled, ns-pulse master-oscillator/power-amplifier (MOPA) architecture featuring a diode-pumped large-core Yb-doped PCF as the terminal stage. From this MOPA, a unique set of performance values [5] can be obtained including pulse energies up to 3mJ, peak power in excess of 1.3MW (see Fig. 1), near-diffraction-limited beam quality ($M^2 \sim 1.1$), pulse average power in excess of 55W, near Fourier-transform-limited output (linewidth < 1 GHz), optical conversion (from 975nm pump diode laser to 1064nm pulsed signal) efficiency >65% and wall plug efficiencies in excess of 25%.

Parameter	**Values**
Pulse energy	> 3 mJ
Pulse width	< 2 ns
Peak power	> 1 MW
Pulse repetition frequency	≥ 10 kHz
Center wavelength	1020-1090nm
Spectral width	< 50 pm
Polarization	100:1
Pointing stability	< 10% of beam divergence
Bus-plug efficiency	> 25%
Mass	< 10 kg
Volume	< 15 liters

Table 1: Performance/packaging parameters enabled by our high-PRF fiber based laser source, which are directly applicable to transmitters in space-based altimetry/topography/mapping missions.

Then, we will address the tasks of designing, building, demonstrating and delivering a complete laser system brassboard based on the above mentioned MOPA architecture and intended as an intermediate step towards TRL 6 systems that can meet or exceed typical performance goals summarized in Table 1 to support space laser ranging/imaging missions.

References/Bibliography

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