Formation of NV centers in Diamond by Femtosecond Laser Irradiation and STED Microscopy Characterization

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Nitrogen-Vacancy (NV) centers in diamonds consisting of a substitutional nitrogen atom and an adjacent vacancy have recently been considered as possible registers for a qubit state, as quantum sensors, and as a possible component in hybrid quantum information processing because of their excellent room temperature electron spin properties as well as their capability as single photon emitters. However, the irregular distribution of NV centers in natural diamonds impedes their effective use for quantum applications, which requires precise placement of NV centers at predetermined locations. To overcome this challenge, an effective method for creating NV center is laser writing, which utilizes a highly focused femtosecond laser spot to displace carbon atoms from the diamond lattice and subsequent annealing produces NV centers at specific positions with greater accuracy [1]. Also, the number of vacancies generated by this method can be effectively controlled by adjusting the laser parameters. This work explores the deterministic creation of NV centers in nitrogen-doped diamond through femtosecond laser irradiation at a wavelength of 800 nm. Various parameters including femtosecond laser exposure conditions and laser annealing conditions are studied. To achieve sub-50 nm spatial resolution for the characterization of NV centers, we employ Stimulated Emission Depletion (STED) microscopy [2], a super-resolution microscopy technique that surpasses the diffraction limit of light. For STED microscopy, the excitation wavelength used is 532 nm and the depletion light wavelength used is 765 nm. To understand the performance of the STED imaging, extensive testing was performed with diamond nanoparticles.

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References

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