Solid-state Quantum Magnetometers

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Abstract

Although ordinary magnetometers are generally bulky, they can measure and resolve magnetic flux densities larger than the earth's magnetic field of 25 to 65 micro-Tesla. A quantum magnetometer, based on the spin of sub-atomic particles such as unpaired valence electrons or nuclei of atoms, should, in principle, be capable of measuring and resolving magnetic flux densities on the order of a pico- to femto-Tesla, which makes it attractive for biomedical applications. This talk will discuss magnetometers based on quantum defects in solid-state materials. Diamond has been the prototypical solid-state material with quantum defects suitable for fabricating quantum magnetometers. We are particularly interested in the feasibility of making magnetometers based on quantum defects in other large bandgap materials that are readily available and could be used for manufacture of magnetometers at scale. Silicon carbide is one such material; it is low-cost and currently serves as platform for a number of important electronic devices that are manufactured at scale.

Quantum magnetometers made from diamond are currently the state of the art in devices based on solid-state media. Although diamond has a number of desirable electronic properties, such as a wide bandgap, which permits room-temperature operation of the magnetometers, it requires specialized tools and processes to fabricate into quantum devices. This presentation will review the essential requirements for solid-state materials suitable for quantum magnetometers. One of the critical requirements for a material for a quantum magnetometer is an ability to host paramagnetic defect states that are long-lived. Depending on the usage mode of the magnetometer, either the magneto-optical or magneto-electrical properties of the solid-state material may play a critical role.