Syncronous generation of nanosecond pulses at 1064 nm and 1240 nm in all-fiber laser

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Abstract— Generation of two synchronized pulses with broadly different wavelengths in the same fiber laser cavity opens up promising possibilities of entering the mid-IR wavelength range by difference frequency generation (DFG). One of the ways to generate synchronous pulses with very different wavelengths is Raman conversion in a P_2O_5-doped fiber incorporated into the laser cavity in addition to an Yb-doped fiber. This work demonstrates, for the first time, efficient generation of synchronized pulses at wavelengths of 1064 and 1240 nm in such an all-fiber nested-cavity laser. An external DFG stage allows conversion of the laser output into pulsed radiation at ~7.5 µm.

Keywords— fiber laser, pulse lasing, Raman conversion

I. Introduction

Generation of Raman pulses in a P_2O_5-doped optical fiber enables a particularly large Stokes shift of 1330 cm^{-1} [1]. However, extra-cavity pulse conversion in such a fiber features comparatively low efficiency due to the interaction time issue for pulses with different wavelengths. We propose an all-fiber nested-cavity laser configuration that allows synchronous generation of pulses at wavelengths of 1064 and 1240 nm. This configuration uses the quasi-synchronous pumping [2] of Yb-doped fiber for generation of the fundamental pulses at 1064 nm, and enables efficient intra-cavity Raman conversion of those pulses in an incorporated P_2O_5-doped fiber. The demonstrated solution holds a promise as a method of mastering the mid-IR wavelength range by difference frequency generation.

II. Experemental

We employed a ring Yb-fiber laser configuration (similar to that used in Ref. [2]) as the basis for development of a bicolor pulsed fiber laser with quasi-synchronous pumping. The novel laser scheme (Fig. 1) features incorporation of a kilometer-long P_2O_5-fiber span for the Raman-based lasing at 1240 nm and a corresponding bypass of the narrow-band amplifying stage intended for the stimulated-emission-based lasing at 1064 nm.

In accordance with the concept of quasi-synchronous pumping [2], pulsed lasing at 1064 nm was driven by modulated pumping of the Yb-fiber at 980 nm with a slightly overrated modulation frequency approaching the fundamental pulse repetition rate of ~208 kHz. In turn, the generated nanosecond pulses at 1064 nm provided synchronous pumping of the P_2O_5-fiber, thereby enabling Raman-based pulsed lasing at 1240 nm. Thus, the laser generated nanosecond pulses at two sufficiently different wavelengths as shown in Fig. 2.

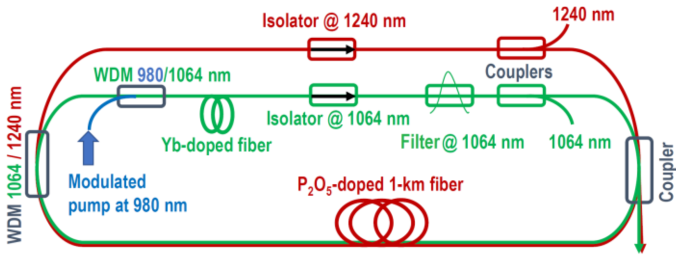

Fig. 1. Schematic of the laser (WDM- wavelength-devision multiplexor).

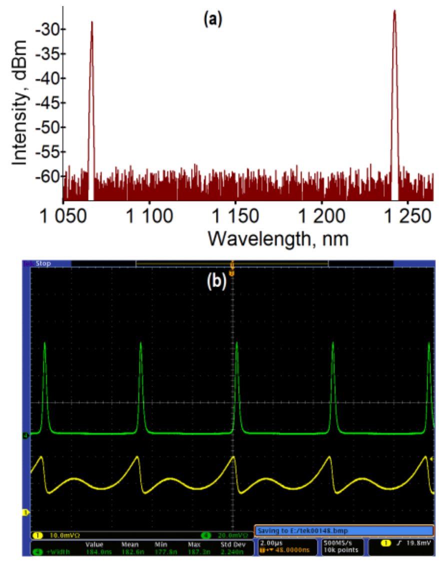

Fig. 2. Optical spectrum of the laser radiation (a) and oscillogram (b) of pulse trains generated at 1064 nm (lower trace) and 1240 nm (upper trace). The shortest duration of pulses at 1240 nm amounted to ~110 ns.

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