STATE AND FUTURE OUTLOOK FOR MEASUREMENTS OF THE CHARACTERISTICS OF VACUUM AND NEAR-ULTRAVIOLET RADIATION

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Features and trends in the development of the stock of measurement instruments for near and vacuum ultraviolet radiation and the metrological characteristics of working measuring devices based on the use of photoelectronic detectors of continuous and pulse radiation that exhibit the photoelectric and photoconductive effect as well as infrared detectors are considered. Principles for the design of universal multichannel devices for measurement of the integral characteristics of ultraviolet radiation in the UV-A, UV-B, and UV-C bands as well as devices for measurement of the effective energy irradiance are presented.

Key words: radiometry, radiation detector, ultraviolet radiation, energy irradiance, effective characteristics, spectral sensitivity.

The development of the field of ultraviolet radiation radiometry has been associated with the formulation of new metrological problems in submicrometric lithography, solid-state physics, space research, and plasma diagnostics in the wavelength range 0.001–0.4 \( \mu \)m. Spectral energy measurements of the characteristics of vacuum ultraviolet radiation in the range 0.001–0.2 \( \mu \)m are especially informative since the intensity of the spectral lines and the continuum of plasma radiation allow us to make judgements about the temperature and concentration of the atoms and molecules of plasma radiators. The important practical value of radiometry of near (open-air) ultraviolet radiation (0.2–0.4 \( \mu \)m) also has to do with the estimation of the photobiological action and control of safety levels. The photobiological effect of ultraviolet radiation is responsible for the division of the near ultraviolet region into the following bands: UV-A (0.315–0.400 \( \mu \)m), UV-B (0.280–0.315 \( \mu \)m), and UV-C (0.20–0.28 \( \mu \)m) [1]. Control over the efficiency and degree of risk of solar oil requires dividing the UV-A band into the sub-bands UV-A1 (0.315–0.340 \( \mu \)m) and UV-A2 (0.34–0.40 \( \mu \)m).

In developing apparatus for measurements in the ultraviolet band of the spectrum performed by working measuring devices, the greatest difficulties are associated with the instability, low sensitivity, selectivity, and zonal heterogeneity of ultraviolet radiation detectors bearing in mind the low intensity of sources of continuous radiation.

According to operating principle, radiation detectors intended for use as primary transducers in radiometry and spectroradiometry may be divided into photoelectronic and infrared. Photoelectronic detectors that exhibit the photoconductive and photoelectric effect are used most widely in the area of the vacuum and near ultraviolet band of the spectrum due to their high sensitivity and high level of maintainability [2].

In ultraviolet radiation spectrographs, silverless photographic materials are used in the study of plasma objects. In recent years, photographic recording of spectra has been superseded by the use of position-sensitive detectors, i.e., CCD arrays and photoelectric diode rules, both of which possess a broad linear dynamic range, are capable of recording time-resolution signals, and possess a sensitivity comparable to photoelectronic multipliers as well as the radiometric stability of sensitivity typical of vacuum photoelectric elements with high spatial resolution.
The basic features of photoelectronic detectors of ultraviolet radiation that exhibit the photoelectric and photoconductive effect [3] are presented in Table 1.

The following basic requirements are imposed on devices used in the measurement of radiant fluxes and energy irradiance on the basis of detectors of ultraviolet radiation:

- stability of spectral sensitivity;
- high quantum yield;
- broad linear dynamic range;
- absence of spectral sensitivity in the visible and infrared regions of the spectrum.

In the short-wave region of the ultraviolet band, time resolution in the microsecond range of wavelengths is also needed for working with pulse plasma radiators incorporated into measuring devices.

It is evident from Table 1 that high precision and highly stable measuring devices in the spectral band 0.001–0.4 \( \mu \text{m} \) can be created with all three types of photoelectronic radiation detectors.

Unlike photoelectrical detectors, infrared detectors, e.g., bolometers and pyrodetectors, are rarely used in the ultraviolet band as independent measuring devices due to their low sensitivity, time lag, and small size of the sensing element. The most important property of infrared detectors is the fact that the spectral sensitivity is not selective, thus making it possible to successfully utilize them for relative measurements. An exception is the Golay opto-acoustic infrared detector; this detector possesses high sensitivity and may be used as an absolute detector in electrical substitution mode.

The basic properties of semiconductor materials used for photoelectric diodes are presented in Table 2 [3].

Radiation detectors based on fine-film structures (a-Si:H) and (a-SiC:H) on a glass substrate possess high sensitivity to pulse radiation at wavelengths less than 110 nm and reliably cut off radiation in the visible band of the spectrum [4]. At room temperature, the effective quantum yield is 50, 1, and 0.1\%, respectively, at wavelengths of 58.4, 400, and 650 nm.