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THE EFFECT OF HIGH PRESSURE ON THE SUPERCONDUCTING TRANSITION TEMPERATURE OF THE ALLOYS $Mo_{90}Re_{10}$ AND $Nb_{75}Mo_{25}$

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The effect of pressures up to 28 000 atm on the superconducting transition temperature T_c of the alloys $Mo_{90}Re_{10}$ and $Nb_{75}Mo_{25}$ was investigated. It was found that in the $Nb_{75}Mo_{25}$ alloy T_c decreases under hydrostatic compression, whereas in $Mo_{90}Re_{10}$ it increases. The results obtained are compared with the variation of the density of states N(0) on the Fermi surface in the course of compression.

As is well known, the superconducting transition temperature is given by the formula[1]

$$T_c = 0.85\Theta \exp(-1/N(0)V),$$

where Θ is the Debye temperature, N(0) is the density of states on the Fermi surface for the given metal, and V is the electron-phonon interaction parameter. In [2, 3], in which we investigated the superconducting transition temperature of zirconium and titanium under compression, we asserted that for transition metals the determining factor in the change of T_c under hydrostatic compression may be the change in the density of states on the Fermi surface.

Data obtained by Morin and Maita[4] and Daunt[5] in investigations of the relation between the electronic specific heat γ and T_c in a large number of transition metals and alloys, indicate a very weak dependence of the parameter V on the effective number of valence electrons n_v. According to Morin and Maita the critical temperatures of the transition metals and of their alloys are determined mainly by the density of states of the d electrons. The dependence of the density of states of the d electrons of the transition metals and their alloys on the number of valence electrons per atom is shown in Fig. 1.

If it is assumed that the dependence of the density of states on the pressure P is given by curves of the same type, or that at least the signs of $dN(0)/dP$ and $dN(0)/dn_v$ coincide, then the sign of the derivative dT_c/dP should be determined by the sign of the derivative $dN(0)/dn_v$. Thus in superconductors with $dN(0)/dn_v > 0$ the temperature T_c should increase under compression, whereas in superconductors with $dN(0)/dn_v < 0$ it should decrease. This rule is in agreement with the results obtained for zirconium,[2] titanium,[3] ruthenium,[6] and the alloy $Nb_{75}Zr_{25}$,[7] in which T_c increases under compression.

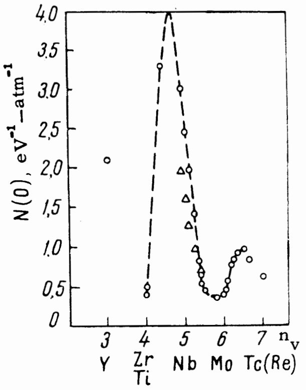

FIG. 1. Dependence of the density of states N(0) on the number of valence electrons n_v: o – data of[4], Δ – data of[5].

In order to check this assumption again, it was of interest to investigate two different alloys with different signs of $dN(0)/dn_v$. As such alloys we chose $Mo_{90}Re_{10}$ and $Nb_{75}Mo_{25}$.

The investigated samples of the alloys, obtained by fusion in a high-frequency furnace at the Metallurgy Institute of the USSR Academy of Sciences,[1)] were prepared by turning on a lathe in the form of cylinders 2.6–2.7 mm in diameter and 3–3.5 mm long. The temperature T_c for the samples of the $Mo_{90}Re_{10}$ alloy was 2.92° K, and for samples of the $Nb_{75}Mo_{25}$ alloy it was 3.47° K. The pressure was produced by a multiplier method, analogous to that described previously.[8]

Figure 2 shows as an example superconducting transition curves of the $Nb_{75}Mo_{25}$ alloy obtained at various pressures. It is interesting to note that the width of the superconducting transition curves

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[1)] We take this opportunity to thank V. V. Baron for kindly supplying the high-quality alloys.

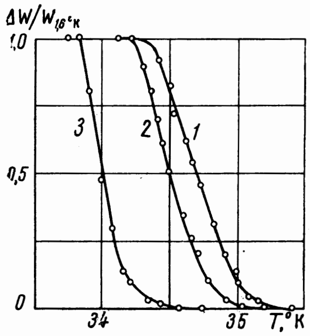
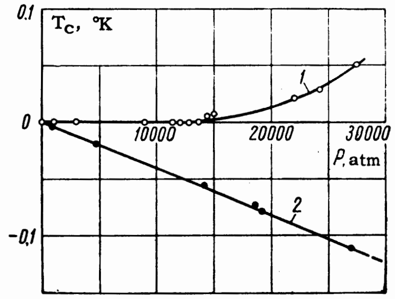


FIG. 2. Superconducting transition curves of the alloy $Nb_{75}Mo_{25}$ at various pressures. The ordinate is the relative change of the signal W at the output of the electronic setup at the superconducting transition: curve 1–P = 0, 2–P = 4700 atm, 3–P = 19 000 atm.

FIG. 3. Pressure dependence of the superconducting transition temperature in the alloys $Mo_{90}Re_{10}$ (curve 1) and $Nb_{75}Mo_{25}$ (curve 2).



in the investigated alloys decreases on compression. The dependence of the superconducting transition temperature T_c on the applied pressure for both investigated samples is shown on Fig. 3.

In accordance with the assumptions considered above, the temperature of the superconducting transition of the $Mo_{90}Re_{10}$ alloy increases on compression, whereas that of the $Nb_{75}Mo_{25}$ alloy decreases. These dependences are reversible and are reproducible in subsequent compression cycles. The pressure dependence of T_c for the $Nb_{75}Mo_{25}$ alloy is approximately linear with a derivative $dT_c/dP \approx -0.4 \times 10^{-5}$ °K/atm. For the $Mo_{90}Re_{10}$ alloy the critical temperature T_c does not depend on the pressure up to pressures of the order of 15 000 atm, after which it increases. Such a character of the dependence of T_c on P, also observed in the investigation of zirconium and titanium, has so far found no satisfactory explanation.

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[1] J. Bardeen, L. Cooper, and J. Schrieffer, Phys. Rev. **106**, 162 (1957); J. Bardeen and J. Schrieffer, Novoe v izuchenii sverkhprovodimosti (New Studies of Superconductivity), Fizmatgiz, 1962.

[2] N. B. Brandt and N. I. Ginzburg, JETP **46**, 1216 (1964), Soviet Phys. JETP **19**, 823 (1964).

[3] N. B. Brandt and N. I. Ginzburg, JETP **49**, 1706 (1965), Soviet Phys. JETP **22**, 1167 (1966).

[4] F. J. Morin and J. P. Maita, Phys. Rev. **129**, 1115 (1963).

[5] J. Daunt, Coll. Progr. Low Temp. Phys., **2**, Amsterdam, 1955, p. 202.

[6] J. L. Olsen, E. Bucher, M. Levy, J. Muller, E. Corenzwit, and T. Geballe, Rev. Modern Phys. **36**, 168 (1964).

[7] E. S. Itskevich, M. A. Il'ina, and V. A. Sukhoparov, JETP **45**, 1378 (1963), Soviet Phys. JETP **18**, 949 (1964).

[8] N. B. Brandt and N. I. Ginzburg, FTT **3**, 3461 (1961), Soviet Phys. Solid State **3**, 2510 (1962).

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