Optimizing nitrogen-vacancy center formation during CVD diamond growth for quantum technologies

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The nitrogen-vacancy center (NV) in its negative charge state is a paramagnetic (S=1) defect in diamond with coherence times up to milliseconds[1] at ambient conditions. Its spin state can be initialized and read out optically and manipulated using a microwave field, which makes it an ideal candidate for a wide range of quantum applications, e.g. for nanoscale magnetometry[2].

Nitrogen needs to be integrated into the diamond lattice in order to create NV centers. It can be incorporated into the diamond by ion implantation or during chemical vapor deposition (CVD) of diamond using a nitrogen-rich atmosphere. Nitrogen doping during CVD growth allows the creation of ensembles of NV centers, which are favourable for sensing applications as ensembles of NV centers show an improved sensitivity compared to single NV centers[2,3].

However, it is still challenging to find the optimal fabrication parameters that allow a homogeneous distribution of NV centers throughout the diamond layer in combination with good coherence properties of the NV centers. One of those parameters is the substrate miscut[4,5], which refers to the angle at which the substrate orientation deviates from the theoretically desired orientation. Our work presents a possibility to achieve a more homogeneous nitrogen incorporation during CVD growth by optimizing the miscut angle. Furthermore, we show that the behaviour of nitrogen incorporation in a layer with a higher nitrogen concentration differs from that of a sample grown with a lower nitrogen concentration.

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