OPTICAL CHARACTERISTICS OF A TRANSVERSE DISCHARGE IN NEON AT ATMOSPHERIC PRESSURE

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We present the results of investigation into radiation of a pulsed transverse discharge in neon at a pressure of 10-200 kPa. Survey spectra of plasma radiation, time characteristics of radiation, and the effect of small impurities of water vapors and air on the optical characteristics of a neon plasma were studied. We show that at a pressure of residual gases at a level of 10 Pa intense OH*, NO*, and Ne bands are observed in radiation of the plasma of a nanosecond transverse discharge in Ne against the background of continuous plasma radiation, and in the spectral region with λ > 400 nm radiation was observed on the Hg 486.1 nm and Ne 585.3 nm lines, and (when P ≥ 100 kPa) on the line at the 3s-3p-transitions of a Ne atom. The radiation intensity of the third continuum of neon increases with pressure and with energy contribution to plasma, with its maximum being located in the VUV spectral region (λmax < 200 nm).

Key words: transverse discharge, neon, radiation, continuum.

Introduction. Neon at atmospheric pressure is widely applied as a buffer gas in electrodischarge excimer lasers [1, 2], and at a lower pressure it is a working gas in a plasma laser at λ = 585.3 nm Ne (3s-3p) [3-5]. A transverse discharge (TD) or a self-sustained space discharge in atmospheric-pressure neon are of independent importance also as sources of intense continuous radiation in the region 190-400 nm, which is of interest for applied spectroscopy [6-8]. Intense continuous radiation of a neon plasma is also obtained in excitation of Ne of atmospheric-pressure by a high-voltage electron beam [9-11]. Most of the indicated investigations were carried out applying photographic recording of radiation, and the spectra given in the papers were presented without account for the spectral sensitivity of the recording systems. In all these works the presence of traces of atmospheric gases and water vapors is noted, since the experiments were conducted at a residual pressure of about 10 Pa, but specific data on the composition of impurities and their effect on the radiation of Ne plasma were not given. Considerable disagreements also exist between the λmax values obtained in [6] and [7] for continuous radiation of Ne in a dense electrodischarge plasma.

In the present paper we present the results of investigation of spectral and time characteristics of radiation of a TD with spark preionization in neon under typical conditions of operation of excimer and plasma lasers at λ = 585.3 nm.

Conditions and technique of the experiment. A TD was fired in a radiator which earlier was used for obtaining generation at λ = 308 nm XeCl and 337.1 nm N2 [12, 13]. The volume of the discharge region was equal to 18 × 2.2 × 0.7 cm (where 2.2 cm is the electrode spacing). Electrodes of stainless steel with a working-surface length of 18 cm and a radius of curvature of 1.7 cm were applied. Lateral UV preionization from spark bars on each side of a cathode was used. The density of spark gaps was 1 gap per 1.8 cm length of the system of electrodes (SE) for a transverse discharge. The high-voltage pulse generator was similar to that applied in [14] and was a double pulse generator. To whom correspondence should be addressed.

Fig. 1. Radiation spectrum of TD plasma in Ne at $P = 100$ kPa, $U_{ch} = 17$ kV.

Fig. 2. Spectrum of continuous radiation of TD in Ne at $P = 100$ (1), 200 (2), and 400 kPa from [7] (3).

LC-circuit for exciting TD. The storage capacitance was 30 nF and the peaking capacitance was 9.4 nF. The two blocks of peaking capacitors were filled with an insulating compound and were installed near the SE for TD. A TGII-1000/25 thyatron served as a commutator of the system of feeding a TD.

The TD current pulses and the voltages across the electrodes were measured by means of a Rogowski loop and a low-induction capacitive voltage divider. The survey spectra of plasma radiation were investigated using an MDR-2 monochromator, a "Foton" PM, an system for recording infrequent radiation pulses with a photocurrent integrator, and a KSP recorder. The reciprocal of the linear dispersion of the monochromator was 2 nm/mm; the widths of the entrance and exit slits were 0.1-0.2 mm. The relative calibration of the monochromator-PM system was carried out by means of a DVS-25 hydrogen lamp ($\Delta \lambda = 190-400$ nm) and an Si8-200 standard lamp ($\Delta \lambda = 400-1000$ nm). The time parameters of TD radiation were measured by a 14-FS electronic linear multiplier with a resolution of 2-3 nsec. All the pulse signals were recorded simultaneously in different channels of a 6LOR-04 oscillograph. The pressure of residual gases before the setting-up of the discharge chamber was 10-20 Pa. We used neon produced by the Balashikha Oxygen-Producing Plant; its main admixtures are He, H$_2$, Ar, H$_2$O, and others at a level $\leq 10^{-2}$ vol.$\%$.

Spectral characteristics of the TD radiation. The radiation spectra of a TD plasma in neon at a pressure of 10-200 kPa were investigated in the range 200-600 nm. Spectrum analysis was performed using the data of [15-18]. A typical spectrum of the radiation of a neon plasma in the visible region is presented in Fig. 1. Continuous radiation of a transverse discharge in the region of 200-600 nm appears only at a pressure of Ne $P > 50-70$ kPa. The Ne continuum at different gas pressures with account for the spectral sensitivity of the radiation recording system is presented in Fig. 2. Also presented is the Ne continuum obtained in [7] for a TD plasma at a pressure of 400 kPa. Curves 1 and 2 and dependence 3 from [7] are presented in Fig. 2 in different relative units. Radiation bands of the impurities CN*, OH*, N$_2$*, and H$_2$ were observed against the background of the continuum. The brightness of the most intense molecular bands of the impurities and the relative radiation intensities of the Ne and H lines are listed in Table 1.