OPINION

on a Dissertation Thesis
for the assignment of the scientific degree a Doctor of Philosophy
in the professional field 4.1 Physical Sciences,
by defense procedure at the Faculty of Physics (FzF)
of Sofia University "St. Kliment Ohridski"(Sofia University)

The opinion is prepared by: **Assoc. Prof. Dr Evgenia Tzvetanova Benova-Shopova,**
(академична длъжност, научна степен, име, презиме, фамилия - месторабота)
Scientific manager at Clean & Circle Center of Competence, Sofia University, as a member of the scientific jury of the competition, according to Order № РД 38-95 / 21.02.2023 г. by the Rector of Sofia University.

Dissertation title: "Conversion of CO_2 using Arc Discharges at Atmospheric Pressure."

Author of the dissertation: Vladislav Valentinov Ivanov

I. General description of the presented materials

1. Data on submitted documents

The candidate Vladislav Ivanov has submitted a dissertation and an Author's abstract, as well as the mandatory tables for Physics from the Regulations for the terms and conditions for acquiring scientific degrees and holding academic positions at SU "St. Kliment Ohridski. All documents required for the defense (11 other documents, including the three publications included in the dissertation; curriculum vitae and bachelor's and master's diplomas; declaration of authorship and documentation of originality of the dissertation and absence of plagiarism), supporting the applicant's achievements are also presented.

The documents presented by the candidate for the defense correspond to the requirements of the ZRASRB, PPZRASRB and the Regulations for the terms and conditions for acquiring scientific degrees and occupying academic positions at SU "St. Kliment Ohridski" (PURPNSZADSU).

2. Applicant data

From the submitted CV it is evident that Vladislav Ivanov has completed his Bachelor (2012-2016) and Master (2016-2018) degrees at the Department of Radiophysics and Electronics of the Faculty of Physics of Sofia University, majoring in "Communications and Physical Electronics", having also acquired a qualification as a teacher in "Physics and Astronomy". He is a full-time PhD

student at the same department. In parallel, he has also graduated from the "Telerik Software Academy", from where he obtained qualifications as a C# developer and JavaScript developer. While still a student he joined the plasma research group of Assoc. Prof. Stanimir Kolev, who is the PhD student's supervisor. Vladislav Ivanov has participated both in discharge modeling tasks (Particle in Cell, PIC-simulations; fluid model of magnetically stabilized arc discharge) and in experimental studies. The CV includes participation in two projects (at the National Fund for Sceintific Research at the Ministry of Education and Science and at the Centre of Excellence in Mechatronics and Clean Technologies under the Operational Programme "Science and Education for Smart Growth" 2014-2020). Unfortunately, no documents supporting this participation have been submitted. There is, however, other evidence of it, such as co-authorship of scientific publications that acknowledge these projects. Thus, it can be considered that the submitted thesis presents research and results obtained with the active participation of the PhD student within the activities of these projects. The PhD student has also participated in national and international conferences and other events and has won awards from them.

3. General characteristics of the applicant's scientific work and achievements

The presented thesis is generally devoted to modeling and experimental studies of arc discharges at atmospheric pressure, as well as the possibilities of their application for CO_2 conversion, which is a particularly hot topic problem at present.

Vladislav Ivanov is co-author of four scientific publications - 2 in journals with Q1 and high impact factor (*Plasma Sources Sci. Technol. u J. CO2 Util*.) and 2 in journals with Q4 (*J. Phys.: Conf. Ser*.), published in the period 2021-2023. Three of them - two with Q1 and one with Q4 - are included in the thesis. It can be confidently said that:

а) the scientific publications included in the dissertation not only meet, but also exceed the minimum national requirements (according to Art. 2b, paras. 2 and 3 of ZRASRB) and, respectively, the additional requirements of SU "St. Kliment Ohridski" for acquiring the educational and scientific degree "doctor"in the professional field 4.1 Physical Sciences;

б) scientific publications included in the dissertation work do not repeat those from previous procedures for acquiring a scientific title and academic position; (see the tables in the applicant's documents);

в) there is no proven plagiarism in the submitted dissertation and abstract.

4. Characterization and evaluation of the applicant's teaching activity

There is no data on teaching activity, which is not required by ZRASRB, PPZRASRB and PURPNSZADSU..

5. Content analysis of the candidate's scientific and scientific-applied achievements contained in the materials

The presented dissertation work consists of an introduction, three chapters, a conclusion and a bibliography, set out on 124 pages and including 45 figures and 4 tables. The literature cited comprises 84 titles.

The First chapter describes in detail the different types of direct current discharges, the main approaches for modeling the processes in the plasma, as well as essential characteristics of the CO_2 molecule and the specifics of its dissociation.

The Second chapter presents the numerical fluid model developed by the PhD student of the positive column of a magnetically stabilized arc discharge in argon at atmospheric pressure. As a result of the numerical simulations, the dependences of the arc characteristics on the wall spacing and the gas flow velocity are established, which are essential for the arc stabilization and its practical applications.

The Third chapter is devoted to experimental studies related to CO_2 dissociation under different sliding discharge configurations – unstabilized sliding discharge, magnetically-stabilized sliding discharge, magnetically-accelerated sliding discharge. A comparison of the characteristics of the three discharges is made and their applicability for CO_2 dissociation is evaluated based on the achieved conversion rate and energy efficiency.

Briefly, the main results of the thesis can be formulated as follows:

(1) A two-dimensional numerical fluid model has been developed to obtain basic discharge characteristics and to identify different stable and unstable operating regimes depending on wall spacing and gas flow velocity.

(2) Through the experimental investigations of specially designed different configurations of sliding and stabilized arc (or glow) discharges, the basic characteristics of the discharges – current density and electric field intensity – have been evaluated, a qualitative analysis of the discharge regime has been performed, the effect of transverse instability in a magnetically stabilized arc in a gas flow has been experimentally confirmed for a flow channel wider than its effective radius predicted by numerical model simulations, and the applicability of different configurations has been evaluated.

6. Critical remarks and recommendations

The numerical model developed is for a discharge in Argon at atmospheric pressure, which in itself is an important contribution to research in this field. It would be good if experimental studies were carried out in the same gas (and not only in CO_2) to allow a direct comparison of model and experimental results. This does not diminish the value of the results obtained in this thesis, but only points towards further research in the future.

7. Personal impressions of the candidate

I don't know the PhD student personally. The applicant's dissertation and professional CV leave an impression of an active young scientist with creative potential and clear prospects for a successful future research career.

8. Conclusion

Having read the submitted dissertation, Abstract and other materials, and on the basis of the analysis of their significance and scientific and applied contributions contained therein, I confirm that the scientific achievements meet the requirements of ZRASRB and the Regulations for its application and the relevant Regulations of the SU "St. Kliment Ohridski" for the requirements of the scientific degree "Doctor" (PhD). In particular, the candidate satisfies and exceeds the minimum national requirements in the professional field 4.1 Physical Sciences and no plagiarism has been found in the dissertation, abstract and scientific works submitted for the defence of the dissertation.

I give my **positive assessment** of the dissertation work.

II. GENERAL CONCLUSION

Based on the above, I recommend to the scientific jury to award the educational and scientific degree "**Doctor**" (PhD) in professional direction 4.1 Physical sciences, to **Vladislav Valentinov Ivanov**.

16.05.2023 Signature: .....

(Assoc. Prof. Dr Evgenia Benova)