MANUFACTURING FLAGSHIP
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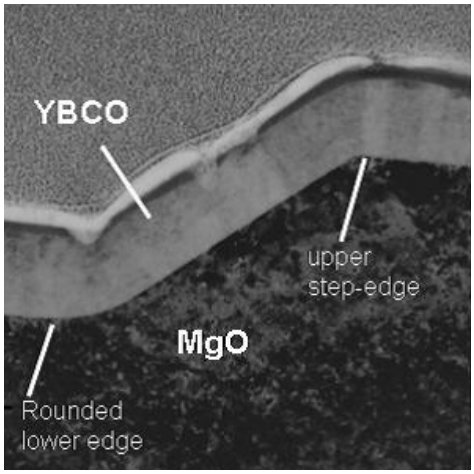
Superconducting devices

Superconductors are materials with special quantum electronic properties when cooled to low temperatures. They can be used to make ultra-sensitive magnetic field and RF sensors based on macroscopic quantum effects. We specialise in novel superconducting devices including Josephson junctions, SQUIDs*, microwave and terahertz devices, and the system development surrounding these sensors.

The step-edge junction

CSIRO has created a new High Temperature Superconducting (HTS) step-edge Josephson junction technology with valuable features, such as using low cost substrates and the flexibility of positioning multiple junctions anywhere on the substrates.

HTS electronic devices, such as SQUIDs, microwave and terahertz devices, have been routinely fabricated using this patented technology.



TEM cross-section of a HTS YBCO step-edge junction; the junction forms on the upper MgO step-edge

New junction array capability

The flexibility of placing our step-edge junction anywhere on the substrate allows the manufacture of 2D arrays and of integrated circuits that can dramatically enhance device performance.

CSIRO has made significant progress in developing new step-edge junction array capability with a coordinated research program since 2011.

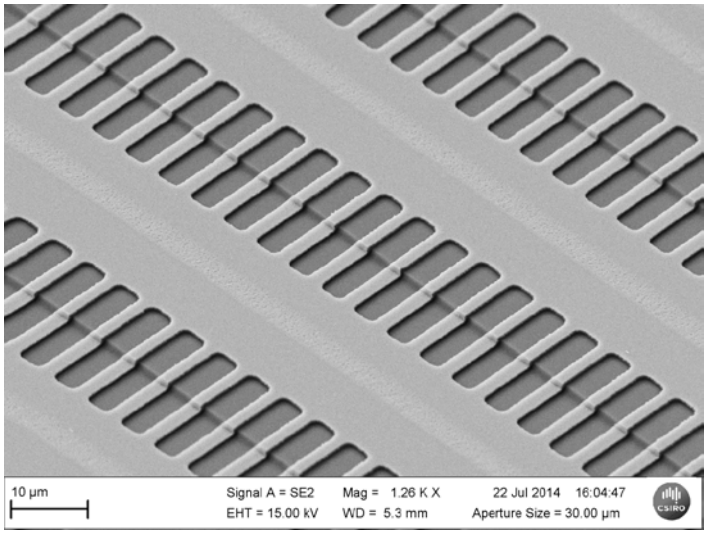
We are now able to offer the new foundry service to potential customers who wish to source or develop the HTS array junction devices using our exciting new capability.

Superconducting Quantum Interference Devices (SQUIDs*)

Superconducting Quantum Interference Devices (SQUIDs) are very sensitive magnetic field sensors; capable of detecting magnetic fields with intensities of less than 10^{-8} of the Earth's field.

CSIRO is a world leader in developing HTS SQUID magnetometers and gradiometers with excellent sensitivity, low noise performance and longevity including tensor information.

CSIRO offers an extensive range of high-Tc superconducting (HTS) SQUID magnetometers and gradiometers for sale.



A part of a large 2D step-edge junction array device

LANDTEM – locating ore deposits

- CSIRO's LANDTEM™ is a highly portable exploration tool which can identify the difference between ore and conductive overburden, even when the ore body is deeply buried.
- LANDTEM™ uses highly sensitive CSIRO HTS SQUIDs which can detect magnetic anomalies at greater depths compared with conventional magnetometry.
- LANDTEM™ accurately measures the magnetic (B) field, rather than the rate of decay of induced eddy currents used conventional coil systems.
- LANDTEMTM is helping unearth large deposits of nickel sulphide and silver worth hundreds of millions of dollars.

LANDTEM

UXOMAG – Unexploded ordnance (UXO) remediation

- UXOMAG is a mobile magnetic tensor gradiometer prototype system capable of not only detecting, but also locating and classifying UXO.
- UXOMAG measures all five independent magnetic tensor components allowing the user to discriminate between harmless metallic debris or shrapnel and a potentially lethal UXO.
- UXOMAG uses multiple CSIRO HTS planar SQUID gradiometers configured unique geometry to determine the magnitude of the full tensor. Referencing magnetometers are used to improve common mode rejection.
- UXOMAG's high sensitivity has the potential to detect 40 mm calibre UXO at a distance of up to 4m away.

UXOMAG HTS tensor gradiometer

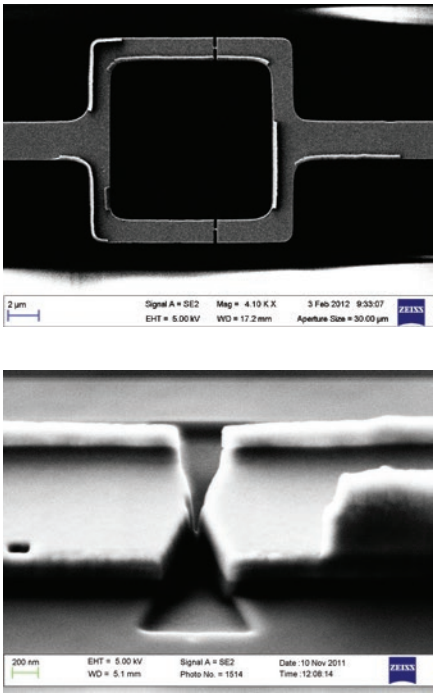
GETMAG – Geophysical exploration and mine detection

- GETMAG is another mobile magnetic tensor gradiometer prototype system specially developed for extremely low frequency magnetic anomaly detection such as geophysical exploration or mine detection.
- GETMAG directly measures the absolute value of all five independent magnetic tensor components.
- GETMAG uses CSIRO patented rotating HTS axial SQUID gradiometers for accurate determination of the full tensor.
- GETMAG's unique rotating drum system enables frequency separation of the common mode signal and gradient signal to generate highly balanced gradient output.

GETMAG HTS tensor gradiometer

Novel nano-structured devices

Using the CSIRO Lindfield Nanofabrication Facilities including E-beam-lithography (EBL) and Focused Ion Beam (FIB), we have fabricated a number of nano-structured superconducting electronic devices. These include Niobium (low-Tc superconductor) nano junction-based SQUIDs, high-Tc superconductor nano step-edge junctions, NanoSQUIDs, for the detection of magnetic nanoparticles.



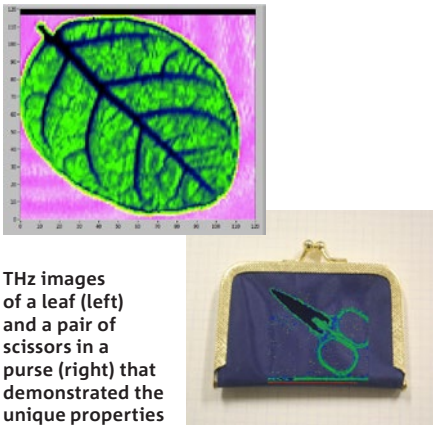
Scanning electron micrograph of micro-fabricated dc SQUID in thin film Nb (left) with nanobridges (right) fabricated using FIB.

Superconducting detector-based THz imager

Superconducting electronic technology enables the generation and detection of electromagnetic radiation at Terahertz (THz) frequencies, a difficult frequency range above the reach of conventional semiconductor devices and below that of optical devices.

CSIRO has developed

- Novel HTS THz detectors based on thin-film antenna-coupled HTS step-edge Josephson junctions.
- A compact solid-state multi-band THz imaging system for combined advantages of penetration depth and resolution.
- A cryogen-free superconducting detector imaging system.
- Currently, working with an industry partner for applications in security check point and safety inspection of food and agriculture products.
- We seek further partnership for application exploration of this new technology.



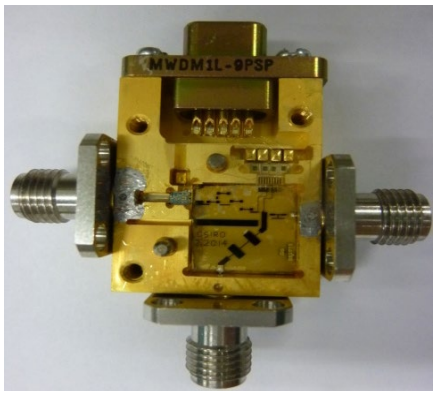
THz images of a leaf (left) and a pair of scissors in a purse (right) that demonstrated the unique properties of THz wave, i.e. sensitivity to water and high transmission through non-conducting package materials.

HTS microwave mixers and MMIC receivers

CSIRO is the word leader in developing novel HTS microwave passive components (filters and resonators) and Josephson junction-based active devices (oscillators and mixers) for wireless communications.

The major achievement and the world-first developments include

- The frequency-tuneable gigahertz HTS Josephson heterodyne oscillator and mixer.
- The monolithic microwave integrated circuit (MMIC) HTS frequency down-converters and receiver front-ends.
- Integrated with a commercial mini cryocooler. Have achieved a portable HTS MMIC receiver front-end.
- Achieved a Ka-band HTS receiver front-end module of high conversion gain (>40 dB) and low (< 0.5 dB) noise figure.



The latest CSIRO demonstrator of a compact, high-gain (40 dB) and low noise (< 0.5 dB) Ka band HTS receiver front-end module.

CONTACT US
t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

AT CSIRO WE SHAPE THE FUTURE
We do this by using science to solve real issues. Our research makes a difference to industry, people and the planet.

WE ASK, WE SEEK AND WE SOLVE

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Manufacturing Flagship
w **www.csiro.au/industrial-innovation**

Marcel Bick
t +61 2 9413 7473
e marcel.bick@csiro.au

Jia Du
t +61 2 9413 7107
e jia.du@csiro.au

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