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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Igor Salimon

PhD Program: Physics

Title of Thesis: Laser synthesis and modification of nanomaterials

Supervisor: Assistant Professor Sakellaris Mailis

Name of the Reviewer: Dr. Fedor S. Fedorov

I confirm the absence of any conflict of interest	**Date: 07-09-2023**

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

The dissertation of Igor Salimon is devoted to the optimization of structuring/synthesis of materials using laser technique. The work is well organized and structured. It includes five chapters where laser treatment of GaAs, AA2024 aluminum allow, porous silicon, and synthesis of MoS_2 and WS_2, as well as the use of e-beam treatment, are discussed. The particular focus is put on the characterization of materials modified and treated by laser irradiation or e-beam.

The author highlights that the "research was aimed at understanding of some aspects of material modification and reorganization into new structures under pulsed laser scanning and continuous wave scanning exceeding the speed of thermal relaxation", and "Laser-induced chemistry and topography modification was investigated in regards to the processing of technologically important materials". Indeed, the topic of the dissertation work is relevant to its actual content. The study evaluated in detail a connection of laser structuring/treatment parameters with oxidation of GaAs in the form of laser-induced periodic surface structures. Also, densification of porous Si was carefully tested showing how treatment parameters might lead to the appearance of dense regions and cavities. The synthesis of MoS_2 and WS_2 facilitated by laser treatment was discussed in detail. Effects of laser radiation on surface structuring of aluminum allow was explained. Thus, the work fully corresponds to the mentioned goals.

The methods chosen to evaluate the results of laser treatments are appropriate and relevant. They include SEM, FIB-SEM, AFM, and profilometry, for checking the morphology and topology and ToF-SIMS, EDX, XPS, and Raman spectroscopy to gain an understanding of material composition and structure. Possibly, the author could try electron diffraction for additional proof of the structure of TMDC materials, e.g., after substrate etching.

The conducted work underlines a new method of synthesis of TMDCs like MoS_2 and phenomena accompanying the synthesis; also, an optimization of localized oxidation of GaAs crystal is rather explored. The mentioned results might bring new insights into development in the field of material science and are at a good international level.

The shown protocols of optimization and engineering studies of materials treatment by laser could be further applied in (1) corrosive and wear resistance protection design, in the case of aluminum alloy, (2) design of optical elements, sensors in the case of GaAs, and (3) photodetectors (MoS_2).

There are 4 papers published on the topic of the thesis. Igor Salimon is the first author in 3 of them. Two are in the mdpi journals - Metals (Q1, IF2.9) and Micromachines (Q2, IF3.4), and one is in Solid State Sciences (Elsevier, Q2, IF3.5). The fourth paper is published in Materials Today Advances (Elsevier, Q1, IF10). The publications reflect most of the results discussed in the thesis, excluding results for porous silicon. The number of publications satisfies the formal criteria for a defense.

In summary, the work is interesting, with a prospective to applications, and carefully prepared. Thus, I recommend that the candidate defend the thesis by means of a formal thesis defense.

Still, I encourage the author to pay attention to the following points.

(1) I encountered a few typos that might require the author's attention.
(2) I would suggest to make the title of the thesis more specific.
(3) What about the anisotropic properties of materials? Can they be considered?
(4) For the GaAs part, a comparison between reflected and adsorbed energies might be beneficial. Both melting and oxidation take place (and other processes). What is the main origin of pores?
(5) The survey XPS spectrum is missing.

(6) How was the overlap between adjacent irradiated tracks (71%) in the case of aluminum alloy optimized?
(7) Proof of MoS_2 nanoribbons formation is needed. It is hard to learn from SEM images. “Nano” according to the IUPAC definition is limited by 100 nm.
(8) The concentration of solution and thickness of the films (MoS_2) are correlated. However, the concentration is rather low, at the level of mMs. Does the change in concentration at this level much affect the thickness? Are density changes relevant at such concentrations?
(9) I would suggest clearly articulating the novelty of the results shown in Chapter 2.

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 are introduced in the 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*