OPTOPHYSICAL MEASUREMENTS

MEASUREMENT OF AVERAGE POWER OF EXCIMER-LASER RADIATION

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Measurement of the average power of laser radiation in the ultraviolet region is examined. The characteristics of working and standard instruments are presented.

Excimer lasers, which operate in the ultraviolet (UV) region, are gaining wider and wider use in science and technology [1]. It is well known that the optical characteristics of many materials undergo great changes with transition from the infrared (IR) to the UV region of the spectrum. For example, the reflection factor of polished copper changes from 98.4% to 25.9% when moving from a wavelength of 10.6 μm to 0.250 μm [2]. Similar changes can occur in the optical characteristics of instruments. This has been one of the reasons for a limit of 0.3-0.4 μm for the shortwave region of the spectral band of most instruments for measuring the energy parameters of laser radiation and of the current verification scheme [3]. Another reason for this limitation has been the possibility of irreversible changes in the optical characteristics of many materials and coatings or their damage after prolonged exposure to strong UV radiation. As a result, instruments that operate in the UV region beyond this limit have not been verified.

Considering the wider use of excimer lasers and the stability of graphite materials to strong laser radiation, we studied the optical characteristics in the UV region of receiving elements made of these materials that have a pyramidal cut on the receiving surface. The obtained spectral characteristic is shown in Fig. 1, where $K_a/K_{0.5}$ is the relative absorption factor, $K_a$ is the absorption factor at any wavelength in the region of 0.24-0.8 μm, and $K_{0.5}$ is the absorption factor at a wavelength of 0.5 or 0.53 μm. It permits correction of the working wavelength of the radiation for operation in the UV region in, for example, the IPSM-1-70 and Gradient-30 average-power transducers and a number of other instruments with similar receiving elements and, if necessary, their certification at up to 240 nm. The average-power unit of laser radiation must be transmitted by these instrument transducers (IT) within the framework of the current verification scheme [3] at wavelengths of 0.53 and 0.4 μm, just as the OSISM-1-70 and Gradient-30 (O) standard instruments based on them.

However, these instruments have lower measurement limits of 100 and 500 mW, respectively, while the excimer lasers that are used in practice often have lower values. Therefore, to expand the possibilities of verification of instruments used in various areas of science and technology, we developed experimental models of the PMK-12GR graphite radiator calorimetric transducer and the OSISM-12GR standard laser-average-power meter, which operate at wavelengths of 240 to 800 nm and have average-power ranges of from 10 to 1000 mW.

The PMK-12GR transducer, a diagram of which is shown in Fig. 2, has a flat disk receiving element 1 with a diameter of 15 mm made of artificial graphite, which is characterized by an anisotropy of thermal conductivity whose value reaches 600 W/(cm·°C) in the radial direction of the disk. The sensing element 2 is made of constantan wire 0.3 mm in diameter wound in a coil 3 mm in diameter, to a half-turn of which a copper coating is applied. This coil is, in turn, wound on a ring in the form of a torus; one end is cemented to the disk receiving element 1, and the other, to the end wall of a cylindrical cavity in the inner section 6 of a Dural passive thermostat. The outer section 3 of the thermostat is in the form of a developed heat-exchange surface. To suppress the effect of external thermal noise on the output signal of the instrument, it is fabricated as a double calorimeter. Its working 1 and compensating 4 transducer elements are in cavities in the inner section 6 of the thermostat. In turn, this section is pressed into the radiator with good thermal contact. Both transducer elements are located in the inner thermostat symmetrically with respect to its narrow fitting.
Fig. 1. Relative absorption factor of receiving elements of "Rektim" graphite material versus radiation wavelength at 0.24–0.8 μm.

In operation of the instrument, the radiation beam is directed onto the disk receiving element 1, where it is absorbed and converted to thermal flux to the zone of contact with the thermopile 2, then the flux passes through the turns of the numerous wire electrodes to the body of the passive thermostat 6, is dissipated through its mass, and transferred to the surrounding medium through the surface of the radiator. The thermal fluxes caused by external noise pass through the radiator 3 on their way to the receiving elements 1 and 4, are dissipated in its mass, attenuated, merge into a single stream, and are mixed in the narrow zone of contact with the thermostat 6, and then are symmetrically divided, dissipated, and attenuated in the mass of the latter and have the same effect on the working 1 and compensating 4 receiving elements, owing to which the noise signals are compensated.

Features of this instrument include the use for the receiving element of a graphite material with high radiation resistance and very high thermal conductivity in the radial direction as well as the formation of thermal fluxes in the compound passive thermostat of the IT. The quality of the material allows the instrument to be used with aggressive UV radiation, and the second factor, in conjunction with the high thermal conductivity of the short multielectrode wire thermopile, yields an instrument of practically the gradient type. The fraction of thermal flux conducted through the electrodes of the thermopile considerably exceeds the heat losses to the surrounding medium from the surface of the receiving element. The high radial thermal