Quantum Diamond Magnetometers for Precision Vector Magnetic Field Sensing

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Precision magnetometers hold enormous promise for a variety of defense-related applications including magnetic navigation in GPS-denied environments, magnetic anomaly detection (MAD), and electromagnetic signal detection and analysis. To deliver a capability edge in each of these areas, precision magnetometers need to meet a detailed list of operating requirements which includes, a high dynamic range to function within the Earth's magnetic field, high bandwidth to probe magnetic signals from DC to MHz, offer vector and/or scalar magnetic field sensing capability with high magnetic field <100pT/√Hz sensitivity at room temperature. There is currently no single technology solution that addresses all of these criteria. Quantum diamond magnetometers (QDMs) which exploit the magnetic sensitivity of engineered defect centres in diamond have seen rapid development towards these goals over the past decade[1-3], resulting in large research programs in government, academia and defence industries.

Here, we will detail our work on developing QDMs for vector magnetic field sensing applications. We will discuss particular use cases where vector magnetic field sensors provide an advantage over traditional scalar magnetic field sensors. We will then present results from our test and measurement facility which benchmark the current magnetic sensitivity and measurement bandwidth of the QDM devices. Finally, we will finish with a discussion about the future opportunities in Australia for engineering quantum-grade diamond materials for precision magnetometry applications.

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