PRESSURE DEPENDENCE OF THE SUPERCONDUCTING TRANSITION TEMPERATURE OF THORIUM *

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The pressure dependence of the superconducting transition temperature of thorium metal to 160 kbar is reported.

Thorium's superconducting properties are very much like those of a nontransition metal. The critical field of this type I superconductor as a function of temperature follows very closely the BCS deviation function from a fiducial parabola [1], while the ratio $\Delta C(T_c)/\gamma T_c$ (where $\Delta C(T_c)$ is the specific heat jump at the superconducting transition temperature T_c and γ is the electronic specific heat coefficient) is equal to 2.42 [2], quite near the value 2.43 predicted by the BCS theory. Moreover, measurements made up to $\sim$ 20 kbar show that T_c decreases with pressure P as is the case with most nontransition element superconductors [3-5]. This letter reports measurements of $T_c(P)$ up to $\sim$ 160 kbar which reveal an unusual pressure dependence of T_c at high pressures.

Superconducting transitions of a Th specimen and Pb manometer were detected resistively by an a.c. (100 Hz) four-lead technique. The Th specimen was cut from a cold-rolled foil which had been annealed in 1/2 atm. of He for 30 minutes at 800 C to remove strains. Opposed Bridgman anvils in a clamp were employed to achieve high pressures in a cell consisting of a pyrophillite retaining ring and two AgCl disks between the Th sample and Pb manometer were placed [6].

The transition temperature is defined as the temperature at which the sample resistance drops to 50% of its normal state value, while the transition width is defined by the temperatures corresponding to the 10% and 90% values. Superconducting transition temperatures of the Pb manometer have been converted to equivalent pressures from an empirical relationship between T_c and P for Pb [6]. The Pb transition width indicates the pressure inhomogeneity in the cell.

The pressure dependence of T_c for Th to $\sim$160 kbar is shown in fig.1. The relatively narrow average width of the Th transitions ($\sim$0.03 K) reflects the small pressure inhomogeneity in the AgCl cell which is estimated from the Pb transition width to be $\lesssim$2 kbar. The resistance ratio $R(300\text{K})/R(4.2\text{K})$ of the annealed Th specimen reported here was $\sim$30 at all pressures.

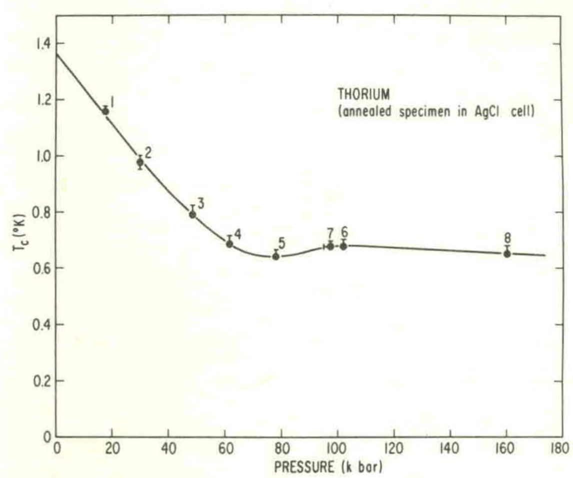

Fig.1. Superconducting transition temperature T_c of thorium as a function of pressure. Measurements were made on an annealed thorium sample pressurized in an AgCl cell. The vertical bars represent the width of the transition, while the horizontal bars are a measure of the inhomogeneity in pressure as determined from the transition width of the Pb manometer. The sequence in which pressure was applied is indicated by the number near each experimental point.

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Another experiment on unannealed Th specimens in cells with steatite rather than AgCl disks gave results similar to those shown in fig.1, except that the transitions below 75 kbar were broader and the scatter in data much greater, presumably due to pressure inhomogeneities of ~10-20 kbar.

Fig.1 shows that T_c initially decreases with pressure, exhibits a weak minimum near 75 kbar, and then decreases slightly with pressure above ~100 kbar. This unusual pressure dependence of T_c may be due to a pressure-induced change in Fermi surface topology or to a crystallographic phase change occurring in the neighborhood of 70 kbar. Although the resistivity as a function of pressure at room temperature does not exhibit any anomalies, such a phase transformation cannot be completely ruled out.

We wish to thank Dr. J. Wittig for advice concerning the high pressure technique employed in this experiment.

References

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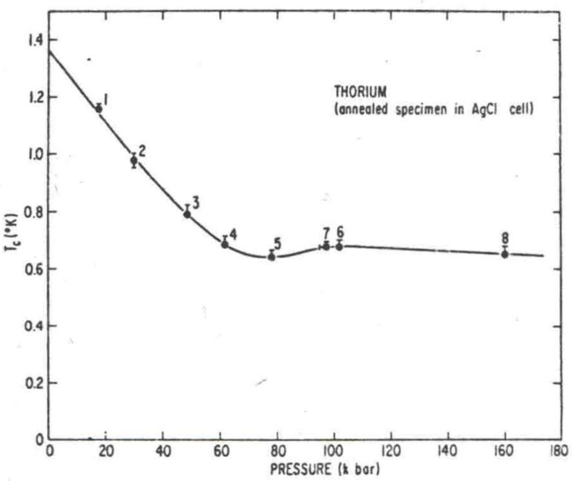

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