



Habilitation Thesis Reviewer's Report

Masaryk University
Faculty

Faculty of Science

Procedure field

Plasma Physics

Applicant

Mgr. Zdeněk Navrátil, Ph.D.

**Applicant's home unit,
institution**

Department of Physical Electronics

Habilitation thesis

OPTICAL EMISSION SPECTROSCOPY OF NON-THERMAL PLASMA

Reviewer

Prof. RNDr. Milan Tichý, DrSc.

**Reviewer's home unit,
institution**

Charles University, Faculty of Mathematics and Physics

Habilitation thesis by Mgr. Zdenek Navratil, Ph.D. summarizes the results of his scientific work achieved especially after successfully completing his doctoral studies in 2006. The basis of the habilitation thesis is a selected set of 16 original scientific papers, which were published in important international journals. In these papers, the author participated as a co-author; in 7 works he is listed as the first author. These works were cited 326 times according to WoS. The set of 16 papers, which are presented in the supplement to the habilitation thesis in their entirety, is complemented in the habilitation thesis by well-formulated commentaries that briefly describe the objectives and content of individual studies and discuss the results achieved. According to WoS, the author of the habilitation thesis has been cited without autocitations 512 times in 438 works by other authors; his h-index is 11 (as of 2019-04-24). It is appropriate to comment that the mentioned 16 papers are an excerpt out of 45 works that were published by the author of the habilitation theses together with the co-authors.

Submitted habilitation thesis by Mgr. Zdenek Navratil, Ph.D. focuses on two topics in the field of non-isothermal plasma diagnostics: (i) the diagnostics of discharges under reduced pressure and (ii) the diagnostics of discharges at atmospheric pressure. In addition to the introduction and the final summary, the text of the habilitation thesis is divided into two main parts, entitled "Diagnostics of low pressure discharges" and "Diagnostics of atmospheric pressure discharges". Each of these main chapters contains three subchapters, which in turn include a description of the current state of research, a summary of the author's contribution in the area under discussion, and a commentary on each of the attached publications. The thesis also contains an annex, which contains copies of 16 publications commented in the introductory textual part. The introductory part includes 34 pages including a list of publications. It provides the reader with a more detailed analysis of the study, the motivation of the research, and explains the links between the different parts of the work. With attached publications, the habilitation thesis has 182 pages. Six of the attached publications are devoted to the study of low-pressure plasma; four are devoted to the so-called coplanar barrier discharge at atmospheric pressure, and three deal with the study of high-frequency discharge at atmospheric pressure. Highly cited are three other works on diffuse barrier discharge and

glow discharge at atmospheric pressure; in total, these three works reached up to now 233 citations. In seven attached publications is Mgr. Navrátil quoted as the first author, in other attached publications he is a member of the team of authors. Four publications are in collaboration with the University of Greifswald, two include collaborations with the University of Belgrade and Charles University. Z. Navratil discusses the issue of the author's contribution to the articles where he is a member of the author's team during the discussion on individual publications.

I consider the topic to be in line with present research. Wide applications of low temperature plasma, both at reduced and atmospheric pressure, require appropriate diagnostic methods. Optical emission spectroscopy is a suitable alternative to the Langmuir probe to determine basic low-pressure plasma parameters such as electron concentration and temperature. Emission spectroscopy is also a suitable method (in addition to, for example, the fluorescence methods LIF, TALIF) to determine the concentration of neutral particles, especially radicals at atmospheric pressure. The habilitation thesis of colleague Navrátil covers both these areas and contributes to the improvement of the mentioned methods in both areas. One of the most interesting improvements is the TCSPC method, which uses Stark polarization spectroscopy to determine rapid changes in the electric field in the gamma mode of high-frequency discharge with a high time resolution of the order of nanoseconds.

The quality of the results of the habilitation thesis is confirmed mainly by the attached articles, of which 6 are in the prestigious foreign scientific journal Plasma Sources Science and Technology (IF 3.939), and another 8 in the Journal of Physics D: Applied Physics (IF 2.373). Other papers are also published in journals with high impact factor (European Journal of Physics D, IF 1.393, IEEE Transactions on Plasma Science, IF 1.253). The important contribution of habilitation work consists, in my opinion, in a wide range of diagnostic methods of plasma physics in which the author has acquired a thorough knowledge. I appreciate that in almost all of the cases discussed in the habilitation thesis Mgr. Zdenek Navratil, Ph.D. did not confine himself to experimental work but devoted also considerable efforts to creating physical models of the processes studied. However, the actual experimental work also required considerable invention, which the author, as it is clear from the results, undoubtedly demonstrated.

Habilitation thesis is written in good quality English; enclosed copies of the publications are also in English. The thesis volume is well prepared both from the factual as well as from the graphics layout point of view. At the beginning of the thesis and every major chapter, the author integrates his research into the context of current research and applications of low temperature plasma. The style of the introductory part of the habilitation thesis is favorable for the reader, as it also includes explanation of the physical processes and diagnostic techniques that are used/described further within the thesis. I did not find any typographical errors.

Presented habilitation thesis summarizes the fundamental and the new knowledge in the field of application of optical emission spectroscopy methods for plasma diagnostics. The author also created physical models for the studied effects. In my opinion, the work is beneficial both for the development of the actual research field as well as for the teaching methodology. The author's scientific erudition is documented by the acceptance of co-authored articles in fine international peer-reviewed journals with high impact factors. From the content of the habilitation thesis, I can state that the author delivered original results in the field of plasma physics. Practically the whole habilitation thesis has already been subject to the peer-review

process during the publication of the individual scientific papers that are part of it. The number of publications of the author of the habilitation is adequate for the habilitation procedure.

Reviewer's questions for the habilitation thesis.

I have the following questions about the work, which the author could answer either during his speech or thereafter:

- (i) The author measures the electric field in the atmospheric pressure discharge by two methods: by means of the Stark effect (article [16] in the habilitation thesis) and by the method of the ratio of the intensities of helium lines (article [13] in the habilitation thesis). What is the sensitivity limit of the electric field measurement by both methods?
- (ii) Why the authors did not use the Stark effect for the electric fields measurement in the work [13]? At the first glance, the quantum effect is more advantageous than the collisional-radiative model.
- (iii) To the article [12] of the habilitation thesis. Would it be possible to use the bremsstrahlung for measurement of the electric field not only during the dark phase, but also during the active discharge phase?

Conclusion

Habilitation thesis by Mgr. Zdenek Navratil, Ph.D. undoubtedly contributes to the development of the investigated field of research. I conclude that the habilitation thesis entitled "Optical emission spectroscopy of non-thermal plasma" by Mgr. Zdeněk Navrátil, Ph.D. **fulfils** requirements expected of a habilitation thesis in the field of plasma physics.

In Brno on September, 12, 2019

