Investigation of Beam Quality in Nd:YAG Crystal Fiber Amplifier

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***Abstract*—We present results of numerical and experimental investigation of beam distortions induced in the single-pass Nd:YAG crystal fiber amplifier injected by ns and ps laser pulses counter-propagating to continuous pump beam of up to 110 W power at 808 nm emitted from the fiber coupled laser diode with spectral narrowing by Bragg grating.**

Keywords—crystal fiber amplifier; spherical aberration

I. INTRODUCTION

Fiber lasers mode-locked by semiconductor saturable absorber mirror (SESAM) are unsurpassed in terms of the beam quality, compactness and easy integration. Among the known techniques for the following power and energy scaling Nd:YAG and Yb:YAG crystal fiber amplifiers benefit from the good overlap between pump and seed beams due to the pump guiding and improved thermal management by the high surface-to-volume ratio [1]. We studied the beam distortions in Nd:YAG crystal fiber amplifier injected by ~5 ps and ~20 ns pulses with beam quality factor of M^2~1.1 and ~1.3 correspondingly.

II. RESULTS

Picosecond seed pulses were emitted by passively mode locked fiber laser running at repetition rate of 29 MHz with average output power of 1.6 mW at 1064.14 nm wavelength. Nanosecond pulses at 10-100 kHz with average output power up to 14W were delivered from Nd:YVO_4 laser. In both cases we used single-pass crystal fiber amplifier end-pumped by fiber coupled laser diode at 808 nm wavelength and collimated seed beam counter-propagating through Nd:YAG rod of 1 mm diameter and 50 mm length doped by 0.2 % Nd (Fig. 1 - left).

Amplified output of 80 mW and 44 W in the ps and ns case has been achieved. This corresponds to the extraction efficiency of > 27 % in ns regime. M^2 ~ 1.24-1.3 has been obtained (Fig. 1 - right) with high quality seed emitted by mode-locked fiber laser. Further improvement to M^2 ~ 1.14-1.19 has been achieved by polarisation control.

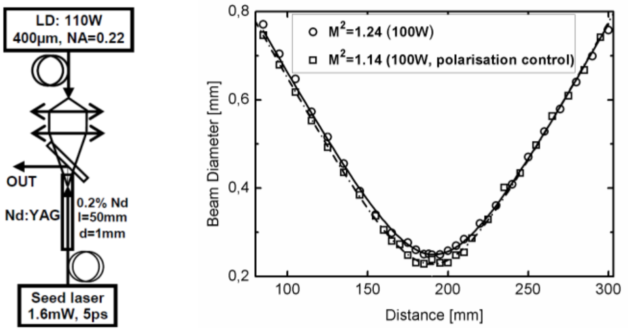

Fig. 1. Experimental set-up (left) and M^2 measurement of amplified laser beam at 100 W pump power (right) without (solid line) and with polarisation control (dash line).

The use of the long rod permits to neglect the contributions to the thermal lens from end face bulging [2]. The analytical solutions for temperature were found for different distributions of pump beam taking into account the temperature dependence of thermal conductivity. In this case the temperature change is not parabolic in the region of pump beam even for top-hat pump beam distribution.

It should be noted that one more cause for the occurrence of thermal aberrations is the nonlinear temperature dependence of thermal refractive index. It was shown that for the precise presentation of refractive index change only two *r*-dependent terms are needed. Then using the methods of matrix optics, the *ABCD*-matrix of thick lens with inhomogeneous refractive index distribution was found and the positions of the principal planes and focal length of thermal lens were calculated. Using the calculated values for the induced spherical aberration we found the change of the quality of seed pulses. Obtained parameters are in good agreement with the measured ones. Any pump beam intensity distributions other than top-hat and amplification saturation further deteriorate the beam quality.

III. CONCLUSION

Amplified beam distortions attributed largely to thermally induced spherical aberration and depolarisation. Nevertheless, high quality output beams with M^2 ~1.14-1.3 have been achieved in the single-pass Nd:YAG crystal fiber amplifier seeded by mode-locked fiber laser.

REFERENCES

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