STUDY ON MAGNETO-RESISTANCE SENSOR FOR LOW MAGNETIC FIELD MEASUREMENT

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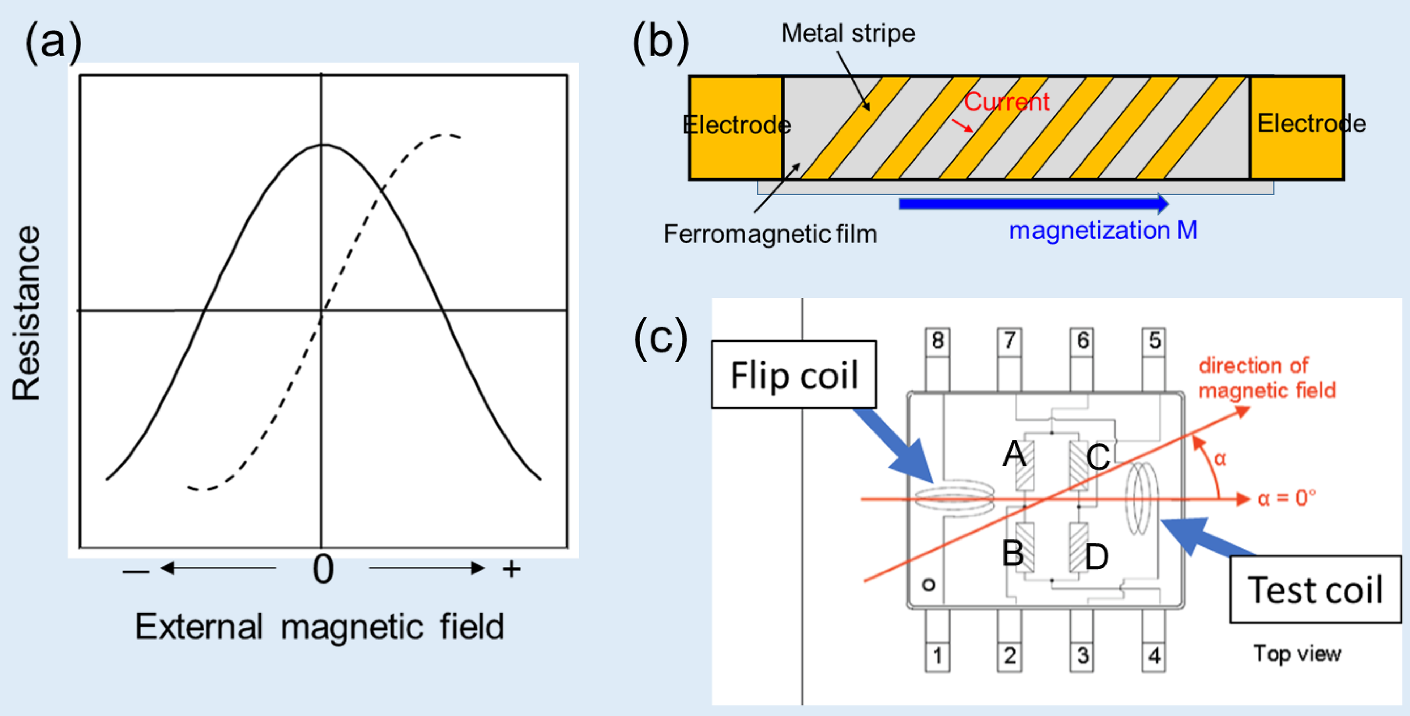
introduction

High-Q operation of a superconducting radio frequency cavity can reduce power loss at the surface and is desirable for CW operation. To realize high-Q operation, the surface resistance, which is a sum of the BCS resistance and residual resistance, needs to be reduced. The residual resistance has been found to originate primarily from magnetic flux trapping in defects in the cavity during the cooling down process. A magnetometer called the "flux gate sensor" has been used to measure the ambient magnetic field; however, it is large in comparison with the cavity and it is very expensive. Sensors based on the Anisotropic-Magneto-Resistance (AMR) sensor, are smaller and much less expensive than a flux gate sensor. We examined the characteristics of magneto-resistance sensors at room temperature and liquid nitrogen temperature.

AMR sensor

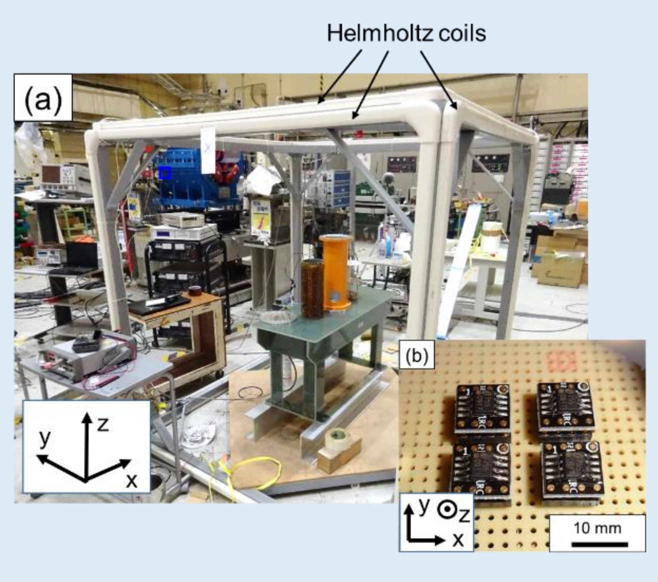
Anisotropic Magneto-Resistance (AMR) sensor is magnetic sensor used AMR effect. The output voltage of AMR sensor, which has barber pole type electrode, changes linearly against external magnetic field. We develop magnetic field mapping system using AFF755B (SENSITEC) as magnetic sensor, which the size of 5 mm × 6 mm. The bridge circuit consists of four AMR elements with barber pole type electrode. The magnetic field strength can be obtained from the voltage balance at the midpoint of the bridge circuit. The sensor gain depends on the voltage applied across the bridge circuit. A flip coil and a test coil are used to initialize the sensor and to validate the sensor, respectively.



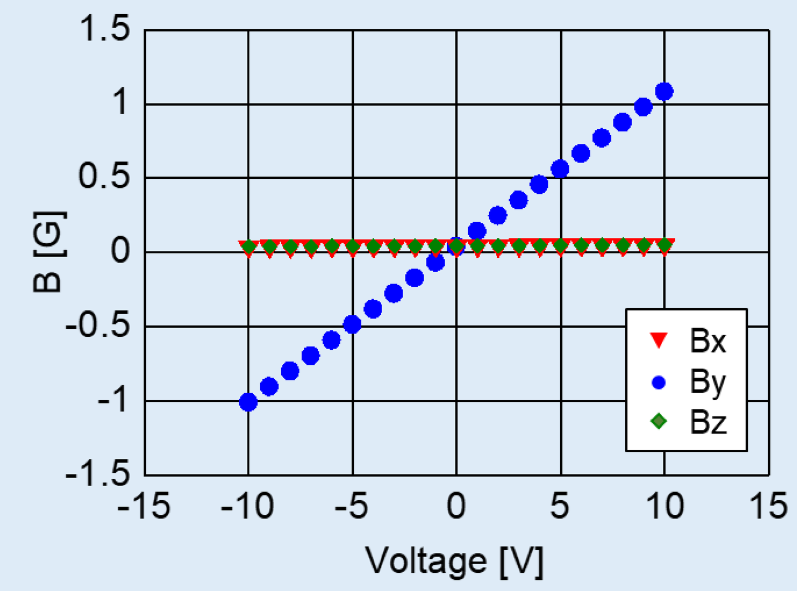
(a) The resistance of film as the function of external magnetic field
(b) Barber pole type electrode (c) The circuit of AFF755B

Calibration system

Three sets of Helmholtz coils are used to evaluate the characteristics of the AMR sensors. Each set of Helmholtz coil can generate magnetic field from -0.1 mT to 0.1 mT by the bipolar power supplies. Four AMR sensors can be mounted on the universal board at one time. The Helmholtz coil currents were adjusted so that the magnetic field at the center of 4 AMR sensors to be zero. The magnetic field in the y axis changed linearly with voltage by approximately 0.2 mT, while the magnetic fields in the x and z axis remain constant.



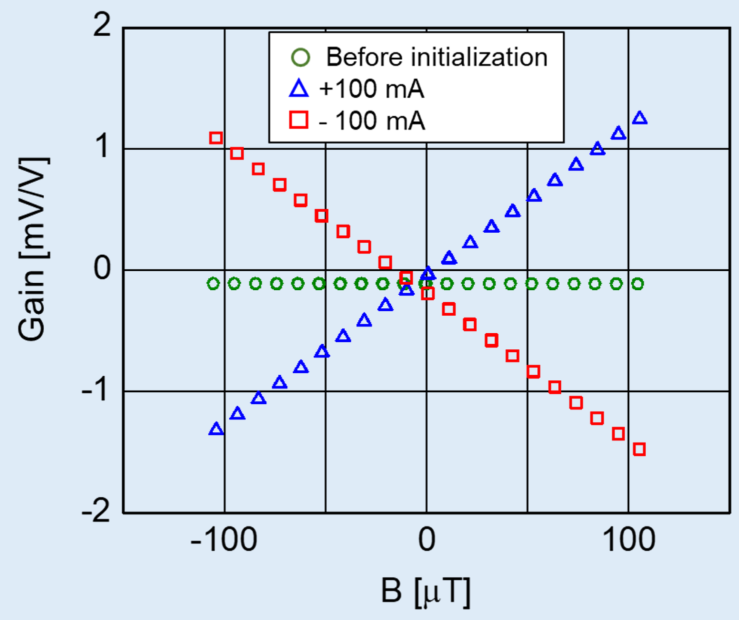
Calibration system by Helmholtz coils



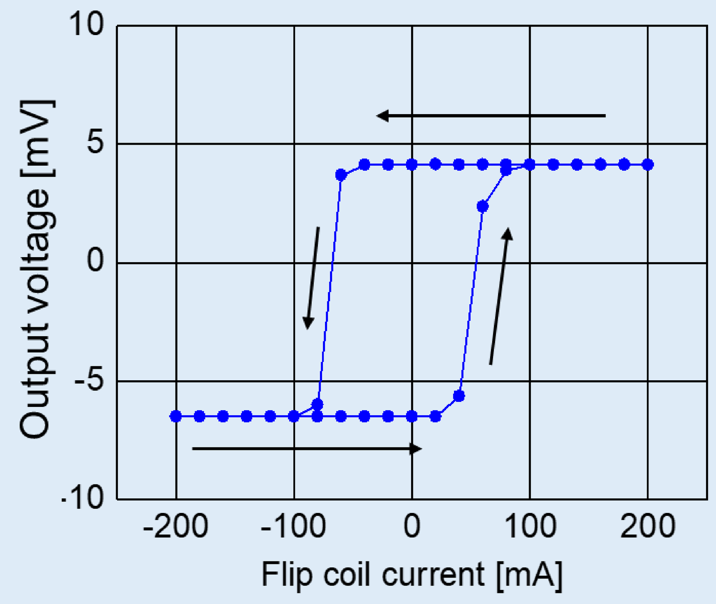
Magnetic fields as function of power supply voltages

Initialization

It is necessary to initialize the AMR sensor prior to using as a magnetic field sensor. The proper magnitude of the flip coil current is determined by the hysteresis curve of the ferromagnetic film used in the sensor. We flow 150 mA to flip coil for initialization of sensor.



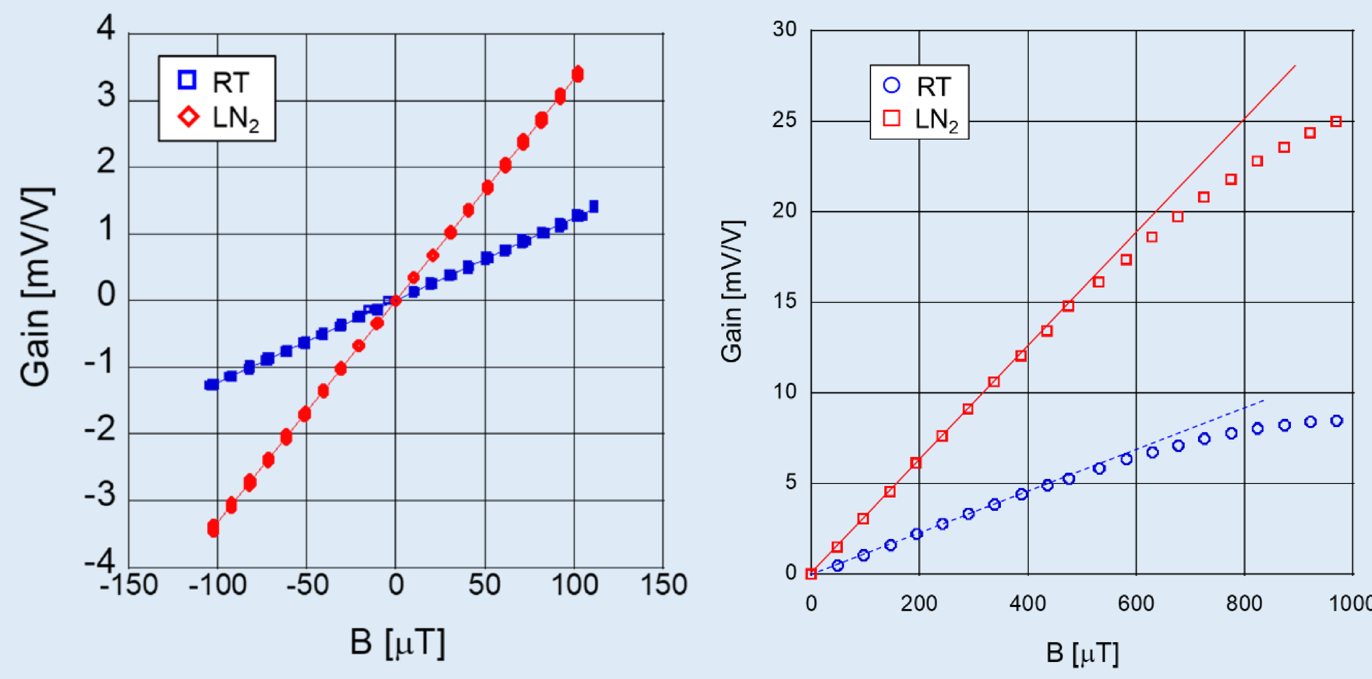
The initialization of sensor by flip coil



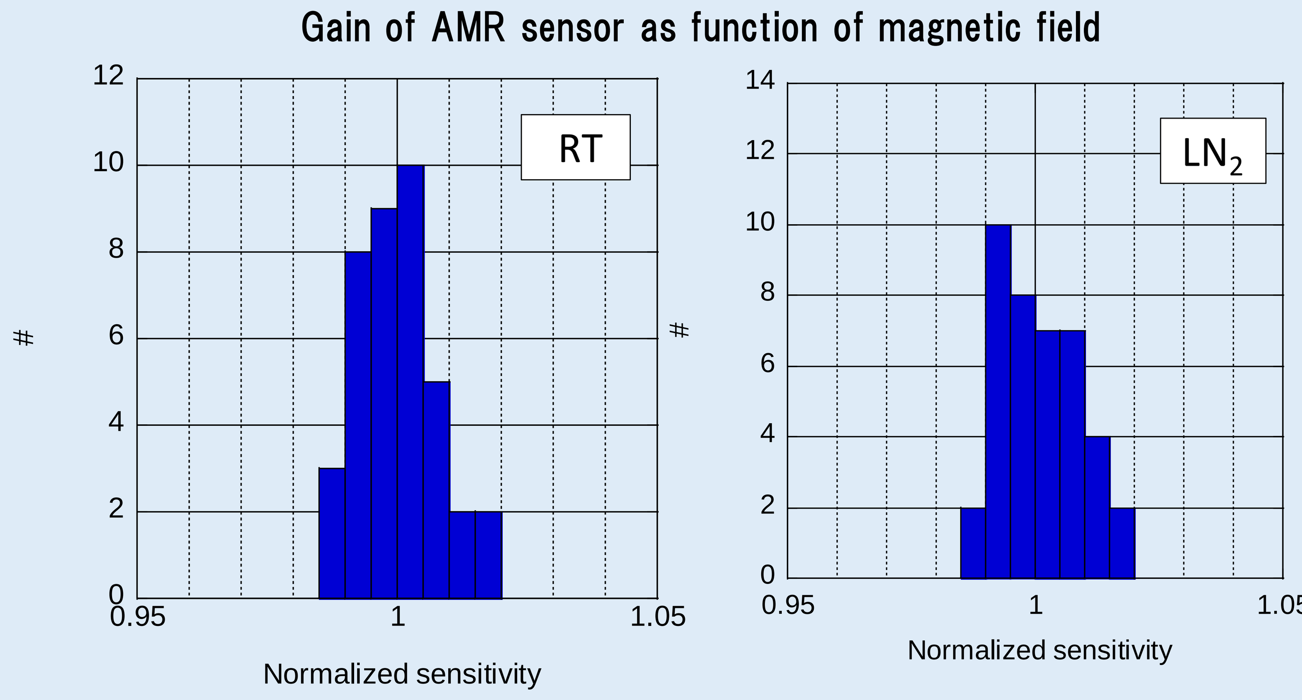
The histories carve of AMR sensor

Evaluation

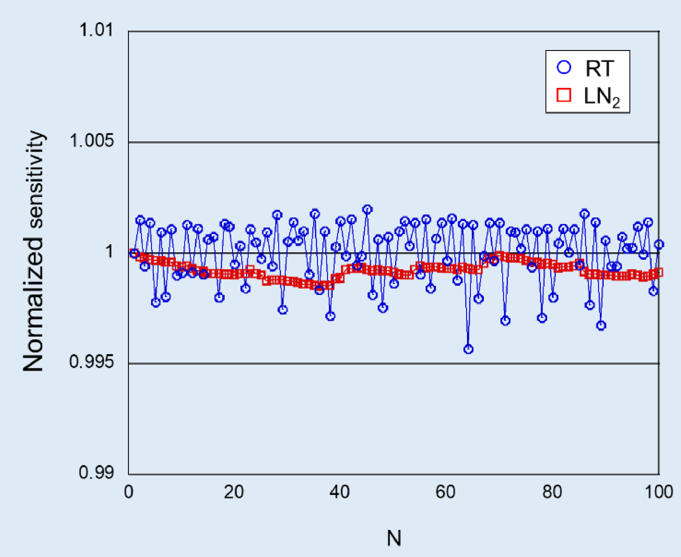
The average of the slopes of the 40 sensors is 3.31 mV/V/0.1 mT at LN_2. The variations of the slopes is less than 2 %. It is seen that the sensitivity is linear up to 0.3 mT. No degradation in the sensor is observed even 14 thermal cycle, between RT and LN_2 temperature.



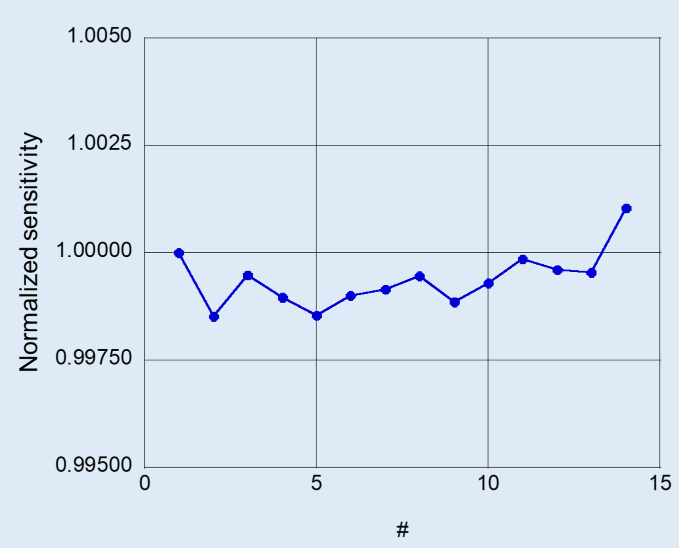
Gain of AMR sensor as function of magnetic field



Histogram indicating the variation of slopes of 40 sensor at RT and LN2 temperature



Change in sensitivity of one sensor



Durability of sensor against Thermal cycles

Summary

We constructed Calibration system of AMR sensors and measured sensitivity at RT and LN_2 temperature. The experiments conform the good stability and durability of the AMR sensor, which are comparable to those of a Hall sensor. The calibration data obtained indicate a good linearity up to 300 μT, which covers the magnetic field range of our interest.
A mapping system based to such AMR sensors can help us understand how the ambient magnetic field is trapped and/or expelled during the cooling down process of an SRF cavity. We plan to repeat this exercise at liquid helium temperature and carry out a flux expulsion experiment when a SRF cavity is cooled down.