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PULSE-PERIODICAL VOLUME DISCHARGES IN CO2–LASER MIXTURES OF SUPERATMOSPHERIC PRESSURE

B.A KOZLOV[1], *D.S. MAKHANKO*[2]

[1]*Ryazan State Radio Engineering University, Ryazan, Russia*
[2]*PLASMA, JSC Research Institute of Gas-Discharge Devices, Ryazan, Russia*

At present, to solve many technological problems, pulses of laser radiation in the infrared range (9–10 μm) with a radiation energy of several tens of millijoules per pulse, a duration of less than 20 nanoseconds, and a maximum pulse repetition rate of up to 20 kHz are required [1].

Such parameters can only be realized at superatmospheric pressure CO2 lasers. The excitation of volume discharges of superatmospheric pressure at pulse repetition rates of units and tens of hertz does not present any particular difficulties. In the repetitively pulsed mode (FRPM $=10^2$–10^4 Hz), the formation of volume pumping discharges becomes a big problem.

The purpose of this work was to determine the conditions for the formation of volume pumping discharges in CO2 laser mixtures at a total pressure of up to 6 atmospheres at pulse repetition rates up to 2.5 kHz in a gap with geometric dimensions V=7.5x0.8x0.8 cm^3.

To initiate a volume discharge in the gap between profiled graphite electrodes, hard VUV radiation was used from a series of corona electrodes installed along the main gap with an interval of 1 cm.

The excitation of the auxiliary and volumetric discharges is carried out from two autonomous pulse generators based on pulse transformers with an adjustable delay between the start moments. If it was necessary to generate voltage pulses up to 160–180 kV, pulse generators were used based on a combination of a two–stage Marx generator and a pulse transformer with a low transformation ratio ($k \leq 4$) [2, 3]. In this case, it is possible to maintain the duration of the leading edge of the voltage pulse at the level of 70–100 nanoseconds and to carry out the breakdown of the gas–discharge gap at the amplitude value of the voltage pulse.

Pulsed hydrogen thyratrons of the TGI2–500/20 and TGI1–1000/25 types were used as switches.

Negative effects from residual voltages in the gas–discharge gap after the pumping current with their negative (relative to the pumping pulse) polarity were eliminated using damping circuits based on high-voltage vacuum diodes and low–inductance resistors [3].

The main results of the work:

1. For the formation of stable volume discharges in CO2–laser mixtures of superatmospheric pressure in the repetitively pulsed regime, it is expedient to make graphite electrodes and multiply the initial ionization level in the main gap.
2. The most efficient and damage–resistant sources of hard VUV radiation for preionization purposes are electrode structures for the formation of pulsed corona discharges.
3. The duration of the volume discharge current should not exceed 30 nanoseconds.
4. In CO2–laser mixtures CO2:N2:He=1:1:8 at a total pressure of up to 6 atmospheres at a pulse repetition rate of 2–2.5 kHz, the specific energy density W=100–150 $mJ \cdot cm^{-3} \cdot Atm^{-1}$ introduced into the volume discharge plasma has been achieved.

REFERENCES

[1] B.A. Kozlov, “TEA–CO2 laser with pulse repetition rates up to 5 kHz for technological applications,” Proceedings - 2016 International Conference Laser Optics, LO 2016. 2016. C. R220.

[2] B.A. Kozkov, V.I. Seredinov, S.A. Pyanchenkov and D.S. Makhanko, “High-voltage pulse generators for effective pumping of super-atmospheric pressure CO2-lasers,” Journal of Physics: Conference Series. The proceeding 14th International Conference "Gas Discharge Plasmas and Their Applications". Institute of High-Current Electronics of the Siberian Branch of the Russian Academy of Sciences. 2019. C. 012010.

[3] B.A. Kozlov and A.Ya. Payurov, "Super-atmospheric CO2 laser with pulse repetition rate up to 2 kHz," Proceedings of SPIE - The International Society for Optical Engineering. XIV International Conference on Pulsed Lasers and Laser Applications, AMPL 2019. 2019. C. 113220F.