S1

HTS SQUID APPLICATION FOR MEASURING THE MAGNETIC PROPERTIES IN LOW MAGNETIC FIELDS

Institute for Low Temperature Physics & Eng.,
National Academy of Sciences of Ukraine, V.P.Timofeev*, V.I.Shnyrkov
Sunmoon University, Phys. Dept. C.G.Kim, H.C.Kim

1. Introduction

SQUID (Superconducting QUantum Interference Device) is known as the most sensitive magnetic sensor, achieving a magnetic-field resolution of the order of several fT in 1 Hz bandwidth. SQUID-based magnetometers in conjunction with superconducting magnets and shields are now being used for susceptometers that provide the unique combinations of sensitivity, speed, resolution, accuracy, etc.

Conceptually commercial liquid helium cooled SQUID susceptometer consists of a superconducting pickup loop located in a uniform magnetic field and coupled to a sensor. When a sample is passed through the pickup loop the change of resulting magnetic flux is detected by the sensor. The sample can be moved in and out of the pickup loop and its temperature can be controlled. Usually applied fields from 0-30 kG are provided by a superconducting solenoid operated in the persistent mode and the sensitivity of systems are about $\{10^{-8}\}$ emu.

However, the use of liquid helium for cooling restricted the broad application of these type susceptometers due to high cost. New opportunities appeared after the discovery of high temperature superconductivity (HTS) in 1986. Now a number of groups around the world have reported HTS SQUID devices with good characteristics at 77 K, already comparable with the performance of earlier commercial 4.2 K SQUIDs.

2. HTS SQUID-based susceptometer

We designed and tested liquid nitrogen (LN) cooled 20 MHz pumped radio frequency (RF) SQUID-based magnetometer for investigating the magnetic properties of small (up to 1.5 mm in diameter) samples in the weak DC and AC magnetic fields. The main parts of susceptometer are : nonmagnetic fiber glass reinforced plastic cryostat for LN 4.2 liter volume in 2-layers mu-metal magnetic shield (about 60 dB suppression); cryogenic probe with glass tube-like dewar and solenoid, thermo-exchanger with thermometer, quartz holder for the moving of a sample along the solenoid axis, SQUID fixed near solenoid and parallel to its axis; standard type SQUID electronics. The system sensitivity is determined by the intrinsic noise characteristics of sensor (not more than 7×10^{-13} T/Hz^{½}) and by the external low frequency interferences in the working place.

3. Results

When a very small cube Gd-based polycrystal sample (3×10^{-3} cc), approximated as a point dipole is passed up near SQUID in DC magnetic field of 0.54 G, the output signal is as shown in Fig.1. The set was calibrated absolutely in magnetic moment by using a tiny coil of precisely known dimensions and current. In our case the transfer coefficient is 8.2×10^{-8} Am^2/V. The total magnetic moment of sample thus can be measured in known DC magnetic field at fixed temperature, then magnetic moment per unit volume (magnetization) allow to calculate magnetic susceptibility of material.

For the measurement in AC magnetic field we used special electronic circuit for the compensation of output signal without the sample. When the magnetic sample is moved near a SQUID the compensation is broken. An amplitude of output signal is proportional to magnetization. The response is shown in Fig.2. AC magnetic field frequency of 1 Hz has 50 mG amplitude. Both methods gave the same results, the volume susceptibility of ~ 0.19 in the temperature range from 120 K to 200 K.

The results by our calibration procedures was in good agreement with that measured by a commercial LT QUANTUM DESIGN susceptometer (KRISS). We will perform the temperature dependence of sample. This HTS SQUID magnetometer is also planed to design for measuring the domain dynamics, B-H loops in low fields and NMR signal etc.

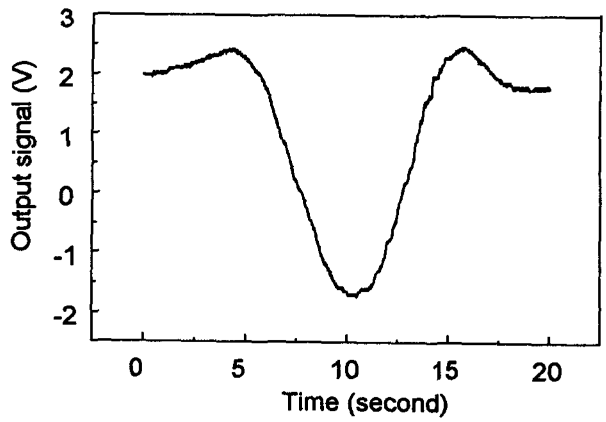

Fig.1. Output signal of SQUID susceptometer in DC magnetic field during the sample movement.

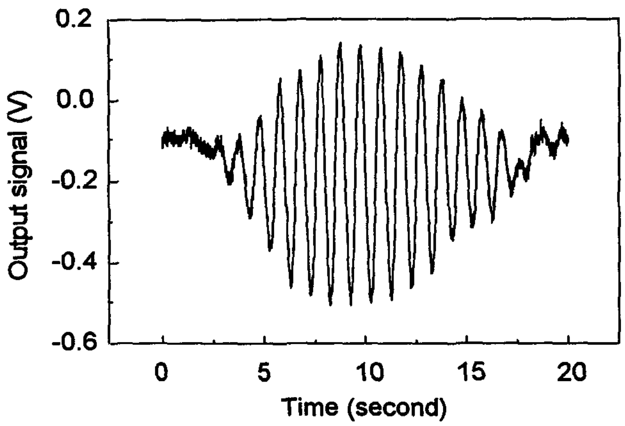

Fig.2. Output signal of SQUID susceptometer in AC magnetic field during the sample movement.