CuBr LASER WITH AVERAGE LASING POWER EXCEEDING 100 W

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A copper-bromide laser was studied for the purpose of increasing the average lasing power and the efficiency. An average lasing power of 112 W with a pulse repetition frequency of 25 kHz was obtained. For an average lasing power of 100 W the efficiency with respect to the rectifier was equal to 1.71%. The highest efficiency with respect to the rectifier (1.8%) was achieved with an average power of 85 W.

The CuBr laser, thanks to its simplicity and low cost, is attracting great interest. However the problems of scaling (the change in the parameters of the laser radiation as the diameter and the length of the active element are increased) lasers of this type remain open.

Systematic investigations of copper halide lasers are being conducted at the Physics Institute of the Academy of Sciences of the USSR and at the Institute of the Solid State of the Academy of Sciences of the People's Republic of Bulgaria. The basic results of these investigations are presented in Refs. 1 and 2. An average power of 19.5 W with a pulse repetition frequency of 15 kHz and an efficiency of 1% (Ref. 3) has been achieved using a gas-discharge tube (GDT) 40 mm in diameter and limiting diaphragms with an inner diameter of 20 mm and 500 mm long. Gas discharge tubes with a diameter of the active zone exceeding 20 mm have not been studied.

In 1986, at the Special Design Office for Scientific Instrument Building "Optika" of the Siberian Branch of the Academy of Sciences of the USSR, V.F. Elaev and V.F. Fedorov investigated a copper-bromide laser with diaphragms ranging from 20 to 40 mm in diameter and a discharge channel up to 100 cm long with different commutators (thyratrons and tacitrons) with pulse repetition frequencies (PRFs) ranging from 3 to 30 kHz and with a buffer gas consisting of Ne with additions of H_2 at pressures ranging from 0.2 to 0.3 torr.

An average lasing power of 35 W with an efficiency of 1.17% with respect to the rectifier was achieved with a GDT with an inner diameter of 40 mm and a discharge channel 100 cm long with a PRF of 18 kHz. An average lasing power of 31 W with a PRF of 16 kHz and an efficiency of 1.29% was obtained using a GDT without diaphragms and an inner diameter of 53 mm and a discharge channel 55 cm long. The maximum efficiency (1.43%) was obtained using this GDT with an average lasing power of 26.6 W. It should be noted that for PRFs of 3–5 kHz the width of the lasing pulse reaches 100 ns, while with PRFs of 15–20 kHz the pulse width reaches 50–70 ns, which is somewhat greater than in pure-copper vapor lasers. Therefore the use of an unstable resonator for forming a laser beam with small divergence in a CuBr laser will be more efficient than in a pure-copper laser.

We investigated a copper-bromide laser for the purpose of further increasing the average lasing power and the efficiency using a GDT without bounding diaphragms and with an inner diameter of 60–80 mm and a discharge channel 100–150 cm long. Bounding diaphragms were not employed, since they did not have a decisive effect on the stability of the laser and the discharge. The use of diaphragms has a significant drawback: after several tens of hours of operation of the laser in the lasing regime metallic copper settles on them; this copper can separate from the surface of the diaphragms and cover the lasing channel. Copper-bromide vapors were introduced into the discharge volume from special furnace-heated containers placed in side arms. Neon at a pressure of 15–25 torr, to which 0.2–0.6 torr of H_2 was added, was employed as the buffer gas.

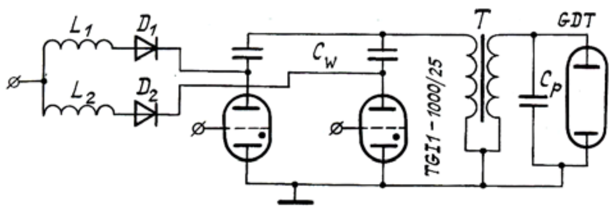

FIG. 1. The schematic electrical diagram of the excitation system.

The excitation-pulse generator was assembled based on two water-cooled TGI1-1000/25 thyratrons, operating alternately, and a pulsed up-transformer with a transformation factor of 1:2. The electrical circuit of the excitation system is shown in Fig. 1. The working capacitance C_w is charged from a high-voltage rectifier through the charging coils L_1 and L_2 and the charging diodes D_1 and D_2; C_p is a peaking capacitance. The air-cooled pulsed transformer T is assembled based on ferrites.

The voltage and current pulses were recorded with the help of capacitive dividers and Rogowski loops, operating in the current transformation mode, using S7-8, S1-55, and S1-75 oscillographs. The lasing pulses were recorded with the help of coaxial FEK-2 photocells. The average lasing power was measured using IMO-2 and IMO-3N calorimeters.

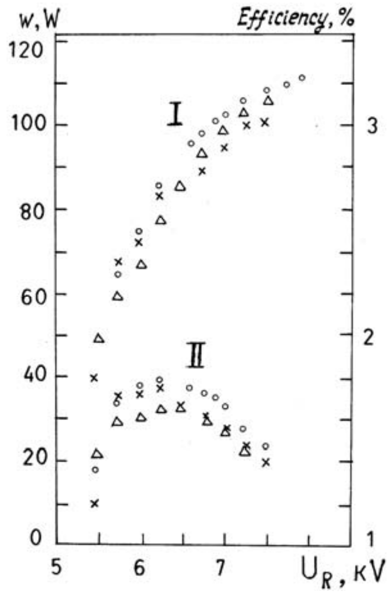

FIG. 2. The dependence of the average laser power W(I) and the efficiency (II) on the voltage on the rectifier with three fillings of the GDT with a gas mixture with the same composition.

The best results for this setup were achieved using a GDT 60 mm in diameter with a discharge channel 150 cm long. An average lasing power of 112 W was achieved with the Ne buffer gas pressure of 18 torr with 0.35 torr H_2 added and a PRF of 25 kHz. The width of the voltage pulse at half-height was equal to ~ 35 ns, the width of the current pulse was equal to ~ 40–45 ns, and the voltage on the electrodes of the GDT was equal to ~ 15 kV. With an average lasing power of 100 W the efficiency was equal to 1.71%. The maximum efficiency (1.8%) was achieved with an average lasing power of 85 W. Figure 2 shows the dependence of the average lasing power and the efficiency on the voltage on the rectifier for three experiments. For each experiment the GDT was filled anew with Ne buffer gas with additions of H_2.

It should be noted that in the investigated range of voltages on the output of the rectifier the voltage dependence of the lasing power does not exhibit any appreciable saturation.

The lasing power density as a function of the diameter of the GDT was measured. The diameter of the laser beam decreased somewhat as the lasing power increased. However the lasing power density as a function of the diameter is always gaussian. For the GDT with an inner diameter of 80 mm the diameter of the laser beam reached 65–70 mm.

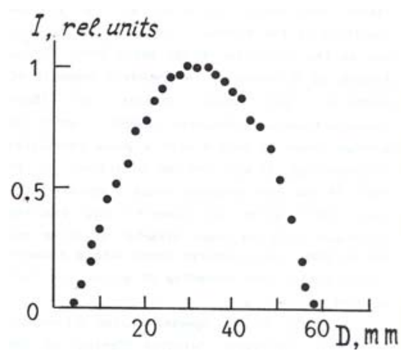

FIG. 3. The average power density of the generator as a function of the diameter of the GDT.

Figure 3 shows the laser power density as a function of the diameter of the GDT with a lasing power of 50–60 W (the inner diameter of the GDT is equal to 60 mm).

The results of the studies performed show that lasers of this type can be scaled and their output characteristics can be improved.

REFERENCES

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