Scanning SQUID Susceptometers with Sub-micron Spatial Resolution

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October 8, 2016 (STH44, HP117). Scanning SQUID microscopy images local magnetic fields above a sample with excellent sensitivity but modest spatial resolution. A collaborative effort between Stanford University and IBM Research [1] has developed scanning SQUID susceptometers with demonstrated sub-micron spatial resolution [2]. The SQUIDs were fabricated using a Nb/AlO_x/Nb trilayer technology with two additional levels of Nb metal. They include integrated modulation coils for flux feedback, a gradiometric design for insensitivity to uniform magnetic fields, pickup loops for localized flux sensitivity integrated into the body of the SQUID through well-shielded coaxial superconducting lines, and integrated single turn field coils concentric and coaxial with the pickup loops for scanning susceptibility measurements. High spatial resolution is achieved by deep sub-micron lithography, planarization of all levels of metal but the last, and a deep etch step so that the pickup loop can be brought to within a few tenths of a micron from the sample surface, without additional processing of the devices.

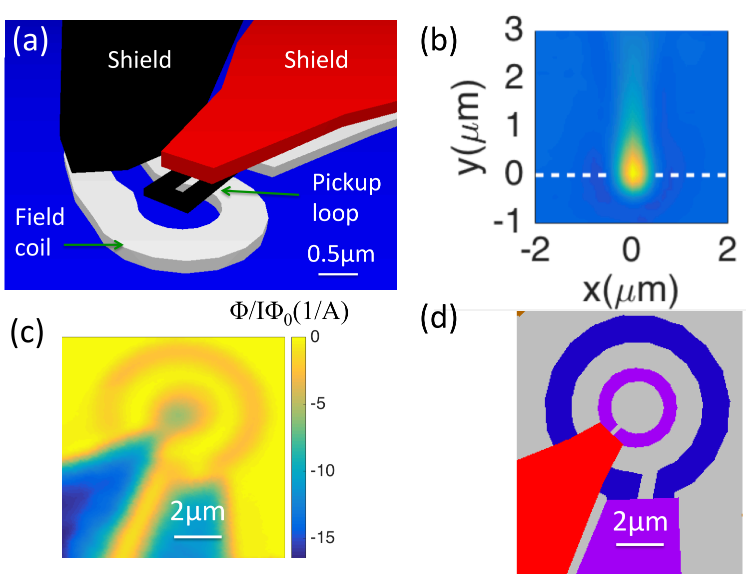

Fig. 1. (a) 3-d rendering of the pickup-loop/field coil region of a 0.2 μm inside diameter pickup loop susceptometer. (b) Magnetometry image of a magnetic nanoparticle. The full-width at half-maximum of a cross-section along the white dashed line is 0.7μm. (c) Susceptibility image of the pickup-loop/field coil region of a 2μm inside diameter susceptometer, taken with a 0.2 μm inside diameter pickup loop susceptometer. (d) Layout of the susceptometer imaged in (c).

The paper describes the design, fabrication, and testing of these susceptometers. It also includes modeling and testing of the response of the pickup loop/field coil region to various magnetic field sources, such as magnetic nanoparticles, superconducting vortices, and lines of current. Such modeling is necessary because the characteristic sizes and spacings are comparable to the London penetration depth. This modeling follows closely a prescription given by Brandt [3].

References

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