Measurement of thermophysical properties of metals used in nuclear energy through experiments with pulsed electric current heating

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In this work, the dependence of enthalpy, electrical resistivity, and sample volume on temperature was measured for metals such as zirconium, iron, nickel, and hafnium using an established setup for assessing the thermophysical properties of materials via pulsed electric current heating. System is equipped with a high-strength steel cell capable of withstanding pressures up to 7 kbar, using helium as a pressurizing medium. A purposely made pyrometer covers a wide temperature range of 1300–6000 K, with heating rates up to 2×10^8 K/s.

Additionally, for several metals, the change in melting temperature as a function of pressure was measured, enabling estimation of the melting line slope up to 4 kbar. This technique assumes that the emissivity of metals remains constant within this pressure range. Conducting these experiments is challenging due to the stringent stability requirements for the pyrometer and the optical path. A significant factor is the change in the refractive index of the gas, which affects the transmittance at the gas-sapphire boundary. For the metals studied, the variation in the pyrometer signal due to the optical system's transmittance is comparable to the change in radiation brightness as the melting temperature increases. The measured melting line slopes align well with estimates derived from the Clausius–Clapeyron relation and recent ab initio calculations.

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