Skoltech

Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Javier Antonio Ramirez Benavides

PhD Program: Materials Science and Engineering

Title of Thesis: Advanced single-walled carbon nanotube membranes for optoelectromechanical applications

Supervisor: Professor Albert Nasibulin

Co-supervisor: Assistant Professor Dmitry Krasnikov

Name of the Reviewer: JI Puguang

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 18-10-2024**

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

Thesis has the proper structure, highlights research motivation in the introduction, provides the current state of the art in the field in the literature review section, includes elaborately discusses methods and results of the work completed. Overall quality of the thesis and results corresponds to the PhD thesis level.

The title of the thesis matches the actual content of the thesis. This thesis aims to develop methods for modification of the membranes for specific applications. Firstly, a SWCNT renewable extreme ultraviolet (EUV) pellicle was designed to filter and further evaporate Sn particles (produced by an EUV light source) at a low pressure by the Joule heating of the membrane. Secondly, by applying the same low-pressure Joule heating, ethylene decomposes on the membrane surface due to the high-temperature pyrolysis. This allows "welding" of the nanotubes within the membrane, improving the mechanical properties and electrical conductivity. By engineering lateral carbon deposits and doping with $HAuCl_4$, the PhD candidate achieved one of the state-of-the-art performances for transparent conductors. This thesis opens new possibilities for carbon nanotubes to be applied for filtration in a harsh environment and for transparent electronics seeking to decrown indium tin oxide in consumer products using transparent electrodes. The methods used in the thesis are relevant to the completed research. The objectives of the research are achieved. Developed or optimized methods for materials modification emphasize the novelty of the research.

The quality of publications written on basis of the results described in the thesis should be considered as sufficient for the PhD level candidate. The thesis could be considered as ready for the defense. However, comment on the following question might be useful:

1. There are three formats for title numbers in the table of contents: large space with point, large space without point, and small space without point.
2. Some paragraphs start with spaces.
3. There are several images which are incorrectly numbered. This needs to be corrected, For example, Figure 38.
4. Does the chirality of SWCNT affect the final performance?
5. Is it possible to add mechanical properties test of the membrane according to the application scenario?
6. Ethylene Welding is a CVD process?

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*