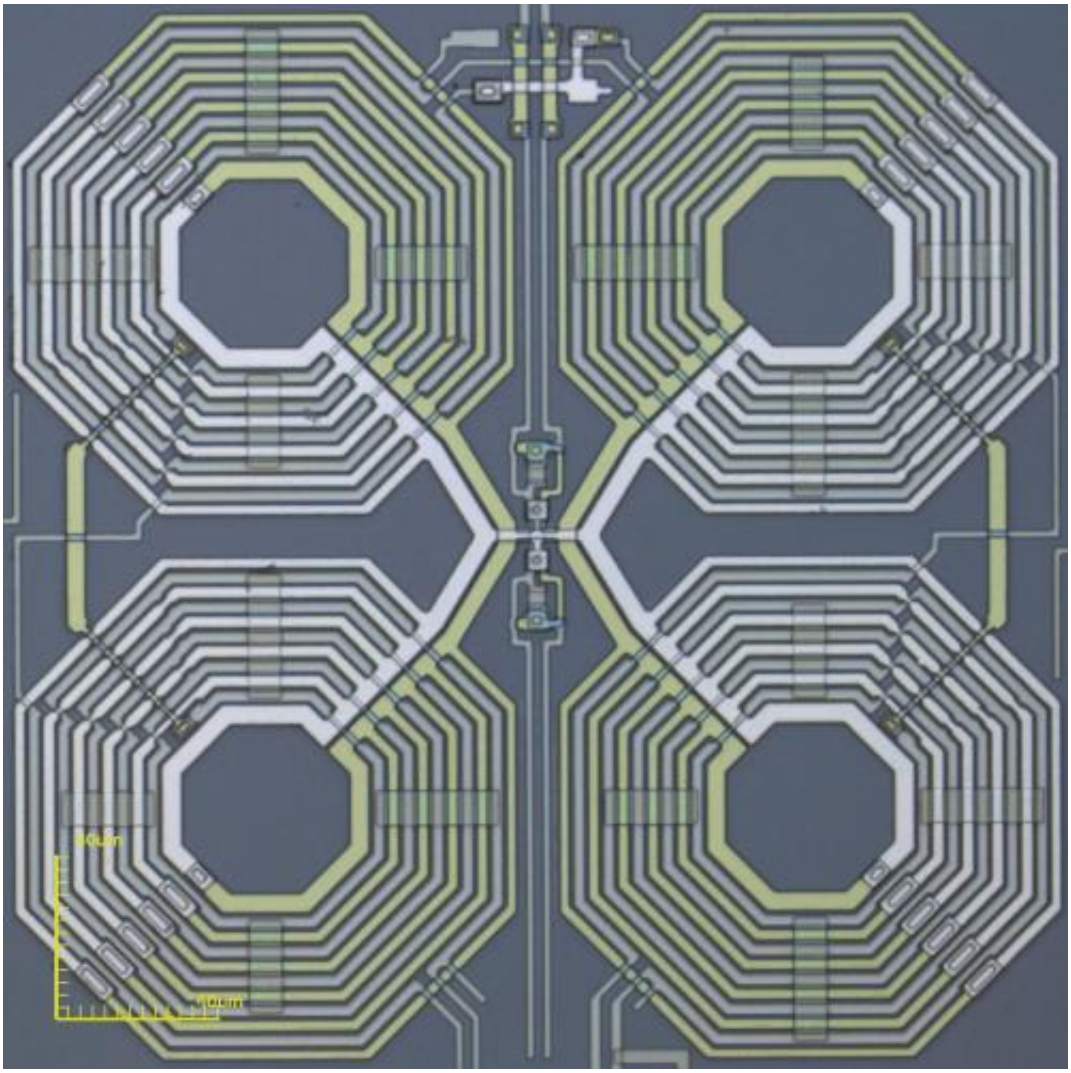
Physicists pay homage to the SQUID at 50

March 13 2014, by Laura Ost



Micrograph of a SQUID amplifier, made at NIST in 2012, that is part of a circuit used to read signals from arrays of superconducting sensors. Small currents generated by the sensors are carried and amplified in the coils, which create magnetic fields detected by the SQUID (two small squares in the center of the image). Credit: NIST

From humble beginnings in a series of accidental discoveries, SQUIDs have invaded and enhanced many areas of science and medicine, thanks, in part, to the National Institute of Standards and Technology (NIST).

SQUIDs—short for superconducting quantum interference devices—are the world's most sensitive magnetometers and powerful signal amplifiers, with broad applications ranging from medicine and mining to cosmology and materials analysis.

Physicists from around the world celebrated last week* to mark the 50th anniversary of the first journal paper introducing the SQUID, published in February 1964.

Celebrants heard about the use of SQUIDS to measure brain activity in Finland, discover mineral deposits leading to a large silver mine in Australia, and detect faint light from the early moments of the universe from telescopes all over the world.

SQUIDs measure magnetic fields based on quantum properties created when a superconducting circuit loop, in which electricity flows without resistance, is interrupted with one or two short sections of resistive material. The current across the resistive section varies predictably, based on the strength of the external magnetic field, making the device an exquisitely sensitive detector of magnetic fields. Typically, SQUIDs need to be cooled to cryogenic temperatures below 4 kelvins (-269 degrees Celsius) with liquid helium.

The SQUID was invented at Ford Scientific Laboratories in the 1960s but was further developed at NIST (then called the National Bureau of Standards). James Zimmerman co-invented one type of SQUID (the RF-SQUID) and coined the term while at Ford, before joining NIST where he worked in the 1970s and 1980s.

Jim Zimmerman with a multi-hole RF-SQUID, a design concept he developed at NIST in the 1970s. Credit: NIST

One of his SQUIDs helped launch the field of biomagnetism—the medical use of SQUIDs. The first magnetocardiogram (MCG) with a strong, low-noise signal was performed with a portable SQUID made by Zimmerman at NIST to measure the magnetic signal of his own heart**. The experiment, performed at the Massachusetts Institute of Technology, was the first time a SQUID recorded a living signal, and launched a growing field today.

Among other advances at NIST, Zimmerman also made early SQUIDs for magnetoencephalography (MEG), which noninvasively measures magnetic fields produced by electrical activity in the brain. In 1987, Zimmerman and NIST colleagues used a then-new high-temperature superconductor to make the first RF-SQUID—and probably the first

superconducting electronic device of any kind—to operate at the temperature of liquid nitrogen, a relatively inexpensive and easily handled coolant.

Today, NIST remains a center of SQUID innovation. In addition to designing and making custom SQUIDs in a microfabrication facility, NIST researchers also invented a method for wiring hundreds of SQUID signal amplifiers together with large arrays of superconducting sensors. When used as amplifiers, SQUIDs measure the magnetic fields created in coils that carry and amplify very small currents generated by sensors.

For instance, SQUIDs made at NIST have been used to amplify sensor signals in more than 10 telescopes in North and South America, Hawaii, the South Pole and elsewhere. NIST SQUIDs also are used in imaging of hidden threats and for X-ray materials analysis.

More information: * The SQUID at 50: Impact and Future, Industrial Physics Forum at the American Physical Society March Meeting 2014, March 4, 2014, Denver, Colo.

** R.L. Kautz. Jim Zimmerman and the SQUID. *IEEE Transactions on Applied Superconductivity*, Vol. 11, No. 1, March 2001

Provided by National Institute of Standards and Technology