

Jury Member Report – Doctor of Philosophy thesis.

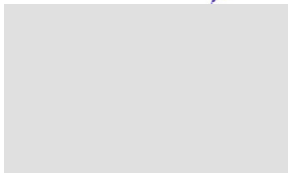
Name of Candidate: Mohammad Owais

PhD Program: Materials Science and Engineering

Title of Thesis: Design and characterization of thermally conductive polymer nanocomposites with tunable electrical resistivity

Supervisor: Dr. Sergey Abaimov, Skoltech

Name of the Reviewer:

<p>I confirm the absence of any conflict of interest</p> <p>(Alternatively, Reviewer can formulate a possible conflict)</p>	<p>Signature:</p>  <p>Date: 04.09.2023</p>
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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 an important task: studies of thermally conductive fillers (such as, boron nitride, graphene oxide, carbon nanotubes) within the polymers (Epoxy resin, Poly vinyl alcohol) to achieve the maximum enhancement in the thermal conductivity of the composite materials. The candidate fabricated a set of composites and investigated their electrical and thermal conductivities. Mohammad Owais's thesis explores this practically very important and challenging task – fabrication of conductive thermal management materials that can dissipate heat energy and be used in electronics and automotive industrial components.

The thesis consists of six chapters set forth on 128 pages.

Introduction nicely reveals the existing problems and needs to develop thermal management materials.

Section 2 provides an in-depth study of materials and methods pertaining to thesis work. In section 2.4 where a summary of the chapter is provided, it is suggested that one paragraph be added which connects the thesis work with the chapter, explaining what materials and approaches were selected based on the literature review and what novelty the thesis addresses.

Section 3 is overall good work. The ratios of loading are comparatively high to what literature shows, but were needed for viable results. The work is explained well. However, the work deals with bulk composites, which is different from the next section 4.

Section 4: the chapter is also well written and describes the process and results well. It deals with thin films rather than bulk materials. The weight %'s are somewhat consistent with the previous chapter, but a summary explanation as to the correlation between weight % and observed properties should be provided in the summary of the chapter. This will allow comparison with the previous chapters and trends.

Section 5: This chapter provides a good summary of CNT-epoxy nanocomposites. The weight percentages used as lower (up to 2%) as compared to the previous chapters and materials. The results and testing all connect logically.

My comments related to the thesis structure:

- Each experimental chapter contains sections *Introduction*, *Objectives*, *Materials* and *Methodology*. Introduction and Objectives must be given in the beginning of the thesis and only once for the whole thesis. The characterization techniques are mostly similar and connected. Individually, the chapters stand as independent, and more interconnectivity between the spectrum of materials may be needed when switching chapters. I propose to make a common chapters *Materials* and *Methodology*, where everything can be described at once. The thesis should be as a single document combining research carried out by the candidate, not as independent chapters based on separate papers. Chapter 6, which is conclusions, summarized the thesis and connects it well, it would be nice to see this interconnectivity logic in the final paragraphs before switching chapters.

Some additional and more specific comments to improve the thesis:

1. Abstract: Guidelines dictate that the abstract size is limited to 400 words. Currently, the abstract is over 700 words long.
2. The list of figures and tables is not necessary and can be easily cut off without harming the quality of the thesis. This is old style, I would call atavism.
3. Section 1.2: *“To achieve maximum improvement in the thermal conductivity of TMMs or TIMs compared to the traditional TMMs currently employed in industry with TC of ~ 4W/mK by investigating the effect of low (≤ 10) to optimum filler loading concentration within a polymer matrix.”*
What is 10? 10% by weight? By volume?
4. Section 2.2: It may be beneficial to describe the difference between thermoset and thermoplastic polymers. The thesis does a good job in explaining their usages and applications, but misses to explain their difference.
5. Section 3.3 – SEM details are missing.
6. Sections 1.2 and 2.1 should start with a short description. For instance, what section 1.2 contain: objectives or scope? The same comment for “2.11” and please check the numbering.
7. Abbreviations must be given in an alphabetic order. Descriptions for Tables should be placed above the tables, but not below.

The thesis describes main results published in the papers. The thesis has been compiled over three publications, all dealing with thermally conductive materials, but the work is spread in terms of weight percentage usage and manufacturing techniques. The 5th publication and book chapter should be cited correctly and complete.

In general, the contribution of Mohammad Owais to the field of Materials Science is important and substantial. The dissertation is written in a good scientific language, but as mentioned above requires some rearrangement. Mohammad carried out most of the work, contributed to fundamental studies of the dissertation, and wrote the most part of the papers, which are the basis for his dissertation. He has sufficient number of scientific publications on the same as dissertation topic. Mohammad’s dissertation is an original work possessing fundamental novelty and practical importance. I recommend the author of this thesis for the PhD degree. The manuscript can be accepted for publication after appropriate changes as a doctoral dissertation after minor changes.

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