

Opponent Review of Doctoral Dissertation

Applicant: Dominika Warmowska, Msc. Eng.

Title of Dissertation: TERAHERTZ ANTENNA ARRAYS FOR COMMUNICATIONS

Opponent: Ing. Michal Pokorný, Ph.D.

Opponent's Department: Resideo Inc.

In accordance with the Study and Examination Rules of BUT, in his/her review the opponent will mainly comment on:

- a) the topicality of the dissertation,*
- b) whether the dissertation achieved its given objective,*
- c) the problem-solving procedure and the results of the dissertation along with the concrete contribution of the doctoral student,*
- d) the significance for practical application or the progress in the field,*
- e) formal and language qualities of the dissertation,*
- f) whether the dissertation fulfils the conditions of Section 47 (4) of the Act,*
- g) whether the student proved his/her creative abilities in the given research field and whether the work does or does not comply with the standard requirements placed on the dissertations in the given field. The review is not valid without this conclusion.*

It is necessary to add a concise commentary to each of the points below.

Ad a) Topicality of the dissertation

The topic of the dissertation is very topical.

Comment:

The "Terahertz gap" is quite well researched from a theoretical point of view, but the design methodologies constrained by technological limits are not yet well explored. Driven by principles of up-scaling from mm-waves or down-scaling from optical-waves, the new problems arise. Each new piece of new knowledge in this field is very valuable and can change the course of future scientific and technological efforts.

Ad b) Objective of the dissertation

The objective of the dissertation was achieved.

Comment:

The objectives were:

- 1. Comparison of modeling approaches of metallic surfaces at terahertz frequencies*
- 2. Developing the design methodology of the antenna suitable for communications in the THz range*
- 3. Manufacture of the designed antenna by microfabrication technologies*
- 4. Generalization of the design methodology by design down-scaling to microwave frequencies*

The common goal of the 3 first objectives was to provide a reliable and cost-effective design and fabrication methodology for communication antenna working at THz frequencies with performance and characteristics above the State of the Art. These objectives were fully achieved at an excellent level.

The 4th objective seems to be affected by unpredictable circumstances, which is evident in the reduced diligence of the discussion and interpretation of the results along with the unfinished build of 35 GHz design. Despite these facts, the core of this objective is thoroughly elaborated with simulations, thus I consider this objective to be achieved.

Ad c) Problem-solving procedure and the results of the dissertation and the concrete contribution of the doctoral student

The problem-solving procedure and the results of the dissertation are above average.

Comment:

The author shows the systematic approach in the solving of the given objectives. Starting with the discussion, evaluation and implementation of the models for accurate simulations of metallization at THz region, over deep analysis of fabrication technology features and limitations, to design methodology of the novel antenna array.

The author designed, fabricated and characterized prototype of novel circularly polarised antenna array operating at 350 GHz providing outstanding characteristics in the bandwidth, axial ration, gain and small-size in comparison with to-date published works. The emphasis was also placed on the corporate feed, which was proven to make the antenna array extension much easier.

In contrary to this very good work, the discussion on the unexpected measurement results and on poor fabrication quality of design efforts at 9GHz and 35GHz is very brief and do not bring the conclusive explaining.

Ad d) Significance for practical application or progress in the field

The significance for practical application or progress in the field is excellent.

Comment:

The dissertation definitely brings new knowledge, unifies the previously described results and is a valuable contribution to the development of science in the field of terahertz and especially sub-terahertz frequency bands.

Specific progress was achieved in the field of the up-scaling of mm-wave approaches for THz applications under challenging constraints of the micro-manufacturing technologies.

Ad e) Formal and language qualities of the dissertation

Formal and language qualities of the dissertation are above average.

Comment:

The work is written in English at a very good level, well readable and clearly communicates the author's intentions and thoughts. Despite the very good level of the overall composition and referencing the sources, few imperfections are present as multiple occurrences of the one and the same sentence (e.g. p. 31) misleading references to literature (e.g. p. 38) and to figures (e.g. p. 60) or even mistakes in equations (e.g. p. 4).

Ad f) The dissertation fulfils the conditions of Section 47 (4) of the Act

The dissertation fulfils the conditions of Section 47 (4)*) Act No. 111/1998 Sb. Higher Education Act: YES

*(*4) Studies are duly finished with a doctoral state exam and dissertation defence, which prove the ability and readiness to work independently in the field of research or development, or in theoretical and creative arts. The dissertation must comprise original and published results or results accepted for publication.*

Ad g) Creative abilities of the student in the given research field. Compliance with the standard requirements placed on the dissertations in the given field.

The doctoral student did prove his/her creative abilities in the given research field and the work does comply with the standard requirements placed on the dissertations in the given field.

Comment:

The author has demonstrated the ability of independent creative scientific work. The presented work contains new scientific findings and procedures that have been published at international conferences and in an impact journal and meets the criteria for a doctoral dissertation.

Overall evaluation:

In conclusion, I can state that the author has demonstrated the ability of independent creative scientific work. The presented thesis contains new scientific findings and procedures that have been published at international conferences and in an impact journal and meets the criteria for a doctoral dissertation. Despite some minor reservations, I rate the overall professional level of the work positively and recommend it for defence.

Opponent's questions:

1. *What kind of spray coating was used for the fabrication of 9 GHz structures in chapter 7.2? There are alternately mentioned the nickel spray and the copper spray, which is quite confusing. Furthermore, if the nickel spray was used, what consequences in antenna characteristics can be expected?*
2. *The thesis is dominantly focused on the discussion of continuous beam steering solutions. Why the discrete beam steering solutions are not discussed in more depth? Are the discrete beam steering solutions suitable for the implementation in the THz region using microfabrication technology?*
3. *Where the 350 GHz prototypes were manufactured (ch. 6.1)? This information is missing in the thesis.*
4. *The impedance bandwidth of 2×2 antenna element at 350 GHz is about 7 % (ch. 5.1.5). However, it is only 2 % after design down-scaling to 35 GHz (ch. 7.1.2.). Can you provide any explanation of this difference?*

I ☒ recommend ☐ do not recommend the dissertation for the defence.

Date: 10.08.2020

Signature:

Ing. Michal Pokorný, Ph.D.