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1962

SovietRxiv

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Abstract

Full Text

PHYSICS

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TEMPERATURE DEPENDENCE OF THE ELECTRICAL RESISTANCE OF POLYCRYSTALLINE GRAPHITE AT PRESSURES UP TO 250,000 kg/cm^2

It seemed of interest to investigate the temperature dependence of the electrical resistance of graphite at high pressures. The substance studied was spectrally pure polycrystalline graphite with a specific electrical resistivity $\rho = 26 \cdot 10^{-4}$ ohm • cm.

Using the high-pressure apparatus mentioned by us earlier ([1],[2]), we determined the temperature dependence of the electrical resistivity of graphite up to 250,000 kg/cm^2. To heat the sample, a dc machine of the ANZhM 5000/2500 type was used. When current was passed through the sample, the voltage and current readings were taken at fixed pressure values. On the basis of these data, curves were constructed for the dependence of the resistance of the sample on the power released in it, which is directly proportional to the temperature of the sample (see Fig. 1). In this way the temperature dependence of the electrical resistance of the graphite sample at definite pressure values was obtained (see Fig. 2).

Fig. 1. Dependence of the temperature of a graphite sample on the power supplied to it

Since the linear dimensions of the sample do not change with pressure beginning at $\sim 30\,000$ kg/cm^2 ([1],[2]) (apart from their extremely small decrease due to compressibility), the change in the electrical resistance of the graphite sample will be directly proportional to the change in its specific electrical resistivity.

Measurement of electrical resistance by the method described has quite satisfactory accuracy. Extending the curves in Fig. 2 to their intersection with the ordinate axis (power $N = 0$), we obtain the value of the electrical resistivity

Fig. 2

Figure 2: Fig. 2

of the graphite sample at room temperature and at definite pressures. These values of electrical resistivity agree to within 3% with the values obtained by measurement using a potentiometric circuit with a PPTN-1 potentiometer; the latter, in turn, agree, in the pressure interval from 30,000 to 100,000 kg/cm^2, with Bridgman' s data (^{3}).

From the results presented in Fig. 2 we see that the electrical resistivity of graphite at a definite pressure decreases with increasing temperature, while the course of the curve differs somewhat from linear; the curves become flatter as the pressure increases. At a definite value of the temperature, the electrical resistivity of graphite decreases with increasing pressure.

As is known, the electrical resistivity of single-crystal graphite, in contrast to polycrystalline graphite, increases with increasing temperature (at atmospheric pressure). As Wallace already indicated (^{4}), the explanation of the -

···the electrical resistance of polycrystalline graphite with increasing temperature should be sought not in the electronic structure of graphite, but in the role played by the boundaries of the crystallites in the specimen (in particular, by defects accumulating at these boundaries). It is clear that as the temperature increases the boundaries are "cleaned," which may ultimately lead to a decrease in resistance. The fact that the curves in Fig. 2 become flatter with increasing pressure qualitatively confirms this explanation, since pressure "heals" the crystal.

Fig. 2. Temperature dependence of the electrical resistance of graphite at high pressures.
1 –30,000 kg/cm^2; 2 –80,000; 3 –140,000; 4 –200,000; 5 –250,000.

In conclusion, it should be noted that the calibration curve in Fig. 1 is determined with an accuracy of $±$5%. The temperature of the lateral surface of the cylindrical specimen located in the high-pressure chamber was measured using a chromel–alumel thermocouple. Calibration was carried out at nearly atmospheric pressure (slight compression was necessary to ensure good contacts). Introducing a thermocouple into the graphite specimen was not possible because of its comparatively small dimensions. Therefore, in all probability, the temperature inside the specimen was somewhat higher. However, this error is common to measurements at different pressures; moreover, its absolute value is small, as indicated by comparison of our results with data in the literature. Thus, at atmospheric pressure the ratio of ρ at 191° to ρ at 21° is 0.776 (5), while in our experiments it is 0.762.

The authors did not set themselves the goal of investigating the temperature dependence of the electrical resistance of graphite at higher temperatures, because of possible irreversible processes resulting from contact of the graphite with the pressure-transmitting medium, which could have led to distortion of the results.

We express our gratitude to Yu. A. Pospelov for his attention to the work and for discussion of the experimental data.

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Received
22 VI 1962

CITED LITERATURE

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Note: Figure translations are in progress. See original paper for figures.