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SBQuantum

# Unlocking the next generation of quantum sensing devices

June 2020 - Customer Case Study

## About Element Six CVD single crystal diamond

- Diamond grades engineered for use in a range of applications including precision machining, optics, thermal management and sensing
- Diamond, an ideal spin qubit host material, is engineered leveraging over 10 years of innovation leadership and multiple patents in quantum technologies
- High sensitivity and long decoherence times
- Wide dynamic range and vector functionality

**Customer: SBQuantum Inc.**
Sherbrooke, QC, Canada

*"Without Element Six, we simply would not have been able to make our magnetometer operate"*
*David Roy-Guay, CEO, SBQ*

SBQuantum (SBQ) is a start-up company that is seeking to transform navigation in GPS-denied environments. The company develops and commercialises diamond-based quantum magnetometers for commercial and research applications, in particular for use in autonomous vehicles. Its goal is twofold: to improve the accuracy and reliability of navigation systems, and to revolutionise magnetic-anomaly detection by more accurately revealing faults in hidden environmental structures. This technology will have the greatest impact in complex and challenging situations, such as those found in cities and other unchartered extreme locations.

# Target applications

SBQ is developing a full service solution that combines a sensor and client-specific dashboard, that can be used in two key areas; navigation and anomaly detection.

## Navigation

- Current forms of GPS systems work by connecting to satellites, and when high-precision geolocation is required, devices may use supplementary signals such as real-time kinematic signals (RTK), which are highly dependent on their landscapes
- To provide the most accurate location, altitude and heading information, GPS systems may be augmented with high-accuracy magnetometers that rely on the direction, strength or relative change of the Earth's magnetic field at a particular location. However, they can experience interference from large metallic structures including buildings. In extreme environments such as in the Arctic, you cannot launch these systems autonomously due to the specific magnetic field line profiles, often resulting in the loss or damage of valuable equipment
- There are also numerous environments where GPS is unavailable, such as underwater or underground. To navigate more complex GPS-denied environments such as these, autonomous vehicles such as delivery drones use high-accuracy magnetometers. Current solutions are inherently prone to drifting, leading to degraded navigational accuracy

## Anomaly detection

- Current magnetometers have a limited understanding of their environments and are corrupted easily by moving metallic objects. For example, if you were undertaking a magnetic survey, you would need to know whether a fault has been detected, or if your signal has been influenced by the car that just drove past
- There are a number of competing technologies that try to achieve this, but each comes with its own limitations. For example, when looking for cracks in underwater pipes, you would struggle with a current system to determine whether you have found a crack or if your machine has turned and you are seeing the influence of the vehicle your device is on

***"Element Six is proud to help, nurture and support exciting new opportunities that seek to explore cutting-edge quantum applications in order to solve real-world challenges"***

Matthew Markham, Principal Scientist, Element Six

## Quantum-based solutions

To meet these challenges, SBQ are developing diamond-based quantum magnetometers, using Element Six synthetic diamond as part of the quantum sensor.

- The navigation systems will use vector-magnetic-field information from a diamond-based magnetometer to get a more accurate understanding of a vehicle's orientation within its environment, enhancing reliability of orientation and direction information and enabling navigation in extreme situations
- When surveying for anomalies, the added specificity provided by diamond-based devices can be used to make more accurate cost estimates based on improved understanding of the location and size of faults
- Diamond-based quantum devices offer a unique combination of low electrical power requirement, with drift suppression, high accuracy and tensor gradiometry in one compact, portable device size. This combination opens the scope of application potential to include geological surveying and underwater pipe detection, setting SBQ's quantum magnetometers apart from other devices

## Why single crystal diamond?

Diamond is a vital supermaterial in applications that exploit quantum phenomena. A particular defect in diamond, the negatively-charged nitrogen vacancy (NV), has quantum properties that are controllable at room temperature such that the defects behave like an isolated atom. These atom-like defects in diamond are unique, as their quantum properties can be manipulated at room temperature, removing the need for costly and heavy cryogenic cooling equipment.

The quantum properties of the NV defect are extremely sensitive to magnetic fields and, as a result, NV in diamond is ideal for highly sensitive magnetometers. In addition to the high sensitivity, the NV defect can also be used to measure the direction of the field due to the multiple alignments of the defect found within the diamond crystal lattice. The combination of these properties mean diamond is suited as a highly accurate sensor for supporting GPS systems.

- Diamond-based magnetometers are consistent because they have intrinsic calibration, given by fundamental physical constants
- Chemical vapour deposition (CVD) diamonds are engineered to add nitrogen into the material which, with further processing, is used to form a uniform distribution of nitrogen-vacancy defects throughout the material
- Element Six is a market leader in the production of synthetic diamond solutions with demonstrable reproducibility
- When compared to current commercially-available devices, the combination of room-temperature operation, large bandwidth, high sensitivity and vector capability make diamond quantum magnetometers suitable for a range of applications such as drones, underground mining vehicles and autonomous underwater vehicles

## Element Six and SBQ

At Element Six, we understand and recognise the importance of supporting and collaborating with new and disruptive companies that are pushing the boundaries in quantum technology.

***"Element Six has been supportive and enthusiastic about the projects we have been doing from the very start"***

David Roy-Guay, CEO, SBQ

Having initially met at the UK annual Quantum Showcase event in 2018, Element Six and SBQ have been in discussion since SBQ was first founded. Element Six have supplied the diamond samples required to develop the diamond-based quantum magnetometer prototypes, while also providing:

- **Expert support** to help our working relationship to continue to flourish
- **A range of high-quality diamond materials** with different specifications for prototyping and optimising application potential
- **Collaboration**, guidance and support to push the limits for new ideas

**For more information about Element Six CVD single crystal diamond solutions please contact:**

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