# NITROGEN LASER PUMPED BY LONGITUDINAL DISCHARGE WITH ULTRAVIOLET PREIONIZATION

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*Results of experimental investigations of a low-pressure* $N_2$ *laser pumped by low-voltage longitudinal discharge with ultraviolet preionization are presented. An average output power of* 0.35 mW *and a pulse duration of* 2.5 ns *have been obtained at a working nitrogen pressure of* 40 Torr. *Based on the data obtained, a miniature sealed-off* $N_2$ *laser has been developed.*

In recent years, interest in the development of miniature UV lasers has been grown.[1-5] Among them, $N_2$ lasers are simpler and cheaper. The application of a sectioned longitudinal discharge with UV-preionization to $N_2$-laser pumping improves the homogeneity of output radiation and allows one to reduce a charging voltage down to 20 kV (see Ref.1). The use of commercial triggered spark gaps instead of thyratrons simplifies the discharge circuit of the $N_2$ laser and improves the laser output parameters.[6] Small size of this gap is important for the development of miniature $N_2$ lasers.[4] In addition, sealed-off miniature $N_2$ laser may be developed,[7] which widens their application area.

In the present paper, results of experimental investigations of a low-pressure UV-preionized $N_2$ laser pumped by sectioned longitudinal discharge at low charging voltage are presented.

The Blymlain excitation was used in the laser. In our previous experiments, it was successfully applied to pump a longitudinal-discharge miniature XeCl laser. Its electric circuit, design features, and general view were described in detail in Ref. 4. An active volume of the laser was formed by a quartz tube with an inner diameter of 4 or 5 mm. Four longitudinal discharge gaps were in the tube. The length of each gap was 4 cm. The laser cavity was formed by an Al-coated mirror and a plane-parallel quartz plate. Five pairs of shaped steel rods were used as electrodes. So, the discharge channel was 16 cm long and the active discharge volume was 2 or 3 cm$^3$. Capacitance of the Blymlain circuit was 12 nF. Additional peaking capacitors $C_p$ used for preionization were connected to each discharge gap. Their capacitance varied from 0.6 to 1.2 nF. The RU−62 commercial triggered spark gap was used as a switch. The energy characteristics of the laser emission were measured with the IMO−2N calorimeter, FEC−22SPU photocathode, and S8−14 oscilloscope. The laser output characteristics were investigated as functions of the parameters of the Blymlain excitation circuit, its charging voltage, and working nitrogen pressure.

Figure 1 shows the average output power as a function of the total peaking capacitance. A maximum output power of 0.35 mW was obtained with a peaking capacitance of 0.9 nF at a pulse repetition rate of 10 Hz, charging voltage of 12 kV, and nitrogen pressure of 40 Torr. The maximum pulse repetition rate reached 15 Hz and was 3 times higher than that reported in Ref. 1. Our experiments have shown that capacitive pumping scheme is preferable to operate with a high repetition rate. An output pulse duration of 2.5 ns FWHM was obtained in our experiments. Service life of the laser in a sealed-off regime of operation was also investigated. One nitrogen filling provided rather stable operation during up to $10^5$ laser shots. Based on the data obtained, the requirements for the development of miniature sealed-off $N_2$ lasers were formulated and a new laser system was developed.

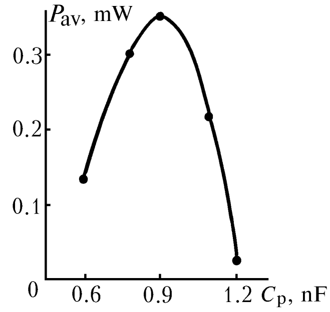


*FIG. 1. Output average power versus total peaking capacitance at nitrogen pressure* $P$ = 40 Torr, *charging voltage* $U_0$ = 12 kV, *pulse repetition rate* $f$ = 10 Hz, *and capacitance of the Blymlain circuit* $C_3$ = 12 nF.

Figure 2*a* shows the average power versus the charging voltage at a nitrogen pressure of 30 Torr and a pulse repetition rate of 10 Hz. The linear increase of the laser output power with charging voltage is observed. It should be pointed out that the laser operates at charging voltage being more than twice

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lower than that used in Ref. 1. It is known that low charging voltage is preferable for various applications of the $N_2$ laser, especially in medicine. In addition, low voltage improves the laser operation reliability.

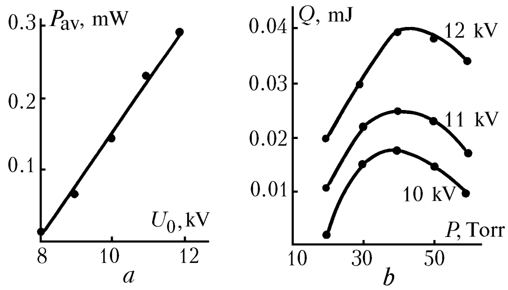


*FIG. 2. Average output power versus charging voltage at P* = 30 Torr, *f* = 10 Hz *(a) and output energy versus charging voltage at f* = 1 Hz *(b).*

The laser output energy versus the nitrogen pressure and charging voltage is shown in Fig. 2*b*. An optimal nitrogen pressure of 40 Torr was found irrespective of charging voltage. The increase of the output energy with charging voltage is also evident. A maximum output energy of 50 μJ was obtained at a charging voltage of 13 kV. Experimental results indicate rigid connection between matching of wave resistance of the discharge plasma and the power source with automatic UV-preionization. So, when the pressure exceeds its optimal value, the output energy falls down regardless of charging voltage.

The output parameters of the miniature low-pressure $N_2$ lasers with longitudinal pumping and UV-preionization obtained with discharge tube 4 mm in inner diameter for indicated active lengths and charging inner voltages are compared in Table I.

*TABLE I. Output parameters of the miniature low-pressure UV-preionized $N_2$ laser pumped by longitudinal discharge with indicated active lengths and charging voltages. The discharge tube inner diameter was* 4 mm.

| *P*, Torr | *L*, cm | *V*, $cm^3$ | $U_0$, kV | $\tau_1$, ns | *Q*, mJ | *Q*, $mJ \cdot cm^{-3}$ | *P*, kW | *P*, $kW \cdot cm^{-3}$ | *f*, Hz | η, % | Literature |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 26 | 3.3 | 20 | 5 | 0.33 | 0.1 | 65 | 20 | 5 | 0.01 | Ref.1 |
| 40 | 16 | 2 | 8–12 | 2.5 | 0.04 | 0.02 | 16 | 8 | 10 | 0.01 | Present paper |

Correlation of the experimental results is well pronounced. Laser dimensions were minimized by using lower gas pressure, shorter active length, and lower charging voltage. The key feature of the $N_2$ laser was the low inductivity of the discharge circuit that enabled us to reduce the output pulse duration down to 2.5 ns.

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