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Optically Detected Electron Spin Resonance in Diamond for Vector Magnetometry

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Nitrogen Vacancy (NV) center is a defect in a diamond with unique optical transitions in the visible wavelength that is spin-dependent, allowing it to be utilized as an optical qubit or as a magnetometer. Our work primarily focus on magnetic field sensing with NV center, as they offer high sensitivity and high spatial resolution at the nanoscale level, along with ability to simultaneously measure magnetic field magnitude and direction. To exploit the NV center as a vector magnetometer, we use a confocal microscope retrieve photoluminescence (PL) emitted by the NV center, in combination with Optically Detected Electron Spin Resonance (OD-ESR) technique that probes the microwave frequencies corresponding to the NV electronic transition. In the OD-ESR, we vary applied microwave frequencies to change the spin population in the ground state triplet. If the applied microwave frequency is on resonance with the transition frequency between m_s=0 and m_s=±1, the measured PL will decrease. A magnetic field can be applied to split the m_s=±1 states, and the splitting depends on the magnitude and direction of magnetic field. As a result, two resonant transition frequencies can be used to determine the vector magnetic field experienced by the NV center, and four different orientations of the NV center in the diamond lattice can provide a complete 3-dimensional components of the magnetic field. In this work, we demonstrate simulated OD-ESR spectra of the NV center as a function of the magnitude and direction of the magnetic field. The results can be used to understand the experimental ODESR data in order to determine the magnetic field vector in nanoscale magnetometry, which can be used as quantum sensors.

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