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A HIGH-SPEED "EXPLOSIVE" METHOD FOR STUDYING THE PHYSICAL PROPERTIES OF SUBSTANCES AND COMPOUNDS AT HIGH TEMPERATURES OF 2000–10000 K *)

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The physical properties of refractory compounds are necessary in the nuclear power industry to create thermal protection at high temperatures. The method of rapid ("explosive") heating and the results of experiments on the thermophysical properties of substances to extremely high temperatures are presented. The founder of this technique is Sergey Vladimirovich Lebedev (1913–1990), studied its application first at the FIAN, and then at the Joint Institute for High Temperatures (JIHT) of the Russian Academy of Sciences. Rapid heating (~5 microseconds) by an electric current pulse is used [1], which ensures that several thermophysical properties (enthalpy H, heat of melting ΔH, specific heat Cp, electrical resistance ρ) are obtained in a single act of heating. The key solution to this technique is to limit the volume around the expanding liquid sample (wire or foil). Pulsed current heating is also effective in terms of cost savings when high temperatures are reached. No financial resources are required to create stationary equipment for constant maintenance of high temperature, heating is provided by Joule heat generation during the short-term passage of a current pulse through a conductive sample. Due to the speed of the heating process, the liquid sample retains its shape and position in space during the experiment. Laser illumination of the sample makes it possible to measure the thermal expansion of liquid metals (Zr, Fe, Hf). The placement of samples in thick-walled sapphire cells makes it possible to study the properties of substances at elevated pressures (up to tens of kbar).

The temperature was measured [2] by a high-speed photodetector from the radiation of the surface of a flat sample, and was calculated further according to the Planck formula (with a known value of the normal spectral emissivity of the material ε). In the absence of the latter in the literature, a sample was used in the form of a corner model of a black body: two thin planes located at an angle (in the form of an open book). This provided a reliable result on temperature, with a reliability of 0.95.

Data for refractory carbides ZrC, ZrC + C, TaC, HfC (up to 5000 K) are presented, an overview is presented in [3]. For the first time in world practice, an experiment was performed (up to 5500 K) with carbide (HfTaTiNbZr)C, which is a solid solution of five carbides [4]. The high thermodynamic stability of such multicomponent carbides, high refractoriness and corrosion resistance are attractive for creating effective thermal protection in the nuclear power industry.

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*) abstracts of this report in Russian