

Pressure dependence of the melting temperature of tungsten carbide up to 80 kbar

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The pressure dependence of the melting point of tungsten carbide (WC) was investigated up to 80 kbar in the high-pressure chamber described by us earlier.^[1] The investigated samples were placed in these experiments inside the working part of the chamber, which was equipped with lateral viewing windows. The pressure was produced in the chamber by pistons moving towards each other. The pressure generator was a 300-ton hydraulic press. The pressure-transmitting medium, in which the sample was directly placed, was rock salt. The stepped windows in the chamber wall were filled with rock salt. The pressure calibration of the setup was based on polymorphic transitions in bismuth, thallium, and barium in accord with the 1968 scale.^[2]

The WC sample was prepared by pouring tungsten-carbide powder into an axial opening in a lathe-turned rock-salt pellet. The pellet was turned to fit the dimensions of the cylindrical opening of the chamber (5 mm dia, 6 mm height). After pouring in the WC powder, the opening in the pellet was closed with graphite to provide a better contact with the end faces of the pistons. The pellet was then placed in the chamber, in which the piston produced the pressure. The pistons were electrically insulated from the chamber walls with calcined talcum.

The melting temperatures corresponding to the applied pressures were measured optically by determining the radiation of the sample heated with alternating electric current. The current was fed to the sample through the same pistons that produced the pressure in the chamber. The radiation intensity corresponding to a definite temperature of the sample was measured at three points of the emission spectrum, corresponding to the wavelengths $\lambda_1 = 420 \mu\text{m}$, $\lambda_2 = 622 \mu\text{m}$, and $\lambda_3 = 825 \mu\text{m}$. The temperature was determined, in accord with Planck's law, from the intensity ratio of two narrow spectral sections corresponding to two wavelengths $I_1(\lambda_1)/I_2(\lambda_2) = f_1(T)$.

Each temperature was determined twice, i. e., from the ratios of the two pairs of spectral-section intensities: $I_1(\lambda_1)/I_2(\lambda_2) = f_1(T)$ and $I_2(\lambda_2)/I_3(\lambda_3) = f_2(T)$.

We were thus able to estimate the temperature-measurement errors due to

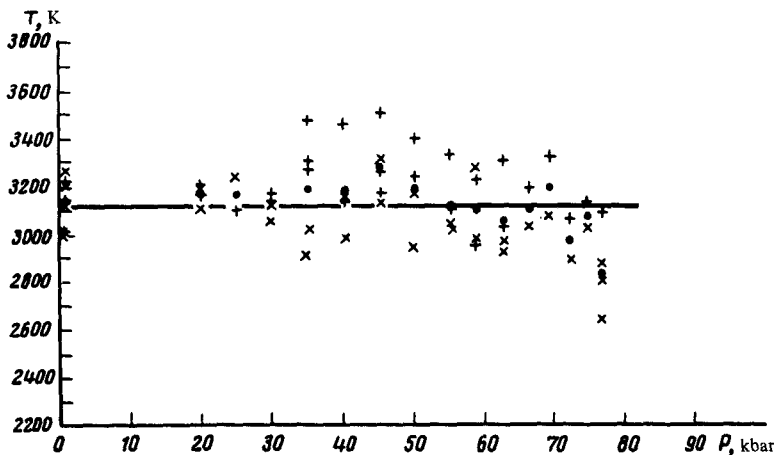


FIG. 1. Pressure dependence of the tungsten-carbide melting temperature.

the change of the selectivity in the vapor of the investigated sample with increasing pressure and temperature. During each experiment the sample became surrounded by vapor of the investigated substance, and this vapor diffused into the salt to form a filter.

We assume that the selectivity of the vapors remains unchanged when the pressure and temperature are increased. However, as noted by us in experiments with refractory metals, the density of the filter produced by the vapor decreases. But this did not affect the temperature measurements, since in our calculations we use the ratios of the intensities. The correction for the selectivity of the vapor of the investigated substance is determined by comparing the ratios $I_1(\lambda_1)/I_2(\lambda_2)$ and $I_2(\lambda_2)/I_3(\lambda_3)$ for the melting temperature at atmospheric pressure and the analogous ratio of the intensities calculated by Planck's formula. The temperature-measurement procedure was described by us earlier.^[3,4]

Investigations of the melting curves of refractory metals^[4-7] have shown that the melting temperatures measured simultaneously using $I_1(\lambda_1)/I_2(\lambda_2)$ and $I_2(\lambda_2)/I_3(\lambda_3)$ do not differ significantly up to the maximum pressures. In the case of measurement of the pressure dependence of the melting point of WC, we noted some discrepancies in the measurement of the same temperature, namely, the temperatures determined from $I_2(\lambda_2)/I_3(\lambda_3)$ (x) lie lower than the temperatures determined from $I_1(\lambda_1)/I_2(\lambda_2)$ (+, see Fig. 1), and this discrepancy is particularly noticeable at high pressures. The reason for this behavior can be sought in the change of the spectral absorptivity of the vapor of the investigated object, possibly as a result of the formation of new compounds, particularly W_2C , or as a result of the decomposition of the original WC into its constituents.

Having no data on the WC transformations at high pressures and high temperatures, we show in Fig. 1 all the experimental points, without mathematical reduction. We note that we have designated by points the mean values of all the measurements of the temperatures for each of the fixed pressures. On the basis of these mean temperatures it seems most probable that the melting point is independent of pressure. Calculation of this temperature by least squares from all the experimental points has shown that this temperature is 3120 ± 166 K. The probable error in the temperature measurement is $\pm 3.6\%$ and $\pm 6\%$ in the pressure measurement.

It should be noted that the melting temperature of the original WC at atmospheric pressure was 3140 ± 50 K.

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