~~TOC~~

Diamond NV Centers

Basics

see also Nitrogen-vacancy center

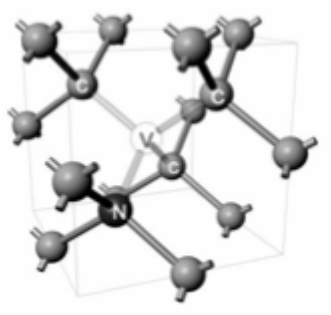

Figure1: Model of the nitrogene vacancy in the diamond lattice

Excitation

- wavelength 532nm
- excitation power should be 100 µW or above

Emission

Figure 3 shows the emission spectra of a NV-center. The pronounced Peak at 637nm is the zero-phonon line of the diamond lattice (comparable to Raman).

- Emission filters therefor should be 650LP.

Fluorescence Lifetime

- Fluorescence Lifetime is approx. 12ns.

Measuring NV centers

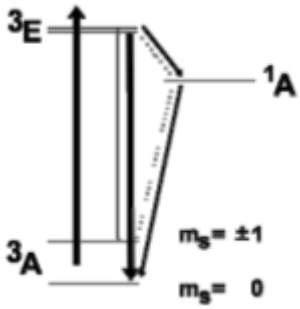

Figure2: Jablonski diagram of the luminescent transition of the nitrogene-vacancy in a diamond lattice. Bright fluorescence corresponds to the ^3E→^3A (m_s=0) transition

Due to their photo-physical stability the NV-ceneters make for excellent demonstration samples for antibunching measurements. They are also potential candidates to image the confocal volume.

The following will explain how to find and measure NV-centers in bulk diamond.

System setup

- refractive index of diamond is 2.4. that means oil immersion is necessary as well as a high N.A.
- used objective: N.A. 1.3 is working, better 1.45 oil!
- Although measurements were possible also with the water immersion objective: with 60×1.2 water less than 50% count rate in comparison to 100×1.3 oil
- 0.95 N.A. air objective did not yield any usable results.
- excitation source: 532 nm
    - MOFA (40MHz - for finding the centers, later 10MHz (12ns fluorescence lifetime))
- excitation power: >7000 a.u. @ 40MHz, > 2000 a.u. @ 10MHz (basically as high as possible)
- major dichroic: 532 / 635
- emission bandpass: 690/70 (for antibunching measurements 2 bandpasses directly in front of detectors)
- objective: 1.3 N.A. oil immersion

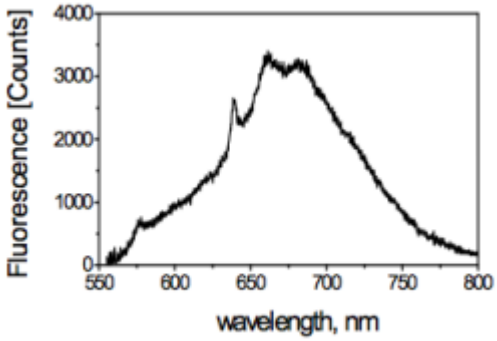

Figure3: fluorescence spectrum of a single NV center in diamond excited with 532 nm

Mounting the sample

sample is mounted directly on top of the objective (with immerision oil, without any coverslips etc.).

Imaging/ finding nv centers

- focus on the interface between oil and diamond (nice reflection should be visible due to refractive index mismatch between oil and diamond)
    - when imaging the surface most likely fluorescent spots will be found. Those are probably dirt and unlike the NV-centers will bleach in a matter of seconds. They also have a shorter fluorescence lifetime.

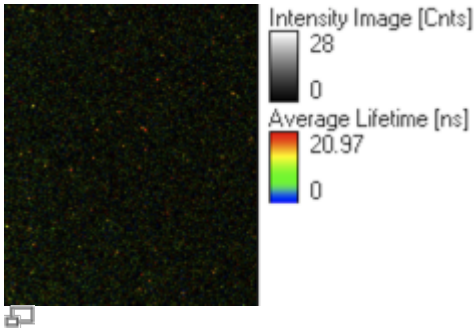

Figure4: Prescan of NV-centers in bulk diamond. 5 micrometer into the sample, 80×80 micrometer, 150×150 pixel resolution. 532nm excitation, 690/70 emission, 40MHz rep. rate, approx. 7000 a.u.

- move approx. 5 micrometer into the sample.
- Although photo-physical stability makes the nv-centers ideal single emitter samples compared to single molecules the laser power to excite them has to be considerably higher. (0.1 mW and above).
- Figure 4 shows a prescan of the complete field of view. The orange dots are NV-centers.
- zoom into a region with a few NV-centers (see figure 5),
- select one, and position the focus on the NV-center.
- use the oscilloscope and pifoc+piezo to move the NV-center in x,y and z into the center of the focus.
- For lifetime analysis switch laser repetition rate to 10MHz (see figure 6)
- check whether the fluorescence lifetime is around 12 ns.
- the NV-center's emission should stay stable (no bleaching)

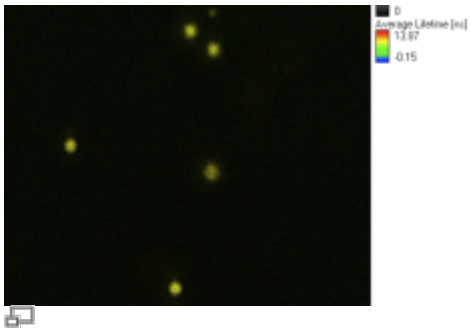

Figure5: NV-centers in bulk diamond. 5 micrometer into the sample, 532nm excitation, 690/70 emission, 40MHz rep. rate, 6789.96a.u., 2ms/pixel, 15×15 micron

Typical Measurement Results

- Prescan should look like figure 4
- smaller area is depicted in figure 5 and figure 6
- Selecting a ROI in figure 6 and plotting the fluorescence lifetime histogram should resemble figure 7
- when measuring the fluorescence intensity of a single NV center, the count rate should stay stable. The time trace in figure 8 shows a reduction of the countrate due to stage drift (temperature etc, or in this case probably because the MT200 inhouse II was mounted on a wheelbarrow instead of an optical table)
- to perform antibunching measurements on a selected NV-center choose a NV-center that is isolated, measuring time of 120 s should be enough to yield an antibunching measurement comparable to figure 9.

NOTE: Measurement setup has to be changed (see antibunching measurements)

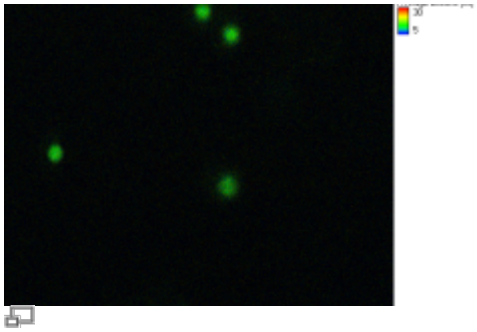

Figure6: same as figure 5 but recorded with 10 MHz rep rate., 2304.94 a.u.;4 ms/pixel 45 min rec. time!

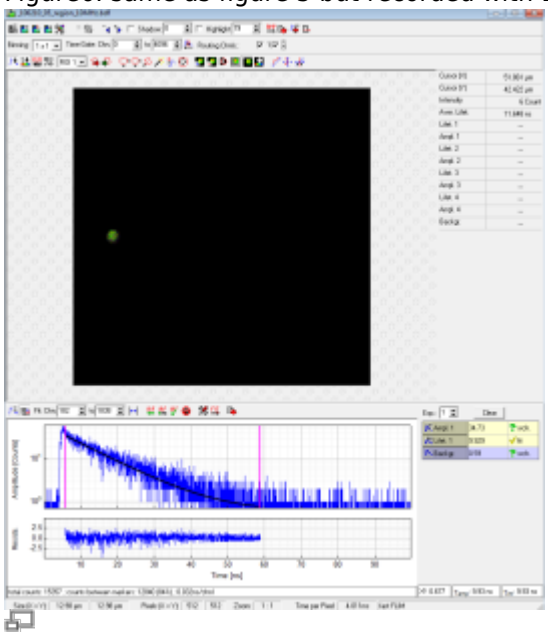

Figure7: Fluorescence Lifetime Fit of a selected NV center, 10 Mhz reprate, Inhouse II, MPD/SPAD

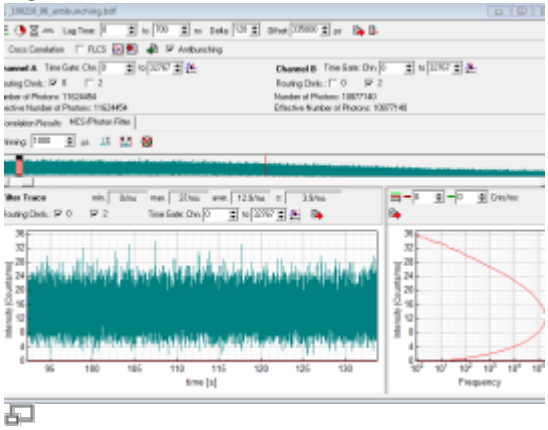

Figure8: No bleaching visible. reduction in count rate is due to mechanical drift (inhouse II) on wheelbarrow

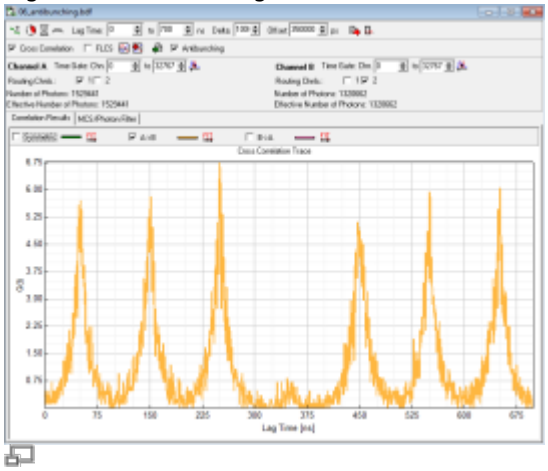

Figure9: Antibunching measured on NV-center. Acquisition time 120 s, 1.3 N.A. oil immersion, 3534.98 a.u. 532

nm 690/70 emmission filters

References

M. Boersch, R. Reutera, G. Balasubramaniana, R. Erdmann, F. Jelezkoa, J. Wrachtrup Fluorescent nanodiamonds for FRET-based monitoring of a single biological nanomotor FoF1-ATP synthase **Proc. of SPIE Vol. 7183, 71832N** (2009)
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