Abstract for graduation paper

«Generation of high-power nanosecond pulses in solid-state erbium lasers at 3-μm wavelength and their effect on highly absorbing media»

By Ivan Slovinskii

Scientific adviser: PhD, associate professor F.V. Potemkin

Radiation at a wavelength of 3 μm is used in a number of fundamental and applied problems. It can be used as a pumping source for different active media, such as Fe:ZnSe and Fe:CdSe, used as femtosecond pulse amplifiers, as well as for optical pumping of CO_2 lasers. Furthermore, radiation at a wavelength of 3 μm is possesses a unique feature of its extremely high absorption in water ($\alpha \sim 10^4$ cm^{-1}) and biological tissues. This allows the application of 3-μm lasers for medical purposes, as well as for microstructuring of transparent materials by laser-induced backside wet etching (LIBWE). The etching process involves many different physical and chemical effects, such as liquid transfer into the supercritical state, formation of cavitation bubbles and shock waves, changes of photorefractive features of water, is of interest for investigating the extreme energy deposition in water.

The use of 3-μm laser sources with nanosecond duration in the abovementioned applications requires high pulse energy as well as sufficiently high repetition rate. However, solid-state erbium lasers are particularly affected by the emergence of different thermal effects such as the formation of a thermal lens and thermally induced birefringence, that limit the specified parameters of the laser generation mode. The aim of the study was to examine and develop methods of compensation of thermaly-induced distortions in an active media of a 3-μm laser, operating in pulse-periodic mode under lamp pumping, and application of such laser sources in laser-induced backside wet etching of transparent at this wavelength materials.

In this study the mechanisms of emerging in an active media thermal distortions are investigated, focal lengths of thermal lenses, formed in various laser media (Er:YAG, Er:YSGG, Cr:Er:YSGG), are measured, various thermal lens compensation resonator designs are discussed. A design for compensating a thermal lens using two diverging lenses is proposed, and their optical parameters are determined by computer modeling. Experimental implementation of thermal lens compensation in Cr:Er:YSGG crystall allowed to generate pulses in acousto-optical Q-switching mode with energies of 23 mJ at a repetition rate of 10 Hz. With this laser source series of experiments on water transfer into a supercritical state were carried out, as well as the experiments on sapphire etching using the LIBWE method in water and alkaline solution.