Measurement of magnetic field below 10 nT using a fluxgate IC sensor for cryogenic magnetic shield

*Shigetomo Shiki[1], Go Fujii[2]

[1] National Institute of Advanced Industrial Science and Technology, 807-1 Shuku-machi, Tosu, Saga, 841-0052, Japan[1]

[2] National Institute of Advanced industrial Science and Technology, 1-1-1 Umezono Tsukuba, Ibaraki, 305-8568, Japan

Abstract

X-ray spectrometers using a 100μm square, 100-200-pixel superconducting tunnel junction detector array have been developed for SEM-EDX and X-ray absorption spectroscopy [1-2]. These instruments use a magnetic shield to prevent flux quantum trapping in the STJs, but this does not completely prevent flux quantum trapping, making it difficult to operate all pixels simultaneously [1]. To clarify the cause of flux quantum trapping, we studied a method to evaluate the magnetic field and measured the magnetic field inside the magnetic shield.

Generally, the magnetic field inside a magnetic shield is affected by the earth's magnetic field, the history of the applied magnetic field, and mechanical stress. When using a magnetic shield in an X-ray spectrometer with a superconducting detector array, the magnetic shield is screwed onto a cryogenic radiation shield and is exposed to mechanical stress. A magnetic field of approximately 10 mT is applied during STJ detector operation, causing partial saturation of the magnetic shield, which remains magnetized after the magnetic field application is stopped. It is difficult to simulate the magnetic field due to these magnetizations. Therefore, we developed a system that can measure the magnetic shield after it is fixed to a thermal shield and cooled (Fig. 1). A compact fluxgate IC, DRV425,

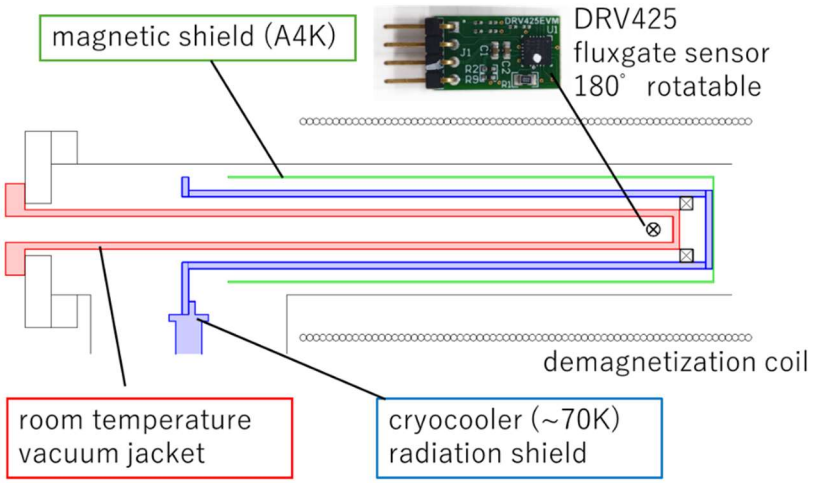

Figure 1. Cross-section of the experimental setup.

was used as the magnetic sensor, and an offset was subtracted for each measurement point. This enabled measurement of weak magnetic fields of less than 10 nT.

The magnetic field inside the A4K single-layer magnetic shield used for SEM-EDX with an STJ array was measured (Fig. 2). The results revealed that (1) when a magnetic field is applied to operate the STJ detector, the magnetic field inside the magnetic shield remains at several tens of nT even after the magnetic field application is stopped, (2) this magnetic field can be removed by AC demagnetization, and (3) the magnetic field near the STJ detector installation position after demagnetization is approximately 15 nT. These results indicate that the magnetic shield is sufficient to block the Earth's magnetic field. Nevertheless, magnetic flux trapping still occurs, likely due to magnetic fields generated by components, screws, printed circuit boards, and connectors used inside the magnetic shield.

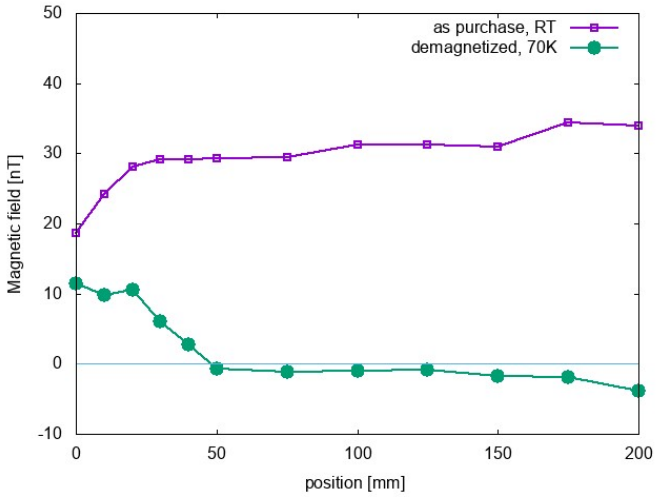

Figure 2 Magnetic field in an A4K magnetic shield at the time of purchase in room temperature (RT) and after AC demagnetization at low temperature (70K). The position of x-ray window is 0-10 mm.

References

1) S. Shiki and G. Fujii, Journal of Physics: Conf. Ser. Vol 3054, 012021, 2025
2) G. Fujii et al. X-Ray Spectrometry Vol 46, pp325–329, 2017

Keywaords: Magnetic Shield, flux gate sensor, STJ, fluxoid, X-ray spectromter