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PULSED LASERS AND LASER APPLICATIONS

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ABSTRACTS

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In this study, we present the data on these parameters in the plasma of a high voltage nanosecond discharge in gas filled gaps with a high overvoltage measured by methods of the optical emission spectroscopy (OES): Stark broadening and Stark shift methods [4] for N_e, a method based on the radiation collisional plasma model [5] for T_e and E/N, as well as the Boltzmann method [6] for T_{tr} and the vibrational temperature T_{vib}. Based on the data obtained, it was established that the impemented plasma is highly non-equilibrium (there is a significant difference between T_e (several eV) from T_{tr} (hundreds of K)), and, in addition, has high electron density at the level of 10^{14}–10^{16} cm^{-3}. The proofs of the use of these methods for measuring the plasma parameters of the object being implemented are presented.

The studies were performed in the framework of the State Task for IHCE SB RAS, Project No. FWRM-2021-0014.

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H-7

SELF FOCUSING MECHANISMS OF AN ELECTRON BEAM FORMED IN A HIGH VOLTAGE NANOSECOND LOW PRESSURE DISCHARGE

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From a practical point of view, the effect of self-focusing of an electron beam attracts, first of all, by the possibility of increasing the beam current density and, accordingly, increasing the power density in the cumulation zone. This can be used to generate highly ionized plasma and powerful X-ray radiation, in the study of matter at elevated pressure and thermonuclear research, in the fields of radiation chemistry and solid state physics, to generate powerful radiation in the terahertz frequency range, excite luminescence of artificial and synthetic crystals, and in others applications. It was found that at currents of tens to hundreds of kA, the beam is focused by its own magnetic field. At the same time, the effect of self focusing of the beam at currents of no more than ≈ 2 kA is interpreted in different ways. Among the reasons for this effect in various publications, indicate the electrostatic repulsion of electrons, the formation of conductive plasma jets from cathode spots formed at the early stage of the discharge, breakdown on the runaway electrons, and others.

This study aims to study the effect of self focusing of an electron beam formed during a high-voltage nanosecond discharge in gas filled and vacuum diodes. It was found that in both cases the distribution of the beam current density in the plane of the grounded anode is nonuniform. The highest beam current density is achieved in the axial part of the anode. It is found that, in the case of a gas diode at a pressure of 0.2 Torr, ≈ 2 ns after the onset of the beam current pulse, the self-focusing effect is enhanced. From the obtained experimental data and the performed estimate of the time required to reach the density of positive nitrogen ions equal to the density of electrons, it follows that the most probable cause of additional self focusing of the beam is the compensation of the electron charge of the beam by the positive charge of ions arising in the process of air ionization in the diode.

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H-8

EFFICIENT LASING IN THE VUV RANGE IN HIGH PRESSURE DIFFUSE DISCHARGES

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Formation and emission features of run-away electron preionized diffuse discharge formed in sharply non uniform electric field by run away electrons in different experimental conditions are studied. The VUV radiation spectra of diffuse discharges in various high pressure gas mixtures have been measured.

It is shown that the sufficient homogeneity of diffuse discharges makes it possible to use it as a source of excitation of lasers based on various gas mixtures at an elevated pressure. This is evidenced by the continuation of the VUV laser pulses during several current oscillations in the gap.

VUV lasing was obtained on ArF* (193 nm) and F^*_2 (157 nm) molecules. The total duration of the laser pulses is as long as 30 ns. The radiation energy of a molecular fluorine laser increased linearly with the active mixture pressure. The maximum lasing energy at He pressure of 8.5 atm is as high as 3 mJ. In this case, a further increase in the generation energy is possible. The electrical efficiency of the F^*_2 laser reached 0.15%, which corresponds to the parameters of F^*_2 lasers obtained upon excitation by a transverse discharge with UV preionization.

The possibility of reaching VUV lasing in mixtures of pure inert gases pumped by diffuse discharges is considered, as well.

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H-9

MULTICHANNEL DIFFUSE PLASMA AS A STABLE FORM OF DISCHARGE COMBUSTION AT HIGH SPECIFIC PUMP POWERS

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The studies were carried out on a discharge XeCl laser developed at the HCEI SB RAS, Tomsk. When the laser was operating in the free running mode, the output radiation energy was 0.2 J. The pump generator used a C–C electric circuit with automatic spark preionization. The storage and discharge capacitors were 36.5 and 22.4 nF, respectively. The volume of the active medium was ~ 70 cm^3. The maximum pump power reached 315 MW, and the maximum radiation power was 5.6 MW. The duration of the lasing pulse, measured in the experiment and obtained in a numerical calculation, was ~ 100 ns. It is noted that the main condition for the ignition of a stable discharge is to ensure the growth rate of the current density dj/dt more than $6 \cdot 10^{10}$ A/$cm^2 \cdot$ s.

When using a Ne–Xe–HCl gas mixture at Xe/HCl ratios ≥ 12/1 and Ne/HCl ≤ 800/1 and a specific pump power of $P \geq 3$ MW/cm^3, the volume discharge transforms into a stable structured diffuse discharge consisting of many current macrochannels ~ 0.5 mm diameter. In this case, the properties of the active medium are preserved during the entire duration of the pump pulse, which has an oscillatory shape of the discharge current.

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