Characterization of defects and dislocations in nitrogen doped CVD diamond film grown on type IIa HPHT substrates.

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The reliable and reproducible production of diamond samples containing uniform and high densities of negatively charged nitrogen vacancy defects (NV^-) is necessary for many quantum technologies using ensembles of defects such as magnetometers, radio-frequency and microwave sensors, solid-state gyroscopes and room temperature masers. The exploitable properties of the NV^- colour centres can be limited by interaction with other defects, strain arising from extended defects, charge state stability and the 1.1% of ^{13}C spins present in materials with natural isotopic composition.

In this work nitrogen doped diamond samples grown by chemical vapour deposition (CVD) on {001}-orientated type IIa HPHT diamond substrates have been studied. The carbon containing source gases were enriched with ^{12}C and the substrates selected so as to minimise the dislocations propagating from the substrate into the overgrown layer. The diamond samples were characterized using various experimental techniques, such as photoluminescence (PL), and electron paramagnetic resonance (EPR). A significantly higher incorporation of the silicon-vacancy defect was detected in material deposited during the early stages of growth. The inhomogeneous incorporation of nitrogen and silicon related defects on the terraces and risers of the CVD material was observed by PL mapping. The diamond Raman line shift due to the differences in the carbon isotopic composition between the HPHT diamond substrate and the CVD overgrowth layer could be observed. A Raman feature at approximately 1540 cm^{-1} can be observed in the CVD diamond using 785 nm and 830 nm excitation, with a significantly higher intensity in risers compared to terraces.

Optical transmission measurements using crossed polarizers, MetriPol (quantitative birefringence measurement) [1], polarized Raman mapping [2] and photoluminescence were employed to study the strain produced by inclusions and dislocation bundles and the point defect distributions in these samples. Particular attention was paid to defects at the boundary between the substrate and CVD overgrown layer. The different experimental techniques are compared in order to quantify strain in the CVD diamond and investigate what limits the exploitable properties of the NV^- defects incorporated.

Reference

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