OPTIMIZATION OF MAGNETIC-FIELD QUANTUM SENSING WITH NV CENTERS

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Nitrogen-vacancy (NV) centers in diamond are a leading platform for room-temperature quantum sensing of magnetic fields, owing to their long spin coherence times and optical addressability [1,2]. In this work, we investigate how diamond crystal orientation and paramagnetic impurity concentration influence the coherence properties and magnetic sensing performance of NV centers. We present a comparative study of bulk diamond samples with different crystallographic orientations, specifically (111)- and (100)-oriented diamonds, as well as varying concentrations of substitutional nitrogen (P1 centers).

Using scanning confocal microscopy combined with optically detected magnetic resonance (ODMR) and pulsed microwave control, we characterize NV spin dynamics through Ramsey interferometry, Rabi oscillations, and longitudinal (T_1) and transverse (T_2) relaxation measurements. We analyse how crystal orientation affects NV axis alignment, ODMR contrast, and magnetic field sensitivity, while P1 center concentration is shown to play a critical role in spin decoherence and relaxation behaviour [2].

Our results demonstrate clear orientation- and impurity-dependent differences in coherence times and sensing performance, highlighting trade-offs between signal strength, spin bath interactions, and achievable sensitivity. These findings provide practical guidance for optimizing diamond material selection for DC and AC magnetic field sensing applications [1].

[1] C. L. Degen, F. Reinhard, and P. Cappellaro, “Quantum sensing,” Rev. Mod. Phys., vol. 89, art. no. 035002, Jul. 2017.
[2] M. W. Doherty et al., “The nitrogen-vacancy colour centre in diamond,” Phys. Rep., vol. 528, pp. 1–45, 2013.