Quantum magnetometer: Precision meets versatility

Room temperature operation and compact design for new applications

www.qant.com/magnetometer

Quantum technology opens up new dimensions in magnetic field measurements

High-sensitivity magnetic field measurements previously required bulky equipment and special laboratory conditions. The Q.ANT magnetometer works under everyday conditions. High-precision magnetic field measurements can thus be rethought.

The NV magnetometer from Q.ANT momentarily allows the measurement of very small magnetic fields in the range of 300 picotesla at room temperature. Until now, this sensitivity range was only achieved by cooling sensor systems to an absolute zero at -273 °C or by heating up to 150 °C. Based on the principles of quantum physics, nitrogen vacancies (NV) in diamonds can be used to high-precisely measure physical quantities such as magnetic fields. Under laboratory conditions, sensitivities in the sub-picotesla range have been achieved.

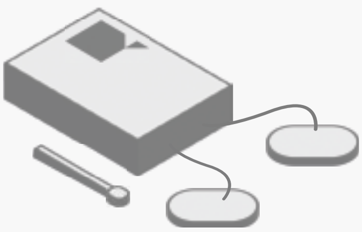
The advantages

- Extremely high sensitivity under everyday conditions
- Wide dynamic range: Detects very small magnetic field changes even with strong background fields
- High spatial resolution
- Detection of magnetic field direction: Allows e.g. conclusions about the location of the magnetic field source

The next level of evolution – the gradiometer

With the gradiometer, Q.ANT is already working on the next generation of magnetic field sensors. In addition to further miniaturisation, the gradiometric measurement effectively suppresses background noise and the resolution of the sensor is increased to 10pT.

The system consists of electronic components and fibre-coupled sensor heads, which are placed at the actual measuring point. This significantly simplifies integration into applications, and makes the sensor robust and mobile enough to be used and applied outside the laboratory.



The advantages

- Higher spatial resolution
- Elimination of interfering signals
- Miniaturisation for a wide application range
- Compactness and robustness for everyday applications

High precision magnetic field measurement for industry and science

NV magnetometers have been researched in science for many years. Under laboratory conditions, the suitability of the NV sensors for measuring the smallest magnetic fields down to below 1 pT could be demonstrated. This corresponds to magnetic fields that are 50,000,000 times smaller than the earth's magnetic field. Physical quantities such as temperature, current flow and pressure can also be resolved with the sensors. Q.ANT has set itself the goal of translating this technology into reliable sensors suitable for industrial use. Concrete scenarios are currently emerging in these areas:

Prosthetics

Locally resolved measurement of muscle signals for the control of prostheses and exoskeletons (MMG)

Medical Technology

Early detection of brain diseases and localized measurement and detection of muscular signals, heart and patient monitoring

Automotive and Mobility

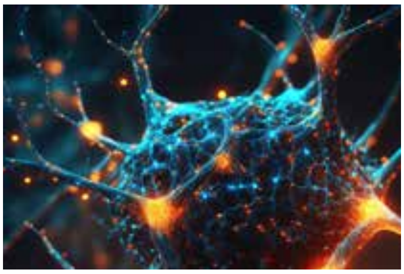
Applications in localization, navigation, identification and communication

Electronic and Material Control

Quality control or failure analysis for electrical and electronic components, e.g. circuit carriers or hard disks; detection of fault currents in power chips or batteries. Identification of defects in the material structure of components

Geophysics

Exploration of magnetic fields in the Earth's interior for the investigation of plate tectonics and mineral deposits



Materials Science and Nanotechnology

Characterization of magnetic materials and nanoparticles. Investigation of biological processes and nanoscale magnetic phenomena in biophysics and nanotechnology

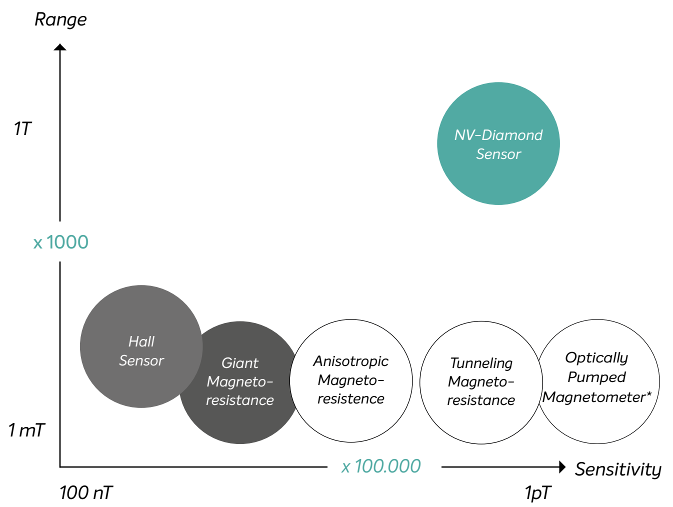
Performance data of the technology demonstrator

Size	150 x 107 x 120 mm
Weight	1,5 kg
Energy consumption	17 W
Interface	Ethernet
Resolution	< 300 pT/sqrt(Hz)
Sensor size	0.5 x 0.5 x 0.5 mm
Dynamic range	2.7 µT (optional: resonance locking)
Laser wavelenght	520 nm
Frequency bandwidth	3kHz

An Outlook on the future of magnetometry

2023 *PORTABLE MAGNETOMETER*	**2024** *INTEGRATED GRADIOMETER*	**2025** *UNSHIELDED INTEGRATED GRADIOMETER*	**2026** *PORTABLE GRADIOMETER*	**2027** *PORTABLE GRADIOMETER*
Dimension *< 1000 ccm*	Dimension *1000 ccm*	Dimension *< 500 ccm*	Dimension *< 300 ccm*	Dimension *< 100 ccm*
Sensitivity Performance *100 pT/√Hz*	Sensitivity Performance *50 pT/√Hz*	Sensitivity Performance *20 pT/sqrtHz*	Sensitivity Performance *10 pT/sqrtHz*	Sensitivity Performance *< 10 pT/sqrtHz*

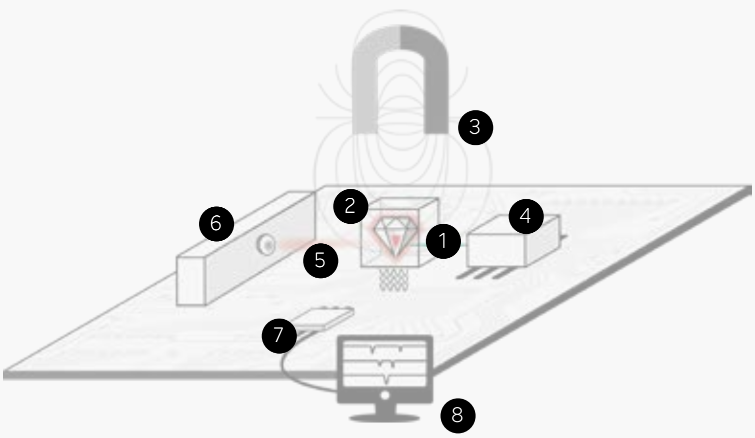
Advantages of diamond magnetometers over state-of-the-art magnetometers



*Further restrictions of OPMs: Low bandwidth of 200 Hz, Operation temperature 120 °C

- Room temperature operation
- High sensitivity (pT/sqrt(Hz))
- Large bandwidth (dc – kHz)
- Large dynamic range (up to several T)
- Contactless measurement
- Vector-magnetometry integratable
- Miniaturizable
- Biocompatible

NV Magnetometry: How the Q.ANT magnetometer works



1. Diamond: located at the heart of the sensor, the diamond becomes magnetic field sensitive by inserting an atomic lattice vacancy and a nitrogen atom, a so-called NV doping

2. Microwaves: bring the NV dopants into a magnetic field sensitive state

3. External magnetic field: has an effect on the sensor

4. Green laser: radiates onto the NV diamond and makes the NV dopants fluoresce with red light

5. Red fluorescent light: changes when external magnetic field changes

6. Photodetector: detects the fluorescent light

7. Control unit: processing of photodetector data

8. Monitor: user-friendly display of the signal

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Everywhere where finest currents have to be measured, the quantum magnetometer opens up new possibilities. This technology enables a wide range of future-oriented applications in industry, research and medical technology, all the way to human-machine interaction.
The control of prostheses by muscle signals with the quantum magnetometer becomes a realistic scenario.

Michael Förtsch, Founder and CEO, Q.ANT

Q.ANT makes quantum technology applicable for numerous industries and use cases. Founded in 2018 as part of the Trumpf Group in Stuttgart, the company develops quantum sensors and quantum computing chips in four product lines. Photonic Quantum Computing, Particle Metrology, Atomic Gyroscopes, and Magnetic Field Sensors.

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