High repetition rate Q-switched Ho:YLF laser pumped by Tm:fiber laser

J. Kwiatkowski*, W. Zendzian, J.K. Jabczynski, M. Kaskow, L. Gorajek
Institute of Optoelectronics
Military University of Technology
00 908 Warsaw, Poland
*e:mail: jkwiatkowski@wat.edu.pl

Abstract— A study of Ho:YLF laser in continuous-wave (CW) and Q-switched operation, single-pass end-pumped by a Tm: fiber laser is presented. For 1 kHz PRF (pulse repetition frequency), pulse energies of 5.7 mJ with a 11 ns FWHM pulse width corresponding to almost 520 kW peak power were recorded. The laser operated at the wavelength of 2050.08 nm delivering a near-diffraction-limited beam with $M^2$ values of 1.05 and 1.09 in the $x$ and $y$ directions, respectively.

Keywords— mid-infrared lasers, Ho:YLF, solid-state lasers, in-band pump.

The mid-infrared spectrum around 2 $\mu$m has been one of the most explored regions in laser technology in recent years. High-power, short-pulse, high-repetition rate and high-energy 2-$\mu$m lasers have a wide range of potential applications in various fields such as medicine, the military and science.

In this paper we report on a CW and high repetition rate, acousto-optically Q-switched Ho:YLF lasers single-pass pumped by a linearly polarized, narrow line width of 1.94 $\mu$m Tm:fiber laser.

A Ho:YLF laser based on a longitudinal pumping scheme was developed according to the conception depicted in Fig. 1.

![Fig 1. Experimental setup of the end-pumped Ho:YLF laser: PBS – polarizing beam splitter, DM – flat dichroic mirrors anti-reflective at 1.94 $\mu$m and 45-deg highly reflective at 2.05 $\mu$m, OC – concave output-coupling mirror, AOM – acousto-optic modulator, HR – high reflector.](image)

The energetic characteristics of the laser in a CW mode of operation were measured for the output coupler transmittance of $T_{OC} = 40 \%$ at 2050 nm. The physical length of the Ho:YLF laser resonator was approximately 145 mm. For the maximum CW incident pump power of 32.5 W, the holmium laser based on 1.0 at. $\%$ crystal generated output power as high as 14.5 W with a slope efficiency of 53.4$, %$, determined with respect to the incident pump power. For the Q-switched operation, a fused silica, acousto-optic modulator was applied. The PRF was varied from 1 to 10 kHz. For the minimum applied frequency, pulses of 5.7 mJ energy were achieved. For the maximum incident pump power (for 10 kHz), the highest average output power of 14.2 W was measured corresponding to the optical-to-optical conversion efficiency of 43.6 $\%$ with respect to the incident pump power. The shortest pulses of 11 ns FWHM width and almost 520 kW peak power were achieved for the PRF of 1 kHz. The results for the incident pump power of 32.5 W are presented in Fig. 2.

![Fig 2. Pulse energy and pulse width as a function of pulse repetition rate, measured for the maximum pump power of 32.5 W.](image)

The output spectrum of the Ho:YLF laser with the central wavelength of 2050.08 nm and the FWHM width of 0.86 nm was recorded. The beam quality parameter $M^2$ at the 5 kHz PRF was measured to be 1.05 and 1.09 in $x$ and $y$ directions, respectively. A nearly perfect Gaussian beam profile inside the resonator within the whole scan resulting from the single-mode pump laser operation was created.

ACKNOWLEDGMENT

This research has been supported by the National Science Centre of Poland under contract No. 2011/03/B/ST7/00256.