Why Quantum Sensing Hub Freiburg?

With our unique infrastructure we offer the ideal starting point for research and development work in the field of magnetometry with quantum sensors. The areas of application of our measurement technology and systems spans from material analysis, industrial process monitoring, space equipment qualification, nanoelectronics to biomedical applications.

Our partners from science and industry have the opportunity to evaluate the innovative potential of quantum sensors for their specific requirements. With our broad range of high-resolution and high-sensitivity measurement systems we have the quantum sensing solution for your individual measurement or R&D needs.

What we offer

- Exploring novel use-cases of quantum sensing and magnetic field sensing
- Validation of samples and measurements
- Test and verification of components
- State-of-the-art benchmark sensors and full imaging instruments
- Experimental characterization via quantum magnetometry and mechanism-based modelling of materials

If you are interested in testing quantum magnetometers for your specific applications, please contact us. We look forward to supporting you and paving the way of quantum sensors into industry!

Further Information

Visit our website and get an overview of our consolidated research infrastructure:
www.s.fhg.de/quantum-sensing-hub-freiburg

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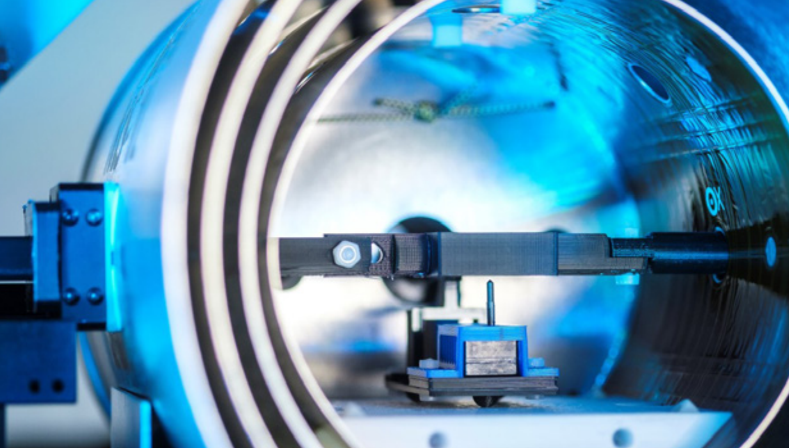
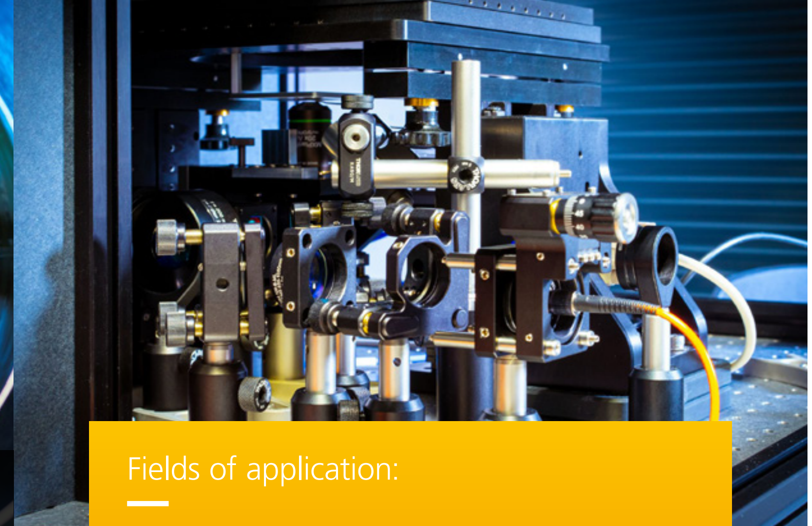
Quantum magnetometry for industry and research

Quantum Sensing Hub Freiburg

Material testing with OPM-based field mapping (left) and NV-based widefield magnetometer setup (right)

Combined quantum sensing expertise and infrastructure

With various innovative approaches, solutions and applications of quantum sensors, a concentrated research infrastructure is gathered in Freiburg im Breisgau with the three institutes Fraunhofer IAF, IPM and IWM—forming the Quantum Sensing Hub Freiburg.

Technological approaches

We are pursuing two classes of quantum magnetometers with complementary properties: the development of magnetometry based on both optically pumped alkali atoms (OPMs) and nitrogen-vacancy centers in diamond (NV centers). With our pooled know-how regarding next-generation quantum magnetometry based on these approaches, we enable the development and realization of application specific measurement systems.

Fields of application:

- Materials science
- Micro- and nanoelectronics
- Aerospace
- Medical diagnostics
- Bioimaging
- Broadband communication, radar, telemetry
- etc.

Sensing principle	Sensitivity	Spatial resolution
	Available systems	
Optically pumped alkali magnetometer (OPM)	< 15 fT/√Hz	< 5 mm
Scanning probe magnetometer (NV)	< 10 µT	< 30 nm
Widefield magnetometer (NV)	< 10 µT	< 1 µm
	In development	
Laser threshold magnetometer (NV)	1 fT/√Hz–30 pT/√Hz	100 µm–1 mm
OPM-based camera (1000 pixel)	25 pT/√Hz	100 µm
RF sensors (NV)	0.1–10 GHz	< 1 µm

Nitrogen-vacancy centers in diamond

NV centers are individual atomic systems that act as highly sensitive sensors. Their unique advantage is their potential to be operated at room temperature and on background fields. They allow for extremely high spatial resolution and are being utilized in different imaging measurement methods.

- **Widefield magnetometry** provides a unique compromise between spatial resolution and measurement time. It allows for the quantitative imaging of magnetic fields and fluctuations.
- **Scanning probe quantum magnetometers** allow to measure magnetic field distributions at the nanoscale.
- **Laser threshold magnetometers** are currently being developed and will enable measurements of the smallest magnetic fields, such as those generated by brain waves at room temperature and on background fields.
- **Radio-frequency (RF) sensors** with optical readout are being developed that analyze the time-frequency behavior of complex, agile RF signals.

Optically pumped alkali magnetometers

In OPMs, alkali atoms are used as probes for the magnetic field. Laser light is used to prepare all atoms in the same state. In an external magnetic field, the atoms then undergo a synchronous ›Larmor precession‹. Its frequency is proportional to the local magnetic field. In the basic operating mode, this precession signal can be read out optically and provides a calibration-free measure for the magnetic field.

In the most sensitive configuration, **OPMs** reach (and even surpass) the sensitivity of cryogenically cooled SQUID magnetometers and can be used for the detection of magnetic signals of the brain. Due to the highly sensitive measurement, a shielding from ambient magnetic noise is mandatory to reach the highest sensitivity values.