The new high-temperature superconductor Nb_3Si

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(Submitted August 16, 1974; resubmitted March 24, 1975)
ZhETF Pis. Red. **21**, No. 8, 494–496 (April 20, 1975)

We have obtained for the first time the compound Nb_3Si, which has a high critical superconducting transition temperature (18.5–19°K). The method of explosive compression was used.

PACS numbers: 74.10.

We have previously synthesized the compound Nb_3Si, which had a structure of the Ti_3P (space group $C_{4h}^4P_2^4/n$) with tetragonal unit cell ($a=10.230$, $c=5.189$ Å, $c/a=0.507$).[1] It exhibited no superconductivity down to 1.5°K.

It could be assumed that a high-pressure treatment would contribute to a transition to another denser crystallographic modification, namely of the β-W type. (An elementary calculation, using the values of the atomic radii of niobium and silicon after Geller,[2] namely $r_{Nb}=1.43$ and $r_{Si}=1.17$ Å, shows that the specific volume should decrease in this transition by 2.5–3%). On the other hand, one could expect that if the Nb_3Si compound were to have a structure of the β-W type then superconductivity with a high critical temperature would be observed.

In the present study, the high pressure was produced by the method of explosive compression. Powdered Nb_3Si, pressed into a metallic ampoule, was placed into a protection device surrounded by high-power explosive matter. The pressure developed in the explosion is roughly estimated at more than one million bars.

After the explosion, the sample comprised three almost coaxial cylindrical layers: a more friable outer layer and a densest and brightest inner layer (Fig. 1).

An x-ray study gives grounds for assuming that explosive compression produces a small amount (not more than 5%) of a phase with a structure of the β-W (A-15) type, with lattice period $a=5.03\pm0.01$ Å. However, as seen from Fig. 2, it is difficult to draw unambiguous conclusions, owing to the strong smearing of the diffraction lines after the shock compression, as well as to the partial coincidence of the strongest diffraction maxima of the type β-W structure with the lines of the initial tetragonal phase (of the Ti_3P type).

Measurement of the critical temperature by the resistive method has shown that 18.5–19°K the samples begin to go over into the superconducting state (Fig. 3). The center of the transition is at 15–16°K, and the end at 13–14°K. Following one hour of annealing at 650°C, the form of the superconducting transition remains practically unchanged, thus evidencing sufficient stability of the metastable phase produced by explosive compression.

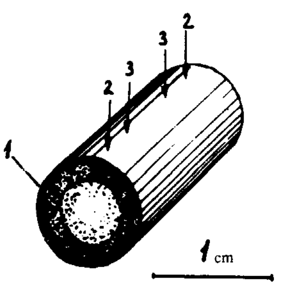

FIG. 1. Appearance of sample after the explosive compression (schematic): 1—metallic shell; 2—current contacts; 3—potential contacts.

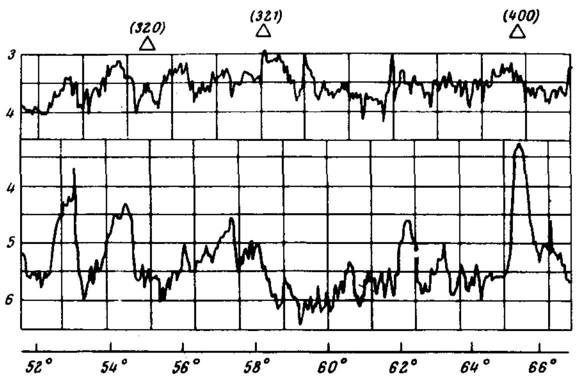

FIG. 2. Microphotometric curves of powder x-ray patterns. Lower—original sample. Radiation—chromium, chamber diameter 57.3 mm. The figure shows the calculated positions of the strong diffraction maxima of a lattice of β-W type (A-15) with periods $a=5.3\pm0.01$ Å.

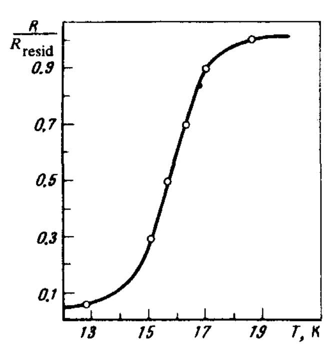

FIG. 3. Resistive superconducting transition curve.

[1]V. M. Pan, V. V. Pet'kov, and O. G. Kulik, in: Metallovedenie fiziko-khimiya i metallofizika sverkhprovodnikov (Metallurgy, Physics-Chemistry, and Metal Physics of Superconductors), Nauka (1967), p. 161; V. N. Svechnikov, Yu. A. Kocherzhinskii, G. F. Kobzenko, V. M. Pan, and A. K. Shurin, in: Metallofizika (Metal Physics), Kiev, Nauka Dumka (1974), Vol. 52, p. 3.

[2]S. Geller, Acta Cryst. 9, 889 (1956).