3 mJ@3.3 kHz single mode single-frequency end pumped pulsed Nd:YAG ring laser

A.S. Davtian, Z. V. Gorelova, V.P. Pokrovskyi, S.S. Sobolev, S.S. Terekhov
Vavilov State Optical Institute
St. Petersburg, Russia

End pumped Nd:YAG ring laser with electro-optical Q-switcher was built. Pumping of each laser rod is provided by 45 Watt laser diode module coupled in high-brightness fiber. Single-frequency and unidirectional performance of laser is provided with injection seeding. End overheating of active rod was reduced by using low-concentration active medium. Thermo-optic distortions were compensated.

I. INTRODUCTION

There was a necessity of the laser with the following characteristics: wavelength λ = 1.064 µm, pulse energy - 3 mJ, pulse repetition rate - 3.3 kHz, pulse duration - 10 ns, single-frequency spectrum, nearly diffraction-limited beam, high stability of characteristics.

II. DESCRIPTION OF LASER

During creating of the laser we’ve solved the following problems: providing uniform absorption of spectral components of pump radiation through the laser rods, achievement of single-mode operation, providing of unidirectional lasing and compensation of thermo-optic distortions at a pump power up to 90 Watts.

To solve the above problems and to achieve the desired characteristics the following technical solutions were applied: end diode pumping system, low-concentration Nd:YAG laser rods, injection seeding, electro-optical shutter for Q-switching, scheme of passive compensation of thermal induced birefringence (TIB), varying distance between lenses of optical relay to compensate thermal lenses in the laser rods.

III. MAIN FEATURES OF LASER

A. Pump system

Pump system consists of two fiber coupled laser diode modules with a fiber core diameter 200 µm and effective numerical aperture 0.17. High brightness of this fiber provides optimal absorption of the pump energy in the active medium having a low concentration of neodymium ions. Power of each diode module is 45 Watts at a wavelength of 808 nm. Pump radiation from each fiber is transferred by a two-lens relay with magnification of 3 into a center of laser rod having 20 mm long and 4 mm in diameter. Unabsorbed portion of pump energy (about 30 %) from the 1st laser rod passes through another optical relay to a center of the 2nd rod without magnification and partially absorbed there. This optical relay is also used in scheme of TIB compensation. Thus the two ends pumping is realized, that results to uniform heat emission along both of the active elements (AE).

B. Resonator and injection seeding

A ring resonator is used for this laser. Four flat mirrors oriented to each other at 90° are fixed in pairs on common base for each pair. Dielectric polarizer and electro-optical modulator act as an output coupler with adjustable transmittance.

Unidirectional lasing is provided with injection seeding. One of the mirrors is located on the piezoelectric transducer (PZT). Slaving of ring cavity laser for seed laser is carried out in order to achieve single-frequency spectrum and minimize build-up time.

C. Compensation of thermo-optical distortions

In case of high-concentration AE the non-uniform absorption of the pump radiation in a small volume takes place. This leads, on the one hand, to appearance of great temperature difference and significant thermo-optic distortions, and, on the other hand, to overheating of the central part of the input end of the AE and the cross-section gain drop due to the temperature dependence of its[2]. To reduce the influence of both effects, we used AE with low concentration of Nd³⁺ — 0.12 atom %.

For TIB compensation there are used two identical active elements, quartz 90° rotator and optical relay which transfers image of one AE to another. Rotator and relay are placed between the AE.

Regular thermal lens with focus distance 11 cm that occurs under uniform heat emission can be well compensated by changing the distance between the lenses of the optical relay. By varying this distance, we can achieve the necessary stability of the cavity.

IV. RESULTS

Pulsed single-frequency laser with high average power 10 W and nearly diffractionquality beam (M² ≤ 1.2) was built. Pulse energy is 3 mJ at repetition rate 3.3 kHz. Pulse duration is 10 ns. RMS fluctuation of pulse energy is less than 1%.

REFERENCES