

Brno University of Technology

Central European Institute of Technology BUT

Supervisor's report

Academic year: **2022/2023**

Student: **MSc Artur Solodovnyk**

Doctoral programme: **Advanced materials and nanosciences**

Field of study: **Advanced nanotechnologies and microtechnologies**

Supervisor: **doc. Dr. Ing. Petr Neugebauer**

Co-Supervisor: **Dr. Oleksii Laguta**

Name of doctoral thesis topic: **Magneto-optical studies of solid states materials**

Overall evaluation of doctoral thesis and study of the doctoral student:

The research in PhD studies of Artur Solodovnyk was dedicated to developing a THz EDMR setup based on the THz FraScan Spectrometer, located in CEITEC BUT. This spectrometer is able to perform the microwave frequency sweeps in the range of 80 GHz - 1.1 THz with the magnetic fields up to 16 T. Performing the EDMR spectroscopy at such frequencies and magnetic fields has certain advantages. This dissertation describes the successful implementation of the EDMR technique in the THz FraScan spectrometer along with the proof-of-concept results obtained on highly N-doped 15R SiC monocrystals including the first ever frequency-field EDMR map. The work is divided into seven chapters, including the Introduction and Conclusions parts. The 'Introduction' chapter explains the motivation of the dissertation work with a brief overview of the importance of crystallographic defects and how EDMR can help in their studies. The second chapter states the aims of the thesis. The next chapter 'Theoretical background' describes the basic principle of EPR, EDMR and the spin Hamiltonian with the emphasis on anisotropy and hyperfine interaction. Also, a brief overview of the most important models that are essential for determining the origin of the spin-dependent mechanism is provided. The 'Instrumentation' chapter provides a general outline of an EDMR experiment and compares the existing EDMR spectrometers. A special attention is brought to the limitations of the spectrometers in terms of the sample size and the available microwave frequencies. The following chapter named 'THz EDMR Setup' is devoted to the first objective of the thesis – implementation of the EDMR technique into the THz FraScan spectrometer, design and fabrication of the THz EDMR sample holder and specifics of the signal acquisition. Also, a general overview of the FraScan spectrometer is provided. The 'Results obtained' chapter presents the results of high-frequency EDMR spectroscopy on a highly nitrogen-doped 15R polytype SiC monocrystal at low temperatures. The multifrequency EPR and EDMR measurements allowed to define the origin of the observed resonance – the nitrogen donors exchange interactions. This chapter also demonstrates some advantages of the frequency domain EDMR over the conventional one, for instance, the ability to record frequency-field

EDMR maps. And the last chapter is 'Conclusions'. Here, the summary of the thesis is stated; the fulfilled tasks and projects are described in details, and the outlook for the future development of the THz EDMR setup is extensively discussed. Additional sections of the thesis include 'References', his publication and output records, a list of abbreviations, and 'Appendices'. All the work is written on 95 pages.

The PhD thesis is good structured and, overall, well written with minor comments/mistypes. During his PhD studies, Artur considerably improved his skills in experimental science, communication and English language. He is able now to plan and execute experiments of high complexity, analyse the obtained results and present them not only to the knowledgeable professionals but to a broader audience as well. Moreover, Artur is capable of writing scientific publications with a minimal guidance. Some of his ideas had not been implemented but they can be a good starting point for future Master and PhD students of our group. While working on the design and fabrication of the EDMR sample holder and integrating it into the THz FraScan spectrometer, he efficiently cooperated with other members of the research group and the CEITEC employees. Artur also had several 1 month-long research stays in other scientific groups with focus on the high-field EPR and EDMR topics, namely, in Stuttgart University (group of Joris van Slageren), Berlin Helmholtz Zentrum (group of Klaus Lips) and Pennsylvania State University (group of Patrick Lenahan). Additionally, he actively participated in organization of the EFEPR School and in numerous events for science popularisation.

In my opinion, the reviewed thesis **fulfils** all requirements posed on theses aimed for obtaining PhD degree. This thesis **is** ready to be defended orally, in front of respective committee.

Place...Brno....date...28.11.2022..

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doc. Dr. Ing. Petr Neugebauer
supervisor

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Dr. Oleksii Laguta
co-supervisor