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# Capacitive-discharge-pumped copper bromide vapour laser

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***Abstract*. A copper bromide vapour laser pumped by a high-frequency capacitive discharge is developed. It is shown that, by using of a capacitive discharge, it is possible to built a sealed off metal halide vapour laser of a simple design allowing the addition of active impurities into the working medium.**

***Keywords***: *copper bromide vapour laser, capacitive discharge, excitation.*

Self-contained metal and metal halide vapour lasers are efficient sources of coherent radiation in the visible spectral range. In this paper, we report for the first time, as far as we know, the development of a self-contained metal halide (copper bromide) laser pumped by a high-frequency capacitive discharge. We call a discharge realised in our experiments the high-frequency capacitive discharge, similarly to papers [1, 2], where the features of discharges of different types (glow, capacitive, barrier) were considered in connection with excitation of excilamps.

The scheme of the gas-discharge tube (GDT) of a CuBr – Ne laser pumped by a high-frequency capacitive discharge is presented in Fig. 1. The vacuum envelope of the GDT is made of quartz. The GDT length was 68 cm and the working-channel diameter was 1.2 cm. Electrodes were made of a tantalum foil of width 10 cm and were located on the external wall of the GDT at a distance of 28 cm from each other. The buffer neon gas pressure $p$ of 20 kPa was typical for such lasers. The GDT operated in the self-heating regime. The active medium was pumped by the direct discharge of a storage capacitor with a shunt inductance. A TGI1-1000/25 hydrogen thyratron was used as a switch. The capacitance $C$ of the storage capacitor was varied from 70 to 330 pF. Current, voltage, and laser pulses were recorded with a Rogowski loop, a Tektronix P6015A voltage probe, and a FK-22 coaxial photocell, respectively. The output signals of the detectors were fed to a Tektronix TDS 3032 oscilloscope. The radiation power was controlled with an IMO-2 power meter and the GDT wall temperature was measured with a chromel – alumel thermocouple. The voltage amplitude across electrodes was varied from 4 to 9 kV. The maximum amplitude of the GDT current was 20 A.

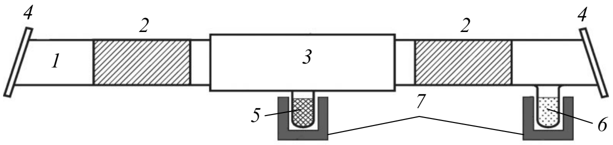

**Figure 1.** GDT scheme: (*1*) quartz tube; (*2*) electrodes; (*3*) thermal isolator; (*4*) windows; (*5*) copper bromide powder; (*6*) HBr generator; (*7*) heating elements.

The main results obtained in our study are as follows. The volume high-frequency discharge in a CuBr – Ne mixture can be comparatively easily realised at buffer-gas pressures up to 100 kPa. In this case, the conditions are provided for producing pulsed inversion on the fundamental self-contained transitions in copper atoms at wavelengths 510.6 and 578.2 nm. The laser pulse repetition rate $f$ was 30 – 100 kHz. It is difficult to obtain such frequencies in a thyratron scheme upon conventional gas-discharge pumping. Figure 2 shows typical oscillograms of the voltage, discharge current and laser pulse. One can see that lasing occurs only at the first (main) pump maximum immediately after the voltage maximum (at the current maximum). This agrees qualitatively with results obtained earlier by using a repetitively pulsed glow discharge [3]. The laser pulse duration (total for both lines) was 20 – 30 ns at the 0.1 level of the pulse maximum. The main pump maximum is accompanied by voltage (and current) oscillations at a frequency of ~ 1 MHz (Fig. 3) caused by the reactive parameters of the discharge circuit and GDT. The total duration of oscillations achieves 8 – 10 μs. It is obvious that the presence of oscillations reduces the pump efficiency. However, it is possible that this discharge phase provides the dissociation of copper bromide molecules, thereby producing conditions required for lasing (in the next pulse). The elucidation of the nature of these oscillations and their role requires further studies. The main advantage of the high-frequency capacitive pumping of the working mixture of a CuBr – Ne laser is a simple GDT design, excluding the

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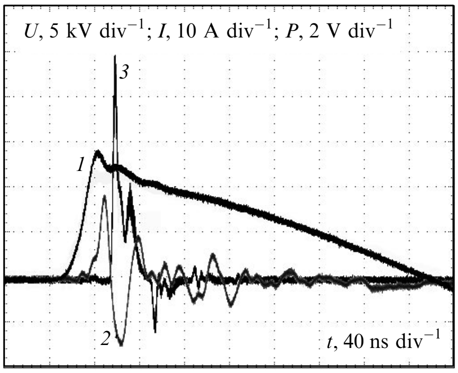

**Figure 2.** Typical oscillograms of the GDT voltage $U$ (*1*), current $I$ (*2*), and the laser pulse $P$ (*3*) for $f = 35$ kHz, $C = 200$ pF, $p = 20$ kPa.

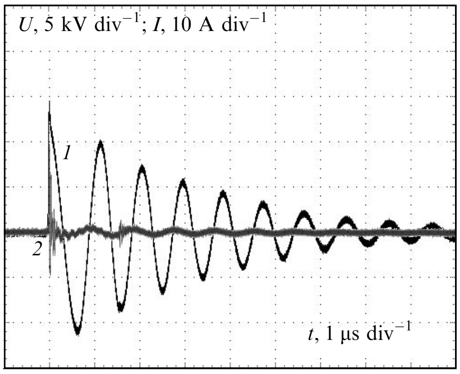

**Figure 3.** Typical GDT voltage $U$ (*1*) and current $I$ (*2*) oscillograms for $f = 35$ kHz, $C = 200$ pF, and $p = 20$ kPa.

necessity of contact between the working mixture and electrodes, and the possibility of obtaining lasing with pulse repetition rates higher than 100 kHz. Thus, already in the first control experiments with pumping by a GMI-42B modulating lamp switch, a pulse repetition rate of 300 kHz was achieved.

Note that lasers with active media modified by additions of the $H_2$, HCl, HBr, etc. impurities to the buffer gas attract the main attention in the study and development of metal vapour and metal halide vapour lasers [4, 5]. These are the so-called modified-kinetics metal vapour lasers. Such a modification improves twice or more the energy and frequency parameters of lasers and also considerably improves the laser beam quality [3, 6, 7]. At the same time, the interaction of active additions (and their derivatives) with working electrodes located inside the GDT severely complicates the fabrication of sealed off lasers of this type. The GDT design proposed in our paper allows the operation not only with CuBr vapours in a pure Ne buffer gas but also with HBr added to the active medium. As shown in Fig. 1, the GDT has a built-in reverse HBr generator, which serves not only to supply HBr into the active medium of the laser but also to pump out HBr back to the generator [3, 8]. We plan to study in the future the influence of the HBr addition on the discharge and lasing parameters.

Note in conclusion that we have developed for the first time a copper bromide vapour laser pumped by a high-frequency capacitive discharge. The average output power of the laser is $\sim 1$ W for the 1-kW input power from a high-voltage rectifier ($C = 100$ pF, $f = 100$ kHz, $p = 20$ kPa). The discharge tube of the laser has a simple design with external electrodes, which provides a long operation time in the sealed-off regime. This is very important for the development of efficient modified-kinetics metal vapour lasers, in which active and often chemically corrosive impurities are used. The service life of the developed sealed-off GDT has not been tested so far. However, our first experiments suggest that the service life of the GDT will exceed the values typical for lasers of this type (hundreds of hours).

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## References

1. Lomaev M.I., Skakun V.S., Tarasenko V.F., et al. *Pis'ma Zh. Tekh. Fiz.*, **25**, 27 (1999).
2. Lomaev M.I., Skakun V.S., Tarasenko V.F., et al. *Usp. Fiz. Nauk*, **173**, 201 (2003).
3. Shiyanov D.V., Sukhanov V.B., Evtushenko G.S., Andrienko O.S. *Kvantovaya Elektron.*, **34**, 625 (2004) [*Quantum Electron.*, **34**, 625 (2004)].
4. Little C.E. *Metal Vapor Lasers. Physics, Engineering & Applications* (Chichester, UK: John Willey & Sons, 1998).
5. Batenin V.M., Buchanov V.V., Kazaryan M.A., Klimovskii I.I., Molodykh E.I. *Lazery na samoogranichennykh perekhodakh atomov metallov* (Self-contained Metal Vapour Lasers) (Moscow: Nauchnaya kniga, 1998).
6. Withford M.J., Brown D.J.W., Mildren R.P., Carman R.J., Marshall G.D., Piper J.A. *Progr. Quantum Electron.*, **28**, 165 (2004).
7. Andrienko O.S., Dimaki V.A., Evtushenko G.S., Sukhanov V.B., Troitskiy V.O., Shiyanov D.V. *Opt. Eng.*, **44**, 071204 (2005).
8. Andrienko O.S., Sukhanov V.B., Troitskiy V.O., Shestakov D.Yu., Shiyanov D.V. Patent of the Russian Federation No. 2295811, 09.11.04; *Byull. Izobret. Polezn. Model.*, No. 8 (2007).