Magnetometer Probe with Low Temperature Rotation and Fiber Optics

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Introduction

Sample rotation is a valuable tool to measure the angular dependence of the magnetization [1], and a new probe was developed to study materials with magnetic anisotropy as well as photoinduced magnetism. This new probe allows for both optical irradiation and uniaxial rotation, all in the low temperature environment of a commercial SQUID magnetometer. As part of the design process, various materials were investigated and characterized for their low temperature, structural, and magnetic properties, including nylons, Vespel, Delrin, Spiderwire monofilament, and PowerPro braided microfilament. Using this information, a prototype was built and operated [2].

Experimental

Sample rotation is uniaxial about an axis perpendicular to the applied magnetic field and is done with a line connecting the low temperature sample holder to a cylinder at ambient temperatures, with an additional line for resetting. Operation can be manual or automated by using a computer controlled stepper motor. A fiber optic cable allows for irradiation. The head of the probe must be light enough to accommodate the servo that translates the entire probe vertically to move the sample through the SQUID coils. Consequently, the housing is aluminum, and the drive shaft uses bearings made from Teflon. Vacuum is achieved by the use of rubber o-rings for the drive shaft seal and for an additional access port on top. Epoxy seals the clear holes made for the fiber optics and the connection between the head and the shaft. The shaft of the probe is constrained to be 0.12 in. OD for use in a commercial QD-MPMS SQUID magnetometer, allowing the commercial shaft seal assembly to be used. The shaft is attached to the low temperature end with epoxy. For the drivelines, Spectra PowerPro 15 lb. braided-line was chosen for its Young's modulus, since stretching of the lines can lead to errors in sample angles. For the low temperature end of the probe, the main pieces are a yoke and a rotatable sample stage. Delrin was chosen for its compromise of strength and small magnetic signal. The yoke is long enough to be locally symmetric with respect to translations vertically through the detector coils, minimizing its flux contributions. The rotation stage is a hollow cylinder employing plastic on plastic bearings, with all but ~90º open for accessibility during irradiation. The drive strings are attached to the rotation stage via nylon set screws.

Results and Discussion

To test the probe operation, a piece of magnetite with the magnetic axis aligned perpendicular to the axis of rotation was measured without any applied field. Sample rotation was tested through greater than 360º and at temperatures down to 2 K. Sample irradiation was also tested using thin films of $A_jCo_k[Fe(CN)_6]_l \cdot nH_2O$ oriented parallel to an applied magnetic field of 100 G at 5 K. Details of the results are reported elsewhere [2].

Conclusions

We have demonstrated the ability to photoirradiate and rotate samples *in situ* while using the convenient setup of a commercial magnetometer, a combination of features previously unreported.

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References

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