Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 71 (2015) 287 – 292

Physics Procedia

18th Conference on Plasma-Surface Interactions, PSI 2015, 5-6 February 2015, Moscow, Russian Federation and the 1st Conference on Plasma and Laser Research and Technologies, PLRT 2015, 18-20 February 2015

Research of the features of generation pulsed radiation in gain-switch thulium fiber lasers

I.V. Obronov[a,b]*, V.E. Sypin[a,c], S.V. Larin[a]

[a]*LLC NTO "IRE—POLUS", 1 Vvedenskogo Sq., Fryazino, Moscow Region, 141120,Russia;*
[b]*National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe shosse 31,115409, Moscow, Russia*
[c]*Moscow institute of Physics and Technology (State University), 9 Institutskiy per., Dolgoprudny, Moscow Region, 141700, Russia*

Abstract

Our work is devoted to the study of the formation of relaxation pulses with a wavelength of 1.9 microns in thulium fiber laser with pumping modulation via erbium pulsed fiber laser (λ = 1.55 μm). This type of thulium pulsed fiber lasers is simpler, than scheme of master oscillator amplification due to high cost, exclusivity and low quality of 1.9 microns semiconductor laser. In addition, our approach permits to achieve shorter pulses, than conventional fiber Q-switch schemes. We have proposed a theoretical model that allowed determining to determine pulses duration and peak power as function of different parameters of the resonator, such as length, fiber Bragg grating reflection, Tm^{3+} concentration, wavelength of pump radiation, pumping pulse energy. Through those dependencies, we determined optimal parameters of resonator for achieving the shortest pulses. Results were approved by experimental work. Laser with optimized parameters provides pulsed radiation with pulsewidth lower than 10ns, peak power 1.8kW and repetition rate 50kHz. We propose following steps to reduce pulse duration and narrow pulses spectral bandwidth.

Peer-review under responsibility of the National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

* Corresponding author. Tel.: +7-946-255-74-46(add 4417, 4117); fax: +7-496-255-74-59.
E-mail address: iObronov@ntoire-polus.ru

Peer-review under responsibility of the National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)
doi:10.1016/j.phpro.2015.08.326

Keywords: Thulium; fiber laser; gain-switch.

1. Introduction

Fiber lasers have demonstrated a great performance in the different operation modes in spectral ranges 1.06 and 1.55 μm using ytterbium- and erbium-doped lightguides. Furthermore, research and manufacture of thulium- and holmium- doped fibers is actively developing. There is a different schemes of such lasers, include lasers, which operate operates in pulse-periodically regime with pulse duration in order of nanosecond. Such kind of devices have a great potential in LIDAR schemes [Scholle et al.(2004)], medical application [Scott et al.(2009)], convertors in spectroscopy, mid infrared and far infrared spectral ranges [Creeden et al.(2008)], different material proceeding tasks.

There are is a different ways to obtain high repetition rate short pulses with wavelength 2 μm. The widespread schemes are Q-switch in bulk Ho:YaG schemes [Duan et al.(2008)]; Q-switch in schemes based on thulium-doped active fibers [Liu et al.(2013)]; schemes with semiconductor seed (MOPA schemes). However, such type of lasers does not allow allows high peak powers and short pulse durations to be obtained or it is complicated and bulky. Traditional schemes with bulk elements in the cavity also have has large losses, prone to heating and out beam quality could be reduced due to thermal effects. For MOPA schemes realizing appropriate semiconductor lasers are needed, but prices still very high and fabrication technology are not so perfectly debugged as in the case of DFB lasers in the range 1.55 μm.

Unlike to these approaches ways, for gain-switch scheme realizing there is no need for additional bulk elements in the cavity and it's possible to actualize simple all-fiber system. Such approach way is the simple and firm alternative for 2μm short pulses producing. Recently a number of researches pay give an attention to for such scheme, but the shortest pulse duration, which was obtained through gain-switch is less than 10ns [Jiang et al.(2007)]. The shorter pulses were obtained just through appearance of self mode-locking in the thulium cavity [Eckerle et al.(2012), Swiderski et al. (2013)]. In our work we built theoretical model of all fiber pulsed thulium laser; from it we derived a parameters of needed components and made a laser with close to optimal configuration. We obtained a stable generation of pulses with duration less than 10ns and peak power around 1.8 kW. For the best of our knowledge we at the first time performed effective optimization of gain-switch all fiber thulium laser, based on theoretical predictions by the variation of different parameters, such as length of the cavity, Bragg grating reflectivity, thulium ions concentration, adsorption cross-sections of pump pulses radiation. The theoretical possibility of obtaining pulses less than 5ns has been showed.

2. Experimental setup

The scheme of experimental setup is shown on Figure the figure 1. Cavity pump for gain switch operation mode has been realized via erbium pulsed fiber laser with wavelength 1558nm based on MOPA scheme. Erbium laser produced pulses with adjustable duration in range 5-60 ns and frequency in range 50-200 kHz. Gain switch laser cavity consisted of thulium doped fiber (TDF) with doping ion concentration 600ppm and core/ cladding diameter 16/125 μm and two fiber Bragg gratings (FBG). High reflective (HR) FBG has reflection more than 25dB; output coupler (OC) has reflection ~8dB.