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Materials science aspects of quantum colour center creation in diamond by means of ion implantation

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Colour centers in diamond are in the focus of interest as single photon emitters for quantum (Q) technologies. Q metrology has already been demonstrated using the nitrogen-vacancy N$V-$ center, which has the crystal symmetry C3. However, defects with D3d mirror symmetry, such as the group IV centers [1] SiV, GeV, SnV and PbV, but also MgV, show optical properties superior to NV, and are envisaged for single photon Q communication. The D3d symmetry is the result of the impurity occupying a lattice site in the center of two vacancies, the so-called split-vacancy configuration as shown in Fig. 1 (bottom).
The most widely used method to create the colour centers is ion implantation. Here one is faced with the challenge to maximize the fraction of implanted impurities in the split-vacancy configuration and to minimize structural damage resulting from ion implantation in order to achieve a narrow spread of optical properties of the centers.
We present results on the lattice location and confocal PL measurements of radioactive 121Sn in diamond [2], where we could unambiguously show that, following annealing at 920°C, »30% of implanted Sn is found in the split-vacancy configuration. Confocal photoluminescence (PL) revealed the characteristic SnV− line at 621 nm, with an extraordinarily narrow ensemble linewidth (2.3 nm) of near-perfect Lorentzian shape.
We are currently addressing colour center creation within a collaboration that includes KU Leuven Quantum Solid-State Physics (Belgium), University of Torino (Italy), and Universidade de Aveiro. Emission channeling (EC) lattice location experiments using the radioactive isotopes 121Sn, 209Pb, 27Mg, 45Ca and 89Sr are performed at the CERN-ISOLDE facility, while PL characterization of diamond samples implanted with stable isotopes (at KU Leuven or ISOLDE) takes place at the Universities of Torino and Aveiro.

References

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