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Improved creation efficiency of nitrogen-vacancy centre ensembles: processing and characterisation of artificial diamond

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Abstract

Crystal defects in the diamond lattice create molecule-sized fluorescent centres that can be used for multiple purposes. The most studied fluorescent centre in diamond is the nitrogen-vacancy (NV) centre because is a photostable single-photon emitter which can be used to sense its environment through fluorescence measurements. At the Centre of Excellence for Nanoscale BioPhotonics (CNBP), we study the NV centres in both single crystal diamonds and nanodiamonds and use their fluorescence to the study of biological processes.

In this study, we go a step back and investigate the process that creates a high density of NV centres. The NV centre density and associated fluorescence is a key property of the diamond material to improve the signal to noise ratio and the sensitivity achievable with an ensemble of NV centres. The typical method to create the highest density of NV centres is to start with a high-nitrogen-concentration diamond sample and irradiate it with high energy particles, e.g. electrons, to create the vacancies. Afterwards, the sample is annealed to combine the vacancies with the nitrogen and create the NV centres.

In our study, we combined high-energy electron irradiation and high-temperature annealing in a single process, referred to as 'annealing in situ'. The aim of this method was to promote the nitrogen-vacancy combination and to prevent the accumulation of vacancies into clusters. Optical characterisation of the resulting samples demonstrated more than 100% improvement of the nitrogen-to-NV centre' creation efficiency using the annealing in situ process in respect with the typical room temperature irradiation followed by separated annealing.

The speaker

Marco Capelli is a PhD student at RMIT University in Melbourne and part of the ARC Centre of Excellence for Nanoscale BioPhotonics. He received his master degree in Physics at the University of Torino on a thesis about the characterisation of nitrogen-vancancy centres in diamond. He is currently studying the magnetic field sensing property of nitorgen-vacancy centres for biological applications and investigating methods to enhance the creation efficiency of colour centres in diamond.