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A METHOD DIAGNOSTIC OF RF PLASMA TORCHES IN ULTRA-VIOLET RANGE

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A method for RF plasma torches diagnostics in the ultra-violet range is suggested and tested. A solar-blind gas-filled photoreceptor is used for radiation registration, the threshold of which is located in the ultra-violet spectrum area. In this way it does not register radiation in the visible spectrum area, Sun's radiation being the most important component to be excluded.

Operating like a Geiger's counter, the gas-filled photoreceptor allows to measure absolute radiation measurements while taking into account the spectral sensitivity of the photoreceptor and the values of quantum output for the given wavelength.

The spectral dependence for the photoreceptor response to the RF plasma torches radiance has been obtained. A continuous spectrum was observed in all three orders in the wavelength range of 190-270 nm.

Electron density was determined using the local thermodynamic equilibrium approach.

Plasma radiation is focused on the entrance slit of the monochromator where the diffraction grid with variable spacing and curvilinear grating. That allowed to substantially compensate spectral line image defocusing and aberration. The number of lines per millimeter at the centre of the grid is 1200.

A considerable advantage of using this monochromator is the possibility to register spectrums of first three orders, it allows not only to solve standard spectrophotometric problems, but also to actually measure radiation coherence time.

The solar radiation that reaches Earth's surface has wavelength λ larger than 290 nm. Radiation with λ<290 nm is absorbed by higher atmospheric layers. Therefore when the solar-blind photoreceptor is used, it is not needed to screen it from the ambient light, i.e. measurements in the ultra-violet range can be performed in the presence of bright daylight.

The solar-blind photoelement has the form of the coaxial system in which the anode having the form of a thin thread is located on the axis of the cylindrical photocathode. The electrodes are placed into a glass tube with an uviol glass window on its end. The tube is filled with noble gas. When the photocathode is exposed to ultra-violet radiation, its surface emits electrons which are accelerated by the electric field in the gap between the photocathode and anode and cause atom ionization of the noble gas, what, by turn, causes arc ignition which is then extinguished by reducing the voltage on the photoreceptor, in order not to allow it become a stand-alone arc.

Such mode limits time resolution of the photoreceptor to 0,05s, but at the same time considerably increases its sensitivity. The main point of this is as follows. The photoreceptor's response to the radiation is not the output current, but the number of discharges within a given time period, i.e. the photoreceptor acts as a Geiger's counter with discharge initialization by electrons from the photocathode's surface. Thus the gas-filled photoreceptor can be used in photon count mode when the average time interval between the two successive photoelectrons is larger than the time resolution of the photoreceptor.

The photoreceptor's threshold is near 270 nm and is determined by the photoelectric work function of copper, and is 190 nm from the direction of short waves what is caused by the transmission cutoff of the uviol glass (Fig. 1.).

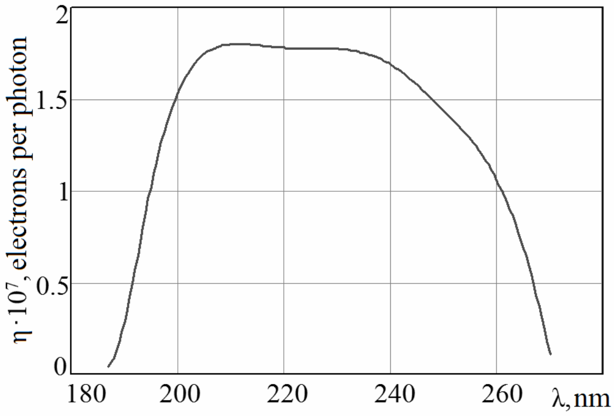

Fig. 1. Quantum response of the gas-filled photoreceptor with copper cathode.

The signal from the photoreceptor's anode was sent to the input of the signal shaping circuit and then was recorded on the PC's hard drive (Fig. 2.). The length of recording is only limited by the capacity of the disk and count speed.

The obtained results allow us to conclude that using a gas-filled photoreceptor as a UV radiation receptor on the monochromator's exit is possible and promising. The developed and validated technique to find plasma radiation intensity in UV wavelength range by the measured number of photoreceptor arc discharges can be used to determine spectral response range of UV radiation receptors. Spectral intensity of the plasma's recombination radiation is determined by [1]. Electron concentration value in RF plasma of $n_e = (1.1 \pm 0.2) \cdot 10^{16}$ cm^{-3} agrees with the results found in the work [2] obtained using "hydrogen thermometer" method for argon RF plasma with the temperature of T_e = 10000 K ($n_e = 1.5 \cdot 10^{16}$ cm^{-3}).

The data obtained in this work allows determination of photorecombination cross-sections of argon ions. In the future, we plan to use a solar-blind electon-optical convertor in conjunction with narrow-band filters to obtain data on the distribution of the radiation intensity over plasma volume.

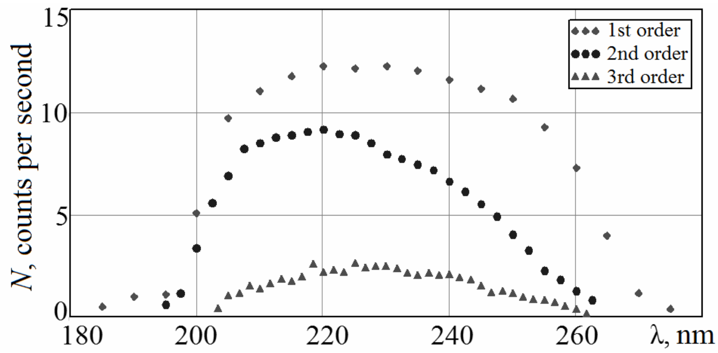

Fig. 2. Spectral dependencies of the photoreceptor's response (counts per second) to the radiation of the argon RF plasma for three diffraction orders:upper line – first order, middle line – second order,lower line – third order.

References

[1] Raiser Y. *Physics of gas discharge*. (1992).
[2] Asinovsky E., Kirillin A., Nizovsky V. *Stabilized electrical arcs and their application in thermophysical experiment.* (2008).