High-power thin-disk laser with composite Yb:YAG/YAG active element

Ivan Kuznetsov, Ivan Mukhin, Oleg Palashov
Nonlinear Dynamics and Optics Department
Institute of Applied Physics of the Russian Academy of Science
Nizhny Novgorod, Russia
ivanushka911@yandex.ru, mib_1982@mail.ru, palashov@appl.sci-nnov.ru

Abstract—Thin-disk laser on the basis of the composite Yb:YAG/YAG active element with 30W average power and 50 % slope efficiency is developed. Investigations of thermal effects in active element showed the perfect laser scalability to the kilowatt power range.

Keywords—thin-disk laser; Yb:YAG, composite active element, anti-ASE cap, thermal effects

Today the average power of thin-disk lasers with one active element (AE) and excellent beam quality is limited at one-kilowatt level. The major problems that limit further laser’s scalability are the thermal effects in AE and amplified spontaneous emission (ASE). The perspective way to decrease ASE influence is to use the composite Yb:YAG/YAG AE (Yb:YAG thin disk and YAG thick disk coupled by end faces). It’s used in cryogenic lasers and in edge-pumped wide-aperture lasers but it has never used in ordinary thin-disk laser scheme with end-pumping. In this work thin-disk laser with the composite Yb:YAG/YAG AE is realized for the first time to our knowledge. Thermal effects in AE and power scalability are investigated and 30W average power with 50 % slope efficiency is achieved.

Fig. 1. (a) AE Cooling scheme (b) Experimental and calculated thermal induced phase distortion after V-pass through the AE. Dashed gray line – experiment with pump spot diameter (D) = 1.2 mm and pump power (P) = 13 W; solid black line – calculation D = 1.2 mm, P = 13 W; solid gray line – calculation D = 3 mm, P = 82 W; dashed black line – calculation D = 6 mm, P = 328 W.

Composite AE is made by the original thermal diffusion bonding method [1]. Laser head with the effective cooling system end multipass pump system is constructed. Cooling scheme is shown at the (Fig. 1 (a)). Heat transfer coefficients between AE and heatsink and between heatsink and water are measured. Temperature distribution, small signal gain and phase distortion of laser radiation after V-pass through the AE are investigated theoretically and experimentally. Numerical model used for theoretical analysis is described in [2] in details. Calculations showed that undoped cap decreases AE maximum temperature in 1.6 times that allows to increase small signal gain. Investigation of phase distortion of laser radiation shows that at any pump power and any pump spot diameter thermal lens are well approximated by parabola and isn’t contains any aberrations (Fig.1 (b)). In addition parabolic thermal lens optical power decreases with the laser power scaling (pump spot diameter increasing with the constant pump intensity). It means that YAG cap removes aberration concerned with pump edges and gives thin-disk lasers the chance to overcome existing power limit.

Fig. 2. (a) Output characteristics of the thin-disk laser with Yb:YAG/YAG AE (b) laser photo.

Laser with V-shaped multimode resonator is constructed and 30 W average power with 50 % slope efficiency is achieved. In near future it will be scaled to the higher average power.

REFERENCES