# Laser dyes excited by high PRR Nd:YAG laser second-harmonic radiation

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## ABSTRACT

The lasing characteristics of red-emitting dyes in ethanol excited by Nd:YAG laser second-harmonic radiation are examined. The Nd:YAG laser was pumped by a diode matrix. The pump pulse repetition rates (PRRs) were 2.5 – 10 kHz and the pulse duration was 60 – 300 ns. The following dyes were evaluated: oxazine 17, DCM, $DCM_{sp}$, and pyridine 1. The conversion efficiency for oxazine was 25 % without wavelength selection and 15 % with wavelength selection over the tuning range from 630 to 700 nm. The Nd:YAG and dye laser designs used are described elsewhere [1,2].
**Keywords:** dye laser, Nd:YAG laser, laser second-harmonic radiation

## 1. INTRODUCTION

Dye lasers are known for more than thirty years. They are one of the basic sources of tunable coherent radiation from UV up to visible range of a spectrum. Among various pump types for dye lasers the most suitable is pump by coherent radiation. For some applications it is essential to obtain pulse-repetitive tunable radiation in a visible range. Laser treatment of cancers - photodynamic therapy is the most promising field of a spectral range between 630 -800 nm. Pulse lasers on Nd:YAG-laser, operating in κHz range, are used as a pump for the dye lasers with high pulse repetition rate. Lasing characteristics of dye solutions pumped by the 2-nd harmonic radiation of the Nd: YAG-laser with diode pump are reported. Lasing parameters at $\lambda$= 532 nm with the average power of units W and pulse power of tens kW at high pulse repetition rate were obtained with the use of a diode pump. The basic characteristics of the laser with a diode pump enable to construct the 2-nd harmonic of the Nd:YAG-laser and a dye laser system.

## 2. EXPERIMENTAL SETUP

Figure 1 shows an optical diagram of the dye laser used in work [2] pumped by a copper-vapor laser (CVL) radiation. In these works an unordinary flowing of a dye solution was used. As Nd:YAG laser experimental setup described in work [1] was used. The longitudinal size of an active dye laser medium was 14 mm, and the diameter of Nd:YAG – laser beam was 2 mm. Thus, before the 2-nd harmonic radiation input the telescope consisting of two spherical lenses was placed so that the diameter of a pumping beam coincided with the longitudinal size of an active dye laser medium. The main aim at obtaining high efficient conversion of pumping pulse radiation into dye solutions lasing is to achieve high pulse power. Various operating modes of Nd:YAG - laser are presented in Table 1.

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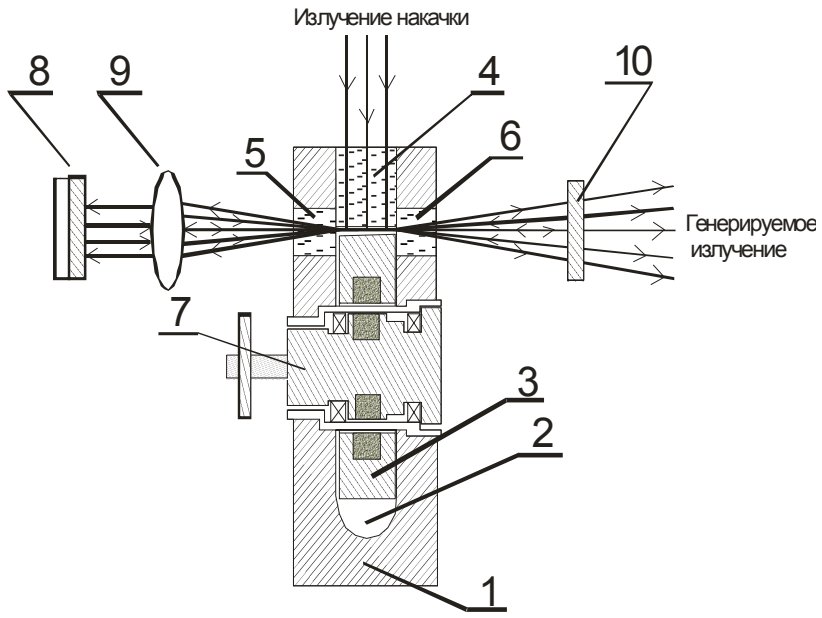


Figure 1 - Optical diagram of the dye laser : 1 – a dye cell frame, 2- a dye solution , 3 - a rotor, 4 - an input cell window, 5,6 - cell windows, 7 - a shaft moved by the direct current engine , 8 – a diffraction grating, 9 - a spherical lens, 10 - a translucent mirror.

Table 1

| | | | |
|---|---|---|---|
| Lasing wavelength, nm | 532 | 532 | 532 |
| Pulse duration, ns | 300 | 170 | 60 |
| Average power, Вт | 7 | 4 | 2,7 |
| Pulse repetition rate, кHz | 10 | 4 | 2,5 |
| Pulse energy, mJ | 0,7 | 1 | 1,08 |
| Pulse power, kW | 2,3 | 5,8 | 18 |

Lasing pulses were recorded by the oscillograph S1-104, and lasing spectra by the electronic spectrometer included in the dye laser system.

## 3. RESULTS AND DISCUSSION

We measured lasing characteristics of four dye solutions: Pyridine1, DCM, DCMsp, Oxazine 17.
When Oxazine 17 was used as a dye laser active medium, we observed superluminescence in Ethanol, while lasing was at a threshold level. With the decrease of pulse repetition rate up to 4 кГц efficiency of radiation conversion reached 8-9 %. To increase pump pulse power the optical diagram of the pump laser has been changed, pump pulse duration was 60 ns and pulse power increased up to 18 kW.
Figure 2 shows efficiency of pump radiation conversion into lasing of Oxazine 17 in ethanol pumped by the 2-nd harmonic radiation of the Nd:YAG-laser with wavelength selection of a diffraction grating 1200 str/mm.
The system of the resonator without wavelength selection has been tested also. The resonator has been formed by a flat translucent mirror and a spherical mirror R=100 mm. Figure 3 presents variations of different dye solutions lasing spectrum pumped by the 2-nd harmonic radiation of the Nd:YAG-laser with diode pump. The obtained results correspond to the pulse duration of 60 ns (table1).

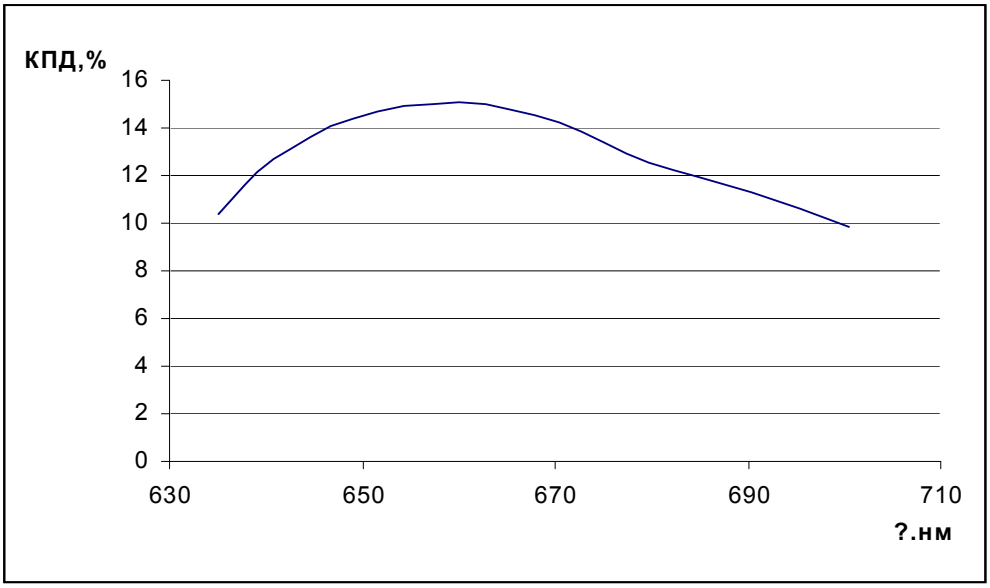


Figure 2 - Lasing spectrum of Ox17 in ethanol pumped by the 2-nd harmonic radiation of the Nd:YAG-laser. Average pump-laser power is 2,7 W, lasing PRR is 2,5 кHz, pumping pulse duration is 60 ns.

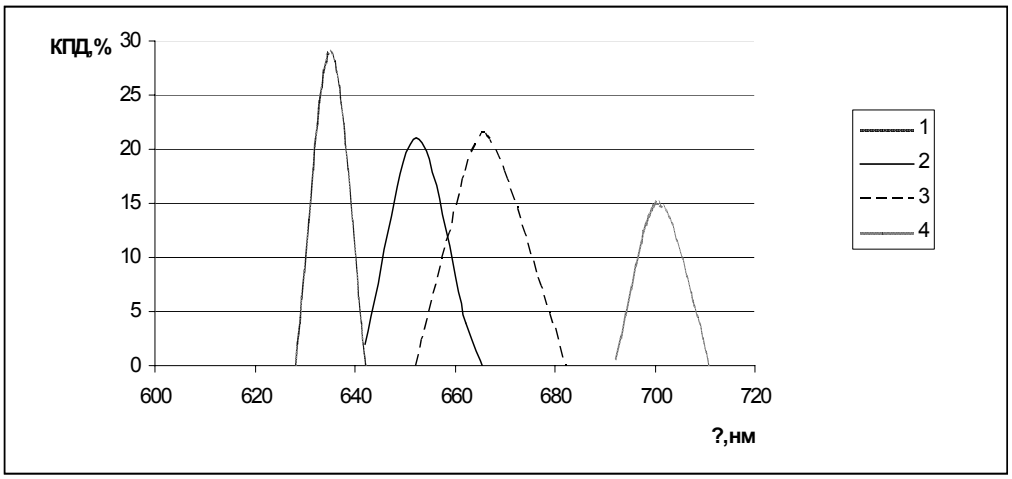


Figure 3 - Lasing characteristics of dyes in ethanol pumped by the 2-nd harmonic radiation of the Nd:YAG-laser: 1 - DCMsp, 2 - DCM, 3 – Oxazine 17, 4 - Pyridine 1 with a nonselective resonator.

## 4. SUMMARY

It should be emphasized, that the dye laser system used in work has been specially developed to pump a copper-vapor laser, and so at the special coordination of the resonator and a solid-state pump obtained efficiency is not lower, than at use of the copper-vapor laser. Experimental results show, that conversion efficiency in the system of a dye laser pumped by the 2nd harmonic of the Nd:YAG-laser at high pulse repetition rate is comparable with the efficiency obtained for the copper-vapor laser.

Research data of the present work and efficiency of the Nd:YAG- laser with diode pump, which is ten times higher than of a copper-vapor laser, appeared to be promising for constructing the system with the continuous wavelength tune between 600 - 800 nm with the increased efficiency. In works [1] construction of radiation sources with $\lambda = 532$ nm and

output power in the $TEM_{00}$-mode of 100 W and more, and consequently construction of powerful tunable dye lasers with the total efficiency ten times more than existent, is expected.

## REFERENCES


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