PLASMA PHYSICS

BROADBAND RADIATION FROM RARE-GAS PLASMAS
EXCITED BY A MODULATED RF DISCHARGE

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An investigation was made of plasma radiation spectra created by a modulated rf discharge having an anomalously low operating voltage, in krypton, xenon, argon, and neon. Broadband radiation was recorded in the ultraviolet and visible spectral regions.

Investigations are currently being made of continuous and line spectra emitted by rare gases using various pumping methods. This situation has been described in [1-5]. Other conditions being equal, the radiation characteristics are influenced by both the methods and regimes of pumping. Thus, for example, when the duration of the beam current pulse is reduced and the current density is increased, individual lines vanish from the emission spectrum and the intensity distribution of the radiation in the broadband continuum changes [5].

It was reported in [6, 7] that a stable plasma was created in gases at atmospheric pressure, pumped by a modulated rf discharge having an anomalously low voltage of ~ 3000 V. The present paper is dedicated to an experimental investigation of the spectra from this new type of discharge in krypton, xenon, argon, neon, and air, and also to comparing the emission spectra of rare gases pumped by a modulated rf discharge and by nanosecond pulses of electrons.

APPARATUS AND METHOD

The design of the discharge chamber is shown in Fig. 1. A voltage from an rf oscillator 1 was applied to a 4 cm long copper spike electrode 2. The spike electrode was positioned in a cylindrical chamber 3 made of fluoroplastic-4 which was evacuated and filled with the gases through a side tube 4. The radiation was coupled out through a KU quartz window 5. The rf oscillator took the form of an LC self-oscillator which generated rf oscillations of frequency 40 MHz and amplitude 3200 V. The rf component was amplitude modulated, and this made it possible to form bursts of rf pulses of half-height duration ~ 8 μsec and having a pulse-repetition frequency of 10 kHz. The rf power was ~ 10 W. When the rf oscillator was switched on a plasma jet was stably formed on the spike electrode. The size of its luminous region was ~ 5-10 mm which depended on the pressure and the type of gas with the maximum brightness at the part of the spike having the smallest radius of curvature. It should be mentioned that it was a single-electrode discharge.

The electron beam pumping was performed using an apparatus described in [8] which utilized a transverse pumping scheme and a small RADAN-220 accelerator. The duration of the beam current was ~ 5 nsec, the current density was up to 500 A/cm², the electron energy was ~ 150 keV, and the pulse-repetition frequency was ~ 10 Hz.

The integrated emission spectra were photographed on RF-3 film using an ISP-30 spectrograph in the wavelength range 200-600 nm. An exposure of 5-15 min was required in order to obtain one spectrogram with rf-dischargepumping, or 10³ pulses.
when using the electron accelerator. Gases with a certified impurity content of less than 0.01% were used in the experiments, although considerable gas evolution was observed in the working chamber due to the action of the electron beam or the discharge. The operating pressure was varied in the range 0.5-3 atm.

RESULTS AND DISCUSSION

For pumping with the modulated rf discharge, emission spectra were photographed at a pressure p atm in krypton, argon, and neon (p = 0.5, 1, 2), in xenon (p = 1, 2), and in air (p = 1) and, for electron beam pumping, under the same conditions and at a rare gas pressure of 3 atm. The main features of the radiation from the rare gases pumped by the rf discharge were as follows.

1. Krypton (Figs. 2a and 2b). At pressures of 0.5 and 1 atm, broadband radiation of relatively low intensity was observed in the visible and ultraviolet spectral regions, together with more intense radiation from impurities (CO, CO⁺, O₂, O₂⁻), the intensity of the broadband radiation increasing with increasing pressure. At a pressure of 2 atm the intensity of the broadband radiation and the spectral range occupied increased markedly, the majority of the impurity radiation bands vanished, and also new lines and bands appeared whose nature is yet to be established (see Fig. 2b). It should be mentioned that the