DTU Library

Optical Investigation of GeV Center in Diamond Observation of Energy Level Fluctuations and Blinking

Bergamin, M.; Raquena, D. A.; Radko, I.; Janitz, E.; Childress, L.; Huck, A.; Andersen, U. L.

Published in:
Optica

Publication date:
2021

Quantum Information and Measurement (QIM) VI © Optica Publishing Group 2021

Optical Investigation of GeV Center in Diamond Observation of Energy Level Fluctuations and Blinking

M. Bergamin[1], D. A. Raquena[1], I. Radko[1], E. Janitz[2], L. Childress[2], A. Huck[1] and U. L. Andersen[1]
[1] Center for Macroscopic Quantum States (bigQ), Department of Physics, Technical University of Denmark, Fysikvej Byg. 307, 2800 Kgs. Lyngby, Denmark
[2] McGill University, Department of Physics, 3600 Rue University, Montreal, QC H3A 2T8 Canada
maxbe@dtu.dk

Abstract: We report on the detailed spectroscopic investigation of a deeply implanted Germanium vacancy centers in diamond at cryogenic temperatures and using a resonant cross-polarization excitation scheme.

1. Main

Point defects in diamond are promising candidates in the solid-state for a wide range of application in quantum information processing. Among different defects with allowed optical transitions, the germanium-vacancy center (GeV) is attractive as it has interesting optical properties already at room temperature including a narrow zero-phonon line and low fractional emission into the phonon sideband [1]. Some of the detailed physical properties related to the optical transitions are however yet not explored.

In this contribution, we focus on the optical investigation of single GeV centers deeply implanted into a synthetic electronic grade diamond crystal at a cryogenic sample temperature of 4K. The implantation to a mean depth of 125nm below the diamond surface with a dose of $5 \cdot 10^9$ cm^{-2} is followed by a 1200 degrees Celsius annealing and yields a concentration of approx. 1.6 emitters per square micrometer. The final sample was etched down into a 1.5 micrometer thick membrane and positioned onto a highly reflective dielectric mirror substrate.

A resonant optical excitation scheme is applied, and the behavior of single GeV centers is monitored both by collecting photons emitted in the phonon side band and in the zero-phonon line using a cross-polarization setup. We obtain a rejection of laser excitation with an extinction ratio up to $4 \cdot 10^6$ in our configuration.

We report on the observation of energy level fluctuations and blinking of the resonant fluorescence signal, as shown in Fig. 1. The energy level fluctuations occur over hundreds of MHz as determined by successive resonant photoluminescence scans and on a time scale in the range of several seconds. Similar observations were previously reported for SiV centers and the level shifts attributed to adjacent P1 centers [2], where charge state fluctuations effectively cause level shift by the Stark effect. Our investigations show that the rate and amount of energy level fluctuations are individual, and we also identify a statistically significant number of GeV with stable energy transitions. Further experimental efforts with varying substrate material and preparation methods are required to reveal in detail the underlying physical processes causing energy level fluctuations and blinking.

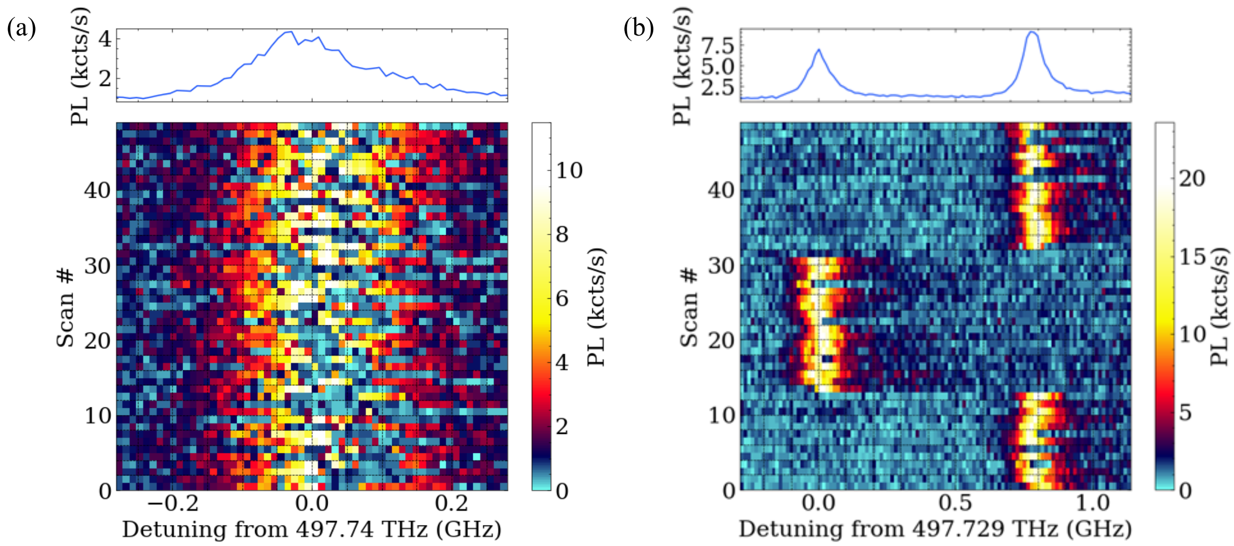

Fig. 1. (a) Resonant fluorescence for consecutive scans on an emitter without energy level fluctions. The resonant excitation power is 10 nW. The sudden descrease of the fluorescence power while scanning the emitter signifies the blinking behaviour. (b) Energy fluctuations between two levels, where blinking can also be observed. Higher excitation power increase both the jump- and blink-rates.

2. References

[1] T. Iwasaki et al., *Germanium-Vacancy Single Color Centers in Diamond*, Sci. Rep.**5**, 12882 (2015)
[2] Z. Mu et al. *Observation of Binary Spectral Jumps in Color Centers in Diamond*, Adv. Opt. Mater **8,19** 2000495 (2020)