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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Mikhail Bulavskiy

PhD Program: Materials Science and Engineering

Title of Thesis: Hybrid functional materials based on single-walled carbon nanotubes

Supervisor: Professor Albert Nasibulin
Co-supervisor: Assistant Professor Fedor Fedorov

Name of the Reviewer: Yulia V. Ioni

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 22-11-2023**

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 thesis is devoted to the synthesis and exploration of new hybrid functional materials fabricated by the modification of single-walled carbon nanotubes for further application as transparent conductive films and supercapacitors. Furthermore, a novel method of highly efficient bilateral doping of SWCNT films with gold nanoparticles and/or nanowires was developed in this study. The outstanding properties of the resulting functional materials have been proven by a combination of physical and chemical (electrochemical) analyses using equipment with a high degree of accuracy.

The thesis has logical straightforward structure, including Introduction, Literature Review, Materials and Methods section and three chapters of Results and Discussion describing the main results of the research followed by Conclusions. The reference list indicates that relevant current literature was thoroughly monitored by the author. The topic of the thesis completely corresponds to the content of the work. The methods used for the study and synthesis of materials are relevant and comply with accepted international research standards.

Main scientific impacts of this work are: the method of fabrication of the transparent conductive films with low equivalent resistance, method of electrochemical opening the single-walled carbon nanotubes for subsequent filling with solutions and doping by gold chloride and/or nanowires, and application of SWCNT/polyaniline composites as supercapacitors in both two- and three-electrode cells. The thesis research results are scientifically significant, relevant and are in accordance with latest trends of the field. Based on the thesis research results, two publications were published in the Journal of Material Chemistry C and in the Journal of Power Sources, one publication has been submitted. This fact highlights the high quality of the research performed.

There are few questions that have to be answered:

-There are no references in the literature review part (Introduction).

- What is the filling efficiency estimated in the second chapter of the results and discussion? Could the filling efficiency be transferred into a value showing the filled nanotubes amount or fraction? Is it possible to determine the relationship between the number of nanorods and gold nanoparticles obtained with bilateral doping of single-walled carbon nanotubes?

-What is the reason for the significant increase in transmittance value of single-walled carbon nanotube films upon the heating above 350°C?

-The study shows that SWCNTs are acting as reducing agents in the chloroauric acid filling process. What by-products of this interaction were obtained and how were the resulting composites purified from them? Would not this also led to additional interaction with hydrogen chloride or chlorine, which could be released during the doping?

-The thesis contains some inaccuracies that need to be corrected. So, in Fig. 13a, the photo of the sample SWCNT80 has the wrong designation (SWCNT95). Figure A13 (Appendix) is of low resolution and the color symbols and formulas are hard to read. In Fig. A21, there is no point corresponding to the specific power value for the SWCNT80/PANI60 sample, when the point is doubled for the SWCNT80/PANI50 sample. In Fig. A1 (Appendix), all components of the device described in the text should be signed.

- The abbreviation UVP is explained in the Abstract (p. 3), the list of Abbreviations (p. 10) and again in the Introduction on p. 13.

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*