CW マルチパス増幅器の線形損失を含んだ特性解析

Analysis of CW regime, multi-pass amplification system characteristics including linear losses

（公財）レーザー技術総合研究所 [1]，（株）三菱重工業 [2]
○ハイク コスロービアン [1]，北村俊幸 [1]，谷口誠治 [1]，李大治 [1]，藤田雅之 [1]，井澤靖和 [1]， 松田竜一 [2]
Institute for Laser Technology[1], Mitsubishi Heavy Industries[2]
○H. Chosrowjan[1], T. Kitamura[1], S. Taniguchi[1], D. Li[1], M. Fujita[1], Y. Izawa[1], R. Matsuda[2]
e-mail: haik@ilt.or.jp

Introduction

Powerful CW lasers with high brightness and good beam quality are increasingly required for many applications. There are several possibilities to obtain high power CW laser irradiation: (i) Building a single source high power laser, (ii) coherently combining multiple low power laser beams or (iii) constructing a multi-pass, laser diode (LD) pumped MOPA amplification system. In this contribution, we will address the third possibility - presenting preliminary experimental results of CW regime, multi-pass amplification system characteristics including linear losses, and analysis of the data by using a simple model.

Experimental results and discussion

The experimental framework was based on cryogenically cooled Yb doped YAG composite ceramics total-reflection active mirror (TRAM) system [1]. A single mode fiber laser (1029.4 nm, 20 W) was used as a seed beam. A 500 W, 940 nm fiber coupled LD was used as a pump source. 9.8 at % doped, 0.4 mm thick Yb:YAG TRAM sample was used as an active medium. One, two and four bounce experiments were performed and some representative results are summarized in Fig. 1. The linear losses occurring due to the non-perfect transmission and reflection properties of different optical elements used in the present study (Faraday rotators, thin film polarizers, etc.) were experimentally determined to be about 3 %, 15 % and 37 % for one, two and four bounce amplification cases, respectively. Although the losses increase with increasing bounce number n, the effective saturation intensity decreases proportionally to 1/n, resulting higher output intensities for larger n. The effective average small signal gain coefficient g_0, which is proportional to the pump power intensity, was determined to be ca. 6.9 cm^{-1} for 3.23 kW/cm^2 pump intensity. This value is somewhat smaller compared to the expected theoretical value. The main reason for it is considered to be the elevated temperature of the active medium due to the insufficient cooling potential of the present cooling system.

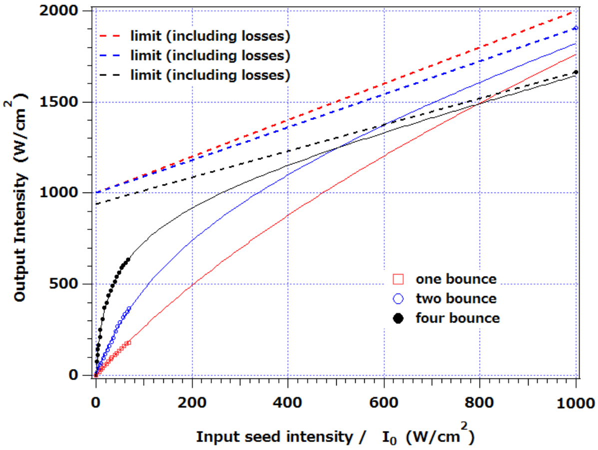

Fig. 1. The amplifier output- versus the input seed beam intensity dependence for one, two and four bounce amplification cases including linear losses. The excitation beam power and spot diameter were ~ 405 W and ~ 4 mm (3.23 kW/cm^2), respectively. The fitting curves were obtained by using an analytical approximation based on Frantz-Nodvik equation [2] including experimentally determined linear losses.

We will also discuss the applicability and accuracy of several models describing CW regime amplification for different seed and pump beam intensity scenarios. Currently work is also underway to achieve ~kW class high output power beam by multi-pass amplification method and some results of these developments will be discussed as well.

[1] H. Furuse et al., Appl. Opt. 53/9 (2014)
[2] L. M. Frantz et al., J. of Appl. Opt. 34/8 (1963)