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INVESTIGATION OF LASING IN Ar-Xe-PLASMA CREATED BY PULSED ELECTRON BEAM AND NON-SELF-SUSTAINED DISCHARGE

D.L. Kuznetsov(*), Yu.S. Surkov, V.V. Uvarin and I.E. Filatov

Institute of Electrophysics, Ural Branch of the Russian Academy of Sciences

106, Amundsen st., 620016, Ekaterinburg, Russia

(*) **kdl@iep.uran.ru**

Self-sustained and non-self-sustained discharges of various types, electron beams and splinters of nuclear reactions are used for pumping of a laser on xenon atom. A formation of laser radiation in argon-xenon mixture in a rep-rated regime is concerned with certain difficulties. Maximum pulse repetition rate of the combined pumping was 25 Hz [1].

A method proposed by us and existing equipment permits implementation of a pumping with a pulse repetition rate of beam and discharge up to 100 Hz.

Two installations were used for conducting the experiments. The installation with the compact nanosecond electron accelerator is described in [2]. The installation with high-current rep-rated electron accelerator previously was used in the experiments represented in [3], however, for the new experiments the substantial changes were introduced into it.

The formation of lasing in the Ar-Xe mixture excited by single pulses of electron beam and non-self-sustained discharge initiated by beam, without circulation of the gas mixture were investigated. The parameters of the pulses of laser radiation are following.

On the installation with the high-current accelerator in the regime of pumping by electron beam the specific energy of lasing at the wavelength of 1.73 μm was 0.33 mJ/l per pulse. The efficiency of lasing was ~0.5%, the maximum pulsed power of laser radiation was 660 W. On the other hand, in the regime of combined pumping by electron beam and non-self-sustained discharge initiated by beam the specific energy of lasing was 51 mJ/l per pulse. The efficiency of lasing was ~1%, the maximum pulsed power of laser radiation was 110 kW.

On the installation with the compact accelerator in the regime of pumping by electron beam energy input into the gas mixture was low, and we had only observed a luminescence with low power. However, in the regime of combined pumping by electron beam and discharge initiated by beam the specific energy of lasing was 0.1 J/l per pulse. The maximum pulsed power of laser radiation was 50 kW. Waveforms of the pulses are presented in Fig. 1.

In all cases the radiation occurred in the regime of afterglow, i.e., the radiation pulse began with a time delay after the beam or discharge current pulse. The observed regime of afterglow confirms that the recombination mechanism with the participation of metastable atoms is the basic mechanism of the population of the upper laser level of xenon atom.

Investigations of laser radiation in a rep-rated regime without the circulation of mixture have carried out. It was discovered that during the pumping by electron beam an increase in pulse repetition rate from single pulses up to 1 Hz and 10 Hz leads to an almost linear increase in the average power of radiation. With further increase in the pulse repetition rate of beam current up to 100 Hz not an increase, but a sharp decrease in the average radiation power practically to zero during several tens of seconds was observed.

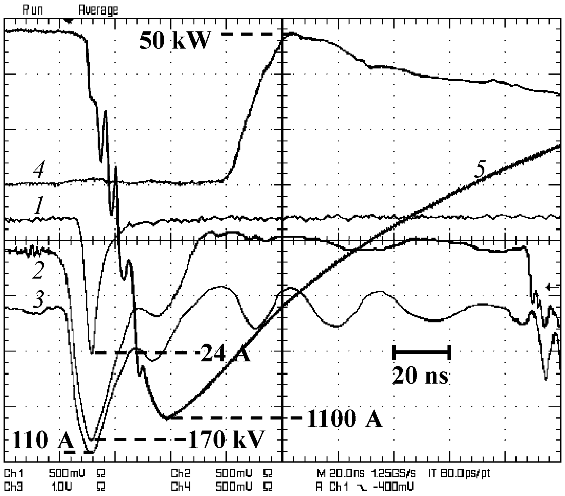

Fig. 1: Waveforms of electron beam current $I_{e.b.}$ *(1)* after passage of the output foil, output voltage U_{out} *(2)* and output current I_{out} *(3)* of pulsed high-voltage generator, pulsed power of lasing *P (4)* at wavelength of 1.73 μm during combined pumping of atmospheric pressure mixture Ar:Xe = 200:1 by single shots of electron beam and non-self-sustained discharge initiated by electron beam, and non-self-sustained discharge current I_d *(5)* initiated by electron beam in the mixture with a voltage U_o = 10 kV at the discharge gap.

In this case an increase in the temperature of gas mixture was detected. However, during the combined pumping by beam and by discharge already with the pulse repetition rate of 1 Hz on both installations the sharp decrease of both the energy of separate radiation pulses and of the average radiation power is also observed. An increase in the temperature of gas mixture also was detected.

It is known [3] that limitation of lasing power during frequency pumping of Ar-Xe mixture by pulsed electron beam is explained by heating of working gas mixture. Since an energy input into gas mixture due to discharge initiated by electron beam in a range of high electric field strength is significantly larger than one due to electron beam itself, the problem of gas heating is a determinative factor in our experiments. With the aid to solve this problem our installation is appointed by a cooling system. The system provides an effective cooling of the gas mixture in close cycle by passage of the mixture through a chamber cooled by liquid nitrogen. A passage process is executed with the aid of fan. The use of cooling system allows us to extend a range of a linear increase in the average lasing power with an increase in pulse repetition rate. The results of our experiments allow to assume that with the pulse repetition rate up to 100 Hz the average power of laser radiation of more than 1 W can be achieved, which will be 3 times higher than the result obtained earlier with the use of the combined pumping [1].

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Reference

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