

MEASUREMENT OF THE THERMAL DIFFUSIVITY  
OF METALS ON THE TEMPERATURE INTERVAL 1100-2500°K

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A method of measuring the thermal diffusivity of metals on the temperature interval 1100-2500°K is described. Values of the thermal diffusivity of tantalum, molybdenum, niobium, vanadium, and cobalt are presented.

In [1] a description was given of a method of measuring the thermal diffusivity of metals at high temperatures. In this case it is difficult to measure the thermal diffusivity at temperatures less than 1700°K, since as the temperature of the specimen decreases the "signal/noise" ratio at the output of the selective amplifier decreases. In order to improve the "signal/noise" ratio it is necessary to reduce the amplifier pass band; moreover, it is desirable to increase the temperature fluctuations  $\Delta T$ . The pass band is reduced by applying the synchronous detection principle. Greater temperature fluctuations  $\Delta T$  with a simultaneous decrease in level  $T_0$  can be achieved by increasing the diameter of the specimen and the distance between the anode and the cathode.

As seen from Fig. 1, the mutual radiating surface of the anode a and cathode c is greater in the first case ( $D_2 > D_1$ ) than in the second ( $D_2 = D_1$ , where  $D_1$  and  $D_2$  are the diameters of the cathode and the anode, respectively) [2]. Given equality of the heat flows from cathode to anode, the anode temperature will be

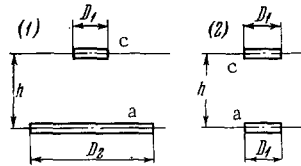


Fig. 1

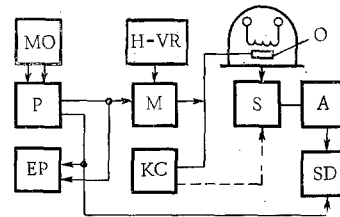


Fig. 2

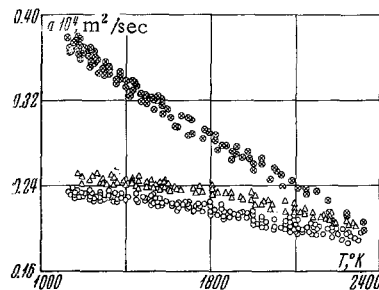


Fig. 3

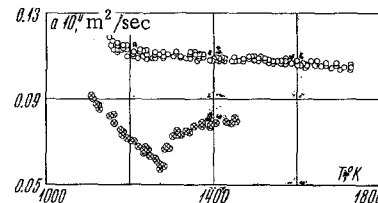


Fig. 4

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lower in the first case than in the second. In order for the anode temperature to be the same in both cases, it is necessary in the first case to supply the anode with additional power  $Q$ . This can be obtained by increasing the electric power, which leads to an increase in the specimen temperature fluctuations.

Thus, to measure the thermal diffusivity of metals at temperatures below  $1700^{\circ}\text{K}$  it is necessary to increase the anode-cathode distance, the accelerating voltage, and the specimen diameter. In this case all the theoretical premises and solutions of [1] are preserved.

The experimental setup (Fig. 2) differs somewhat from that described in [1]. To reduce the pass band and increase the signal/noise ratio a synchronous detector SD is used as phase null indicator. The phase is registered by an electronic phasemeter EP; a modulator M is incorporated in the initial phase shift compensation circuit, which employs a Kerr cell KC.

The thermal diffusivity is measured as follows. The master oscillator MO (Fig. 2) is adjusted to the necessary frequency value; the specimen O is heated to the required temperature. By means of a rotatable mirror, light from the Kerr cell is directed at the sensor S and the initial phase shift introduced by the measuring circuit is compensated. Compensation is achieved by varying the tuning of the selective amplifier A to obtain zero at the synchronous detector. At the same time, the temperature of the specimen is measured with a OPPIR-017 optical pyrometer. Then by means of a rotatable prism the signal from the specimen is transmitted through the optical system to the sensor. A value of the specimen signal amplitude equal to the compensation amplitude is established by regulating the diaphragm of the optical system. Zeros at the synchronous detector are obtained by means of the phase shifter P. The phase shift introduced by the specimen is registered by a F2-1 instrument. The frequency is measured with a PST-100 scaler.

This method was used to measure the thermal diffusivity of tantalum (containing about 99.3% of the basic metal), molybdenum (grade MCh, total impurities not exceeding 0.08%), niobium (about 99.9% basic metal), vanadium (experimental batch from the Experimental Chemico-Metallurgical Plant GIREDMETA), and cobalt (not less than 99.9% basic metal). The specimens investigated were 0.2-0.8 mm thick and 10-20 mm in diameter. The electron flux modulation frequency varied between 20 and 600 Hz, the accelerating voltage supplied by the high-voltage rectifier H-VR (Fig. 2) from 500 to 3000 V.

In Fig. 3 the thermal diffusivities of tantalum, molybdenum, and niobium are shown as functions of temperature with allowance for the correction for thermal expansion (the experimental points are represented by circles, crosses, and triangles, respectively). The analogous relations for vanadium (circles) and cobalt (crosses) are shown in Fig. 4.

To determine the true temperature we used published data on the emissivity of tantalum, molybdenum, niobium [3, 4], and vanadium [5]. Since there are as yet no reliable data on the emissivity of cobalt, we have plotted the thermal diffusivity of cobalt as a function of the brightness temperature at a wavelength of  $0.655\ \mu$ .

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