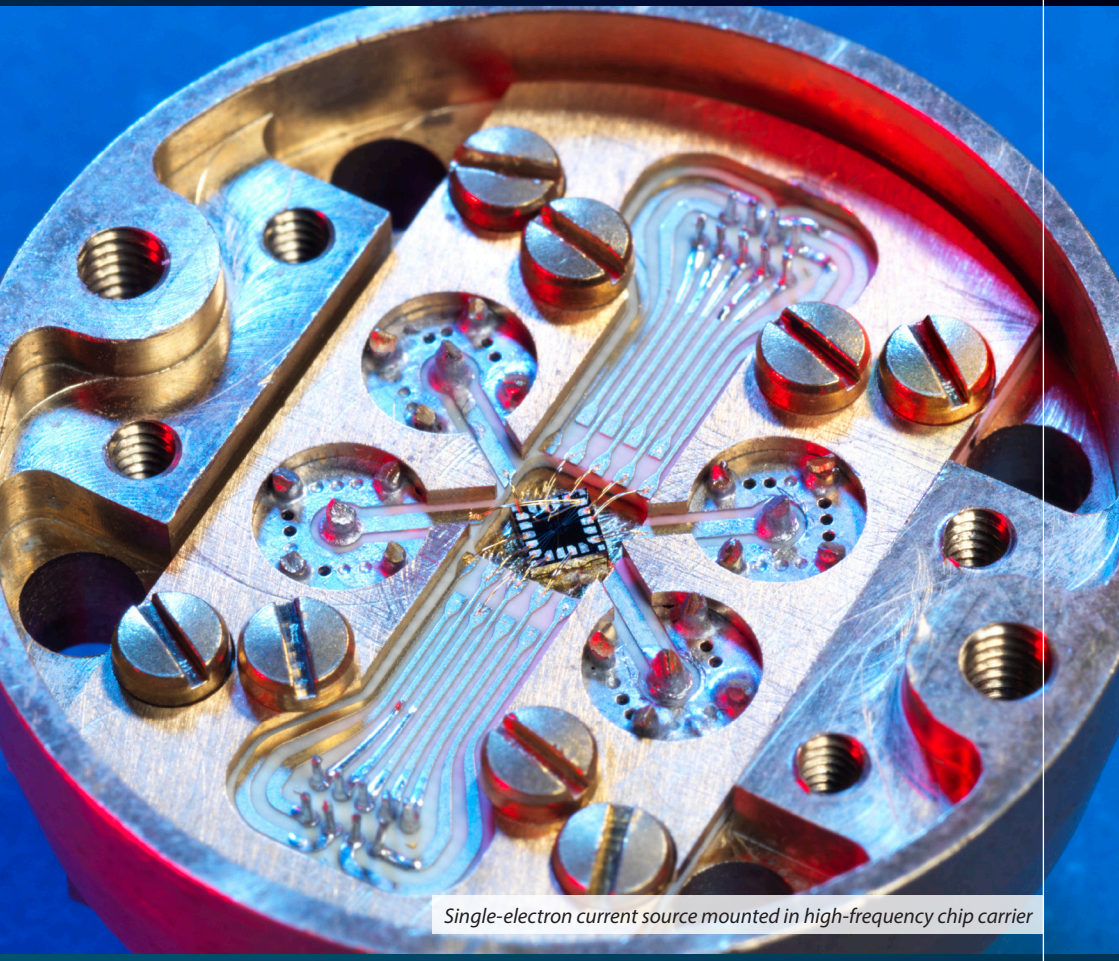
NPL

Quantum



Single-electron current source mounted in high-frequency chip carrier

Metrological capabilities for solid state quantum technologies

NPL is developing novel metrology to support the characterisation of components and enable ultra-high accuracy electrical measurements for the emerging quantum industry.

npl.co.uk/qmi

What it is:

We are showing two solid-state technologies: a cryogenic near-field scanning microwave microscope (NSMM) and a noiseless single-electron current source.

The NSMM is an instrument for mapping out microwave properties and pinpointing individual defects in quantum circuits. These defects are a key limitation in the performance of quantum computers.

The single-electron current source moves individual electrons a billion times each second to generate noiseless currents with ultrahigh accuracy for metrological applications.

Who it's for:

The NSMM is being developed to help the emerging solid-state quantum technology industry image and characterise the materials and devices that are used to build chips for superconducting quantum computers and so improve their performance. It enables:

- On-chip characterisation of working quantum processors at ultra-low temperatures.
- Spatial mapping of microwave losses at the nanometre scale
- Identification of fabrication-induced defects and impurities.

The single-electron current source is aimed at primary electrical metrology following re-definition of the SI unit ampere in 2019. Advances in small current measurement techniques enabled by this source are benefitting the following fields through ongoing projects:

- Radionuclide metrology and dosimetry
- Characterisation of low leakage currents in semiconductor devices
- Measurement of environmental particulates

Key facts and data

- The NSMM is operated in a dilution refrigerator at a temperature of 10 mK and signal levels corresponding to a few hundred microwave photons
- The spatial resolution of the NSMM is approximately 100 nm.
- Single-electron current source. Up to 10^9 electrons per second (a current of 160 pA) with a relative error rate less than 10^{-7}.
- The current source does not contribute any thermal or shot noise: the noise is dominated by the device under test.

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Department for Business, Energy & Industrial Strategy

FUNDED BY BEIS