Atmospheric-pressure CO_2 laser with nonautonomous discharge controlled by ultraviolet radiation

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We developed an atmospheric-pressure CO_2 laser with a nonautonomous discharge controlled by a source of ultraviolet radiation. The photoionization of the gas medium was produced by adding dimethylaniline vapor to a gas mixture CO_2:N_2:He = 1:1:8. The laser pulse duration was 20 μsec.

The development of CO_2 lasers operating at atmospheric pressure, in which external ionization of the gas volume by ultraviolet radiation is used, was recently reported for the first time.[1,2] The generation time in these lasers did not exceed several microseconds.

It was shown in[3] that by using longer-acting ultraviolet radiation sources and by adding to the gas components that are easy to analyze it is possible to stretch out the duration of the nonautonomous discharge in the atmospheric-pressure gas to several hundred microseconds. Prolonged quasistationary generation of an atmospheric-pressure CO_2 laser was first realized in[4,5], the external ionizers being sources of nuclear radiation or stationary electron beams.

We report here the accomplishment of lasing and the measurement of the gain of a CO_2 laser at atmospheric pressure with a nonautonomous discharge controlled by a source of ultraviolet radiation. The lasing pulse duration was several dozen microseconds and was limited by the corresponding time dependence of the ultraviolet radiation.

The experimental setup is illustrate in Fig. 1.

A dc voltage was applied to the principal electrodes of the discharge chamber (electrode length 30 cm, width 1 cm, gap between electrodes 2 cm) and charged the capacitor C_1 to a voltage below the breakdown level of the working gas mixture at the pressure in the discharge chamber ($U = 5$ kV). The discharge in the chamber was initiated by turning on two ultraviolet-radiation sources located 8 cm away from the electrodes and spanning a length $l = 35$ cm. The UV sources were multigap dischargers assembled of a large number of metallic rings. The circuit was actuated by discharging the gaps D_1 and D_2, which are located in the discharge circuits of capacitors C_2 and C_3.

The active medium was a gas mixture $CO_2 : N_2 :$ He $= 1 : 1 : 8$ at atmospheric pressure, to which easily-ionized additive was added in the form of dimethylaniline vapor [$C_6H_5N(CH_3)_2$], the partial pressure of which did not exceed 1 Torr. The ionization potential of the dimethylaniline molecule is 7.14 eV. It should be noted that the experiments were performed with a large number of easily-ionized additives, including the tri-n-propylamine investigated in the literature.[2] However, the use of dimethylaniline vapor ensured the largest nonautonomous discharge-plasma conductivity and the largest gain.

The resonator was made up of two gold-coated mirrors located at the ends of the discharge chamber at a distance 50 cm apart. One mirror was flat and the other had a curvature radius $R = 3$ m and a central opening of 2 mm diameter to let the radiation out.

During the experiment we registered the current of the nonautonomous discharge in the chamber, and also the laser pulse, using a Ge-Au receiver.

Figure 2 shows the typical synchronized oscillograms of the nonautonomous discharge current and of the radiation pulse.

It is seen from the oscillograms that the characteristic duration of the generation pulse amounts to 20 μsec, and its fall-off is connected with the time variation of the nonautonomous discharge current. Measurement of the corresponding gain, performed by passing the beam from a master CO_2 laser once along the optical axis of the system, has shown that the maximum gain is

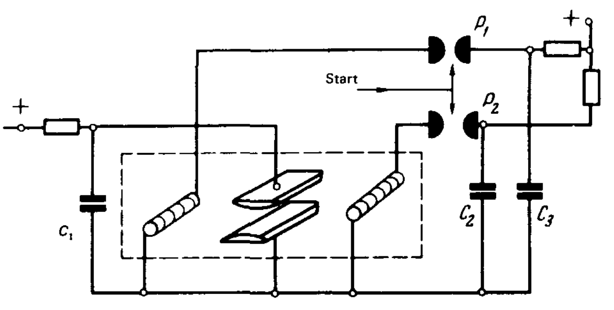

FIG. 1. Diagram of experimental setup.

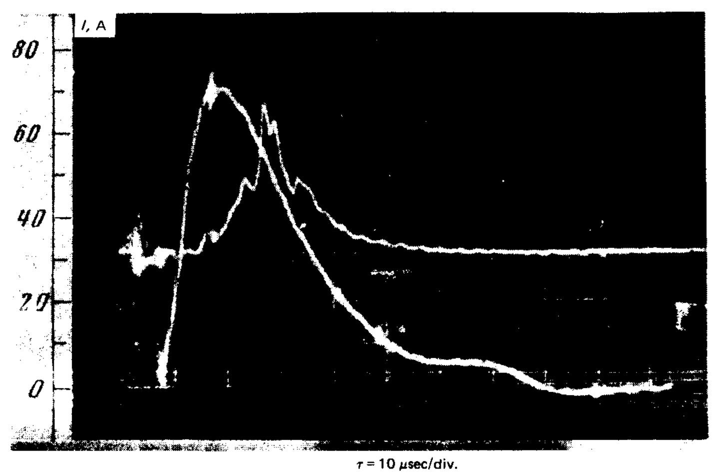

FIG. 2. Oscillograms of radiation pulse (upper trace) and of the nonautonomous discharge current.

~1.3% cm^{-1}, which is close to the value measured in[5].

The experimental results have shown that by ultraviolet irradiation of a CO_2—N_2—He gas mixture with easily-ionized additives it is possible to produce an optically active medium in a gas at atmospheric pressure, with times amounting to several microseconds. It should be noted that the optical and electrical characteristics of the obtained excitation scheme may make it also promising for the development of amplifiers required to produce high-power pulsed lasers.

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