Short-wavelength fiber Raman laser pulse-pumped by multimode laser diode at 806 nm

Tianfu Yao and Johan Nilsson
Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, UK
ty4g10@orc.soton.ac.uk

Abstract: We demonstrate a fiber Raman laser emitting at 835 nm when pumped by bursts of 50 - 100 ns pulses from a multi-mode laser diode at 806 nm. The slope efficiency reaches 38%.

OCIS codes: (060.3510) Lasers, fiber; (060.4370) Nonlinear optics, fibers.

Fiber Raman lasers (FRLs) and amplifiers offer many of the benefits of the more widespread rare-earth doped ones, and in addition wavelength agility and instantaneous pump-to-signal conversion [1]. These latter properties are highly attractive for diode-pumping, since pump diodes can be directly modulated to create short pulses of complex shapes and are available for a number of wavelengths where alternative approaches are unsatisfactory. It is particularly interesting to use short-wavelength diodes to realize fiber devices at similarly short wavelengths, which are otherwise hard to reach. However, higher scattering loss and limited pump brightness has hampered progress, and to the best of our knowledge, the shortest wavelength of a diode-pumped fiber Raman device is 1525 nm [2].

Here, we report a diode-pumped FRL generating 50 – 100 ns pulses at a record-short wavelength of 835 nm. For this, we used a multimode diode with 100 µm stripe width, capable of 50 W of output power in short pulses at a center wavelength of 806 nm. The diode was fabricated by the Ferdinand Braun Institute and was synchronously driven at the fiber laser roundtrip frequency of 207.88 kHz by a Picolas diode driver. The driver was unable to generate the average current required for a continuous train of pulses, so we resorted to bursts of 50 (50 ns pulse duration) and 20 pulses (75 ns and 100 ns durations) at a total duty cycle of 0.1%, 0.06% and 0.08%, respectively. These were then launched into a 944 m long relatively conventional highly nonlinear fiber (HNLF) from Sumitomo Electric Industries, Ltd. See Fig. 1. The HNLF output end is spliced to a piece of standard single mode fiber (SMF-28). The total background loss (including the splice loss, which is small) is 6 dB at 806 nm, leading to an effective length of ~ 512 m. The loss at 835 nm is expected to be ~ 0.6 dB lower. The core diameter is 4 µm, the effective area about 10 μm^2, and the NA 0.3. Thus, the fiber supports around nine modes at the pump and signal wavelengths. The Raman gain coefficient is 2.9×10^{-13} m/W for unpolarized light, as estimated from the refractive index and inferred composition of the germanosilica core (Ge concentration 26% (mol)). The arrangement of polarizing beam splitters (PBS's) and zero-order half-wave plates allow us to vary the outcoupling and the pump power, without changing the profile or polarization properties of the beams.

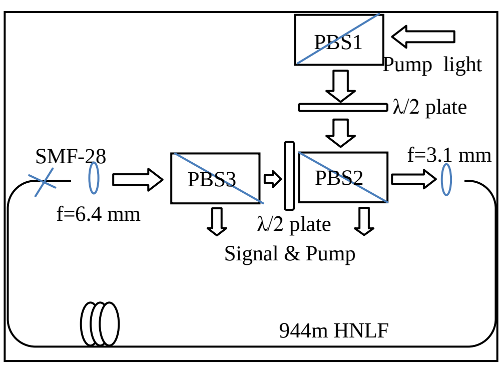

Figure 1 Experimental setup of FRL.

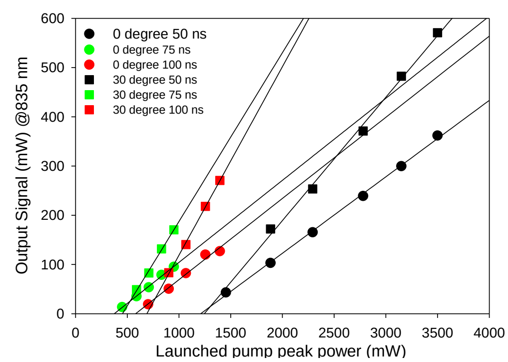

Figure 2 FRL output power for different pulse durations and output coupling (0 and 75% outcoupling in PBS2)

The peak laser output power from PBS3 and PBS2 together, as calculated from the measured average power and the duty cycle, is shown in Fig. 2 for different pulse durations and output coupling (0 and 75% outcoupling in PBS2). A slope efficiency of between 15% and 38% is reached. We tentatively attribute the higher slope efficiency for the longer pulse durations to the smaller number of pulses in the bursts: The signal builds up over a number of pulses, which can be significant in a short burst. At higher pump power the signal power develops fewer pulses, which leads to a higher slope. In addition, the increased pump depletion at higher pump powers can, over a limited range of powers, bring the slope efficiency above the 24% limit set by the 6 dB fiber loss and the 3.5% Stokes shift. The higher threshold for shorter pulses may be due to pump – signal walk-off of around 50 ns. More results on FRLs with shorter fibers and thus higher efficiency will be presented at the conference.

[1] G. P. Agrawal, *Nonlinear Fiber Optics*, 3rd ed. (Academic Press, Inc., San Diego, CA, 2001)
[2] Shu Namiki and Yoshihiro Emori, “Ultrabroad-Band Raman Amplifiers Pumped and Gain-Equalized by Wavelength-Division-Multiplexed High-Power Laser Diodes,” IEEE J. Selected Topics in Quantum Eledtronics, Vol. 7, no. 1, Jan/Feb (2001).