Optical Characterization of Nitrogen-vacancy Centers in Nanodiamonds Using Time-resolved Photoluminescence Spectroscopy

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Nitrogen-vacancy (NV) centers in diamond are recognized as indefinitely stable highly efficient single-photon sources [1]. Embedded in nanocrystals, they can serve, for example, as vectors for quantum computing devices [2]. At the single-emitter level, they are also suitable candidates for applications in nanoscopy and bio-marking [3]. With an increasing interest in diamond-based photonics, experimental techniques for the characterization of optical properties of NV centers are now of great importance.

In this study, time-resolved photoluminescence spectroscopy (TRPL) is explored as a method for measuring fluorescence lifetimes of NV centers embedded in commercially available diamond nanoparticles. Nanodiamond suspensions with different concentrations of NV centers were investigated and compared with respect to their fluorescence lifetimes. The suspensions were diluted and deposited on silicon wafer chips using drop-casting method followed by drying. A TRPL system based on time-correlated single photon counting (TCSPC) was set up in order to measure fluorescence lifetimes of NV centers at room temperature using a Ti-sapphire femtosecond laser with an excitation wavelength of 400 nm. For benchmarking, the fluorescence lifetime of Rhodamine B dye encapsulated in a thin polymer film was measured and found to agree with previously reported results. The fluorescence lifetimes of nanodiamond samples with low and high densities of NV centers were compared and analyzed in order to establish the effect of an ensemble of NV centers on individual NV center lifetime. A future extension for this study is to implement $g_2(t)$ autocorrelation measurements. This technique can identify single NV centers which have applications in quantum information.

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