The titan-sapphire laser pumped by the second harmonic radiation of the diode-pumped pulse Nd:YAG laser for the purposes of two-photon spectroscopy.

Donin V.I., Yakovin D.V., Gribanov A. V.
Institute of an automation and electrometry Siberian Branch of the Academian of Science, Russia, 630090 Novosibirsk
donin@iae.nsk.su

The characteristics of the ring titan-sapphire laser with modulated amplification and the frequency tuning by the prizms selector are presented. The pulse duration of output radiation was equal to 50 ns, at a repetition rate 7-18 kHz. The width of tuning was 30 nm. The generation bandwidth of the laser was equal to12 GHz with a 0.7 mm Fabry-Perot etalon . The maximum average output power achieved 160 mW at 4,5 W of pump and the repetition rate 7 kHz. As the pump laser was used the diode-pumped Nd:YAG laser with the second harmonic generation and Q-switching.

1. Introduction

Since the first obtaining of generation from the titan-sapphire cristal [1], the Ti^{3+}:Al_2O_3 laser was the object of extensive research. Today it is prevailing a solid-state laser. The titan-sapphire laser have the most wide range of tuning (650 - 1100 nm) and it is a convenient and universal source of a laser radiation. There are many usages of such lasers: laser photochemistry, nonlinear exitation of atoms and molecules, laser photokinetics, remote diagnostics of an atmosphere, photobiology, spectroscopy, isotope separation, etc.

A nonlinear exitation of atoms needs a high peak power of radiation, because it is a two-photon process. Such power is easily accessible in pulsed conditions of laser operation. In the pulsed mode simultaneously there are the problems with a selection and tuning of the laser radiation by the Lyot filter, which usually is used for a control of radiation frequency in the widely tunable lasers.

In the case of two-photon exitation of atoms [2] there are two optical circuits: with one-direction and counter-direction of rays. The second circuit is more preferable, because it eliminates the Doppler undercoat in absorption. In absentia an optical diode in the ring resonator the generation arises on two counter propagated waves.

In this article we report about the titan-sapphire ring laser with the counter propagated waves and the wide tuning by a multiprisms selector for the two-photon spectroscopy.

.

2. Experimental setup and results

The optical design of the laser is shown in a figure 1. The titan-sapphire cristall (length 10 mm, diameter of 5 mm, absorption on 532 nm is ~1 $см^{-1}$) was pumped the second harmonic (a wavelength 532 nm) radiation from the all-solid-state Nd:YAG laser with the Q-switch [3]. The duration of pumping pulses was 70 ns. One of beams Ti^{3+}:Al_2O_3 laser was returned in the resonator by an additional mirror R5, that allowed, if necessary, to have one-direction mode of the generation [4] (or counter direction in absence R5). The power meter LM-2 was used for the measurement of the titan-sapphire laser output-power from a repetition rate and the pump power. For measurement of a generation linewidth of $Ti^{3+}:Al_2O_3$ laser was used the scanning Fabry-Perot interferometer with changed base. The selection of the laser frequency was carried out by the multiprism selector consisted of five 60-degrees prisms [5] (material: flint TF-5) and the Fabry-Perot etalon from a fused quartz. The prisms were installed in the resonator under the Brewster angle. An etalon thikness was L=0,7 mm, reflectivities from the etalon surfaces r=0,3. We used the monochromator MDR-23 for measurement of the tunable characteristics of laser. For a simultaneity of measurements the powermeter LM-2 was placed instead of the mirror R5.

The following datas were obtained. The generation bandwidth of the titan-sapphire laser with multiprisms selector was equal to 110 GHz, and it was narrowed up to 12 GHz by placing the Fabry-Perot etalon in the resonator laser.

The tunable characteristic of the laser represents in a Fig. 2. The tunable width was defined by a spectral range of the mirrors and a level of intracavity losses.

The $Ti^{3+}:Al_2O_3$ laser output power depending on the pump power is shown in fig. 3. It was obtained at the repetition rate 10 kHz of the Nd:YAG laser. The threshold of generation of the titan-sapphire laser was 1,5 W of the pump power. The rather high threshold of generation was bound with a low FOM=30-50 of the crystal, the high level of intracavity losses, not absorbed in laser crystall pump radiation and reflection on the mirror R5 (common losses of pump radiation were about 50 %). The duration of generation pulses of $Ti^{3+}:Al_2O_3$ laser was 50 ns and measured by the high-speed photodiode LFD-2 and an oscillograph with a transmission band 250 MHz. The Nd:YAG pump power was 4 W at the repetition rate 10 kHz and duration of pulses 70 ns.

The dependence of the $Ti^{3+}:Al_2O_3$ output power from the repetition rate is represented in a fig. 4. From the graphic we can see, that at increase of the repetition rate the output power is down. The possible explaination to that is the decrease of the peak power of pumping pulses, which causes the decrease of average output powe. At the repetition rate less than 7 kHz an entry surface of the titan-sapphire crystal was damaged. The threshold of damage was $1,2*10^9$ W/cm^2 at the pulse duration of pump (wavelength 532 нм) 70 ns.

3. Conclusion

It was created the tuning ring $Ti^{3+}:Al_2O_3$ laser with the counter propagation output rays, and with the peak output power ~0.5 kW. The exitation of the active media of the laser was fulfill by the second harmonics from diodepumped Nd:YAG laser with a Q-switching. In further we have a plan to use of such laser for exitation of the 5S-7S transition in Rb for the purposes of laser photochemistry.

References.

1. Moulton P.F. Spectroscopic and laser characteristics Ti:Al2O3 // J. Opt. Soc. Am. B. - 1986. - V. B3. - Issue 1. - P.125-133.

2. Letokhov V.S., Chebotaev V.P. A nonlinear laser spectroscopy of ultrahigh resolution. - M: Science, 1990. - 512 p.

3. Donin V.I., Nikonov A.V, Yakovin D.V. Efficient frequency doubling in transversly diode-pumped Nd:YAG laser // Quantum Electronics. - 2004. V. 34. - № 10. – P. 930-932.

4. Bagaev S.N., Kuznetsov V.P., Troitskii U.V., Troshin B.I. The Spectral characteristics of a gas laser with a travelling wave // JETF Letter. - 1965. - V.1. - N1 – P. 21-23.
5. Strome F.C., Webb J.P. Flashtube-pumped dye laser with multiple-prism tuning // Applied Optics - 1971. - V. 10. - Issue 6. - P. 1348-1353.

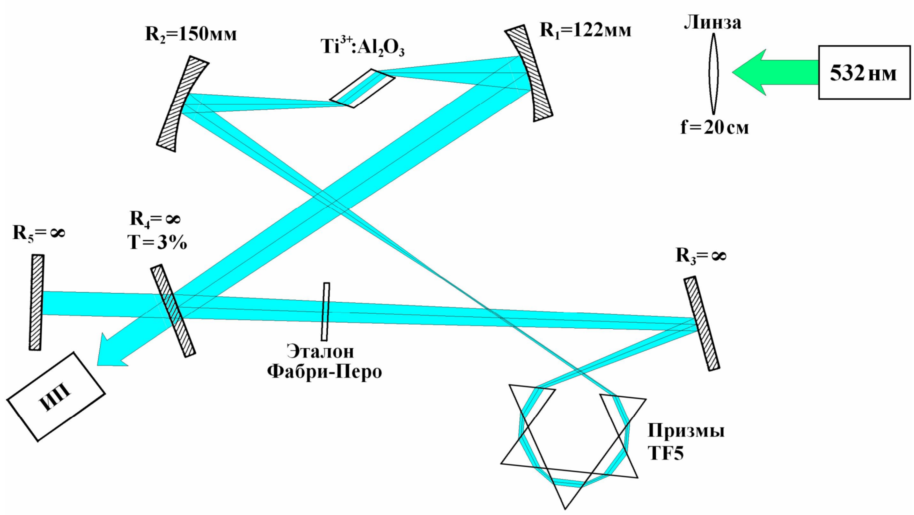

Figure 1 Optical circuit of the laser. R1-R4 - mirrors of a resonator (mirror R1 dense in the tuning field of the laser and with transmittance > 80 % on 532 nm, mirror R2 and R3 dense r > 98,5 %, R4 with transmittance 3 % in the wavelenghs of generation), R5 - additional mirror, $Ti^{3+}:Al_2O_3$ - active unit, prisms TF5 - frequency selector, ИП - measuring instrument - power meter LM-2 or scanning Fabry-Perot interferometer, lens - focusing radiation 532 nm a lens.

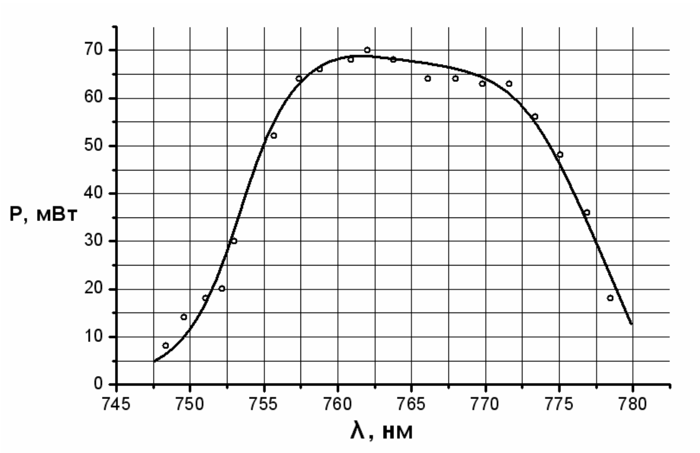

Figure 2 The tuning characteristic of the laser.

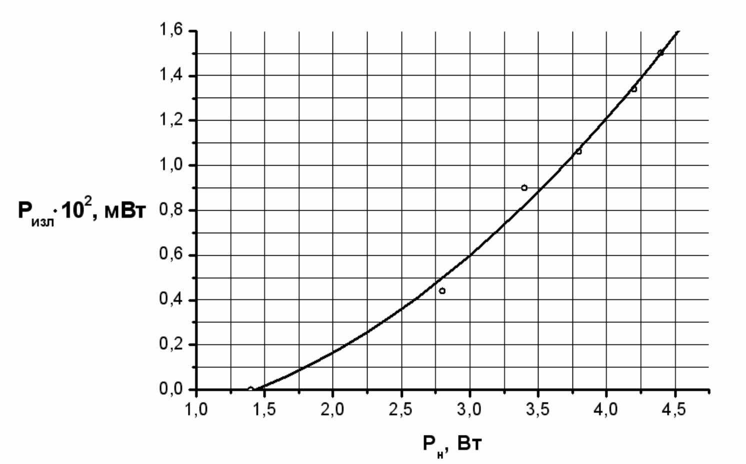

Figure 3 Dependences of the output power of the Ti^{3+}:Al_2O_3 laser from the pump power .

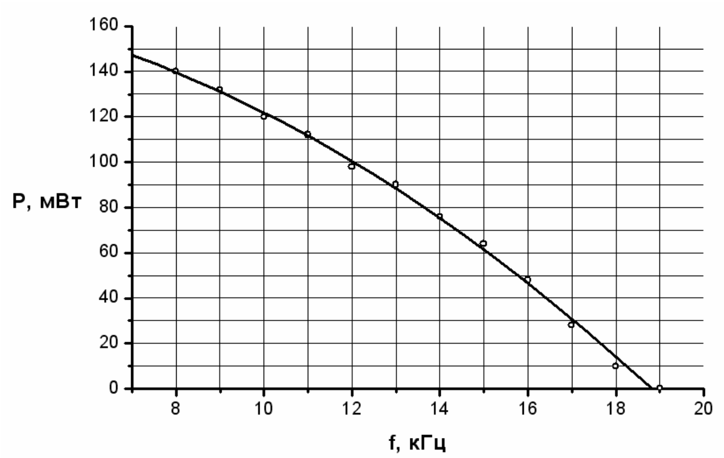

Figure 4 Dependence of the output power of the Ti^{3+}:Al_2O_3 laser from the frequency of the pumping pulses.