Physics

Corresponding Member of the Academy of Sciences of the USSR L. F. Vereshchagin, A. A. Semerchan, and S. V. Popova

1961

SovietRxiv

Fig. 1. Change in the electrical resistance of praseodymium

Figure 1: Fig. 1. Change in the electrical resistance of praseodymium

Abstract

Full Text

Physics

Corresponding Member of the Academy of Sciences of the USSR L. F. Vereshchagin, A. A. Semerchan, and S. V. Popova

Change in the Electrical Resistance of Praseodymium, Dysprosium, Erbium, and Ytterbium up to a Pressure of 250,000 kg/cm^2

The present work is a continuation of the work of the same authors ([1–3]) on the study of changes in the electrical resistance of metals at high pressures.

Figure 1 shows the change in the electrical resistance of praseodymium R/R_{25} as a function of pressure, where R_{25} is the electrical resistance of praseodymium at $P = 25\,000$ kg/cm^2. The value R_{25} is taken as the initial value, since at lower pressures a strong change in the electrical resistance of the specimen occurs owing to a change in the geometrical dimensions, which is caused by the extrusion of the pressure-transmitting substance from the working volume of the chamber. The praseodymium specimen was cut in the form of a cylinder 8 mm long and 1 mm in diameter (for the degree of purity of the material, see Table 1).

As is seen from the curve shown in Fig. 1, the electrical resistance of praseodymium in the pressure range $25\,000 \div 100\,000$ kg/cm^2 changes by 21.7%, reaching a minimum at 100,000 kg/cm^2; then it drops (the jump-like change in electrical resistance is less than 1%) and in the range $110\,000 \div 150\,000$ kg/cm^2 increases, after which it again decreases slowly with pressure. The change in the electrical resistance of praseodymium is analogous to the change in the electrical resistance of lanthanum ([3]), which is apparently due to the same type of crystal lattice (hexagonal). The change in the electrical resistance of cerium with pressure (face-centered cubic lattice) has an entirely different character. Apparently praseodymium, like lanthanum, undergoes a polymorphic transformation at a pressure of 100,000 kg/cm^2.

Fig. 1. Change in the electrical resistance of praseodymium

Table 1

Impurity content (in percent)

Fig. 2. Change in the electrical resistance of dysprosium

Figure 2: Fig. 2. Change in the electrical resistance of dysprosium

Fig. 3. Change in the electrical resistance of erbium

Figure 3: Fig. 3. Change in the electrical resistance of erbium

Element	Impurity content
Pr (PR-1)	La_2O_3 0.2; Sm_2O_3 not detected, sensitivity 0.1; CeO_2 not detected, sensitivity 0.1; Nd_2O_3 not detected, sensitivity 0.1; Fe 0.008; Ca 0.011; Cu 0.003
Dy	Σ r. e. 0.35; Fe 0.007; Cu 0.05; Ca 0.033
Er (ERM-1)	Σ r. e. 0.09; Ca not detected, sensitivity 0.02; Cu 0.025
Yb	Lu not detected; Tu not detected; Er 0.01; W not detected; Fe 0.003; Ca 0.005

The change in the electrical resistance of praseodymium was studied by Bridgman ([4]) up to 100,000 kg/cm^2; he found that the minimum of the electrical resistance lies at 80,000 kg/cm^2; this difference in the positions of the minima is apparently connected with the different degree of purity of the specimens studied.

Figure 2 shows the change in the electrical resistance R/R_{25} of dysprosium with pressure. The specimen was cut and had the same dimensions as ⋯

sample of praseodymium. As is seen from the curve, the electrical resistance of dysprosium passes through a minimum at a pressure of 75,000 kg/cm^2, then increases (by approximately 0.5%) and subsequently falls with pressure almost linearly.

Fig. 2. Change in the electrical resistance of dysprosium

Fig. 3. Change in the electrical resistance of erbium

The change in the electrical resistance of dysprosium is analogous to the change in the electrical resistance of neodymium ([3]). Dysprosium has a hexagonal close-packed lattice. The degree of purity of the specimen studied is given in Table 1.

In Fig. 3 is shown the change in the electrical resistance R/R_{25} of erbium with pressure. The geometrical dimensions and the method of preparation of

Fig. 4. Change in the electrical resistance of ytterbium

Figure 4: Fig. 4. Change in the electrical resistance of ytterbium

the specimen were the same as for dysprosium and praseodymium; the degree of purity is given in Table 1. The electrical resistance of erbium decreases smoothly with pressure and has no peculiarities in the pressure range investigated.

Fig. 4. Change in the electrical resistance of ytterbium

Of great interest is the change in the electrical resistance of ytterbium (see Fig. 4). In the pressure range from 25,000 to 50,000 kg/cm^2, the resistance of ytterbium increases by almost 50%, reaching a maximum at 50,000 kg/cm^2, and then falls sharply (the electrical resistance decreases by a factor of 10 when the pressure is increased by 10,000 kg/cm^2) and thereafter changes hardly at all with pressure. Undoubtedly, at $P = 50{,}000$ kg/cm^2, ytterbium undergoes a polymorphic transformation or has an electronic transition.

Ytterbium has a face-centered cubic lattice. It is interesting to note that a similar type of change in electrical resistance is exhibited by cerium ([3]), which also has a face-centered cubic lattice. The degree of purity of the specimen studied is given in Table 1. The specimen was extruded through a die and had the same dimensions as the specimens of the metals described above. All measurements were carried out at room temperature.

In subsequent works the authors will continue the study of changes in the electrical resistance of lanthanides under pressure.

Institute of High-Pressure Physics
Academy of Sciences of the USSR

Received
31 III 1961

CITED LITERATURE

1. L. F. Vereshchagin, A. A. Semerchan, N. N. Kuzin, S. V. Popova, DAN, **136**, No. 2 (1961).

2. L. F. Vereshchagin, A. A. Semerchan, N. N. Kuzin, S. V. Popova, DAN, **138**, No. 1 (1961).

3. L. F. Vereshchagin, A. A. Semerchan, S. V. Popova, DAN, **138**, No. 5 (1961).

4. P. W. Bridgman, Proc. Am. Acad. Arts and Sci., 1952, **81**, 165 (1952).

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