quNV

Quantum Sensing and Manipulation
by Nitrogen-Vacancy Centers

Key Features

- HPHT Diamond Sample
- Pulsed Laser, Microwave and Photodiode Read-out
- Pattern Generator for variable Pulse Sequences
- 4 GHz RF Microwave Sweep Generator
- Magnetic Bias Field by 3 Helmholtz Coil Pairs

Experiments

- NV Center Fluorescence
- Optically Detected Magnetic Resonance (ODMR)
- Spin Initialization and Readout (T1 time)
- Rabi Oscillations
- Dynamical Decoupling, Hahn Echo
- Coherent Qubit Control

quNV Specifications

Diamond Sample

Type	Ib HPHT
Orientation	typ. {100} faces
Nitrogen concentration	< 200 ppm
Boron Concentration	< 0.1 ppm
Diameter	typ. < 2 mm x 0.5 mm
Mount	on antenna PCB, changeable

Excitation Laser

Laser Diode	CW, pulsed
Power	<50 mW
Wavelength	516 ± 2 nm
Min. pulse length increment	20 ns
Min. delay increment	20 ns

Photodiode

Type	Silicon PIN photodiode
Responsivity (@ 650 nm)	0.45 A/W
Wavelength range	300 ... 1100 nm
Mode	CW, gated
Min. gating increment	40 ns
Min. delay increment	40 ns

Microwave Source

Frequency range	2.2 ... 4.4 GHz
Frequency increment	1 kHz
Power	-43 ... +20 dBm
Antenna	Coplanar wave guide
Rise Time	<10 ns
Min. pulse length increment	20 ns
Min. delay increment	20 ns

Helmholtz Coils

Coil pairs	3 (x,y,z)
Max. magnetic field	30 G (z), 12 G (x,y)
Max. current	2 A

Optics

Objective	20x, NA 0.4, Air
Dichroic mirror (Reflection/Transmission)	>96% @638 nm >95% @520 nm
Photodiode bandpass (Transmission/Absorption)	> 96% @ 638 nm > OD7 @520 nm

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Operation

Laser safety, laser class 2	Orange tinted housing with laser interlock
Interface	USB 3.0
Operating systems	Windows, Linux
Supplied software	GUI / DLL
Dimensions (in mm)	440 x 330 x 500
Weight	18 kg
Power consumption	< 50 W at 100 to 230 VAC

Stage

Coarse z travel	190 mm
Coarse z travel increment	40 µm
Coarse z drive	motorized

General Operation

The NV centers are excited by a powerful CW laser diode. The laser is collimated and expanded to create optimal conditions for the microscope objective. The objective focuses the laser light onto the nitrogen-doped diamond.

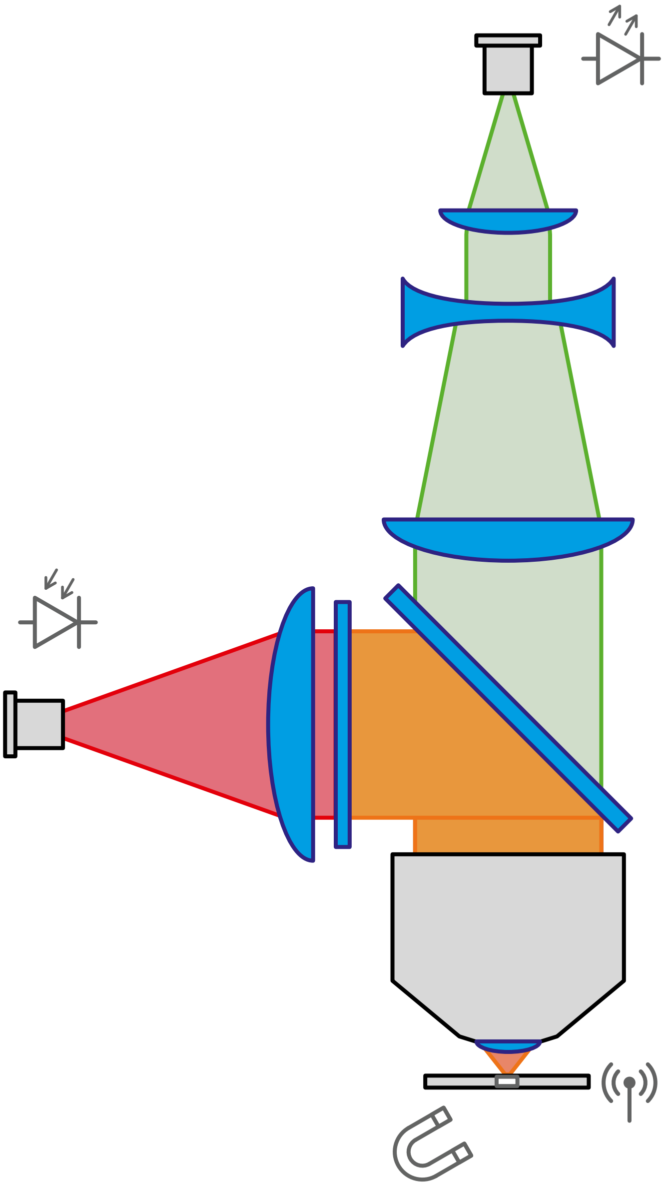
The diamond is integrated into a circuit board including the microwave antenna. The circuit board with the antenna and the diamond can be replaced by other boards with different diamonds, depending on the experiment.

The microwave radiation is emitted by the antenna and controlled by electronic components in the base of the quNV. The microwave can be varied in amplitude, swept in frequency and even be pulsed.

All three Helmholtz coil pairs surround the sample stack. These three coils generate a homogeneous magnetic field as a bias for the NV centers. The three pairs can be controlled individually to adjust the field in three dimensions.

The electronics in the base of the quNV also include a pattern generator. This pattern generator can control and pulse the laser, the microwave and the photodiode for fluorescence readout. Different pulse patterns can be applied to all three components with the desired time intervals in between. The CW laser can be pulsed for excitation and readout, the microwave for the emission of π and π/2 pulses and the photodiode gated.

The fluorescence from the excited NV center is collected by the microscope objective. The red fluorescence is separated from the green excitation laser by a dicroic mirror and filtered by a bandpass. In the end, the light is focused on the active region of the fast photodiode.



Schematic of the optical setup with green laser excitation via the objective and readout by the photodiode of the filtered NV fluorescence.

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