Short Introduction to:
NV Centers in Diamond

Molecular and carbon-based electronic systems lecture, Märta Tschudin, 31.05.2017
Nitrogen-Vacancy Center in Diamond

Optical access to individual spins

- Long coherence time
- Small size
⇒ good magnetic sensor

- Spin entanglement

Content:

- NV structure
- Detect and address single NV centers
- Magnetometry, Single Photon Source

L. Childress, Diamond Sensing Workshop, 2015
NV Center Structure

Charge states: NV$^0$ (5 e$^-$), NV$^-$ (6 e$^-$)


F. Jelezko and J. Wrachtrup, phys. stat. sol. (a) 203, No.13 (2006)
NV Center Formation

Irradiation and annealing
- High NV density possible

Implantation and annealing
- Locate NVs

CVD growth
- NVs near surface

Fig. 6 Fluorescence intensity autocorrelation function of a single NV defect at room temperature.

Fig. 7 (online colour at: www.pss-a.com) Confocal fluorescence image of various diamond samples with different electron irradiation dosages.

F. Jelezko and J. Wrachtrup, phys. stat. sol. (a) 203, No.13 (2006)
Single Quantum Emitter

Autocorrelation function $g^2(\tau)$

adapted from Gerry & Knight, *Introductory Quantum Optics*

Spin-Dependent Fluorescence

Electron Spin Resonance (EPR)

Conduction band

\[ |e\rangle \quad m_s = \pm 1 \quad \text{or} \quad m_s = 0 \]

\[ |s\rangle \quad m_s = 0 \]

Valence band

\[ |g\rangle \quad m_s = \pm 1 \quad \text{or} \quad m_s = 0 \]

Strong

\[ 1.945 \text{ eV} \]

Weak

\[ 5.5 \text{ eV} \]

No magnetic field

\[ m_s = \pm 1 \quad \text{or} \quad m_s = 0 \]

With magnetic field

\[ m_s = \pm 1 \quad \text{or} \quad m_s = 0 \]

\[ D = 2,870 \text{ MHz} \]

\[ 2\gamma B = 250 \text{ MHz} \]

\[ 2\gamma B = 4.4 \text{ mT} \]

EPR spectrum (zero field)

EPR spectrum ($B = 4.4 \text{ mT}$)

Luminescence intensity

Microwave frequency (MHz)
Magnetometry on Nanoscale

Sensor: NV center

- Small size
- Close proximity to sample surface

⇒ High resolution

Setup with diamond nanopillar


Single Photon Source

Emission of coherent photons from ZPL

NV photon source:

- Small ZPL emission

Solution: Microcavity

ZPL emission probability from ~ 3 % to ~ 46 %
Conclusion

NV structure

Scanning NV magnetometry

NV single photon source
Thank you for your attention.