Lamp pumped LiSrAlF₆: Cr laser with Bragg grating

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Abstract. The paper presents LiSrAlF₆: Cr lamp-pumped laser. The possibility of tuning the central radiation wavelength in the range of 795–895 nm is shown. The passive Q-switching mode was provided by a saturable LiF: F₂-absorber with an initial transmission of about 72%. In the single-pulse generation mode with a duration of 100 ns, the pulse energy was 3 mJ with a spectral width of 45 pm. The fundamental possibility of operating in the generation mode of two spectral components for the range of 865–885 nm is shown.

1. Introduction

Tunable radiation sources are in demand in various fields of technology, including remote sensing systems of the atmosphere, such as the complex presented in [1]. In Ti: Sa-based lasers widely used in this field, pumping is performed by the second harmonic of the Nd: YAG laser, which significantly increases the size and reduces the reliability of the system. In [2], a Cr: LiSrAlF₆ lamp-pumped laser tuned according to the wavelength using intracavity prisms is shown, which cannot provide a sufficiently low value of the spectral contour of the laser radiation. For many practical applications, it is interesting to use the simultaneous generation of two longitudinal modes. The possibility of a laser with two longitudinal modes on an active Cr medium: LiSrAlF₆ with the selection of longitudinal modes due to dispersion prisms was shown in [4]. And in [5], the mode of operation at two wavelengths was carried out using an extra-resonator diffraction grating. The use of the Bragg grating will make it possible to provide radiation with a rather narrow width of the spectral contour.

2. Experiment

A laser with a Fabry-Perot cavity and an active medium Cr: LiSrAlF₆ is presented. The active element (3) is 75 mm long, with a diameter of 6.3 mm, the alloying percentage is 1.5%, manufactured by Kazan Federal University, Russia. As a reference, a broadband mirror (1) was used with a reflection coefficient of more than 99.3% for the spectral range 720–930 nm. In the region of 800–827 nm, the reflection of the mirror is less than 2.8%. The laser was generated in the passive Q-switching mode. As a passive Q factor modulator (2), a LiF: F₂-crystal was used with an initial transmission of 68–76% for the spectral range of 790 - 900 nm. The feedback necessary for the development of generation was provided by mirror (4) with a transmission of 50% for the spectral range 600–850 nm. As a spectral selector, a Bragg volumetric transmission grating (5), manufactured by SRU ITMO, provided by the authors of the work [5], was used. For a given diffraction grating, the measured diffraction efficiency
was 40-45%. In the first diffraction order, a mirror (6) was installed with a reflection coefficient of more than 99% for the spectral range 600–850 nm. The transverse pumping of the active element was carried out by pump lamps, model INP 6-90, manufactured by Laticom, Russia. The power supply, manufactured by Fedal, Russia, is capable of providing pump energy of 45 J at a pulse duration of 250 μs. A pump energy of 27 J ensured the generation of a single pulse. The laser emitter circuit is shown in figure 1. The cavity length is 55 cm.

![Figure 1. Experimental setup.](image)

Radiation developing from spontaneous luminescence in a resonator formed by mirrors (1) and (4) falls on a transmitting Bragg grating (5). A dull mirror (6) provided additional feedback for radiation propagating in the first diffraction order. The radiation was removed from the resonator in the direction of the zero-diffraction order. Tuning of the laser radiation wavelength was carried out by simultaneous rotation of the Bragg grating (5) and the mirror (6). The rotation of the lattice determines the wavelength for which the Bragg condition will be satisfied. Coordinated rotation of the mirror allows for additional feedback for radiation of a specific wavelength.

3. Results and discussion

Figure 2 shows the dependence of the energy in the output pulse on the central wavelength. The standard deviation of the pulse energy from the average value is within 1 mJ. This low accuracy is due to the temperature instability of the lamp pump radiation.

![Figure 2. Graph of energy from the wavelength.](image)

The high level of Fresnel reflection loss at each media interface for the transmission Bragg grating, as well as the difference in the diffraction efficiency of the grating from 100 percent, significantly reduces the value of the output energy. The value of the output energy is affected by the non-optimal value of the transmittance of the mirror (4), and the low reflection coefficient of the mirrors (1), (6).

In the range of 865-885, radiation contains two spectral components. One of the components with a wavelength of 828 nm corresponds to the radiation of the resonator formed by the mirrors (1) and (4). The characteristic spectra are shown in figures 3 and 4. The presence of two spectral components takes place due to the approximate equality of the ratio of the losses in the cavity to the gain in the active medium for the radiation generated by the Fabry-Perot resonator and for the radiation receiving feedback from the Bragg grating. This is consistent with the results presented in [5], where one
spectral component with a slightly varying wavelength is also present, and the other component is tunable in a wide range of wavelengths. A strong background signal is caused by radiation from a pump lamp that is not absorbed in the active medium.

The ratio of the intensities of the spectral components depends on the level of losses for each of the longitudinal modes of the generated laser radiation. The dependence illustrating the fraction of the spectral component of radiation with a wavelength of 828 nm is shown in figure 5.

The nonlinear dependence of the relative intensity of the spectral components can be explained by the difference in losses due to the different efficiency of the Bragg grating, and the inhomogeneity of the reflection coefficient of the mirrors.

The Fabry-Perot interferometer is designed for spectral measurements in the visible range. The radiation focused with a lens with a focal length of 70 mm was converted into the second harmonic by a nonlinear BBO crystal. The interferometer free dispersion interval was 33.6 pm for radiation with a wavelength of 414 nm. The obtained interferogram was projected onto the receiving platform of the Ophir Spiricon SP620U camera using a lens with a focal length of 40 mm. The presented images are
the result of overlapping 50 interferograms obtained in a single pulse mode. Figure 6 shows the image and cross section of the integrated radiation interferogram with a central wavelength of 414 nm.

Figure 6. Interferogram and cross section for radiation with a wavelength of 414 nm.

Figure 7. Interferogram and cross section for radiation with a wavelength of 420 nm.

Despite the fact that as a result of overlapping interferograms, a slight overlap of orders is observed due to instability of the central wavelength from pulse to pulse, peaks corresponding to the first and second order of interference can be distinguished in the image.

The width of the spectrum in the presence of one spectral component of the first harmonic of the radiation was 34.6 pm for radiation with a central wavelength of 828 nm.

Figure 7 shows the image and the cross section of the integrated interferogram for radiation with a wavelength of 420 nm.

The width of the spectrum for radiation in the first harmonic with a wavelength of 840 nm was 45 pm.

4. Conclusion
A solid-state Cr: LiSrAlF laser operating in the mode of passive Q-switching with a pulse duration of 100 ns and a spectrum width of no more than 45 pm is presented in the work, which is tunable in the wavelength range of 790-885 nm. The large absolute error in the measurement of energy in a pulse is explained by the use of tube pumping with high temperature instability of energy in a pulse.

The width of the spectral contour can be further narrowed, and the energy in the pulse is increased by using the Bragg reflective grating, adapted for the spectral range of 750-1000 nm. An increase in energy can also be achieved through the use of mirrors with a large reflection coefficient.

The presence of approximately equal energy for a wide spectral range is a feature that allows the use of such a radiation source in a number of practical problems. For example, when processing the results of sounding of the atmosphere by systems with wavelength adjustment, it is possible to process the results without amending the radiation energy.

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