

UC Irvine

UC Irvine Previously Published Works

Title

Superconductivity of single-crystal NbGe₂

Permalink

<https://escholarship.org/uc/item/90f6t78h>

Journal

Journal of the Less Common Metals, 62(C)

ISSN

0022-5088

Authors

Remeika, JP
Cooper, AS
Fisk, Z
[et al.](#)

Publication Date

1978-11-01

DOI

10.1016/0022-5088(78)90033-4

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at

<https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

SUPERCONDUCTIVITY OF SINGLE-CRYSTAL NbGe₂*

J. P. REMEIKA and A. S. COOPER

Bell Laboratories, Murray Hill, N. J. 07974 (U.S.A.)

Z. FISK and D. C. JOHNSTON

Institute for Pure and Applied Physical Sciences, University of California, San Diego, La Jolla, Calif. 92093 (U.S.A.)

(Received July 17, 1978)

Summary

Small single crystals of NbGe₂ were grown by the hydrogen reduction of potassium-containing oxides. Measurements of electrical resistivity and superconductivity are given.

Matthias *et al.* [1] were the first to show that the A15 compound Nb₃Ge was a high transition temperature superconductor. Subsequent to the work of Gavalier [2] and later Testardi *et al.* [3] which pushed the T_c of Nb₃Ge to 23 K, Ghosh and Douglas [4] reported superconductivity to 16 K in sputtered films containing Ge and NbGe₂. It appeared that the Ge-rich portion of the Nb-Ge phase diagram might also be interesting from the standpoint of superconductivity, especially since Hardy and Hulm [5] found the C40 compound NbGe₂ to be normal to 1.2 K. The sputtering target used in ref. 4 had $T_c = 1.85$ K.

The work described here is based on the observation that KNbO₃ could be reduced to Nb metal in H₂ at relatively low temperatures. This suggested the possible production at relatively low temperature of Nb₃Ge by hydrogen reduction of KNbO₃ and K₂GeO₃ mixtures with a Nb:Ge ratio of 3:1. These mixtures were made both by ball milling the crushed oxides and by reaction of K₂CO₃ with a Nb₂O₅-GeO₂ mixture.

Hydrogen reduction was carried out overnight at temperatures in the range 800 - 1100 °C with little variation in the result. The mass that resulted from this reduction was interspersed with small columnar metallic crystals (typically 0.5 mm × 0.05 mm × 0.05 mm). A measurement of superconductivity on the entire product gave an incomplete transition with T_c onset of 2.0 K.

X-ray analysis of these crystals showed them to be NbGe₂ with lattice parameters $a_0 = 4.965$ Å, $c_0 = 6.783$ Å. A quantity of these crystals was isolated, crushed and found to have a T_c onset of 2.1 K and width 0.4 K. It

*Dedicated to Professor B. T. Matthias in celebration of his 60th birthday.

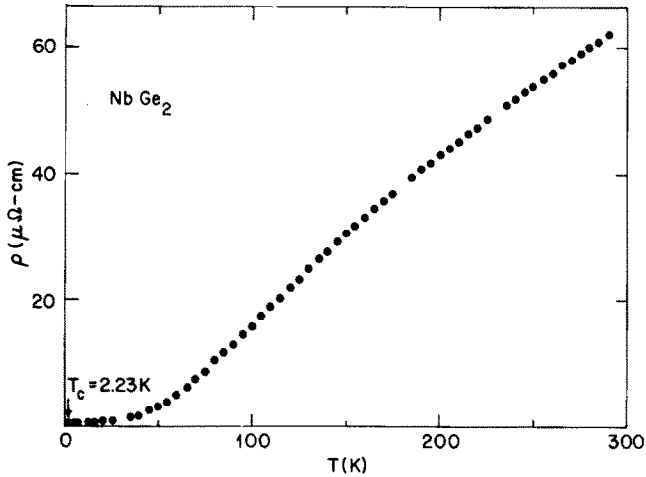


Fig. 1. Temperature-dependent electrical resistivity of an NbGe_2 single crystal. A similar crystal was found to have growth axis $\langle 11\bar{2}0 \rangle$, and this is quite probably the direction measured here.

is likely, therefore, that the T_c seen in the bulk reduction mass is due to NbGe_2 . A four-probe electrical resistivity measurement on one of these crystals (Fig. 1) gave $T_c = 2.23 \pm 0.03$ K. The resistance ratio to 4.2 K for this crystal is 100, the room temperature resistivity is $60 \pm 15 \mu\Omega \text{ cm}$. An X-ray rotation photograph of one of the crystals showed that its growth axis was $\langle 11\bar{2}0 \rangle$.

This result was compared with arc-melted samples at nominal compositions NbGe_2 and NbGe_5 , annealed at 950°C for one week. The NbGe_2 sample had $T_c = 2.09 \pm 0.02$ K and for the NbGe_5 sample $T_c = 2.16 \pm 0.01$ K. This last sample reacted somewhat with its protective Ta wrapper, possibly influencing the T_c . Nothing in the a.c. susceptibility was observed at higher temperature in either of these samples.

By varying the ratio of Nb:Ge in the initial mixture of oxides we were unable to produce material with a higher transition temperature. The actual mechanism for the growth of the NbGe_2 crystals is not clear. The possibilities include vapor growth and growth from KOH flux. It would be interesting to investigate this last possibility, but the container problem for molten KOH under these conditions is severe.

It is interesting that the hydrogen reduction of these oxides proceeds so readily, apparently due to the presence of potassium. This reduction technique might prove useful in the low temperature synthesis of a number of other intermetallics.

Acknowledgments

This work done at U.C., S.D., was supported by the National Science Foundation under Grant Numbers NSF/DMR77-08469 and NSF/DMR77-23774. We are indebted to H. Barz for some of the measurements of superconductivity.

References

- 1 B. T. Matthias, T. H. Geballe, R. H. Willens, E. Corenzwit and G. W. Hull, Jr., *Phys. Rev. A*, 139 (1965) 142.
- 2 J. R. Gavaler, *Appl. Phys. Lett.*, 23 (1973) 480.
- 3 L. R. Testardi, J. H. Wernick and W. A. Royer, *Solid State Commun.*, 15 (1974) 1.
- 4 A. K. Ghosh and D. H. Douglas, *Superconductivity in d- and f-Band Metals*, Plenum Press, New York, 1976, p. 59.
- 5 G. F. Hardy and J. K. Hulm, *Phys. Rev.*, 93 (1954) 1004.