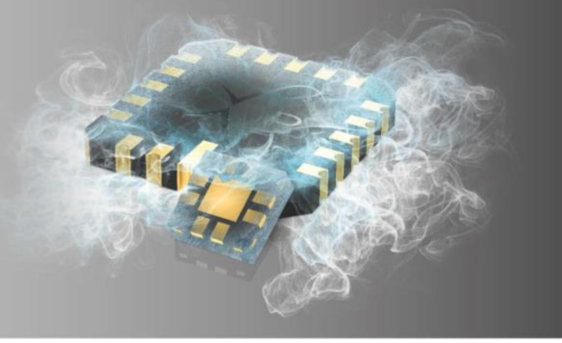
PARAGRAF SENSORS



Paragraf® is enhancing its customers' ability to conduct magnetic field measurement in low-temperature and high-field environments.

Because of limitations in size and power dissipation, many prevalent measurement methods are incompatible with these applications. Consequently, Hall effect sensors have emerged as the superior option due to their compact size. Until now though, conventional Hall sensors have themselves been limited by material capabilities and a phenomenon known as the quantum Hall effect (QHE). With our unique graphene deposition process, Paragraf is averting these limitations by producing a Cryogenic Graphene Hall Sensor (GHS-C) which has achieved operation down to mK temperature and fields measurements of over 30 T.

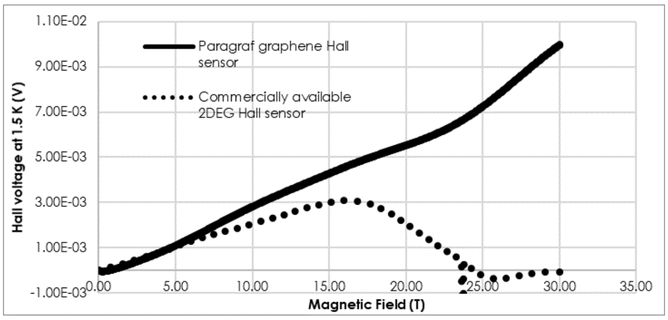
Graphene and Robustness

Conventional Hall effect sensors can experience thermal expansion and contraction of their components when moving between varying temperatures, leading to the degradation of materials and failure of the sensing function.

Owing to its two-dimensional structure, graphene is an exceptionally flexible and robust material, capable of withstanding extreme temperatures and temperature shocks. Paragraf's GHS-C makes use of that flexibility, while enhancing the overall material strength of the sensor, by handling the entire construction process in our own facility. Using our patented technique, we incorporate the graphene layer into the sensor in a structurally-sound and impurity-free manner. This produces a sensor with a superior, highly durable construction.

Paragraf and the QHE

The QHE involves a loss of linearity for voltage outputs above a particular field strength in low temperatures. Once sensors encounter fields above that threshold, the corresponding readings increase in plateaus and sharp inclines, rather than in a continuous, proportional trendline. This makes the device unusable as a cryogenic magnetic field sensor.



This chart illustrates that Paragraf's GHS-C maintains its linearity in high-field environments well beyond the capability of a common Hall sensor.

Paragraf's graphene deposition enables us to modify the sensitivity of our sensors. Through experimenting with the GHS-C, we have found we can delay the onset of QHE so that we are producing sensors that maintain their linearity up to ~30T, as demonstrated at the The High Field Magnet Laboratory in Nijmegen (The Netherlands).

Ease of use

The Paragraf GHS-C's ability to operate at low temperatures means that it does not require the use of additional inserts to protect it. This allows for enhanced flexibility in locating a device within the sample loader. The small size of the GHS-C (3 x 3 x 1.2 mm), and its very low power dissipation (a few nanowatts), mean that the device can be placed closer to the field of interest and have the accuracy of its measurements improved.

Benefits

- Linearity up to 30T
- Operable at mK
- Low form factor (3 x 3 x 1.2mm ceramic QFN package)
- Lack of planar Hall effect, owing to 2D construction
- Very high resolution

Applications

- Magnetic field monitoring for Quantum computing.
- Electromagnet R&D and manufacture.
    - Mapping of superconducting magnets – direct in cold bore (no room temperature insert required).
- Accurate magnet calibration at cryogenic temperatures.
    - Monitoring of persistent mode magnet drift.
    - Flux pinning identification.
- Magnetic field monitoring during cryogenic experiments.
    - Built into superconducting magnet coils (active or persistent mode).
    - Built onto sample stages designed for cryogenic use.
- Magnetic shielding attenuation factor determination – use the same sensor for field measurement on the inside and outside of the shield.
    - To characterise shielding of superconducting magnets.
    - To characterise magnetic shielding composed of superconducting material.

Paragraf GHS mounted on an Oxford Instrument's Proteox development fridge

www.paragraf.com
sales@paragraf.com