Laser Activation of Single Implanted Group-IV Quantum Emitters in Diamond

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Spin-photon interfaces based on group-IV colour centres in diamond offer a promising platform for 'quantum 2.0' devices such as quantum networks [1] and quantum memory [2]. A key challenge in the field is realising precise single-defect positioning and activation, which is crucial for scalable device fabrication.

Here we address this problem by demonstrating a two-step fabrication method for tin vacancy (SnV^-) centres that uses site-controlled ion implantation followed by local femtosecond laser annealing with in-situ spectral monitoring.

The ion implantation is performed with sub-50 nm resolution and a dosage that is controlled from hundreds of ions down to single ions per site. Isotopic selectivity and hence control of the spin of the dopant nuclei is also possible.

Using this approach, we successfully demonstrate site-selective creation and modification of single SnV^- centres. Our in-situ spectral monitoring opens a window onto materials tuning at the single defect level, and provides new insight into defect structures and dynamics during the annealing process. While demonstrated for SnV^- centres, this versatile approach can be readily generalised to other implanted colour centres in diamond and wide-bandgap materials.

References

[1] Bradac, C., Gao, W., Forneris, J., Trusheim, M. E., & Aharonovich, I., Nature communications, 10(1), 5625.Authors, Journal, Issue (Year) page

[2] Senkalla, K., Genov, G., Metsch, M. H., Siyushev, P., & Jelezko, F., Physical Review Letters, 132(2), 026901.

Figures

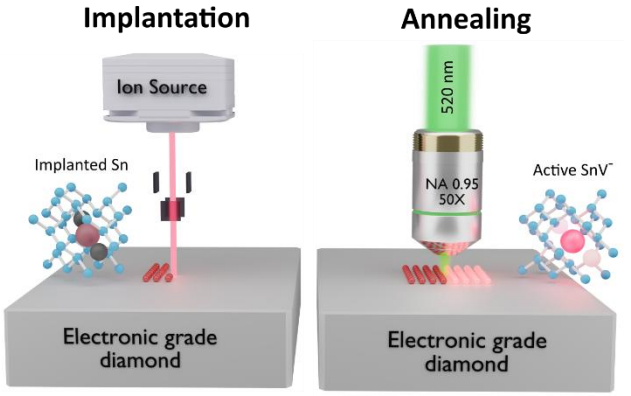

Figure 1: Schematic illustrating the process of ion implantation followed by femtosecond laser annealing. Sn^{117} ions are implanted into the diamond lattice and, as a side effect, create lattice damage in the form of carbon vacancies and self-interstitials. Subsequent laser treatment activates SnV^- and other defect centres.

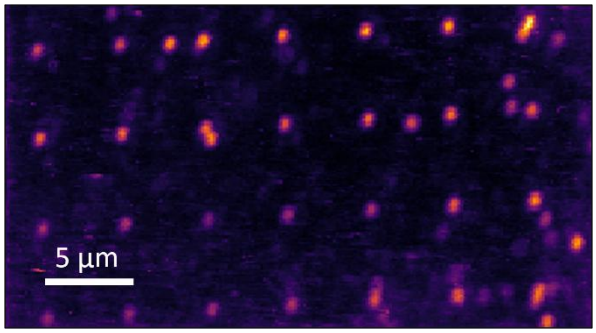

Figure 2: False-colour confocal photoluminescence image of an implanted array of Sn ions after annealing. The ample was excited with a 520 nm diode laser and the image colours correspond to the counts detected with a 600 nm long pass filter in place to remove the first- and second-order Raman peaks.