

Brno University of Technology

Central European Institute of Technology BUT

Supervisor's report

Academic year: **2021/2022**

Student: **Ing. Antonín Sojka**

Doctoral programme: **Advanced materials and nanosciences**

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

Supervisor: **doc. Ing. Petr Neugebauer, Ph.D.**

Co-Supervisors: **Dr. Vinicius Santana** and **Dr. Oleksii Laguta**

Name of doctoral thesis topic: **Development of a Novel Terahertz Magnetic Resonance Spectrometer for Spin Dynamics Investigations**

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

Antonín Sojka's focus in his Ph.D. work was developing a novel High-Frequency Electron Spin Resonance (HF-ESR) spectrometer capable of performing frequency rapid scan (FRaSCAN) measurements. The frequency rapid scan measurements open a new way to access spin relaxation times of various samples in HF-ESR. The submitted Ph.D. work is divided into six chapters, in addition to the introduction and conclusion parts.

Chapter 1 (5 pages) reviews high-field ESR spectroscopy history up to nowadays progress in Rapid-Scan ESR, including a short history of magnetic resonance in the city of Brno. Chapter 2 (26 pages) provides the theoretical background to ESR spectroscopy, emphasizing the high-field and high-frequency aspects of ESR. The end of the chapter introduces the different methods for studying relaxation times of paramagnetic samples, namely pulsed ESR and Rapid Scan ESR. Chapter 3 (10 pages) introduces the concept of an HF-ESR spectrometer, describing its parts. Then, the chapter focuses on the HF-ESR transmission system and shows the implementation of a quasi-optics solution with a detailed look at microwave beam coupling between the ESR probe and ESR quasi-optical table. Chapter 4 (28 pages) shows one of his main contributions: the design of the THz-FRaSCAN-ESR spectrometer. It describes its main parts: ESR Table, ESR probe, ESR frame, an airlock, and a sample transfer vacuum suitcase which provides a solution to load air-sensitive samples into the ESR spectrometer in an isolated atmosphere. Furthermore, an automatic microwave beam coupling solution is described. The chapter includes several test measurements of the described components. His second significant contribution is in Chapter 5 (41 pages), dedicated to sample holders. In this chapter, he describes the design and performance of six different sample holders: (i) simple sample holder for measurement of compressed pellets or solid samples; (ii) liquid sample holder; (iii) single-crystal rotator; (iv) chip sample holder for studies of electrical devices under the microwave irradiation; (vi) carousel sample holder which can host up to 6 pellets. The last chapter (8 pages) is dedicated to rapid scan measurements and determining the sensitivity of the developed ESR spectrometer. Three examples of the rapid scan are

(i) multi-frequency rapid scan on a Lithium Phtalocyanine (LiPc) single crystal, (ii) rapid scan on an oriented LiPc single crystal in the single-crystal rotator sample holder and (iii) rapid scan on 2,2-diphenyl-1-picrylhydrazyl (DPPH) dissolved in toluene. The conclusions summarize the main results and outline the main topic of the thesis with a perspective on the field. Additional parts of the PhD thesis include References, his publication and output records, a list of abbreviations, and Appendices. All the work is written on 156 pages.

Overall, the PhD thesis is reasonably well written with minor comments/errors. During the PhD studies, Antonín made significant personal and professional progress. He was one of the team's key persons who put a very complex measurement system into operation from the first delivered screw to the whole presented THz-FRaSCAN-ESR spectrometer. His PhD involved not only the hardware parts of the spectrometer itself, but he needed to also communicate well with people in charge of all the electronics, optics, spectrometer software etc.; he was involved in the preparation of the entire lab for the installation of the spectrometer. Some of his ideas were not yet realized and are not described in the thesis but will provide helpful guidance to future PhD students in the group. He has meaningful experience in operating sophisticated systems, including high-frequency ESR spectrometers located in Brno and Stuttgart. He can characterize and analyze EPR spectra independently. He has been involved in many articles published under my supervision, including a book chapter. He is now skilled in writing scientific publications with minimal guidance. He worked in an international team during his studies and communicated his results with others. He was also interacting with other researchers from the chemistry laboratory on interdisciplinary tasks. Moreover, he worked in different groups as a visiting student in Stuttgart (Joris van Slageren, 3 months, high-frequency ESR), Santa Barbara - California (Mark Sherwin, pulsed EPR powered by a free-electron laser). He was/is also a member of USA-CZ team dealing with deposition on highly sensitive THz radiation sensors in collaboration with Prof. Barbara (Georgetown University). He was actively involved in supervising bachelor's and master's students, and he dedicated efforts to popularising science during open days at the institute. Last, not least, he participated in many conferences and developed good soft skills for disseminating scientific results.

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

Place...BRNO....date...01.04.2022

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doc. Ing. Petr Neugebauer, Ph.D.
supervisor

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co-supervisor

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