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Abstract

Full Text

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PHYSICS

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INVESTIGATION OF THE ELECTRICAL RESISTANCE OF CERIUM, LANTHANUM AND NEODYMIUM AT PRESSURES UP TO 250,000 kg/cm^2

The present work is a continuation of the work ([1,2]) on a systematic investigation of the electrical resistance of metals at pressures up to 250,000 kg/cm^2. All three elements investigated—cerium, lanthanum and neodymium—belong to the lanthanide group; they were studied by Bridgman ([3]) up to a pressure of 100 atm. It was established that all three elements have a minimum of electrical resistance in the pressure interval

Fig. 1. Calibration curve of the high-pressure chamber

Fig. 2. Change in the electrical resistance R/R_{30} of cerium under pressure

50,000–100,000 kg/cm^2. The minimum of the electrical resistance of cerium corresponds to $P = 70{,}000$ kg/cm^2; then it increases, reaching a maximum at $P = 90{,}000$ kg/cm^2, after which it falls again. For lanthanum the minimum of electrical resistance lies at $P = 90{,}000$ kg/cm^2, after which it increases somewhat; the increase continues up to 100,000 kg/cm^2. Neodymium, according to Bridgman' s data, has a minimum of electrical resistance at $P = 70{,}000$ kg/cm^2; further, up to 100,000 kg/cm^2, the resistance increases smoothly. Since in the indicated pressure range the course of the electrical resistance of cerium,

Figure 3 and Figure 4 plots

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lanthanum and neodymium is not smooth, it seemed of interest to study the character of the change in electrical resistance also at higher pressures. The presence of maxima in electrical resistance, as well as abrupt changes, indicates polymorphic transformations undergone by the substance under investigation under pressure.

In a high-pressure chamber making it possible to obtain pressures up to 250,000 kg/cm^2, the change in electrical resistance of cerium, lanthanum and neodymium was investigated. The calibration curve of the chamber is given in Fig. 1.

Figure 2 gives the curve of the change in the electrical resistance of cerium R/R_{30} with pressure (R_{30} is the resistance at a pressure of 30,000 atm.). As can be seen from the curve, the electrical resistance of cerium has a minimum at a pressure of 55,000 kg/cm^2; it then increases, reaching a maximum value at 80,000 kg/cm^2. Apparently, the maximum in the electrical resistance of cerium indicates a polymorphic transformation occurring at this pressure.

Figure 3 presents curves of the change in the electrical resistance of lanthanum. Lanthanum of two degrees of purity was used: grade La-I *(a)* and chemically pure grade *(b)*.

The impurity content (in percent) in lanthanum of these grades was as follows:

La-I:	Nd 0.75;	Pr 0.70;	Fe 0.04
La c.p.:	Nd 0.3;	Pr 0.2;	Fe 0.02

As can be seen from the results presented, contaminated lanthanum has no features on the curve of the change in electrical resistance.

Fig. 3. Change in the electrical resistance R/R_{30} of lanthanum under pressure: a —lanthanum grade La-I, b —chemically pure grade.

The electrical resistance of chemically pure lanthanum first decreases, reaching the first minimum at a pressure of about 95,000 atm.; then it increases very slightly, reaching a maximum at 110,000 atm., after which it drops sharply (the decrease in electrical resistance is small, less than 1%); then it increases again, reaches a maximum at a pressure of about 140,000 kg/cm^2, and decreases smoothly up to a pressure of 250,000 kg/cm^2. It may be assumed that lanthanum, like cerium, undergoes a polymorphic transformation, but at a somewhat higher pressure ($P = 110{,}000$ kg/cm^2).

Fig. 4. Change in the electrical resistance R/R_{30} of neodymium under pressure.

Figure 4 shows the course of the electrical resistance of neodymium with changing pressure. A minimum in the electrical resistance of neodymium is observed at a pressure of 80,000 kg/cm^2; then it increases slightly, reaching a maximum at about 90,000 kg/cm^2, and with further increase in pressure it falls rather sharply. Apparently, neodymium, like lanthanum and cerium,

undergoes a polymorphic transition at a pressure of about 90,000 kg/cm^2. It should be noted that the discrepancy between the maxima and minima of the curves for the change in the electrical resistance of cerium and neodymium and Bridgman' s data exceeds the inaccuracy in determining the pressure from the calibration curve (see Fig. 1), which in this pressure range does not exceed 5000 atm. It is possible that this is caused by the different degree of chemical purity of the materials studied.

The composition of impurities (in percent) in neodymium and cerium is as follows:

Ce: Nd < 0.75; Pr < 0.75; Fe $2 \cdot 10^{-2}$; Cd $1 \cdot 10^{-3}$; Pb $1 \cdot 10^{-3}$; Bi $1 \cdot 10^{-3}$; Sn 10^{-3}
Nd-3: Sm 10; Pr and La not detected, sensitivity 0.36; Ca $2 \cdot 10^{-2}$

All measurements were carried out at room temperature on metal samples made in the form of wires with a diameter of 1-1.5 mm.

In the future we shall attempt to interpret theoretically the results of previous works ([1], [2]) and of the present work.

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CITED LITERATURE

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