Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Ilya Novikov

PhD Program: Materials Science and Engineering

Title of Thesis: Assembling networks of single-walled carbon nanotubes for electronic and optical applications

Supervisor: Professor Albert Nasibulin, Skoltech
Co-supervisors:
Professor Tanja Kallio, Aalto University
Assistant Professor Dmitry Krasnikov, Skoltech
Assistant Professor Fedor Fedorov, Skoltech

Name of the Reviewer: Ayrat M. Dimiev

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:** **Date: 04.09.2023**

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 ɜresented Doctoral Thesis "ASSEMBLING NETWORKS OF SINGLE-WALLED CARBON NANOTUBES FOR ELECTRONIC AND OPTICAL APPLICATIONS" by ILYA NOVIKOV is devoted to carbon naotubes (CNTs) and their applications.

The work consists of two parts. The first one is devoted to the aerosol-based synthesis of CNTs and CNT-based transparent conductive films. The second part is devoted to fabrication and testing the CNT/polymer composites. Both directions are very important for practical applications.

The thesis consists of five chapters set forth on 130 pages of the main text, plus 12 pages Appendices.

After the Introduction (Chapter 1), Chapter 2 starts with thoughtful description of the CNTs structure and properties. This follows by a nice review on the conductivity/resistance of the CNTs assemblies. Special attention is given to transparent conductive films, and CNT/polymer composites,

Chapter 3 describes Methods, used in the work: the methods of the CNTs synthesis, preparation of CNT/polymer composites, and their characterization, including characterization of neat CNTs.

Chapter 4. Here, a new strategy is proposed that allows to controllably vary residence time and maintain catalyst activation at the same time, the task not achieved before. The dependence of CNT diameter and chirality on residence time was registered. The CNT growth stage was thoroughly investigated as the function of several parameters, including feeding regime, additives, temperature, etc.

Chapter 5 is devoted to CNT/polymer composites. The role of the 3D assembly of CNTs inside the polymer matrix on the properties of composites is evaluated. The low percolation threshold for conductive properties is achieved.

The topic of the dissertation is relevant to its actual content. The methods, used in the work, are typical for the field, and appropriately used. The scientific significance of results is high and corresponds to the international standards.

The content of thesis was reported in 5 publications, from which in 2 Ilya was the first author, elucidating his contribution to the work. The papers are published in the highly ranked journals, such as ACS Appl. Mater. Interf., Chemical Engineering Journal, Carbon, etc., confirming high level of research.

Some additional and more specific comments to improve the thesis:

1. Page 20, Fig. 1. In Figure caption, the copyright is shown incorrectly. It is 2015, not 2023.
2. Page 48, line 1: Two Figure numbers (1 and 4) are given; old Figure # is not removed.
3. Page 60; the role of the excitation laser frequency is missing in describing the G-band shape. Either list all the factors in details (preferred), or none of them.
4. Page 67. Here, and at several occasions throughout the text, the English grammar needs to be improved.
5. Page 101. The conclusions, formulated here (kinetic nature of percolation threshold, etc.) inspired by ref [92] are not typical for the field. Flocculation between nanotubes cannot lead to "formation of a nanotube network within the whole host material" since this leads to filler-free spaces between the flocculates; the situation is opposite. This needs to be either further detailed, or removed/reformulated.

In general, the contribution of Ilya Novikov to the field of carbon naotubes is important and substantial. The dissertation is written in good logics and appears as a separate completed study. Professional

description of various details confirms deep understanding of the material in the research field. Ilya carried out significant part of the work, contributed to fundamental studies of the dissertation, and wrote significant part of the papers, which are the basis for his dissertation. The dissertation is an original work possessing fundamental novelty and practical importance. I strongly recommend the author of this thesis for the PhD degree. The manuscript can be accepted for publication as a doctoral dissertation after minor corrections.

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*