# Superconducting Quantum Interference Device Micro Arrays for Biomagnetic Imaging

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Superconducting quantum interference device (SQUID) magnetometers are the most sensitive detectors of magnetic field. The high sensitivity makes them a leading candidate for imaging of the magnetic fields associated with biomagnetic activity. Historically, only SQUIDs fabricated from low temperature superconductors operating at 4.2 K (the boiling point of liquid helium) have been able to reach the necessary sensitivities for practical biomedical applications, however recently we have developed a unique manufacturing method for high transition temperature (high-$T_C$) SQUIDs that can operate at 77 K (the boiling point of liquid nitrogen).

In this approach, very small nanometer-scale Josephson junctions are directly written in a $YBa_2Cu_3O_7$ high-$T_C$ superconductor with a focused helium ion beam. The key to this technique is that high-$T_C$ materials are very sensitive to point defects in the crystal lattice caused by ion irradiation. Increasing irradiation levels has the effects of increasing resistivity and reducing the superconducting transition temperature. At moderate irradiation doses of around $10^{15}$ ions/cm$^2$ the material no longer superconducts and becomes insulating. The irradiation-induced metal-to-insulator transition comes about because the electron mean free path is very sensitive to disorder of the oxygen lattice. Disorder shortens the mean free path of electrons and increases resistivity.

Using this manufacturing technique, we have investigated different arrangements of micro SQUID arrays for a biomagnetic microscope. Figure 1 shows an example of a 9 SQUID imaging array. Each individual SQUID is approximately 10 x 10 microns and the entire array is contained in a 100 x 100 micron area. In this presentation, we will report on the different designs, and electrical properties.

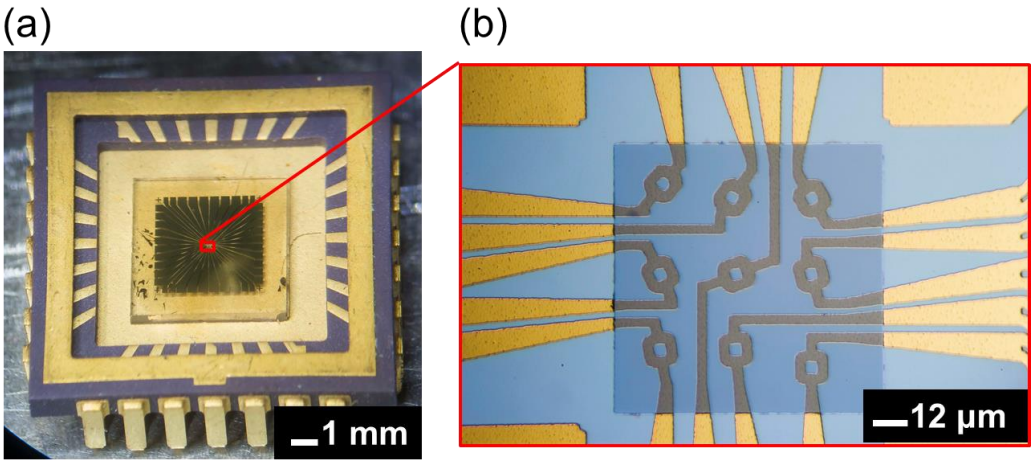


*Figure 1. A 3x3 array of high-Tc SQUIDs for microscope development. (a) 5 mm SQUID array on sapphire chip mounted in a chip carrier. (b) the center of the substrate containing a 3x3 array of high-Tc SQUIDs. SQUIDs with 3-10 µm dimensions can be fabricated reliably using the helium ion microscope fabrication method.*