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Abstract

Full Text

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CHANGE IN THE ELECTRICAL RESISTANCE OF CERTAIN METALS UP TO A PRESSURE OF 200,000 kg/cm^2

As is known, Bridgman ([1]) carried out a study of the change in the electrical resistance of most simple metallic substances up to a pressure of 100,000 kg/cm^2. In the present work the authors, having at their disposal an apparatus for obtaining pressures exceeding 100,000 kg/cm^2, investigated the electrical resistance of antimony, arsenic, and calcium.

Fig. 1. Change in electrical resistance R: *a*—bismuth; *b*—antimony; *c*—bismuth and antimony connected in parallel.

Antimony and arsenic are analogues of bismuth in crystal structure and chemical properties. The change in the electrical resistance of bismuth is known up to 140,000 kg/cm^2 (see Fig. 1a) ([2]). Owing to the above-mentioned analogy, the supposition arose that jump-like changes in electrical resistance exist in antimony and arsenic.

A jump in the electrical resistance of antimony was found at 130,000 kg/cm^2; the increase in electrical resistance is equal to $\sim$ 50%. The course of the electrical resistance of antimony is shown in Fig. 1b. As can be seen, the portion of the curve up to 100,000 kg/cm^2 coincides with Bridgman' s data ([1]); the decrease in electrical resistance continues up to a pressure of 125,000 kg/cm^2, after which a sharp increase in electrical resistance begins, continuing up to 140,000 kg/cm^2; with a further increase in pressure a new fall begins, but already slower than in the initial portion up to 100,000 kg/cm^2. The comparison of the press load with the pressure inside the chamber was made from a calibration curve (see Fig. 2), constructed from the known jumps in electrical resistance: bismuth I—II 25,000 kg/cm^2, bismuth II—III 27,000 kg/cm^2, thallium 45,000 kg/cm^2, barium

Fig. 2. Calibration curve of the apparatus

Figure 2: Fig. 2. Calibration curve of the apparatus

Fig. 3. Change in the electrical resistance R of arsenic

Figure 3: Fig. 3. Change in the electrical resistance R of arsenic

80,000 kg/cm^2, bismuth VI—VII 125,000 kg/cm^2 up to a load of 180 tons. It was assumed that at higher loads this dependence also remains linear.

To refine the newly obtained dependence of the electrical resistance of antimony on pressure, it was compared with the already known jump in the electrical resistance of bismuth (bismuth VI—VII, p = 125,000 kg/cm^2). Both metals were placed in the chamber simultaneously, and the total electrical resistance of two conductors connected in parallel was measured. As can be seen from Fig. 1c, the minimum of the elec-

of the electrical resistance of antimony lies near the bismuth VI—VII transition; thus, it was confirmed that the stepwise increase in the electrical resistance of antimony occurs at a pressure of about 130,000 kg/cm^2—this coincides with the determination from the calibration curve. The accuracy of the pressure determination is 5%.

The course of the electrical resistance of arsenic with pressure is shown in Fig. 3. As is seen from the curve, the electrical resistance of arsenic undergoes no stepwise changes up to a load of 280 t, which, according to the calibration curve, corresponds to a pressure exceeding 200,000 kg/cm^2. The change in the electrical resistance of calcium under pressure was also investigated (see Fig. 4).

Fig. 2. Calibration curve of the apparatus

Since the last reference point of the calibration curve corresponds to a pressure of 125,000 kg/cm^2, there is no complete certainty that the linear dependence of pressure on load is preserved further on. However, it seemed reasonable to the authors to extrapolate the curve linearly, since in the load interval 200—280 t, for the metals investigated, no slowing of the course of the electrical resistance with load is observed, as would be expected if the calibration curve deviated from a straight line toward the abscissa axis. A deviation toward the ordinate axis should be excluded for natural reasons.

The investigations were carried out on samples of bismuth and calcium in the form of wires, and on samples of antimony and arsenic, which were thin cleavages along the cleavage planes of a single crystal. The samples were placed in silver chloride, whose volume was ~0.1 cm^3. The total volume of the chamber was ~0.5 cm^3. The samples of all the metals investigated were chemically pure.

Fig. 3. Change in the electrical resistance R of arsenic

Fig. 4. Change in the electrical resistance R of calcium

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Figure 4: Fig. 4. Change in the electrical resistance R of calcium

The authors believe that the sharp increase in the electrical resistance of antimony described above at 130,000 kg/cm^2 can serve as a new reference point for calibrating high-pressure apparatus.

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