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Annex No. 10 to the MU Directive on Habilitation Procedures and Professor Appointment Procedures

HABILITATION THESIS REVIEWER'S REPORT

Masaryk University	
Applicant	Mgr. Ondřej Caha, Ph.D.
Habilitation thesis	Thin films of topological insulators
Reviewer	Prof. Dr. h.c. Ullrich Pietsch
Reviewer's home unit, institution	Department of Physics, University of Siegen, Germany

Dr. Caha presents an extended review of his recent years research activities dealing mainly with analysis and understanding of thin films of topological insulators. In collaboration with several groups his research was concentrated on pure topological insulators thin films like Bi_2Te_3, Bi_xTe_y, and $Bi_2(Se_xTe_{1-x})_3$, magnetically doped topological insulator thin films of Bi_2Te_3, Bi_2Se_3 and Sb_2Te_3 and topological crystalline insulators, like (Pb,Sn)Se and (Pb,Sn)Te alloys. The research focussed in several highly ranking publications as in *Nature*, *Nature communications*, New Journal of Physics and others where Dr. Caha was one of the co-authors. He was first author of the 2013 paper published in Crystal Growth and Design. This first paper of the series reports on epitaxially growth of bismuth telluride layers of stoichiometry Bi_2Te_3 and BiTe analysing the structure films using XRD techniques in terms of stoichiometry, domain size, lattice parameters and twinning accompanied by other techniques as optical spectroscopy, Raman spectroscopy, transport measurements and APRES. The paper documents the main techniques Dr. Caha has used, namely the x-ray measurements and analysis. The non-stoichiometric alloy layers of Bi_2Te_3 were analysed in the second paper by x-ray diffraction and a model was developed to analyse the stacking behaviour of thin films with different umber of layers. For the other papers focussing on analysis of more fundamental properties of thin film topological insulators he contributed by his x-ray diffraction expertise. Among them paper Nr. 5 is remarkable, where Dr. Caha acts as second author dealing with magnetic alloy layers of $(Bi,Mn)_2Te_3$ were of Bi_2Te_3 layers were doped with Manganese. Using x-ray absorption spectroscopy the Mn position within the crystalline was analysed complemented with APRES data.

The thesis is composed by an introduction followed by a review summarizing the knowledge of topological insulators, i.e. their particular electronic properties and the peculiarities of 2D and 3D topological insulators. This includes presentation of properties of the Bi_2Te_3, Bi_2Se_3

and Sb_2Te_3 family, which is characterized by random stacking of sublayers explaining the behaviour of these topological insulators. Chapter 3 summarized the experimental methods used. Chapter 3.1. explains the x-ray diffraction techniques used. This subchapter contains an extensive explanation of simulation results of random stacking behaviour in Mn doped Bi_2Te_3, Bi_2Se_3 and its impact to x-ray diffraction pattern. It is followed by analysis of impact of anti-site defects and how to analysis strain and lattice parameters by x-ray reciprocal space mapping. Here a subchapter summarizes the temperature dependent measurements in PbSnSe and PbGeSe, which mainly documents the technical possibilities of the CEITEC x-ray laboratory. Chapter 3.2. summarizes the other methods used for the analysis of topological insulators, such as X-ray absorption (XAFS) techniques, high-resolution TEM (HRTEM), angular resolved photo emission spectroscopy (APRES) and electrical transport measurements. Here the XAFS chapter contains results of EXAFS and NEXAFS of materials used in the thesis.

Chapter 4 collects nine preprints. In the beginning, Dr. Caha briefly summarizes the main content of each paper and his specific contribution. Although the results are remarkable, as confirmed in the referee process, Dr. Caha´s specific contribution to the scientific outcome is not clear to me. It is obvious that the publication record is result of strong collaboration and intense discussion among collaborators. However, considering the aim of a habilitation thesis it would be important to know by which ideas or particular new experimental solutions the candidate did contribute to the final achievement beyond the x-ray service.

Reviewer's questions for the habilitation thesis defence (number of questions up to the reviewer)

By which specific ideas or particular new experimental solutions beyond the x-ray service the candidate did contribute to the final achievement published in high ranking journals.

Conclusion

The habilitation thesis entitled “Thin films of topological insulators” by Ondřej Caha **fulfils** requirements expected of a habilitation thesis in the field of Condensed Matter Physics.
Considering his leading role in the CEITEC laboratory, the supervision of students and his contributions to the excellent research of topological insulators, I recommend the faculty of science to accept the habilitation thesis.

Date: Dec 15 2023 Signature: