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Applied Physics Master Lab:

Diamonds for Sensing Applications

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conducted from 28.05.2018 to 01.06.2018

Abstract

Contents

1 Introduction

Diamonds are not just known and appreciated by their beauty but also for it important technical properties like their mechanical hardness which they mainly get from their crystal structure. Nevertheless there are defects in their lattice structure which enable us to use diamonds more variously. Colour centres, for example, are fluorescent lattice defects which can be used for many sensing applications [**anleitung**]. In this experiment we will examine the properties of the so-called nitrogen vacancy (NV) centre and it's sensitivity to magnetic fields.

Colour centres (CC) are regular spacing in the lattice that absorbs a particular colour in light. Each CC involves the absence of an atom from the place it would normally occupy in the solid and the relation of an electron with such an empty place, or vacancy. Solids without colour centres may still have colour if impurity atoms or other structures that absorb light are present.
getting lifted into an excited state and then decaying back into the ground state by emitting a photon with a wavelength in the visible range which gives the diamond their many different colours. The fluorescence of the here examined NV-centres can be used to detect magnetic fields.

This is done using the measurement method of optically detected magnetic resonances (ODMR) in which the NV-centre is excited by microwaves which leads to a loss in fluorescence at a certain microwave frequency. The recorded frequency spectrum in a frequency range around that frequency depends on the external magnetic field.

Also the fluorescence spectrum of the diamond as well as its size will be measured using an optical spectrometer and a CCD camera.

2   Theoretical Background

In the following some physical concepts needed for the understanding of this experiment are explained.

2.1   Colour Centres

Colour centres are a kind of point defects in crystal structures which contain a electron that absorbs light of certain wavelengths. This creates a colour in the crystal and therfore these defects are called colour centres.

2.2   NV-Centres in Diamonds

2.3   Optically Detected Magnetic Resonance

3   Experimental Set-up and Procedure
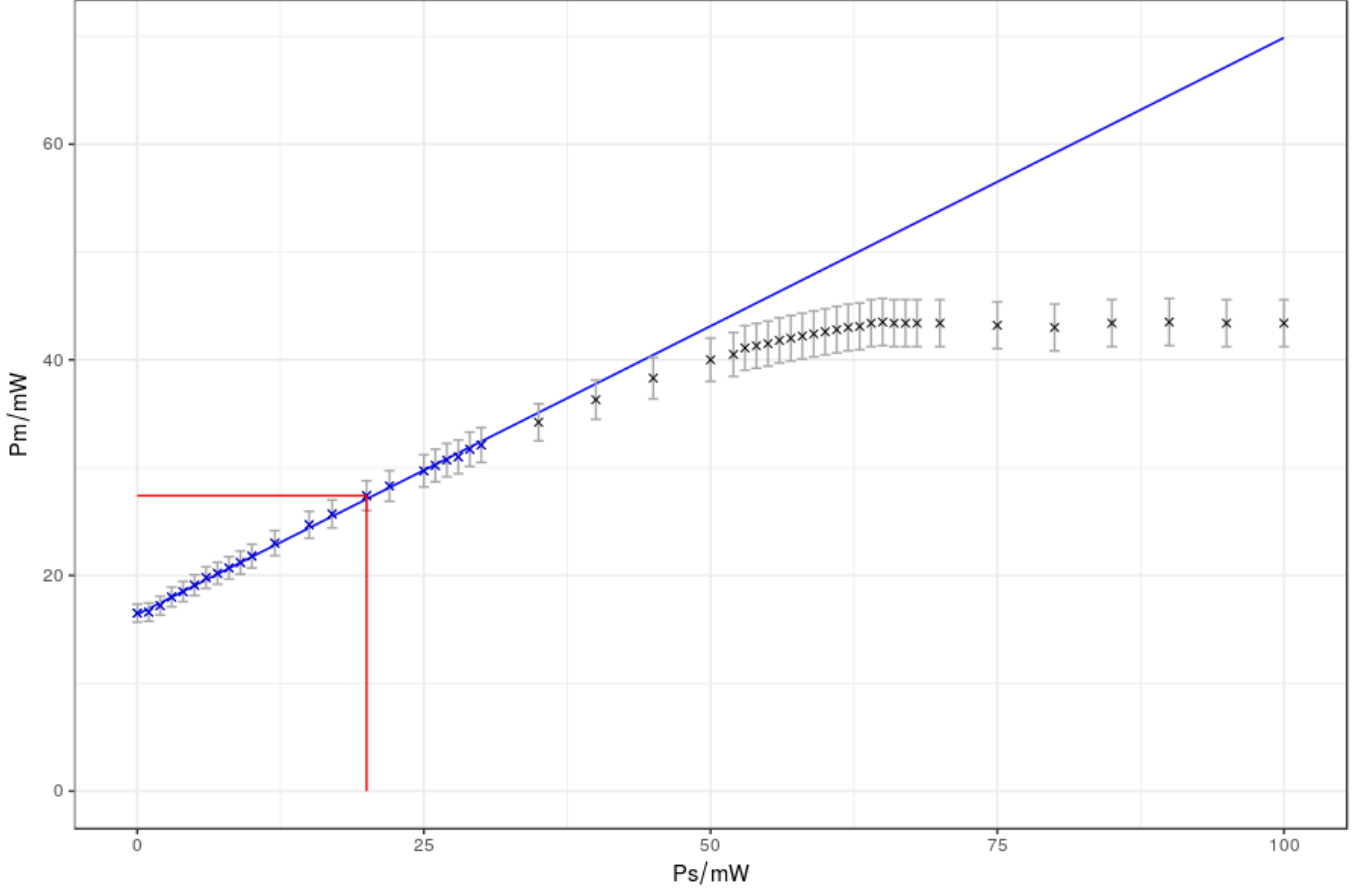
3.1   Set-Up

3.2   Calibration

3.3   Measurements

Figure 1: Measurement of the laser power

4   Evaluation

4.1   Calibration

4.2   Size of the Diamonds

4.3   Fluorescence Spectrum

4.4   ODMR Measurements

Peak	Position	Element	Position [**fraunhoferlines**]	Difference
1	526.8 ± 1.7	Fe I	527.0	-0.2
2	590.0 ± 0.5	Na I	589.6	$+0.4$
3	628.9 ± 0.3	Fe I	630.3	-1.4
4	657.2 ± 0.3	H α	656.3	$+0.9$
5	688.6 ± 0.5			
6	763.5 ± 1.3			
7	824.7 ± 0.3			

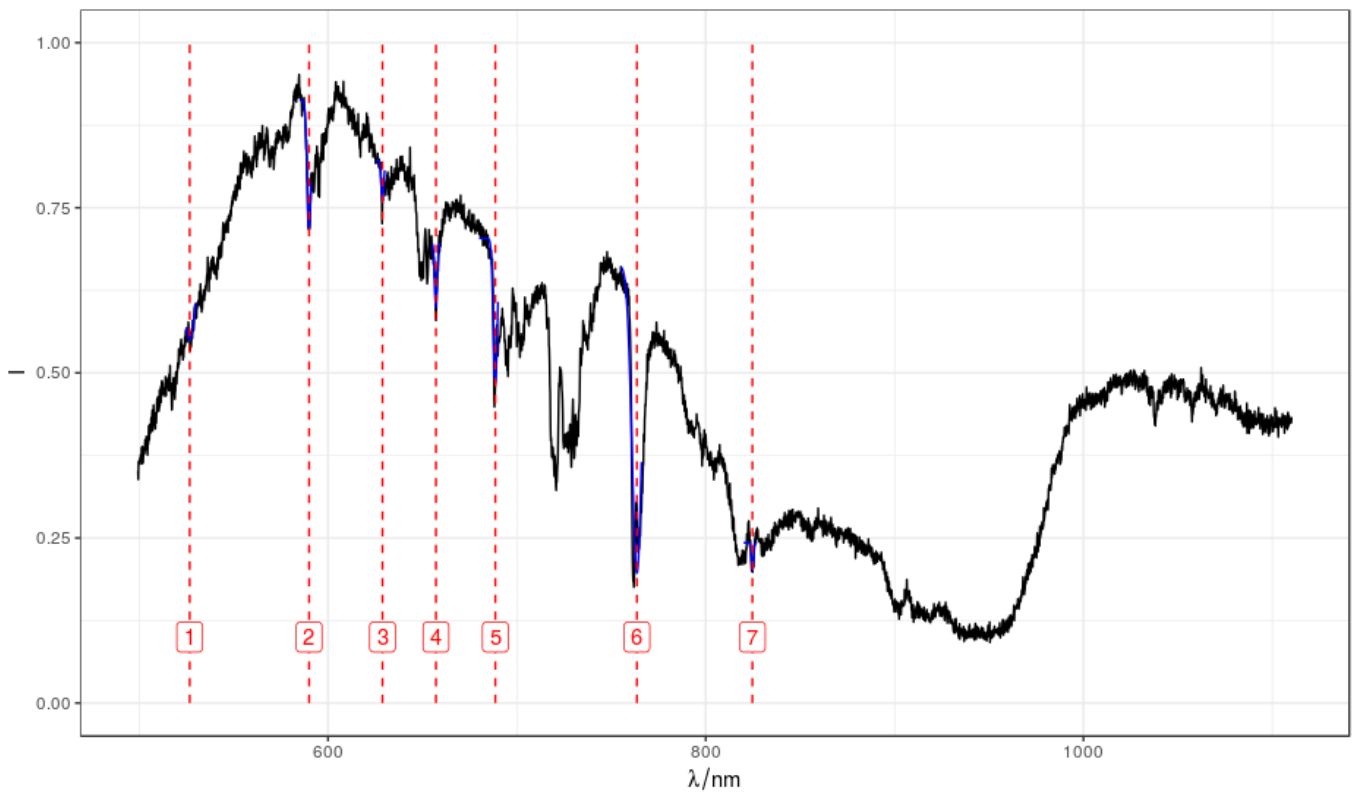**Table 1:** Positions of the Fraunhofer Lines compared to the literature values

Figure 2: Spectrum of the sun with identified Fraunhofer lines for calibration of the optical spectrometer
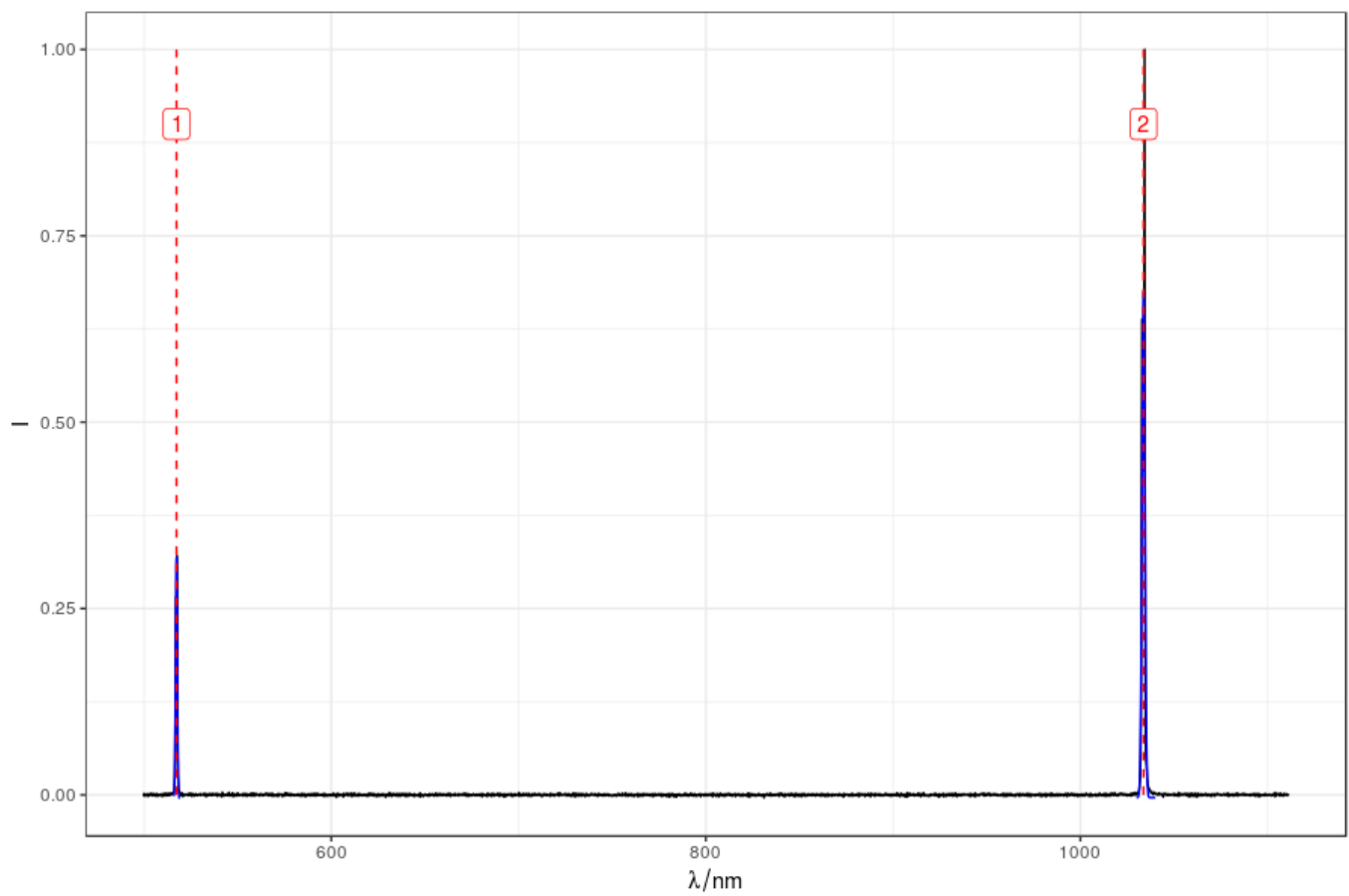
Figure 3: Spectrum of the laser width identified peaks at the wavelengths $\lambda = (517.3 \pm 0.2)\,\mathrm{nm}$ and $\lambda = (1033.7 \pm 0.4)\,\mathrm{nm}$
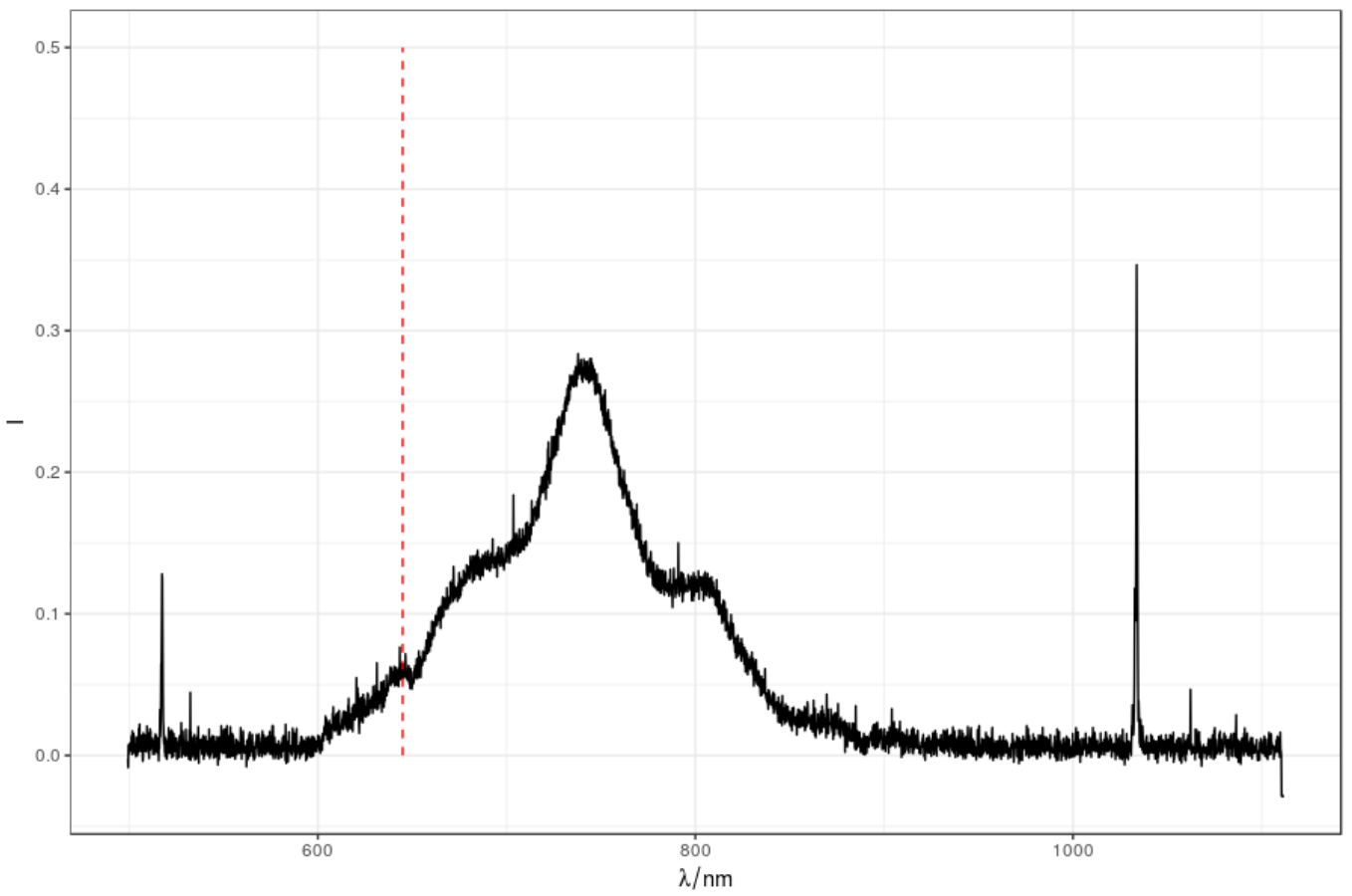
Figure 4: Fluorescence spectrum of the diamond with the zero phonon line (red line) at $\lambda = (644.9 \pm 1.8)\,\text{nm}$

5   Summary and Discussion

6   Appendix

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