MEASUREMENT OF THE MAGNETIC FIELD PENETRATION INTO SUPERCONDUCTING THIN FILMS*

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ABSTRACT

The magnetic field at which first flux penetrates is a fundamental parameter characterizing superconducting materials for SRF cavities. Therefore, simple, efficient and accurate tool is needed to measure the penetration of the magnetic field directly. The conventional magnetometers are inconvenient for thin superconducting film measurements because these measurements are strongly influenced by orientation, edge and shape effects. In order to measure the onset of field penetration in bulk, thin films and multi-layered superconductors, we have designed, built and calibrated a system combining a small superconducting solenoid capable of generating surface magnetic field higher than 500 mT and Hall probe to detect the first entry of vortices. This setup can be used to study various promising alternative materials to Nb, especially SIS multilayer coatings on Nb that have been recently proposed to delay the vortex penetration in Nb surface.

OBJECTIVE

Design, build and calibrate a simple, efficient and accurate tool to measure onset penetration directly through bulk, thin film and multilayer superconducting samples.

MAGNET

Magnetic coil was fabricated by winding NbTi thin wire carefully on dielectric spool using strategies followed in magnet fabrication. An epoxy was used after winding to obtain a good insulation and a monolithic structure which cannot allow any movement of the conductor inside the coil.

EXTERNAL SETUP

External (left) and internal (right) view of nonmagnetic container which supports the sample, solenoid magnet, and Hall probe symmetrically.

EXPERIMENTAL SETUP

To pass high current

To push the magnet down

Current

To generate a magnetic field parallel to the sample

Field lines from the right half of solenoid magnet placed at 1 mm above the superconducting sample (From Poisson Simulations)

• To maintain a fixed distance (2.5 mm) between the sample and the magnet
• To keep the sample intact during the experiment.

FIELD FROM THE MAGNET ON THE SAMPLE

Magnetic penetration measurements on Nb thin film with thickness 2 µm deposited on sapphire plate using Electron Cyclotron Resonance (ECR) at 4.35 K (left) and 1.97 K (right).

MEASUREMENTS OF THIN FILM SUPERCONDUCTORS ON BULK

Magnetic penetration measurements on Nb thin film deposited on bulk Cu with thickness 1 mm using Electron Cyclotron Resonance (ECR) at 4.35 K (left) and 1.97 K (right).

• The new experimental setup for magnetic field measurements of superconducting samples was designed, built and calibrated successfully at Jefferson Lab. This experimental system is appropriate for bulk samples as well as thin films.

• The linearity of calibration curve confirms that the system is ready for the future measurements to study
   o the possible alternatives to Nb and multilayer system.
   o the dependence of field penetration on the sample thickness and different coating parameters which contribute to the film quality.

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REFERENCES


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