

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Stanislav Chernyshikhin

PhD Program: Mathematics and Mechanics

Title of Thesis: Tailoring the functional properties of NiTi shape memory alloy by high-resolution laser powder bed fusion

Supervisor: Associate Professor Igor Shishkovsky

Name of the Reviewer: Professor Igor Yadroitsev (Ihar Yadroitsau)

The Central University of Technology, Free State, South Africa

Head of Department of Additive Technologies,

Light Materials and Technologies Institute

I confirm the absence of any conflict of interest.

Igor Yadroitsev

Date: 28-08-2023

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Review of the thesis of Mr. Stanislav Chernyshikhin entitled “Tailoring the functional properties of NiTi shape memory alloy by high-resolution laser powder bed fusion” which was performed at the Skolkovo Institute of Science and Technology, under supervision of Associate Professor Igor Shishkovsky.

The applicant field of study is related to an interdisciplinary field at the intersection of Additive Manufacturing and Materials Science. Additive Manufacturing (AM) is a relatively new field of the applied manufacturing science, which includes interdisciplinary aspects of physics, materials science, design and manufacturing. Currently AM is a hot topic, quickly growing towards fundamental understanding of relationship between process parameters and final structure and properties of the product. Further development in this field will gain knowledge in physical principles on interaction of matter with laser radiation but also in applied aspects of additive manufacturing as porosity, surface roughness, microstructure and final properties. The development of this manufacturing method will provide environmentally friendly time- and materials-efficient manufacturing of parts and components with unique shapes and properties, which are impossible to be manufactured by conventional technologies.

The candidate has done an extensive work of studying the influence of laser powder bed fusion (L-PBF) process parameters on the various properties of NiTi shape memory alloy. Stanislav demonstrated the change in the temperatures of the martensite phase transformation, irreversible strain after a single cycle loading, and variation in the phase composition. Obtained experimental data was used to implement the concept of 4D printing when the property (temperature of shape memory effect activation) was tailored for different parts of the printed sample only by L-PBF process conditions. The physical mechanisms of shift in temperatures of martensite phase transformation were clearly explained by evaporation during the laser influence. The simulation of the evaporation for bicomponent system was carried out. The results are presented in many scientific manuscripts (articles, conference proceedings and patent), two of which (on the topic of the thesis) have already been published in high quality peer-reviewed journals – Materials (Basel) (Impact Factor – 3.4).

The candidate illustrates a broad approach to research activities, including both applied process engineering aspects of manufacturing and a fundamental understanding of physical processes and materials science. It is important to note that the interdisciplinary field, the combination of advanced technology and materials science, application of modern scientific analysis, are key indicators of the high quality of research presented by the applicant.

Mr. Stanislav Chernyshikhin is a young scientist, but he has already published quite a lot of scientific manuscripts in highly rated journals. Scopus, which is the world's largest abstract and citation database of peer-reviewed literature (scientific journals, books and conference proceedings), reflects under his name 18 documents with 59 total citations by 49 documents, h-index – 4. Google Scholar reflects under his name 24 documents with 78 total citations, h-index – 6. This is a good indicator for an ambitious young researcher.

Mr. Chernyshikhin has demonstrated (through a careful reading of his dissertation) a deep understanding of methods for studying the temperatures of phase transformation, the phase composition, and mechanical properties of materials, as well as a thorough analysis of the results obtained. Fundamental study and understanding of the multiphysical phenomena that appearing

in the melt pool during laser powder bed fusion will help him to become a unique specialist with broad knowledge in various fields of science and technology.

The dissertation is divided into six chapters. Motivations and objectives of the thesis are clearly described. I would especially like to mention the fifth chapter and the well-structured thesis. Chapter 5 “Endodontic files manufacturing via high resolution LPBF” shows that the applicant understands the potential practical application of his research. The rest of the chapters also demonstrate a thorough understanding of the subject of research, used scientific methods, methods of analysis and presentation of scientific data.

Before the defense I recommend revising the list of abbreviations, and symbols as far as not all are involved in the present version. In my opinion the introductory part can be expanded in terms of problems during laser fusion of intermetallic materials and existing applications of NiTi (including the concept of files for endodontics). There are no studies of the microstructure of the obtained NiTi samples. Knowledge about the features of the microstructure (grain/subgrain size) and crystallographic texture could refine the results obtained on the relationship between L-PBF regimes and functional properties. I hope that the applicant will take into account my minor comments and enhance the quality of the dissertation.

As a result of my acquaintance with Mr. Stanislav Chernyshikhin's thesis, I can state that the thesis meets all the requirements for a graduate degree in the field of Mathematics and Mechanics (Research Area 01.02.04: Solid Mechanics).

Provisional Recommendation

I recommend that the candidate should defend the thesis by means of a formal thesis defense

I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report

The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense