

EVALUATION REPORT

on dissertation

for acquiring of scientific degree "Doctor of physical sciences"

in professional field 4.1 Physical Sciences (speciality Physics of Condensed Matter) according to the defense procedure at the Faculty of Physics (FP) of Sofia University "St. Kliment Ohridski" (SU)

Reviewer: Prof. Dianka Dimitrova Nesheva-Slavova, Dr.Sci., Institute of Solid State Physics of the Bulgarian Academy of Sciences, member of the scientific jury according to Order No. RD 38-464 / 27.07.2022 of the Chancellor of the Sofia University.

Dissertation title: "Surface photovoltage spectroscopy of semiconductor optoelectronic materials and nanostructures"

Author of the dissertation: Assoc.prof. Dr. Veselin Todorov Donchev

I. General description of the presented materials

1. Data on the submitted documents

Assoc.prof. Dr. Veselin Todorov Donchev submitted a dissertation in English and dissertation abstracts in Bulgarian and English. All other documents that are required by the Act on the development of the academic staff in the Republic of Bulgari (ADASRB), the Regulations for implementation of ADASRB (RIADASRB) and the Regulations for the terms and conditions for acquiring scientific degrees and occupying academic positions at SU "St. Kliment Ohridski" (RTCASDOAPSU) when defending a dissertation for obtaining the degree of "Doctor of Science", including tables for the fulfillment of the minimum national requirements for "Doctor of Science" and the Additional requirements for candidates for obtaining scientific degrees in the Faculty of Physics of SU "St. Kliment Ohridski" in the field 4.1. Physical sciences were also submitted.

The dissertation is written on 172 pages, including title pages in Bulgarian and English, table of contents, list of abbreviations, introduction, four chapters, main results and contributions, list of the author's publications on which the dissertation is based and a list of 300 quoted titles. The dissertation contains 85 figures and illustrations and 5 tables.

2. Applicant data

Veselin Todorov Donchev obtained "Doctor of physics" degree at the Faculty of physics of Sofia University in 1991, after defending a thesis on "Investigation of electrical and optical

properties of point defects in gallium arsenide". In 2004, he was elected as an "Associate professor" in the Department of Condensed Matter Physics and Microelectronics of the Faculty of Physics, and since 2013 he has been the head of this department. In the period 1992-2021, assoc.prof. Donchev made eight scientific visits to prestigious scientific laboratories in France, Germany, Great Britain, Sweden and Brazil, where he conducted research on three-dimensional and low-dimensional materials with optical and electrical methods and with Kelvin probe force microscopy. He is author and co-author of 2 book chapters and 47 articles in specialized scientific journals, 38 conference reports published in scientific journals and 44 reports published in collections of conference materials, as well as 3 training aids. My Scopus search showed a total of 564 independent citations to his 82 registered publications, a Hirsch index of 11, and 5 publications cited more than 20 times.

Assoc.prof. V. Donchev has a diverse teaching activity, which includes courses in "General Physics - Mechanics, Molecular Physics" and "Optoelectronic Devices", as well as courses in the Master's program "Microelectronics and Information Technologies" ("Nanostructural materials and instruments for information technologies" and "Physical basis of optoelectronics"). He headed a student laboratory in electricity and magnetism at the FP of the SU. He was supervisor of 6 and consulted 4 graduate students, supervisor of 1 PhD student and consulted 2 PhDs, currently he is supervisor of 1 PhD student.

3. General characteristics of the candidate's scientific achievements

Scientific research of assoc.prof. Donchev is mainly on electronic and optical properties of semiconductor materials and structures. His work is in two directions - the first one is the application and improvement of surface photovoltaic spectroscopy, which is an important method for studying semiconductor materials and nanostructures promising for optoelectronic and photovoltaic applications. This spectroscopy has been used to obtain quantitative information on bulk properties of the studied materials (bandgap, conductivity type, energy of defect states, etc.), as well as to measure energy levels in quantum structures and construct band diagrams at the surface and interface. The second direction is calculation of transmission and reflection spectra of nanostructured materials and comparison with experimental results. Attention has to be paid on the fact that in these calculations the interface roughness in the multilayer structures is considered.

The list of the author's works, on which the dissertation is based, includes 24 articles, of which 15 are in journals with impact factor, 6 - with impact rank and 3 in other refereed

journals. Of these publications, 15 are in group I and 20 are of significant contribution by assoc. prof. Donchev, one was used in the competition for "Associate Professor", 117 independent citations of these articles are announced. No plagiarism was found in the dissertation and the dissertation abstract.

The tables prepared by assoc.prof. Donchev for the fulfillment of the minimum national requirements for the "doctor of science" degree show that the assets of Dr.V. Donchev far exceed these requirements. In groups of indicators "G" the points of his assets are 400 with the required 100, and in "D" his points are 352 with the required 100 in ADASRB and 200 in the requirements of FzF included in RTCASDOAPSU. In principle, assets in indicator groups "B" are not required for the "Doctor of Sciences" degree, but assoc.prof. Donchev has included articles there giving 335 points with a min. of 200 points, of which 13 articles are in group I. The data in tables D3 and D4 prove that the Additional requirements for applicants to acquire academic degrees in the Faculty of Physics of SU "St. Kliment Ohridski" in the field 4.1. Physical sciences are very much exceeded.

4. Analysis of the applicant's research achievements included in the submitted materials

The results in the dissertation, some of them pioneering, represent a significant and original contribution to the total scientific knowledge in the world. From the submitted materials, it can be seen that all results were obtained with the active participation or under the guidance of assoc.prof. Donchev, with one part being of a fundamental nature, and the other - of an applied nature. In general, the achievements include:

(a) development of an experimental set-up for precise and reliable measurement of surface photovoltage spectra (SPV) in a wide temperature range and suggestion of new approaches for their interpretation. It is shown that a combined analysis of the amplitude and phase spectra is necessary for a correct interpretation of the experimental data, and a vector model of the signal is developed to facilitate data analysis.

(b) investigation of various state-of-the-art materials by applying the established experimental set-up and proposed new approaches.

- An original study of the optical properties and electronic structure of shortperiod AlAs/GaAs superlattices with embedded quantum wells of GaAs was performed, the degree of interface grading was evaluated, and it was concluded that photoluminescence from embedded quantum wells at room temperature is dominated by recombination of free excitons;

- New information on interdiffusion and optical transitions in interdiffused InAs/InGaAlAs structures with quantum dots-in-quantum-wells was obtained (enrichment of existing knowledge);
- Pioneering SPV studies on complex nanostructures with InAs quantum dots-in-quantum-wells were carried out, the energies of optical transitions in the quantum dots (QDs) were determined, it was found that the main mechanism for carrier separation in the process of SP generation is drift of holes to the substrate;
- In multilayer structures with InP/GaAs type-II QDs, optical transitions associated with QDs and well layers were successfully identified, electronic interaction between the layers and vertical coalescence of large QDs, leading to the formation of quantum posts were observed, the mechanism of separation of charge carriers was identified (enrichment of existing knowledge);
- A pioneering SPV study was made on silicon nanowires, prospective for reducing the reflection in Si solar cells, the presence of a large concentration of positively charged surface recombination centers was established, which was successfully reduced by appropriate chemical treatment;
- Detailed pioneering studies of InGaAsN and InGaAs(Sb)N dilute nitride layers and structures grown by liquid epitaxy were carried out. It was found that with the addition of In facilitates the incorporation of N and thus the band gap of InGaAsN decreases more effectively. The dominant radiative recombination mechanisms in In-GaAs(Sb)N layers are recombination of free carriers and excitons.

The obtained results are new information about phenomena in poorly studied or new materials that are promising for the creation of electronic, optoelectronic, photonic and photovoltaic devices. They are proof of the efficiency and high quality of the developed set-up and the proposed new approaches for data interpretation.

5. Critical notes and recommendations

I have no critical remarks regarding the knowledge of the scientific literature by assoc. prof. Donchev and the staging, analyzes and summaries in the dissertation. The dissertation abstract very accurately reflects the content of the dissertation. There are some linguistic and stylistic problems in the Bulgarian version of the dissertation abstract, which I will not deal with in detail.

6. Personal impressions of the candidate

I have excellent personal impressions of assoc.prof. Donchev. He is very precise and

competent in his work and a very fair partner when conducting joint research.

7. Conclusion

Getting acquainted with the submitted dissertation, its Abstract and other materials, and based on the analysis of their significance and the scientific and applied contributions contained in them, I confirm that the scientific achievements meet the requirements of ADASRB, the Regulations for its application and the corresponding Regulations of the SU "St. Kliment Ohridski" for the acquisition of the scientific degree "Doctor of Physical Sciences". Assoc.prof. V. Donchev greatly exceeds the minimum national requirements in professional field 4.1. Physical sciences and the additional requirements of the Faculty of Physics of SU. No plagiarism was found in the dissertation, abstract and scientific papers submitted for the competition. **I give my positive assessment of the dissertation work.**

II. GENERAL CONCLUSION

Based on the above, I strongly recommend the scientific jury to award the scientific degree "Doctor of Physical Sciences" in professional field 4.1. Physical Sciences (Physics of Condensed Matter) by assoc.prof. Dr. Veselin Todorov Donchev.

21.09. 2022

Signature:

(Prof. Dr.Sci. Dianka Nesheva-Slavova)