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PULSED LASERS AND LASER APPLICATIONS

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ABSTRACTS

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the faster heating of electrons to a temperature that is optimal for the predominant pumping of the upper laser levels relative to the lower ones, especially at a high pulse repetition frequency. The preference of operating at a high PRF lies in the high prepulse concentration of metal ions in the active medium and the possibility of pumping the upper laser levels directly from the ground state of the ion. This contributes to obtaining a higher average lasing power and efficiency.

For the first time for lasers on self terminating ion transitions, the positive effect of hydrogen additions into the active medium on the average output power is demonstrated. For a Ba^+ laser for the GDT wall temperature of 745 °C, the increase in P_{av} achieved due to the introduction of hydrogen was more than 1.5 times with an increase in the optimal PRF by a factor of 1.5.

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1. *Bokhan P.A., Belskaya E.V., Gugin P.P., Lavrukhin M.A., Zakrevsky D.E., and Schweigert I.V.* Investigation of the characteristics and mechanism of subnanosecond switching of a new type of plasmas switches. II switching devices based on a combination of 'open' and capillary discharges—eptrons // Plasma Sources Science and Technology. 2020. V. 29, No. 8. C. 84001.

A-4

NEW NEON LASER PUMPED BY A PULSED INDUCTIVE DISCHARGE

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For the first time, a new neon laser pumped by a pulsed inductive discharge on the $3p \to 3s$ transitions of neutral neon atoms has been created. The developed circuit with an increased specific pumping power of the active medium [1] was used as a high voltage excitation system. The laser cavity was formed by a flat aluminum mirror and CaF_2 substrate with transmittance of 8% in the investigated wavelength range. Neon and its mixtures with NF_3 and SF_6 gases at pressures up to 30 torr were used as active media.

Lasing was obtained at wavelengths of 540.1, 594.4, and 614.3 nm, corresponding to the $3p \to 3s$ transition of neutral neon atoms. The duration of the optical radiation pulses was at the level of 13 ± 1 ns (FWHM). The lasing energy reached 50 μJ with a maximum pulse power up to 4 kW. Direct excitation of neon from the ground state by electron impact is proposed as the main mechanism of population inversion formation on the $3p \to 3s$ electronic transitions of neutral neon atoms pumped by a pulsed inductive cylindrical discharge.

1. *Razhev A.M., Churkin D.S. and Tkachenko R.A.* MW peak-power UV inductive nitrogen laser // Appl. Phys. B 126. 2020. DOI: 10.1007/s00340-020-07459-8.

A-5

OPTIMAL PUMPING PARAMETERS OF A COPPER VAPOR LASER UNDER BREAKDOWN CONDITIONS

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The active medium of pulsed-periodic copper vapor lasers (CVL) is characterized by a high pre-pulse electron concentration $n_{e0} \sim 10^{13}$ cm^{-3}. Therefore, it was assumed that the development of the discharge under these conditions is carried out without the breakdown stage. However, as studies have shown, the development of a discharge in gas discharge tubes (GDT) with electrodes located in cold buffer zones (CBZ) is carried out with a breakdown stage.

The presence of breakdown makes it possible to explain the observed electrophysical process in the discharge circuit of the laser; however, previous studies did not reveal the mechanism of this process. The purpose of this work is to elucidate the mechanism of breakdown formation by studying in more detail the electrophysical process in the discharge circuit of a CVL and to determine the optimal conditions for pumping the active medium.

The report presents the results of the study of the electrophysical process in the discharge circuit of the CVL. It is shown that the pumping of the active medium of a CVL in gas discharge tubes (GDT) with electrodes located in the CBZ is carried out in two stages. At the first (preparatory) stage, the capacitive components of the laser discharge circuit are charged from the storage capacitor, and at the second stage, the active medium is directly pumped.

In this case, the pumping of the active medium is determined by the energy input from the peaking capacitor. The pumping efficiency relative to the energy stored in the peaking capacitor was ~ 3–6%, depending on the excitation conditions. The analysis of the experimentally obtained results made it possible to conclude that breakdown is a transient process in the development of a discharge from a glowing to a non thermal arc discharge and is characterized by a sharp change in the cathode potential drop across the GDT.

It is shown that the inductance of the discharge circuit is a factor determining the efficiency of pumping the active medium since the release of the energy stored in the inductance at the preparatory stage provides heating of the cathode spot and determines the conditions for the occurrence of thermal emission of electrons from the GDT cathode.

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EXPERIMENTAL INVESTIGATION AND THEORETICAL SIMULATION OF LASING ON THALLIUM ION TRANSITIONS EXCITED BY AN ELECTRON BEAM

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Lasing on thallium ion transitions with the wavelengths: λ = 1.922, 1.385, 0.595, 0.695, 0.707 μm was investigated under an excitation with an electron beam obtained in an open discharge. Lasing with the first two wavelengths was obtained for the first time. In the investigated range of pump parameters (cathode voltage U up to 5 kV, pulse repetition rate f up to 3.5 kHz), an increase of the lasing generation power, P_{las}, and the saturation absence were observed, that indicates the efficiency of electron beam excitation of lasers with pumping of upper states in charge exchange reactions.

At λ = 595 nm ($7p^3P^o_2 - 7s^3S_1$) an average power P_{las} = 42 mW was obtained at the following parameters: total grid-anode transparency μ = 50%, U = 5.4 kV, current amplitude I = 1.4 kA, current duration at half-height τ = 26 ns, amplitude of power invested in the discharge $P = 3 \cdot 10^6$ W, f = 1 kHz, thallium vapor pressure p(Tl) = 0.14 Torr. The efficiency with respect to the energy invested in the plasma was 0.2%. Theoretically calculated with the same excitation parameters, but with increased μ from 50% (the present experiment) to 90% (calculated value), the radiation power was 80 mW, which corresponds to the efficiency of 0.4%.

Numerical modeling of the kinetics of the working and downstream levels of the thallium ion was performed. The energy characteristics of the generation energy at thallium ion transitions were calculated. To determine the effect of various processes on the laser generation power, the system of kinetic equations for the populations was solved under different conditions: including all processes, without taking into account the increase in the lifetime due to radiation transfer of excitation, without considering the electronic mixing of levels, without considering the mixing of levels due to collisions of the excited thallium ion with thallium and neon atoms.

Calculation results showed that when the influence of deexcitation is reduced by half, collisions with neon atoms practically do not change the power of generation, collisions with electrons affect