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Review Report on PhD Thesis entitled

"LABORATORY WATER-WINDOW MICROSCOPE BASED ON Z-PINCHING CAPILLARY DISCHARGE SOURCE FOR BIOLOGICAL IMAGING"

by PhD candidate

Tomáš Parkman

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This dissertation was prepared in a combined form of doctoral studies at the Department of Natural Sciences of the Faculty of Biomedical Engineering (FBE) of the Czech Technical University in Prague. The main objective of the thesis was to develop and demonstrate a laboratory, transmission table-top water-window microscope for biological imaging. The thesis is logically divided in 6 chapters, covers nearly 100 pages, and contains a comprehensive overview of state-of-the-art soft X-ray sources, optics and water window microscopes, as well as detailed investigation of specific table top soft X-ray sources available at the FBE, and most notably convincing experimental data on the performance of the full-field transmission water-window microscope developed there.

First of all, the dissertation reads well in clear scientific English with very few typos, and it is well organized. The theoretical part, Chapters 2 and 3, contains a lot of useful information on the basics of soft X-ray physics, updated comparison of laboratory and synchrotron sources used for the water-window microscopy in terms of spectral brightness, overview of soft X-ray optics, principles and peculiarities of image formation in soft X-ray microscopy, and recent survey of table-top water-window microscopes based on laser-produced and discharge-produced plasma sources, respectively. Chapter 4 is devoted to detailed description and characterization of two distinct compact soft X-ray sources based on nitrogen plasma available at FBE, which are both in principle applicable for microscopy in the water-window spectral region. Critical comparison of laser- and discharge-produced plasma as a source for soft X-ray microscopy was performed with the conclusion that Z-pinching capillary discharge nitrogen plasma source at 2.88 nm is more suitable for the realization of full-field transmission water-window microscope. Chapter 5 is of crucial importance as it presents a design and experimental results on

imaging performance of this table-top water-window microscope using a capillary discharge plasma source. Imaging experiments with a copper mesh confirmed a half-pitch spatial resolution of 75 nm, and signal-to-noise ratio analysis was correctly performed. Finally, the applicability of developed water-window microscope was demonstrated by successful imaging of green algae *Desmodesmus communis*. As expected, the soft X-ray images have shown a superior spatial resolution as compared to standard visible light microscopy. Despite longer exposure time and lower spatial resolution as compared to synchrotron based systems, the developed soft X-ray microscopic system can be still useful for various applications thanks to its accessibility and compactness.

The thesis is in its nature an applied soft X-ray device development thesis, which does not take any value away from the work presented. However, I request the candidate to comment on the following points:

1) Novelty and originality
2) Specification of candidate's own contribution
3) Future utilization of the microscope

In summary, the results presented in the thesis represent satisfactory scientific level of the author's research work and skills. The results were presented at several international conferences and published in journals with medium impact which is common for such technical and development work, showing their reasonable visibility in the scientific community. The thesis is written to a standard acceptable for academic and professional communication.

The submitted thesis satisfies the requirements for the award of PhD degree. Therefore, I recommend the candidate for the PhD award subject to the successful oral defense.

In Dolní Břežany on November 8, 2021.

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