Luminescent defects in single crystal diamond are the focus of intense research activities due to a broad range of possible applications in quantum computing, cryptography and magnetometry. Among them, the so called Nitrogen-Vacancy (NV) centre is particularly promising due to exceptionally long spin coherence times at room temperature. The spin state of this defect can also be optically manipulated and read-out which could pave the way to innovative solid-state quantum mechanical systems. In this context, the Plasma Assisted Chemical Vapour Deposition (PA-CVD) technique has emerged as a very efficient way to directly create such defects during epitaxial growth of diamond. However the creation of a given NV density in a high-purity diamond matrix is still very challenging. Besides, most applications require the defects to be spatially localized in the crystal so that they can be easily addressed and manipulated. In this work we performed CVD epitaxial growth on a pattern of micro-pillars etched on a diamond substrate. Cathodoluminescence (CL) analysis revealed that NV centres were successfully localized at the edges of the pillars.

**Fabrication of the diamond micro-pillars**

Cylindrical pillars with a diameter of 20 µm and a height of 5 µm were etched on a High Pressure High Temperature (HPHT) synthetic diamond substrate (Fig. 1a).

**Cathodoluminescence analysis**

Cathodoluminescence analysis was carried out using a HCLUE system mounted on a ZEISS EVO MA 15 Scanning Electron Microscope (SEM) equipment and operated at 10 kV with a current of 2 nA. The light emitted by the sample under the impinging electron beam was collected by a parabolic mirror and sent to a IHR 550 spectrometer for analysis using either a Photomultiplier tube (fast imaging mode) or a CCD camera (hyperspectral mode). The sample was kept at room temperature during analysis.

The SEM image of Fig. 2a shows the morphology of the pyramidal diamond pillar. The panchromatic CL image (Fig. 2b) reveals the hybrid HPHT-CVD diamond structure where the central part corresponds to the initial cylindrical pillar, and the lateral part the CVD-grown material.
A spectral mapping of the pillar (Fig. 3a) was carried out in order to resolve the spatial distribution of the NV defects. The red emission spectrum (Fig. 3b) corresponds to the emission spectrum of the NV centres in their neutral state (NV0): both the Zero Phonon Line (ZPL) at 575 nm and the phonon side-bands of NV0 are observed. The blue colour area is indicative of a region with no luminescence at 575 nm. The hyperspectral CL image confirms that the bright luminescence observed in the panchromatic CL image mostly originates from NV defects. The star-shape pattern corresponds to their non-uniform incorporation in the different growth sectors.

Conclusion

Nitrogen-Vacancy centres were successfully spatially localized at the edges of a pyramidal structure made of CVD diamond. Conditions were chosen so that growth only occurred in the lateral direction with almost no vertical growth. NV centres were preferentially incorporated in the lateral sides of the CVD-grown diamond. The fabrication of diamond microstructures and arrays is believed to pave the way to innovative solid-state quantum mechanical systems making use of the exceptional properties of NV luminescent defects. In that sense cathodoluminescence is a useful tool allowing identifying and localizing such defects and their environment.

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