High Pressure Apparatus for Magnetization Measurements

Author(s):
Y. Uwatoko
T. Hotta
E. Matsuoka
H. Mori
T. Ohki
J.L. Sarrao
J.D. Thompson
N. Mori
G. Oomi

Submitted to:
The Review of High Pressure Science and Technology
AIRAPT-16/HPCJ38
Kyoto, Japan
August 25, 1997

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. The Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy.
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
High Pressure Apparatus for Magnetization Measurements

Y. Uwatoko, T. Hotta, E. Matsuoka, H. Mori, T. Ohki, J.L. Sarro†, J.D. Thompson†
N. Mori†† and G. Oomi†††

Department of Physics, Saitama University, Urawa, Saitama 338, Japan
†Los Alamos National Laboratory, Los Alamos, NM 87544, USA
††ISSP, University of Tokyo, Roppongi, Tokyo 106, Japan
†††Department of Mechanical Engineering and Material Science, Kumamoto University,
Kumamoto, Kumamoto 860, Japan

A hydrostatic high pressure micro cell for studying heavy-fermion materials in a commercial magnetometer is developed. Experiments of pressures up to 10 kbar and temperature range 2 K ≤ T ≤ 400 K have been carried out. The sensitivity of measurement of under high pressure is as same as ambient pressure one within experimental error.

1. Introduction

Electrical correlations in Ce-, Yb- and U-based intermetallic compounds lead to a variety of interesting ground states, including superconducting, semiconducting, magnetically ordered and non-magnetic [1]. To understand these ground states and interactions responsible for them, measurements as a function of pressure are particularly informative. Recently, much interests have focused on very high hydrostatic pressure apparatus (up to 100 kbar) for low temperature electrical resistivity and magnetic susceptibility studies [2], apparatus capable of triextreme condition for thermomagnetic measurements [3] and micro-cell apparatus for magnetization measurements [4]. We have developed a log type hydrostatic high pressure micro-cell for studying heavy-fermion materials in a commercial (Quantum Design) SQUID magnetometer.

2. Apparatus and Procedures

A schematic drawing of the micro high pressure cell is shown in Figure 1. First idea of this cell have been described by Diederichs et al. [5]. Micro pressure cell was constricted from harden CuBe alloy (C1720B-H). At room temperature, additional force was transmitted to the high pressure region by a beryllium-copper pushing piston and then clamped in by tightening a beryllium-copper bolt against the piston. The high pressure sample space was contained the Quartz spacer with a pressure-medium and shield at both end by a beryllium-copper plug with the O-ring, the Teflon-ring and the Cu-ring, as seen in fig.2. As a
pressure-transmitting fluid mixture of Fluorinert FC70 : FC77 = 1 : 1 is used. The sample are located between on the two quartz rods.

The pressure at liquid helium temperature was determined from value of superconducting transition temperature $T_c(P)$ for 99.9% Sn which has a well-known pressure dependence [6]. The temperature dependent susceptibility of the Sn is shown in Fig. 3 for several applied forces. An estimate of pressure can be derived from the transition curves when one uses the susceptibility to zero. The superconducting temperature $T_c(P)$ decreases with applied force. From the data in Fig. 3, liquid He temperature pressure as a function of applying force at room temperature is shown in Fig. 4. There is a linearly variation in the low temperature pressure slope $dP(T=3K)/dF(T=R.T.)$. For above about $xx(kgf/cm^2)$ the pressure coefficient is constant.

The view of shielding plug setting is shown in Fig. 2.

![Fig. 2: The view of the shielding plug setting.](image)

![Fig. 3: Temperature dependent susceptibility of Sn for several applied forces.](image)

![Fig. 4: Pressure at about T=3 K versus applied pressure at room temperature.](image)

3. Magnetic Measurements of YbInCu$_4$

The intermetallic compound YbInCu$_4$ exhibits the well-known sharp phase transition around T=40 K due to valence fluctuation of Yb ion. Fig. 5 shows $\chi(T)$ plotted versus temperature for each pressure of single crystal YbInCu$_4$. At 1 bar, the temperature dependence of susceptibility is the same over all behavior as previous results [7] within experimental error. The sharp rise at T=40 K (P=1 bar) due to valence change from Yb$^{2+}$ to Yb$^{3+}$ with increasing temperature decreases with increasing pressure with the rate of $dT_c/dP=2.23$ K/kbar, which is larger than the coefficient as previous one [7]. This difference may be caused mainly by change the inside pressure of micro cell with temperature. At High temperature region, susceptibility follow a Curie Weiss low with values of paramagnetic temperature and paramagnetic moments, $\theta_w=7K$ and $\mu_p=4.50(\mu_B/Yb)$ at 1 bar. This Curie Weiss behavior is no change under pressure within experimental error.
4. Summary

A hydrostatic high pressure micro cell is developed. It is known that magnetization is able to measure with pressure range $0 \leq P \leq 10$ kbar and temperature range $2 \, \text{K} \leq T \leq 300$ K under magnetic field up to $115\,\text{T}$. We are now going to measure under pressure of the over 10 kbar.

Fig. 5 : $\chi(T)$ plotted versus temperature for each pressure of single crystal YbInCu$_4$.

Fig. 6 : Valence fluctuation transition temperature versus pressure of YbInCu$_4$.

References

[7] ?