Pulsed Single-Frequency Polarization-Maintaining Holmium Laser at 2050 & 2090 nm

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We report on the development of a nanosecond pulsed multistage fiber master oscillator power amplifier (MOPA) targeted as a pump source for mid-infrared conversion; long wavelength (≥ 2 µm) pulsed lasers are needed to mitigate losses in the nonlinear crystals [1]. Mid-infrared sources can be used for sensing or medical applications. N. Simakov et al. have shown that Holmium-doped fiber amplifiers (HDFA) are a great solution to amplify signals above 2 µm, with an adjustable bandwidth depending on the pump wavelength [2].
Our MOPA setup consists of a semiconductor laser centered at 2050 nm or 2090 nm as seed (linewidth < 13 MHz), followed by a two-stage HDFA build with polarization-maintaining fibers only. The Amplifier configuration was optimized with a simulation tool. The first stage is operated in CW regime, pumped at 1993 nm. Pulses are generated by external modulation through an acousto-optic modulator (AOM) placed at the output of the first stage and are then amplified by the second stage pumped at 1950 nm.
Figure 1 (a) shows the output power of the first stage versus the input pump power at 1993 nm. For the first stage at 2050 nm we measure a slope efficiency η = 63.2 % (resp. 59.9 % at 2090 nm) and a maximum output power of 902 mW (resp. 920 mW) for a input power P_{in} = 9.8 mW (resp. P_{in} = 3 mW), which corresponds to a gain of 19.6 dB (resp. 24.8 dB).

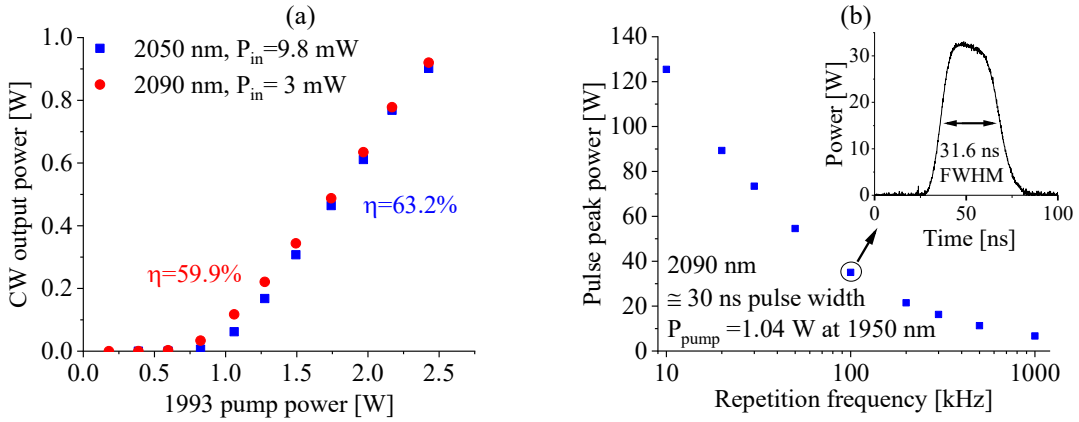

Fig. 1 (a) First stage output power at 2050 nm and 2090 nm versus input pump power at 1993 nm. (b) Second stage peak power for a ≅ 30 ns pulse at 2090 nm versus the repetition frequency.

We investigate the amplification of ≅ 30 ns rectangular pulses from 10 kHz to 1 MHz. The output pulse peak power versus the repetition frequency is shown in figure 1 (b). At a repetition rate of 10 kHz a maximum pulse peak power of 125 W is measured. The inset shows the output pulse shape at 100 kHz repetition rate, the pulse distortion is caused by gain saturation. For repetition rates of 10 kHz up to 100 kHz the pulse peak power out of the second stage was limited by the onset of stimulated Brillouin scattering. Meanwhile no parasitic lasing of the amplified spontaneous emission in between pulses is observed. We present a comparison of the two-stage MOPA performance for a second stage co- or counter-pumped at 1950 nm with the goal of reaching the highest peak power at both signal wavelengths.

References

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[2] N, Simakov et al., "High gain holmium-doped fibre amplifiers," Opt. Express 24, 13946-13956 (2016)