TRISTAN TECHNOLOGIES

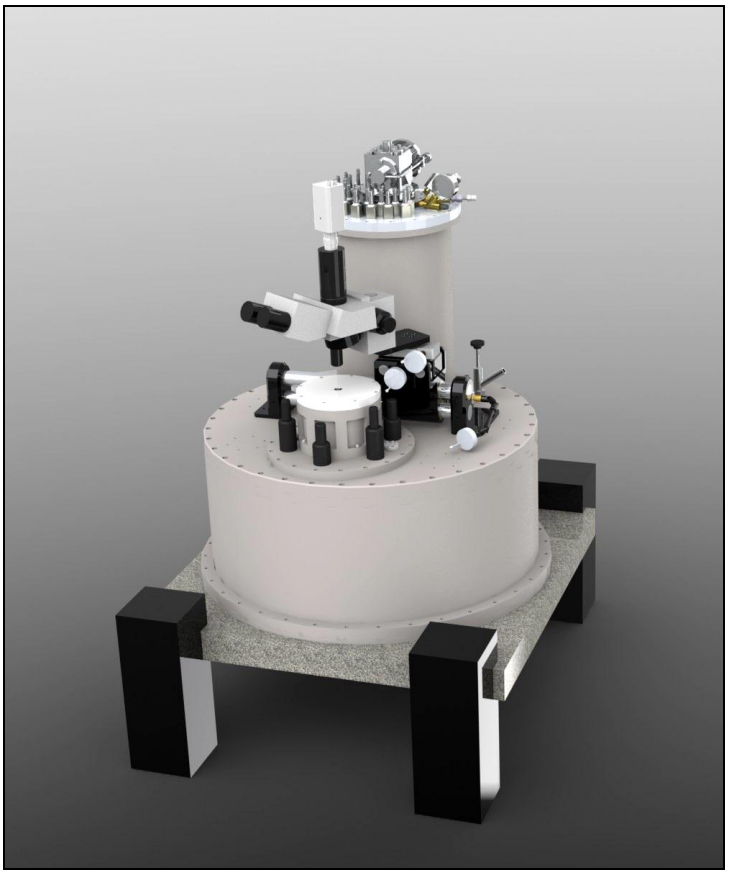
The Inverted SQUID microscope

Tristan Technologies has developed a prototype Inverted SQUID (**S**uperconducting **Qu**antum **I**nterference **D**evice) Microscope for neuroscience research. The target signal levels are much weaker (100-500 fT, fT = 10^{-15} Tesla) than signals in the area of non-destructive evaluation (> 1 pT, pT= 10^{-12} Tesla) where SQUID microscopes have been used previously.

We have shown that a magnetometer-SQUID assembly with a sub-millimeter diameter pickup coil can be constructed with a noise level of about 50 fT/√Hz. We have also determined the minimum thickness of the sapphire window that serves as the barrier between the sample at atmospheric pressure and the SQUID sensors in vacuum.

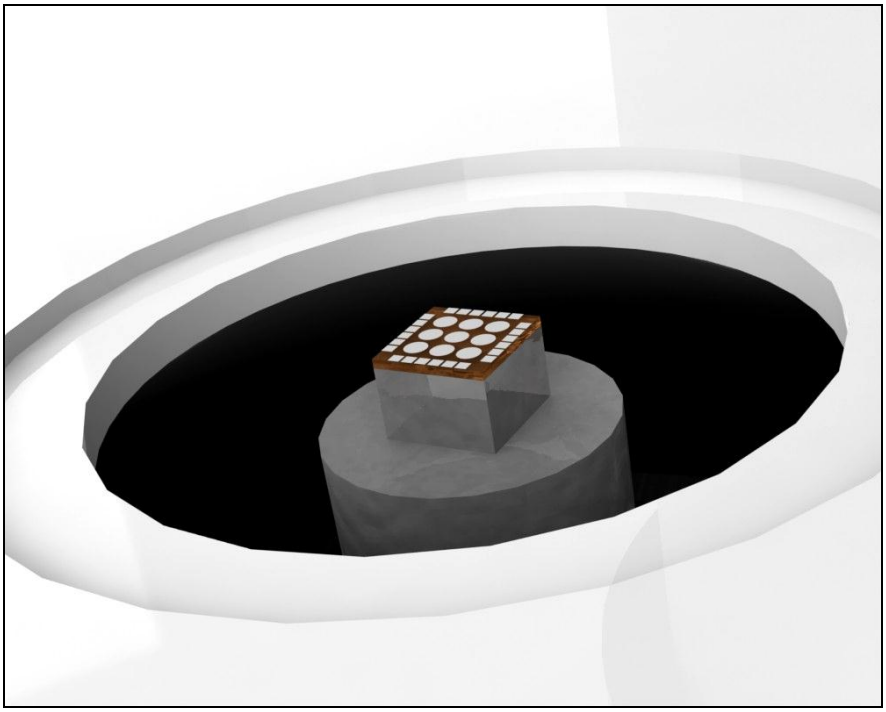
The current prototype features:

- 8-channel magnetometer SQUID sensory array
- 600 μm diameter magnetometer pick up coil
- Nominal field sensitivity better than 70 fT/√Hz
- 200 μm from pickup coils (at 4 K) to neurons and glial cells (at room temperature)



The inverted SQUID microscope, shown with optical microscope and cryocooler

The term “inverted” is adopted because the microscope is similar to an inverted optical microscope except the objective lens is replaced by an array of superconducting miniature magnetic field sensing coils.



Sample window showing the 3x3 superconducting pickup coil array centered beneath the sapphire disk (not shown).

Testing of the microscope in an experimental setting is underway in order to evaluate its full range of capabilities in neuroscience research. We first determine the field sensitivity (in fT/√Hz) in a magnetically shielded room without sample. We then measure magnetic fields produced by a neocortical slice. We determine the signal levels from the slice and compare with our predictions. The microscope should be useful for other applications that include measurements of:

(1) Electrical currents from single neurons and glial cells in culture
(2) Efficiency of bonding of antigens and magnetically tagged antibodies (immunoassay)
(3) Movements and conformational changes of a small number of magnetically tagged molecules in a cell for studying signaling pathways

The inverted SQUID microscope is be useful in both academic setting and industry for understanding the electrophysiology of small cells that are difficult to study with electrodes, for drug discovery and for studying second-messenger systems.

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