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Engineering defects in diamond

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Defects in diamond have great potential for use as quantum sensors and qubits. The negatively-charged nitrogen-vacancy (NV⁻) center in diamond is established as a leading platform in solid state quantum applications, with potential technologies in sensing, computation and communication enabled by its long spin-coherence time and optical spin polarization. However, NV's poor photonic properties (Debye-Waller factor ~0.04) have resulted in significant efforts on optical cavities to enhance its coherent emission, and search for alternate color centers with comparable spin properties and superior optical properties.

Currently, the vacancy-impurity family of defects is most promising, with major interest in group IV centers SiV⁻ [1,2], GeV⁻ [3] and SnV⁻ [4,5]. Of these, SiV⁻ is the most-studied, with T₂ > 10 ms and single-shot readout demonstrated at 100 mK. Nonetheless, the onerous experimental requirements and low quantum efficiency (~10% [6]) motivate further research on alternative centers. In this presentation, I will discuss recent work alternative color centers, including the neutrally-charged silicon vacancy, SiV⁰ [7,8], its spin physics and electronic structure.

Full exploitation of their optical and spin properties necessitates that we control the position, orientation and environment of the chosen colour centre to optimise all of the desirable properties simultaneously. I will review our understanding of the production of intrinsic defect complexes and present new data on the production of preferentially orientated defect complexes by electron irradiation and/or annealing whilst the sample is subjected to a large uniaxial stress. I will show that near 100 % preferential orientation can be achieved for a number of different defects.

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