Study of spectral spread in nitrogen vacancy centers in diamond for coherent spin control of electron and nitrogen nuclei ensembles

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Nitrogen Vacancy centers in diamond are a promising platform for a vast number of applications such as quantum sensing and quantum computing [1-3]. Many of these applications would also benefit from using spin ensembles to, for example, increase the signal-to-noise (SNR) in sensing applications, as the SNR increases proportionally to the square root of the number of Nvs [4]. The resonant frequency of different NV centers can vary within the same diamond crystal due to different variables such as strain. A large number of promising control protocols have been proven on single NVs, but these often rely on driving in resonance electron (Electron Spin Resonance - ESR) and/or nuclear spins (Nuclear Spin Resonance - NMR) through microwave and radio-frequency irradiation. Thereby, to be able to translate single NV protocols to exploit the benefit of NV ensembles, it is important to know the frequency spread in ensembles of NVs. In this work we assess the frequency spread existing in NV ensembles in sample of diamond grown via Chemical Vapour Deposition (CVD) containing about 4.5 ppm (0.79×10^{18} cm^{-3}) of NVs, which is about the highest density of NVs available in the market. We optically detected the ESR signal of an estimated population of ~0.79×10^{6} NVs within the active volume of our confocal instrument (~1 μm^3), which can be seen in Fig.1. This signal shows the typical ESR signature of one of the ESR peaks revealing the hyperfine coupling of the electron spin to the nuclear ^{14}N spin triplet conforming the NVs. Different power levels were employed to minimise the power broadening introduced by the MW pulses. The acquired image suggests that the spectral spread in the hundreds of thousands of NVs is small. These results suggest that sequences designed for simple NVs should be compatible with bulk sensing, paving the way to orders of magnitude sensitivity boosts.

References

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Figures

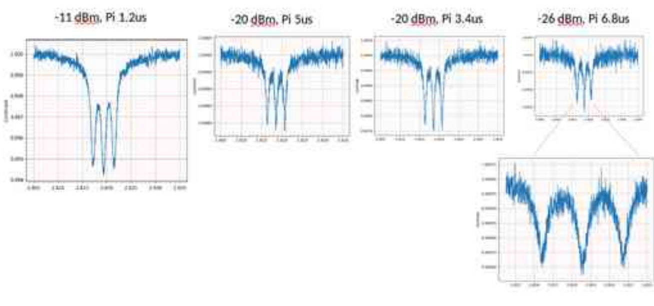

Figure 1: Optically detected ESR signal for different microwave power levels.