ELECTRON-BEAM-PUMPED LASER ON XENON ATOMIC TRANSITIONS WITH AN ENERGY OF 100 J

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Results of experimental investigation of laser generation on xenon atomic transitions under excitation of Ar-Xe *and* He-Ar-Xe *gas mixtures by e-beam in a laser chamber with an active volume of* 600 l *are presented. Output energy of the order of* 100 J *and efficiency of* 2% *of the energy deposited in the gas have been obtained.*

1. INTRODUCTION

At present the laser generating on xenon atomic transitions is one of most promising in the IR region of the spectrum. Already in the first experiments on e-beam pumping of Ar-Xe gas mixtures at total pressures 1–3 atm, the record lasing parameters were achieved, in particular, specific output energy up to 3 J/l and efficiency up to 2–3% (see Ref.1 for more detail). The evolution of the electron accelerator technology allowed one to expand the active volume of Xe laser up to 270 l but the efficiency and output parameters obtained in those experiments were rather low[2] (9.5 J and 0.4%, respectively). In 1990, lasing energy of 650 J for the volume 0.5×0.65×3 m filled with Ar-Xe mixture was reported.[3] Efficiency of laser generation at λ = 1.73 μm ranged from 0.57 to 0.85%.

In this paper, results of experiments on laser generation on xenon atomic transitions under excitation of Ar-Xe and He-Ar-Xe gas mixtures by an e-beam in a laser chamber with active volume of 600 l are presented. In the setup used, electron beams were injected into a laser chamber from six accelerating double diodes arranged symmetrically about the optical axis. The obtained output energy was about 100 J with efficiency of 2%.

2. EXPERIMENTAL SETUP

The setup described in Ref. 4 in detail was used for laser excitation. An accelerator system includes 12 accelerator modules supplied by 12 pulsed voltage generators (PVG's) arranged in a common evacuated tank in a two-storey six-rayed star (see Fig. 1). Output voltage of the pulsed generator was 0.6 MV at a current of 60–80 kA per module. The width of the leading pulse edge was 0.1–0.2 μs and pulse duration FWHM was 0.5–0.7 μs.

The cylindric laser chamber 3 m long and 0.6 m in diameter had an active volume of 560 l and was equipped with a plane-parallel resonator composed of an Al-coated mirror and a quartz plate.

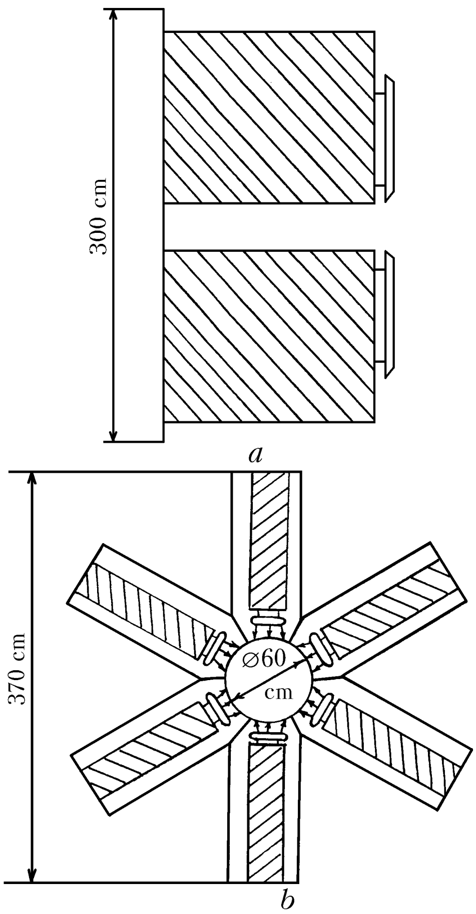

FIG. 1. Schematic drawing of the modular accelerator for pumping of a laser with an active volume of 600 l: *configuration of modules (a) and cross-sectional view (b).*

Energy deposited in gas by an electron beam was recorded by the pressure jump technique. Distribution

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of laser output energy over the beam cross section and total energy were measured by means of an automatic system built around the TPI-2M1 calorimetric converters.[5] Each calorimeter had a detecting area of 36 cm^2. In our experiments, a linear array composed of 31 calorimeters joint in a module was used. An electric signal from each calorimeter was delivered to the input of a digital voltmeter through a multiplexer (a standard CAMAC module). Then a digitized signal was processed and stored on a DVK–3 computer. Time waveforms of laser pulses were recorded using the FSG–22 germanium photoresistor and the S8–14 oscilloscope.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The accelerator system allowed us to change the excitation energy by changing the number of operating high-voltage generators and hence to optimize the excitation regime for its efficiency. Figure 2 shows the specific output energy as a function of gas pressure of the mixture Ar:Xe = 100:1. It is seen that excitation by all 12 accelerators is much less efficient than pumping by two electron sources. The maximum output energy density at $\lambda = 1.73$ μm for the mixture Ar:Xe = 100:1 at a total pressure of 1.5 atm was 50 mJ/cm^2, which corresponded to a total energy of 100 J and efficiency of 2%. When the energy deposited in the gas was increased with the increase of the number of operating accelerator modules, almost exponential drop of output energy was observed. When all 12 high-voltage generators were used, the output energy density decreased down to 5 mJ/cm^2. This result can be explained by faster electron collision mixing of xenon working levels at higher electron concentration in plasma.[1,6] At pumping powers higher than 1 kW/cm^3, addition of lighter buffer gas helium may result in the increase of output energy and/or efficiency of the Xe laser as well as in change of laser wavelength[7–9] from $\lambda = 1.73$ μm to $\lambda = 2.03$ μm. In our case, initial gas mixture diluted by helium (see Fig. 2, curve *2*) derived somewhat lower output energy at $\lambda = 2.03$ μm, apparently due to insufficient rate of gas mixing in a large volume (see Ref. 3).

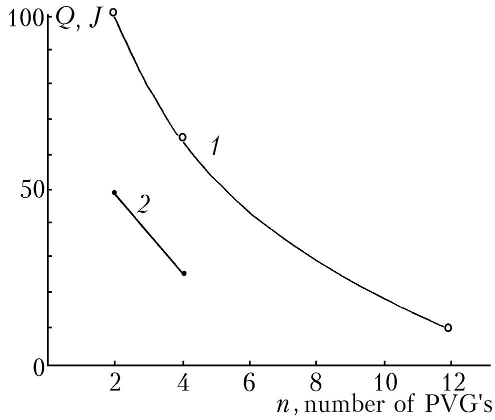

FIG. 2. Output energy Q derived from the mixture He:Ar:Xe = 0.4:1.1:0.01 atm *(1) and* Ar:Xe = 100:1 *at* $p = 1.5$ atm *(2) versus the number of accelerator modules used.*

Thus, optimization of pumping power enabled us to obtain laser efficiency of 2% and output energy of 100 J at $\lambda = 1.73$ μm for an active volume of 600 l.

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