Title
Magnetization of U0.9688Th0.0312Be13

Journal
Physica B Condensed Matter, 163(1-3)

ISSN
0921-4526

Authors
Schmiedeshoff, GM
Ma, YP
Brooks, JS
et al.

Publication Date
1990-04-01

DOI
10.1016/0921-4526(90)90204-8

Physica B 163 (1990) 335–336
North-Holland

MAGNETIZATION OF $U_{0.9688}Th_{0.0312}Be_{13}$

G.M. SCHMIEDESHOFF[a], Y.P. MA[b,1], J.S. BROOKS[b], M.B. MAPLE[c], Z. FISK[d] and J.L. SMITH[d]
[a]*Department of Physics, Bowdoin College, Brunswick, Maine 04011, USA*
[b]*Department of Physics, Boston University, Boston, Massachusetts 02215, USA*
[c]*Department of Physics and Institute for Pure and Applied Physical Sciences, University of California, San Diego, La Jolla, California 92093, USA*
[d]*Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA*

We present measurements of the low temperature dc magnetization of a single crystal of $U_{0.9688}Th_{0.0312}Be_{13}$ as a function of magnetic field for two orientations of the crystal with respect to the field. A qualitative difference in the behavior of the amplitude of the magnetic hysteresis in the superconducting state may be interpreted as evidence for the existence of two superconducting phases, at least one of which is anisotropic.

The low temperature behavior of the heavy-fermion superconducting system $U_{1-x}Th_xBe_{13}$ suggests the presence of two co-existing anisotropic superconducting states [1]. Recent studies of the dc magnetization of a single crystal of pure UBe_{13} suggest the presence of an anisotropic magnetic moment in the superconducting state [2]. We report similar measurements on a single crystal of $U_{0.9688}Th_{0.0312}Be_{13}$, measurements which can be interpreted to indicate the presence of at least one anisotropic superconducting phase in this material.

Measurements of the dc magnetization M below 100 mK are made using a capacitive magnetometer [3] in a top-loading dilution refrigerator. The change in capacitance ΔC is proportional to the force on the sample, which in turn is equal to the product of M and the gradient of the magnetic field. Measurements of ΔC at fixed temperature with the external magnetic field H oriented normal to a crystal face are shown in fig. 1. Measurements with H oriented about 45° with respect to a crystal face are shown in fig. 2. The asymmetry between these two orientations is surprising for a crystal with cubic symmetry. The amplitude of the magnetic hysteresis ΔM for both orientations is nonetheless quite similar and shown in fig. 3. A peak in ΔM is observed for both orientations at a field H_p. The "peak effect" has been observed in conventional superconducting systems and can be attributed to one of several mechanisms [4]. One such mechanism involves the co-existence of two superconducting phases with similar thermodynamic critical fields but with differing values of the Ginzburg–Landau parameter κ. Each phase, as expected for the $U_{1-x}Th_xBe_{13}$ system [5], therefore has a different H_{c2}. The peak at H_p occurs at the lower H_{c2}. It is important to note that this particular peak effect generally arises from a *spatial* separation of the two phases, a fact that suggests stoichiometry difficulties with the crystal (which may suffer from aluminum inclusions from the growth process). In what follows, we assume that the peak arises from such a mechanism.

As shown in fig. 3, H_p varies as a function of angle with respect to the external magnetic field. This vari-

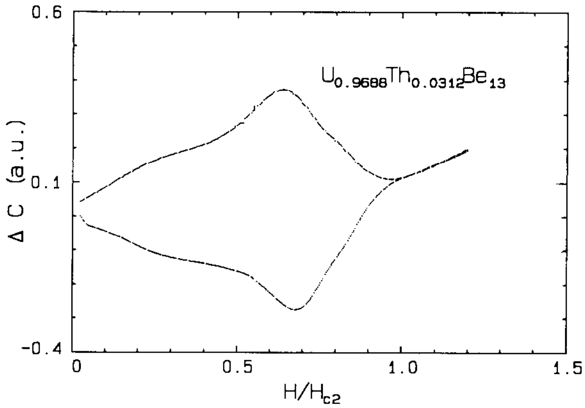

Fig. 1. Change in capacitance as a function of magnetic field for a single crystal of $U_{0.9688}Th_{0.0312}Be_{13}$ at 70 mK oriented with a crystal face normal to the external field.

[1] Present address: Department of Physics, Vanderbilt University, Nashville, Tennessee 37235, USA.

0921-4526/90/$03.50

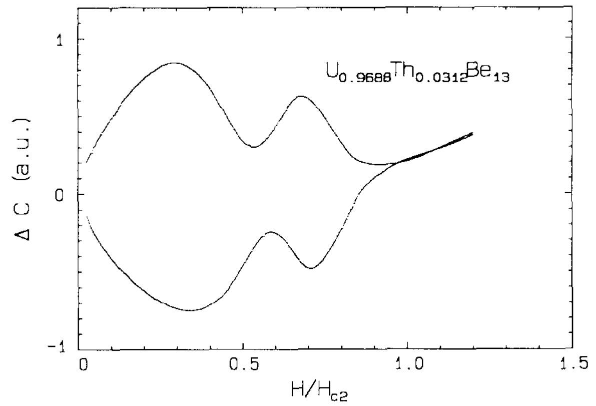

Fig. 2. Change in capacitance as a function of magnetic field for a single crystal of $U_{0.9688}Th_{0.0312}Be_{13}$ at 95 mK oriented with a crystal face approximately 45° to the external field.

ation is a clear sign of anisotropy in H_{c2} for at least one of the two phases. We note that this conclusion is not affected by stoichiometry difficulties: in this case at least one of the spatially separate phases must be anisotropic for this shift to occur. It should be noted that each curve in fig. 3 has been scaled by its own H_{c2} as determined in a manner described previously [6]. Our conclusions are not affected by this choice. In the 0° and 45° magnetization data, the position of the peaks are 2.35 and 2.56 T, and the upper critical fields are 3.87 and 3.78 T, respectively. Since the 45° data are at a slightly higher temperature, H_{c2} decreases. Surprisingly, however, H_p increases.

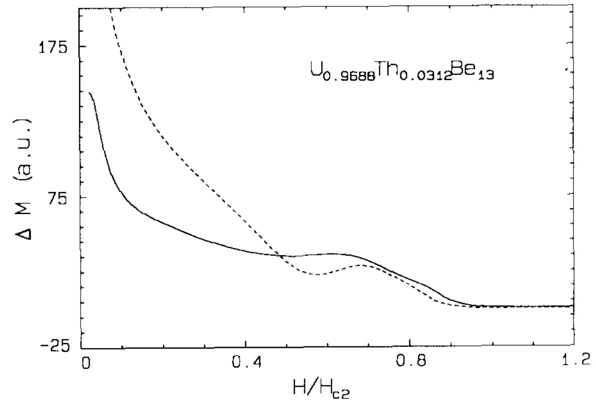

Fig. 3. Amplitude of the magnetization hysteresis as a function of magnetic field for a single crystal of $U_{0.9688}Th_{0.0312}Be_{13}$. Solid line: crystal face normal to external field. Dashed line: crystal face approximately 45° to the external field.

We would like to thank B.S. Held, R.L. Stevens, and P.W.C. Emery for their assistance. This work was supported by a Cottrell College Science Grant from the Research Corporation and by Bowdoin College. Work at the Magnet Laboratory was partially supported by NSF-DMR-85-1326 (Boston University). Research at the University of California at San Diego was supported by the US Department of Energy under Grant No. DE-FG03-86ER45230. Work at Los Alamos was performed under the auspices of the US Department of Energy. The measurements were made at the High Field/Low Temperature Facility at the Francis Bitter National Magnet Laboratory (supported by the National Science Foundation).

References

[1] See, for example Manfred Sigrist and T.M. Rice, Phys. Rev. B 39 (1989) 2200.

[2] Y.P. Ma, J.S. Brooks, G.M. Schmiedeshoff, M.B. Maple, Z. Fisk, J.L. Smith and H.R. Ott, Jpn. J. Appl. Phys. 26 Supp. 26-3 (1987) 1235.

[3] J.S. Brooks, M.J. Naughton, Y.P. Ma, P.M. Chaikin and R.V. Chamberlin, Rev. Sci. Instrum. 58 (1986) 117.

[4] A.M. Campbell and J.E. Evetts, Critical Currents in Superconductors (Taylor and Francis, New York, 1972) p. 178.

[5] U. Rauchschwalbe, C.D. Bredl, F. Steglich, K. Maki and P. Flude, Europhys. Lett. 3 (1987) 757.

[6] G.M. Schmiedeshoff, Y.P. Ma, J.S. Brooks, M.B. Maple, Z. Fisk and J.L. Smith, Phys. Rev. B 38 (1988) 2934.