High Energy Pulses from a Wavelength Tunable Dy:ZBLAN Mid-Infrared Fiber Laser

Matthew R. Majewski, Robert I. Woodward, and Stuart D. Jackson
MQ Photonics, School of Engineering, Faculty of Science and Engineering, Macquarie University, North Ryde, NSW 2109, Australia

Laser sources in the mid-infrared (MIR 3 - 5 µm) are increasingly in demand to meet the needs of a variety of applications which exploit the strong ro-vibrational molecular absorption lines in this spectral region. Requirement of high energy *pulsed* light is found in time-resolved sensing applications such as LIDAR. Fiber lasers in the mid-infrared are promising candidates for generating such pulses, with Q-switched erbium-doped systems demonstrated covering both the 2.8 µm and 3.5 µm bands [1,2]. However, there remains a sizable 'gap' in spectral coverage of such lasers, motivating interest in pursuing alternative rare earth dopants. Dysprosium in particular is a compelling solution, as it possesses a wide gain bandwidth covering 2.8 to 3.4 µm with recent electronically tunable systems closing much of this 'gap' [3].

In this work we present the introduction of a tunable dysprosium laser into the high-energy pulsed regime via active Q-switching. The cavity is presented in Fig. 1a. The dysprosium fiber is pumped resonantly (in-band) with an erbium fiber laser, and an acousto-optic tunable filter (AOTF) provides wavelength selectivity and serves as a Q-switch when the required RF drive is pulsed on and off. Observation of multiple pulsing is recreated with detailed numerical modeling (Fig. 1b), allowing for prescription of operating parameters which result in stable single-pulse operation; this will be discussed in detail.

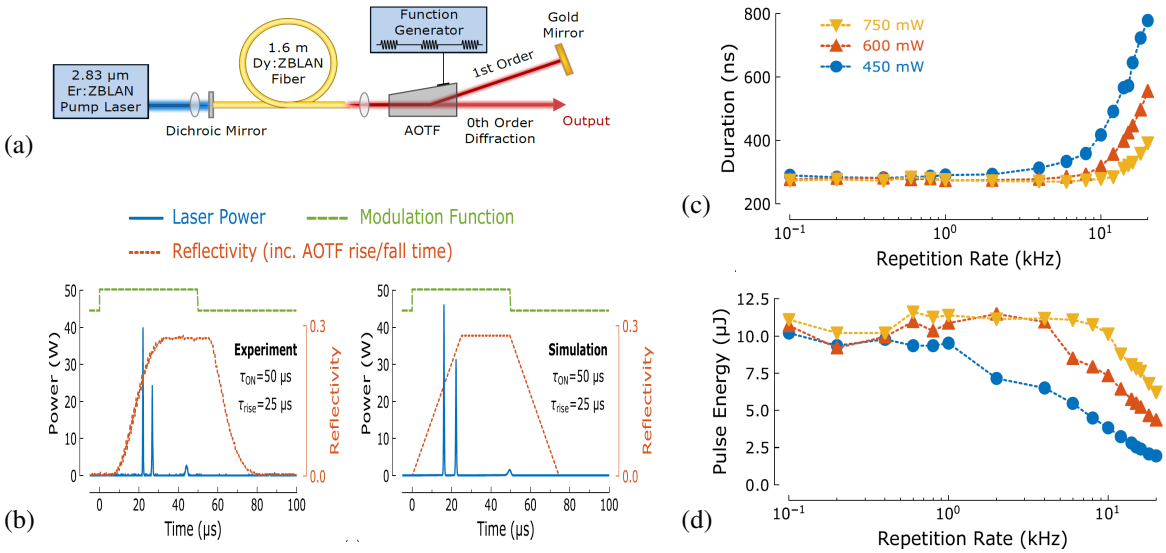

Fig. 1 a) laser schematic; b) comparison of numerical simulation to experiment identifying multiple pulse regimes; c) pulse duration as a function of repetition rate; d) pulse energy as a function of repetition rate.

Performance of the Q-switched fiber laser is characterized as a function of the repetition rate and pump power (Fig. 1c,d). Beyond 2 kHz the pulse duration is seen to increase with a corresponding decrease in pulse energy. However, system performance is reasonably stable at all pump powers for repetition rates between 0.1 and 1 kHz with a maximum pulse energy of 12 µJ at a duration of 270 ns. Further, while maintaining stable pulse operation, this system is electronically tunable by simply altering the center RF drive frequency to the AOTF, resulting in pulses over a range of 2.97 to 3.23 µm. Potential for system optimization and further scaling of the pulse energy will be discussed.

References

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