ATMOSPHERIC PRESSURE MINIATURE NITROGEN LASER

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Design and performance of a miniature nitrogen laser with a UV preionization operating at a gas pressure from 0.25 *to* 1.5 atm *are discussed. Effect of* He, O_2, *and* SF_6 *additions on the output energy and pulse repetition rate of this laser is discussed. Peak output power of* 240 kW, *pulse duration of* 0.9 ns, *and pulse repetition rate ranging from* 1 *to* 25 Hz *are demonstrated.*

High peak power coherent UV pulses are necessary in different areas including diagnostics, microelectronics, and pumping of dye lasers.

Results on design and performance of both low pressure nitrogen lasers[1,2] and nitrogen lasers operating at atmospheric pressure[3] are known. In this paper, output parameters of a miniature nitrogen laser with a UV preionization operating at a gas pressure from 0.25 to 1.5 atm are presented, and effect of He, O_2, and SF_6 additions on output energy and pulse repetition rate of this laser is described.

The miniature nitrogen laser has been developed on the basis of an LMI-3 miniature CO_2 laser and consists of two units: the laser head and the power supply. The laser head is made as a chamber with a side cover. Resonator optics is mounted on the ends of the laser chamber and includes Al mirror with radius of curvature of 5 m and a quartz plate. The latter has a multilayer coating and the reflectance of 53% at 337.1 nm. The laser head also includes an electrode assembly with preionization. Two profiled electrodes of duralumin form the laser volume of $0.4(0.28)\times0.4\times14$ cm^3 size. Electrode system of preionization is formed by the cathode of the main discharge gap and ends of textolite plates covered with metal stripes. The plates are placed on both sides of the cathode. Each preionization discharge is driven by a separate 33 pF capacitor.

Specific feature of the preionization discharge in the miniature laser is that this discharge should provide intense preionization but should not cause decomposition of the gas mixture. Our configuration allows one to eliminate this problem by redistribution of high current flowing in the arc channel between several arc channels close to each other. In this case, gas temperature is lower and, as a result, mixture degradation is slower.

Parameters of the pulsed self-sustained volume discharge are determined mainly by the intensity and homogeneity of the preionization as well as by the parameters of a high-voltage pulse applied to the discharge gap. High-voltage pulses are formed by a Blumlein generator. An RU-62 spark gap was used as a high-current switch. Six KVI-3 capacitors with $C = 2200$ pF served as the capacitive energy storage. Energy and temporal characteristics are monitored with an IMO-2N calorimeter, an FEK-22 SP4 photodetector and a fast S7-19 oscilloscope.

Our excitation system allows us to form a homogeneous discharge at a gas pressure from 0.25 to 1.5 atm. Lasing on 2^+ nitrogen system at 337.1 nm is observed in the entire range of the gas pressure studied. Optimization of the gas pressure is done for a charging voltage of 10 kV. Output energy versus pressure of pure nitrogen and its mixture with helium obtained with two different discharge gaps of 0.28 and 0.4 cm are presented in Fig. 1*a*. The shapes of the curves are similar for different discharge gaps, but their peaks are shifted to lower gas pressure at larger electrode separation since E/p value decreases with the increase of the discharge gap (E is field strength, p is the gas pressure).

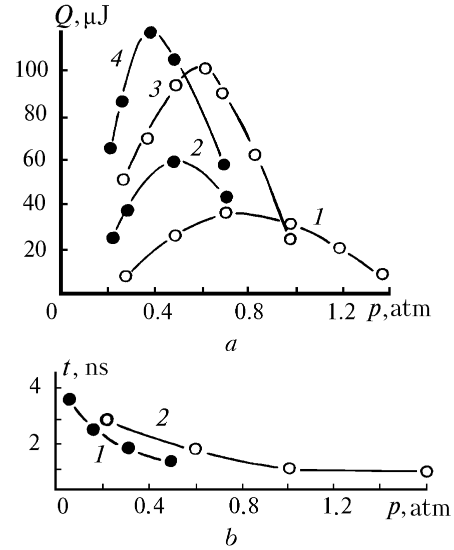

FIG. 1. Output energy versus pressure of pure nitrogen (curves 1 and 3) and in N_2*—He mixture (curves 2 and 4). Discharge gap is equal to* 0.28 cm *(curves 1 and 2) or* 0.4 cm *(curves 3 and 4) (a). Pulse duration (FWHM) as a function of nitrogen pressure (curve 1) and* N_2*—He mixture (curve 2) (b).*

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Figure 1*b* presents pulse duration as a function of nitrogen pressure. It is seen that the higher is the gas pressure, the shorter is the laser pulse. The shortest pulse duration obtained in our experiments was 0.8 ns (FWHM).

Consider now output energy of a nitrogen laser versus oxygen concentration. It should be noted that materials used in construction of the laser head can desorb oxygen under influence of UV radiation (lateral illumination, high E/p values), and its equilibrium concentration in the chamber substantially influences laser parameters, especially the discharge stability. Experiments demonstrated that addition of 2–3% of oxygen into the gas mixture leads to arcing and break of lasing.

Consider laser parameters in a repetitively pulsed operation mode. Figure 2 depicts average output power versus number of laser shots obtained with two different electrode separations (0.28 and 0.4 cm) at a pulse repetition rate of 10 Hz. It is seen that output power drops with the increase of the number of laser shots if pure nitrogen is used. When helium is added into the mixture, the average power is increased and stabilized. This is caused by an improved stability of the volume discharge and higher value of E/p parameter during the excitation.

It is known that addition of SF_6 leads to longer pulses and an increase in the output energy of a nitrogen laser. Small addition of SF_6 (about 1%) is of interest. In this case, when $E = 60$ kV/cm at $d = 0.28$ cm the effect of SF_6 on the output energy is insignificant since in such a high field the electron temperature is sufficient for efficient population of the upper laser level in pure nitrogen. However, in the presence of SF_6 the discharge is more stable and the gas lifetime increases. Quite a different picture is observed at $E = 42.5$ kV/cm and $d = 0.4$ cm. Appreciable increase in the output power and its drop with the increasing number of laser shots are evident when SF_6 is added to nitrogen. The same results were obtained with N_2–He mixture.

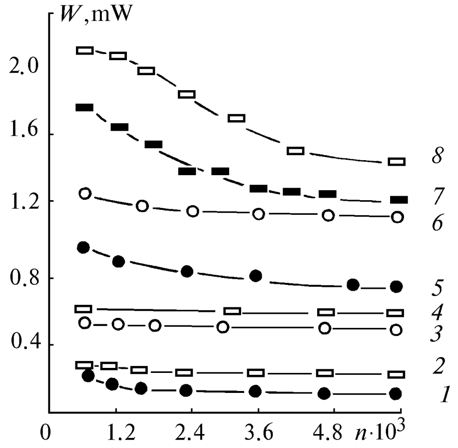

FIG. 2. Output power versus number of laser shots in the following gas mixtures: 0.5 N_2 *(curves 1 and 5);* 0.5 N_2 + 1% SF_6 *(curves 2 and 6);* 0.5 N_2 + 0.5 He *(curves 3 and 7);* 0.5 N_2 + 0.5 He + 1% SF_6 *(curves 4 and 8). Curves 1–4 were obtained with a discharge gap of* 0.28 cm, *whereas curves 5–8 were obtained at* $d = 0.4$ cm.

Optimal operation mode of our miniature nitrogen laser demonstrates pulse duration of 0.9 ns (FWHM) put energy of 0.22 mJ, and pulse repetition rate of 25 Hz.

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