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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Timur Ermatov

PhD Program: Physics

Title of Thesis: Optical properties of hollow-core microstructured fibers modified by polymers and/or inorganic nano- and submicron particles

Supervisor: Professor Dmitry Gorin

Name of the Reviewer: Kirill I. Zaytsev, Prokhorov General Physics Institute of RAS, Moscow, Russia

I confirm the absence of any conflict of interest	 **Date: 21-09-2021**

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

In this thesis by Timur Ermatov, entitled “Optical properties of hollow-core microstructured fibers modified by polymers and/or inorganic nano- and submicron particles”, several approaches to functionalize the microstructured optical fibers by different biocompatible and removable nanocoatings were developed, studied experimentally and, then, applied for sensing of liquid analytes. For this aim, the author proposed a fiber-based refractive-index sensor of liquids. It relies on measurements of the spectral shift of the Fabri-Perot resonances at the fiber output end, while a liquid analyte is streamed through the fiber capillaries via a judiciously-designed liquid chamber. The developed functionalized fibers possess high sensitivity to changes in the refractive index of a liquid analyte, along with a high energy efficiency. These forms advantages of the developed functionalized fibers over the existing ones in sensing applications.

Microstructured optical fibers and fiber-based sensors attract considerable attentions in modern optics and photonics. This is justified by a comprehensive overview of this topic by the Author, as well as by increasing number of research papers in these demanding areas according to the Scopus, Web of Science, and other databases.

This work is quite interdisciplinary in nature. In order to solve the problem posed in this thesis, the Author applied experimental methods of fiber optics, colloidal chemistry, biophysics, and other disciplines. In my opinion, properly selected methods of the experimental study ensure correctness of all Author’s estimates.

This thesis is clearly written and well organized. It presents novel scientific results in the areas of physics, optics and material sciences. It was shown that the obtained results are of practical importance and can be applied in different branches of fiber optics and optical sensing technologies, including sensing the refractive index of biological liquids aimed at medical diagnosis.

I have few minor comments to be addressed to the author:

1) Nowadays, a number of hollow-core fibers exist, which exploit different fiber cross-section geometries and which rely on antiresonant (anti-resonant reflecting optical waveguide – ARROW), Fabri-Perot, photonic crystal (Bragg), or even mixed guiding mechanisms. All these hollow-core fiber designs have a potential in sensing applications. In my opinion, the work lacks some classification of the existing hollow-core fibers and description of the related guiding mechanisms, before selection of the particular hollow-core fiber geometry, that was considered in this study.

2) Why did the author select this particular geometry of the hollow-core microstructured optical fiber for his experiments? Was the fiber cross-section geometry optimized somehow for the further functionalization and sensing of liquids? Please, comment.

3) I guess the considered fiber operates in a multimode regime due to considerable dimensions of a fiber core. Please, comment, whether the large core diameter and, thus, the multimode operation regime are necessary for the considered sensing application.

4) Please, comment, whether it is possible to supplement your analytical and experimental estimates of the Fabri-Perot resonances positions by some numerical analysis of the fiber guiding properties? Can such a large-cross-section fiber be modeled using, for example, eigenmode expansion technique in Lumerical MODE Solutions or COMSOL Multiphysics?

5) Coupling and banding losses, mode coupling, and decoupling of core-guided modes into lossy cladding modes are quite interesting topics of fundamental and applied research topics. Are you planning to consider them for your functionalized fibers in future work?

The abovementioned minor issues and comments do not reduce the overall positive opinion about the PhD thesis by Timur Ermatov.

The author has published his finding in top-rank journal in the areas of optics and photonics, fiber optics and optical materials technologies, including the Light: Science & Applications (Q1, Impact Factor: 17.782), Optics Letters (Q1, IF: 3.776), and Optics Express (Q1, IF: 3.894). He also presented his research results at several leading scientific events. Such a high publication level emphasizes novelty and importance of the obtained results.

Thus, I recommend *that* Timur Ermatov should defend the thesis by means of a formal thesis defense.

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*