Weak magnetic field NV diamond sensor

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We report on our efforts aimed at creating a compact magnetic field sensor for biological applications based on a bulk NV diamond. As a rule, sensors used in biology and medicine should be sensitive to low-frequency variations of weak (0–1 G) magnetic fields. In addition, an ideal magnetic sensor designed for invasive study should not create intense microwave (MW) fields around it. At the moment there is no way to satisfy all these requirements in one setup, but we have taken some steps in these directions, such as the multi-frequency excitation of hyperfine NV triplets [1], the dual-frequency ODMR excitation with resonant MW and radiofrequency (RF) fields [2], and single-frequency ODMR excitation with resonant RF field [3].

Most recently, we investigated the single-frequency non-resonant RF excitation of ODMR in 1–10 MHz range and found a strong dependence of NV photoluminescence level on the magnetic field scalar value in 0–1 G range; we attribute it to the zero-field NV level anticrossing. The signal parameters obtained to date (Fig.1) correspond to the ultimate shot-noise-limited sensitivity at the level of 3.6 nT/√Hz in 0.01 mm^3 NV diamond sample, which allows to create a sensitive low-field sensor that does not use MW excitation.

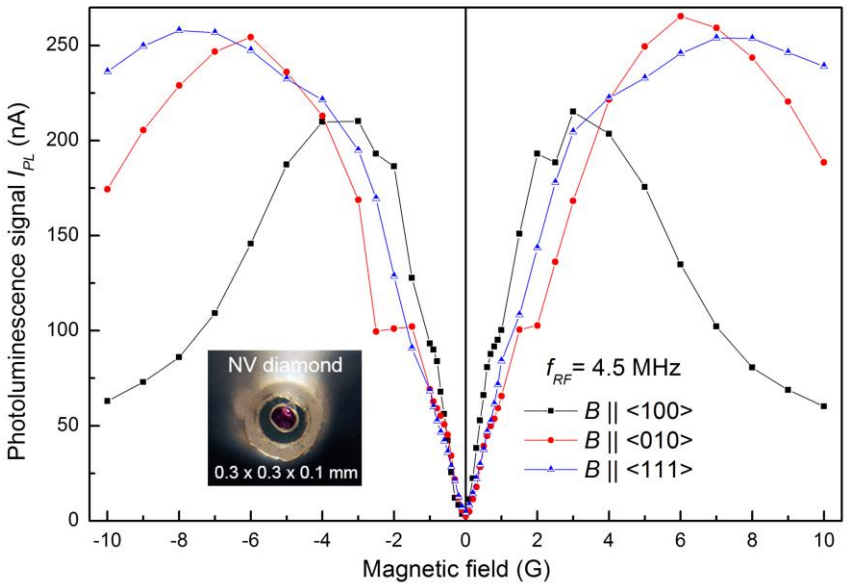

Figure 1. Photoluminescence dependency on the magnetic field applied in certain crystallographic directions at non-resonant RF excitation (f_{RF} = 4.5 MHz); total photocurrent is 40 μA, shot noise level is 3.6 pA/√Hz. Low-frequency amplitude modulation of RF field is used in order to subtract the luminescence background.

[1] A.K. Dmitriev, A.K. Vershovskii, Concept of a microscale vector magnetic field sensor based on nitrogen-vacancy centers in diamond, JOSA B., **33**, 3, B1-B4 (2016).

[2] A.K. Dmitriev, A.K. Vershovskii, Multi-frequency ODMR of Nitrogen-Vacancy Color Centers in Diamond Crystals in zero magnetic fields. - Journal of Physics: Conference Series, **1135**, 1, 012051 (2018).

[3] A.K. Dmitriev, A.K. Vershovskii, Ultra-Narrow Low-Field Nuclear Spin Resonance in NV Centers in a Bulk Diamond Crystal, Appl. Magn. Reson., **50**, 4, 599 (2019).