RESEARCH AND DEVELOPMENT OF HIGH–POWER SEALED–OFF CuBr VAPOR LASERS

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Some results are presented of investigations of a sealed–off CuBr *vapour–laser, its active zone* 60 cm *in diameter and* 100 cm *long (no screening diaphragms). After* 300 hours *of operation the laser output power dropped by about* 25% *due to lowered transmission of the discharge tube windows. Operation is described of an experimental CuBr vapour–laser capable of* 50 W *mean output. Specifications of such a device are given in this paper.*

A CuBr vapor laser (CBVL) is comparable to a Cu-vapor laser (CVL) in its lasing action.[1] However the chief drawback of CBVL is short service life of its active element. A CBVL active element consists of a quartz gas-discharge tube (GDT) with two electrodes and is very simple and production cost saving. Its cost is an order of magnitude lower than that of CVL, described in Ref. 2, while the CBVL efficiency is two times higher than that of CVL.

Systematic and comprehensive research of CBVL, in particular regarding its GDT service life, may be found in Ref. 3. A GDT 20 mm in diameter, 75 cm long was studied. Diaphragms were introduced into the discharge channel to provide discharge stability. Lasing power averaged was 20 W at ~ 1% efficiency. (Efficiencies cited were defined from power output of the rectifier.)

Authors of Ref. 4 described a CBVL with its discharge channel of Φ = 20–80 mm and l = 55–150 cm. No diaphragms were used at 50–80 mm diameter, and the GDT inner diameters were indicated in that case. The mean lasing power was 112 W at 1.7% efficiency (for a GDT with Φ = 60 mm and l = 150 cm.) The maximum efficiency (1.8%) was obtained at 85 W of the mean lasing power. The laser beam diameter at maximum lasing power reached 35–40 mm.

Limited service life of the BCVL gas-discharge-tube[3] is due to the following reasons, as supported by our experiments:

1) decrease of the exit window transmission due to precipitation of working substance or its decay products on the window;

2) increase of free bromine inside the laser tube to critical concentrations;

3) precipitation of pure copper to GDT walls and diaphragms;

4) destruction of electrodes;

5) removal of working substance and of its decay products from active zone of the laser. This effect precipitates all of the above, itself resulting from concentration diffusion.

Authors of Ref. 3 described the approach of successive elimination or attenuation of negative factors affecting the service life of the CBVL gas–discharge tube. It did not always bring success but anyhow substantially increased the GDT lifetime. Essentially that approach consisted in fully heating the GDT, including its exit windows.

However practical application of a fully heated GDT meets with specific problems and difficulties. For example, precipitation of elemental copper to heated windows is not reduced but increases instead, which leads to a decrease in lasing power during the first 300 working hours of CBVL. Besides the obvious inconveniences external furnaces used to heat the terminal zones of GDT add to overall energy consumption by the laser thus decreasing its total efficiency.

In our study we refused to fully heat the GDT, and kept its terminal zones, including exit windows at the lowest possible temperature, force-fanning the cooling air to them to remove heat from laser head. Moreover the terminal zones were made as short as possible. They were built as sets of diffusion traps, where the main part of the axial flow of substance from the active zone was transformed into radial. Thus one could reduce the removal of working substance and products of its decay and decrease respectively their precipitation, particularly, in the region of exit windows.

As indicated in Ref. 5, removal of substance from active laser zone can be decreased or terminated stimulating the process of thermal diffusion. In a CBVL the thermal-diffusion flux of substance is directed from "cold" (thermal) zones to the "hot", active laser zone. Creating the necessary temperature gradient between those zones one may completely or partially reverse diffusion thus substantially reducing those negative factors which shorten the useful life of GDT.

The gas–discharge tube tested in the sealed–off regime was 6 cm in diameter, its electrodes spaced 100 cm from each other. The total length of GDT was 170 cm. Special containers with CuBr were positioned at four GDT extensions and heated with furnaces. No diaphragms were introduced into the discharge channel. As the buffer gas 20 Torr of Ne plus 0.3 Torr of H_2 were used.

Excitation pulse generator similar to the one described in Ref. 4 operated by two alternating water cooled TGIl–1000/25 thyratrons and a pulsed step-up transformer with its transformation ratio 1:2. If needed, the generator may work without the transformer.

Figure 1 plots mean–power generation vs power fed from the rectifier. The upper curve corresponds to step–up transformer operating, and the lower one to no transformer. Figure 2 shows voltage pulse on GDT electrodes and current pulse (below) with step-up transformer on.

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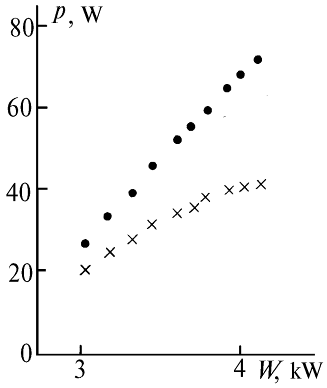

FIG. 1.

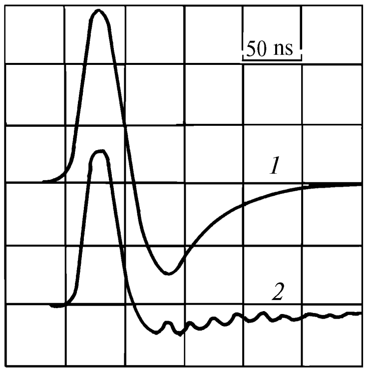

FIG. 2.

In 300 hours of CBVL operation the mean generated power decreased by about 25% due to a respective reduction in transmission by the exit windows. There was no precipitation of working substance in the terminal zones and no electrode erosion.

Our studies resulted in building a CuBr vapor laser according to specifications listed below.

Radiation wavelengths, nm	510.6, 578.2
Pulse repetition rate, kHz	15–20
Lasing pulse duration, ns	20–30
Mean radiation power, W:	
first mode	30
second mode	50
Power supply, kW	5
Dimensions of a laser head, cm	30×48×205
Dimensions of a power supply, cm	32×85×130

The laser operates by three–phase a.c. supply. Its head consists of two compartments, one of them holding the active element and the other – a communication unit. The laser is provided with back–up active elements on demand.

Note that Cu–vapor lasers (models Cu40 and Cu60 with lasing power 40 and 60 W, respectively) produced by Oxford Lasers have 300 h of service life and operate in the regime of buffer–gas pumping. The length of the Cu60 laser head is much longer (60 cm) than ours. The size of our laser head makes it possible to construct a CBVL with 100 W of lasing power.

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