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Shallow NV- colour centres in diamond

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Negatively charged Nitrogen-Vacancy (NV-) colour centre in diamond is a well-known and characterized point defect with notable properties such as photostable bright fluorescence and spin states that can be initialised and read out, making it of great appeal for quantum technology applications.

Specifically, the latter can benefit from forming NV- defects in the proximity of the diamond surface. As an example, for nuclear magnetic resonance (NMR) sensing, it is necessary to have the NV- spins close to the surface as the coupling strength between magnetic dipoles decreases with the distance of the defects from the surface1,2. Shallow NV- defects can also be easily coupled with nanophotonic cavities for photon extraction. Furthermore, shallow NV- can be beneficial also in the biomedical field since the proximity to the surface allows the coupling with biomaterials for sensing applications, such as nano thermometry.

Our study focused on creating shallow and low-density NV defects in a CVD epitaxial diamond (‘electronic grade’) using 30 keV broad beam nitrogen ion implantation and subsequent thermal annealing. In particular, to produce shallow distributions of NV-, the implantation was carried out through a screen layer deposited on the diamond surface before the irradiation3. The screen layer makes possible to tune both the nitrogen depth distribution and the actual fluence reaching the diamond surface while keeping a good acceleration of the ions and a bright beam. Furthermore, using an amorphous screen layer, it is also possible to prevent ion channelling effects that would hinder the formation of a shallow distribution. At this aim, a 100 nm layer of SiO2 was deposited by CVD on the diamond surface to act as a screen layer. Ion energy and incidence angles were tuned in order to have nitrogen ions implanted in the top 10-20 nm of the diamond, while several fluences were tested in order to achieve the desired N concentrations.

After annealing at 1000℃ for three hours in ultra-high vacuum, we optically characterised the implanted samples by Raman and photoluminescence (PL) analysis, while angle-resolved x-ray photoemission spectroscopy revealed a distribution of implanted ions confined in the first 15 nm depth below the surface for the sample with the most intense PL signal.

References

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Abstract category

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