



HAL
open science

Spin properties of NV ensembles in phosphorus doped diamond

Ingrid Stenger, Christophe Arnold, Mohamed Elhachmi Bouras, Rémi Gillet, Pauline Perrin, Estelle Loire, François Jomard, Alexandre Tallaire, Gabriel Hétet, M.A. Pinault-Thaury, et al.

► **To cite this version:**

Ingrid Stenger, Christophe Arnold, Mohamed Elhachmi Bouras, Rémi Gillet, Pauline Perrin, et al.. Spin properties of NV ensembles in phosphorus doped diamond. Hasselt Diamond Workshop 2025 SBDD XXIX, Mar 2025, Hasselt, Belgium. <hal-05008819>

HAL Id: hal-05008819

<https://hal.science/hal-05008819v1>

Submitted on 27 Mar 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Spin properties of NV ensembles in phosphorus doped diamond

Ingrid Stenger¹, Christophe Arnold¹, Mohamed Elhachmi Bouras¹, Rémi Gillet¹, Pauline Perrin², Estelle Loire¹, François Jomard¹, Alexandre Tallaire^{2,3}, Gabriel Hétet³, Marie-Amandine Pinault-Thaury¹, Julien Barjon^{1*}

¹GEMaC, UVSQ, CNRS, Université Paris Saclay, Versailles, France

²IRCP, Chimie ParisTech, CNRS, PSL Research University, Paris, France

³LSPM, CNRS, Université Sorbonne Paris Nord, Villetaneuse, France

⁴LPA, Ecole Normale Supérieure, CNRS, PSL Research University, Paris

julien.barjon@uvsq.fr

Nitrogen-vacancy (NV) color centers in diamond have demonstrated their full potential in various applications, ranging from highly-sensitive nanoscale magnetometers¹, high-pressure sensors² and diamond-based quantum applications³. As a solid-state spin, the properties of these color centers strongly depend on the host material. Recent works nicely demonstrated this point: isotopic purification has shown to improve the spin coherence time of low impurity concentration diamond⁴, while phosphorous doping allows to improve NV charge stability⁵ and lead to record spin coherence⁶.

In this work, we investigate the spin properties of native NV ensembles in phosphorus-doped diamond layers, homoepitaxially grown on (100) Ib HPHT substrates with either natural or isotopically purified methane. The concentrations of phosphorus, nitrogen and NV centers, [P], [N] and [NV], are quantified by different techniques including SIMS, absorption and photoluminescence (PL) at low temperature. First, low temperature PL confirms phosphorus doping ($7 \times 10^{13} - 7 \times 10^{15}$ P.cm⁻³) stabilizes the negative charge state of the NV center with a NV⁰ population that remains below 10% even at 1 mW laser power. Then, the dephasing time of spin ensemble (T_2^*) is characterized by Optical Detected Magnetic Resonance (ODMR) under continuous excitation (Fig. 1). We investigate the T_2^* dependence with [N], which is the majority impurity in the samples. We found results that are consistent with a dipolar coupling of NVs with a bath spins made of nuclear ¹³C and/or substitutional nitrogen. We found T_2^* around 0.5 μ s for natural isotopic composition, and up to ~ 3 μ s for ¹²C purified diamond with [N] = 6.3×10^{16} cm⁻³. These results are promising for diamond quantum magnetometers with NV centers.

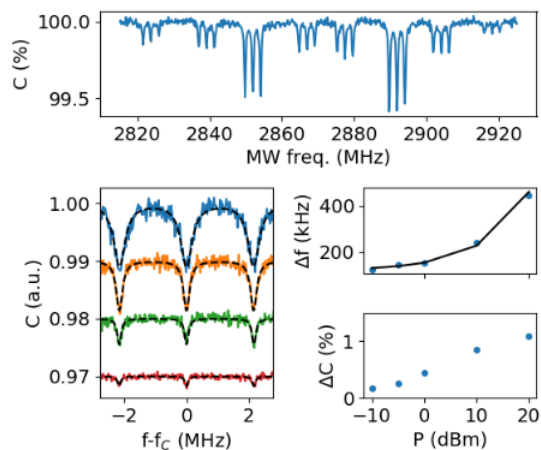


Figure 1 – cw ODMR analysis of NV centers in phosphorus-doped diamond

References

1. G. Balasubramanian, *et al. Nature* **455** (2008), 7213.
2. M. Lesik, *et al. Science* **366** (2019), 6471.
3. L. Childress *et al. Science* **314** (2006), 5797.
4. G. Balasubramanian *et al. Nature Materials* **8** (2009), 383.
5. Y. Doi *et al. Physical Review B* **93** (2016), 081203.
6. E.D. Herbschleb, *et al. Nature Communications* **10** (2019), 3766.