Diamond Science Technology Centre

Defect Studies in CVD Diamond: Production, Identification and Exploitation of New Defects

It has been known for over 15 years that homoepitaxial diamond can be synthesised by chemical vapour deposition (CVD) with very high purity (residual nitrogen and boron impurities less than 1 part per billion), but typically this material contains high concentrations of dislocations (>10^4 dislocations cm^{-2}). The strain resulting from dislocations and dislocation bundles, as well as point defects, is undesirable for many quantum and optical technologies.

Furthermore it is known that High Pressure High Temperature (HPHT) synthesis of single crystal diamond from a transition metal solvent can, with careful selection of the seed crystal and precise control of the temperature and pressure, produce material with a much lower dislocation and stacking fault density in (100) growth sectors (< 100 dislocations cm^{-2}) over areas exceeding 25 mm^2. However in HPHT synthetic diamond the incorporation of nitrogen and boron impurities varies dramatically between different growth sectors but even with the use of additives in the solvent (e.g. Ti, Al) to "getter" the nitrogen, the nitrogen impurity levels are not believed to be as low as those observed in the best CVD diamonds. Furthermore, boron is a persistent impurity in HPHT diamond.

It has been shown that if sufficient care is taken in the selection and preparation of the HPHT diamond substrate and in the initial stages of CVD growth, the number of dislocations can be dramatically reduced (< 400 dislocations cm^{-2}) in the homoepitaxially overgrown CVD material over areas of order 10 mm^2, whilst still retaining high purity. However, many applications that require both high purity and low strain also demand areas. At the moment such samples are not available primarily because of the lack of large high quality single growth sector single crystal substrates.

This project will focus on:

(i) Characterisation of the defects in CVD diamond available commercially. This work will impact on the identification of material produced for Gem applications.

(ii) Via collaboration with the several growers we will focus on the characterisation of CVD diamond grown in such a way to minimise the incorporation of point and extended defects. Such work with contribute to the production of higher quality diamond for a variety of photonic and quantum applications.

(iii) Study of diamonds implanted with short lived radioactive ions to facilitate the production and identification of new defects not attainable by in situ doping or traditional ion implantation.

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