REVIEW

in competition for occupation of the academic position of "Professor" in the professional field 4.1 "Physical Sciences", Scientific specialty "Wave physics", according to the announcement in State Gazette no. 12 of 11/02/2020

Applicant: Dr. Dimana Ilieva Nazarova, Associated Professor at the Institute of Optical Materials and Technologies "Acad. J. Malinowski" (IOMT)-BAS

Reviewer: Dr. Tsvetanka Krumova Babeva, Professor at the Institute of Optical Materials and Technologies "Acad. J. Malinowski" (IOMT)-BAS

General description of the materials presented

The documents under review submitted by the sole candidate in the competition, Assoc. Prof. Dr. Dimana Nazarova, fully comply with the requirements of the Law of the Development of Academic Staff in Republic of Bulgaria (ZRASRB), the Regulations for its implementation, the Regulations of BAS and the Regulations on the terms and conditions for acquiring scientific degrees and occupation of academic positions at IOMT-BAS. In the competition the candidate participates with the equivalent of habilitation thesis, consisting of 6 publications, merged thematically and concerning the field of development of recording media for polarization holography. Out of the habilitation thesis the applicant presents 15 scientific papers published in peer-reviewed and indexed journals as almost half of them are in journals classified in category Q1, for example *Optical materials*, *Optics Express*, *Optics and Lasers in Engineering*, *Spectrochimica Acta Part A* etc. A list of all citations (132 citations) found at the time of document submission was presented, and 69 from them were selected for the competition. All documents were carefully arranged and presented materials are sufficiently convincing.

Minimum requirements

The applicant meets the minimum national requirements, as well as those of BAS and IOMT:

group A – 50 points (minimum requirements – 50 points)
group B – 105 points (minimum requirements – 100 points)
group Г – 257 points (minimum requirements – 220 points)
group Д – 138 points (minimum requirements – 120 points)
group E – 281 points (minimum requirements – 150 points)

All publications and citations included in this competition have not been used in acquiring PhD degree or in the competition for the academic position "Associated professor".

General characteristics of the applicant's scientific, teaching and applied activities

Dr. Nazarova has conducted research work more than 17 years in the field of polarization and

imaging holography, diffraction optical elements and polarimetry. In 1992 she graduated as an engineer – physicist at the Faculty of Physics of Sofia University, major Applied Optics. Her scientific career began in 2003, when she was appointed as a physicist at the Central Laboratory of Optical Storage and Processing of Information (CLOSPI) - BAS. After one year she became a full-time PhD student and successfully defended her dissertation within the regular three-year term in the field of surface and localized plasmon-polariton resonances and their applications for sensing. Her scientific career continues in CLOSPI-BAS as a research associate II degree (2009) and research associate I degree (2010). In 2011 Dr. Nazarova was habilitated at the Institute of Optical Materials and Technologies - BAS (established in 2010 by merging CLOSPI and the Central Laboratory of Photoprocesses - BAS). Since 2016, Dr. Nazarova has been the head of the Department of Optical Metrology and Holography at IOMT. In 2006 and 2009, Dr. Nazarova completed two one-month scientific missions at the Center for Industrial and Engineering Optics at Dublin Institute of Technology, Ireland.

Dr. Nazarova has presented personally or as a co-author 27 oral and 84 poster presentations at 67 national and international scientific events. So far, she has led 5 research projects funded by the Bulgarian Science Fund and Ministry of education and science and has participated in a total of 15 projects - 10 national research and educational projects, 3 with international funding and 2 projects funded by industry. Throughout her scientific career, Dr. Nazarova has co-authored 91 scientific publications (71 of which with IF or SJR) and 1 book chapter.

As part of the scientific and applied activity of the candidate, I should mention her main role in organizing and conducting numerous exhibitions of holograms of IOMT, as well as delivering public lectures and making demonstrations related to holography and holograms recording.

Apart from the active research activity, Assoc. Prof. Nazarova is also very actively involved in the training and teaching of students. She is currently co-supervisor of two full-time PhD students. She has supervised and co-supervised 12 students, including three bachelors, two masters and seven interns.

Basic scientific and applied scientific contributions

The scientific papers presented in the competition are interdisciplinary in nature and are devoted to actual problems in polarization holography, holographic recording, organic-inorganic structures and diffractive optical elements for applications in optoelectronics and photonics.

Habilitation thesis - includes 6 thematically merged scientific publications [№ 3, 6, 7, 10, 16 and 17 of the list of publication], concerning the development of "hybrid materials" composed of azopolymer (poly [1- [4- (3 -carboxy-4-hydroxyphenylazo) benzenesulfonamido] -1,2-ethanediyl, sodium salt], doped with semiconductor (ZnO) and metal (Au) particles of different sizes. Studies show that these new materials have a larger birefringence, which leads to stronger photoinduced anisotropy, and hence to higher diffraction efficiency of polarization recording, which is the ultimate goal in the development of optical recording media and diffractive optical elements.

Since I witnessed the birth of this topic and the subsequent successful research, I should mention that the idea of adding nanoparticles to the azopolymers belongs mainly to Dr. Nazarova, who did not hesitate regardless of the doubts from colleagues, including me that isotropic particles would lead to an increase in photoinduced anisotropy.

I would summarize the ***main contributions of the equivalent of the habilitation thesis*** as follows:

- New materials suitable for polarization recording were developed, consisting of three different polymers synthesized in IOMT [16, 17] with incorporated ZnO particles with sizes of 50 nm and 100 nm [16] and those with sizes smaller than 50 nm [17]. There was a 30% decrease in response time at all particle sizes and a 40% increase in photoinduced birefringence when smaller particles are utilized as dopants;

- New composite materials were obtained, composed of water-soluble PAZO (commercially available azopolymer), doped with nanosized particles of Au (diameter of 10 nm) [3] and particles of ZnO (diameter <50 nm) [7, 10]. The optimal concentrations of dopants that lead to the highest birefringence compared to undoped azopolymer samples have been determined. In the case of ZnO particles, an almost twofold increase in the diffraction efficiency was obtained for gratings with a spatial frequency of 1250 lines / mm and more than 4 times an increase in the height of their photoinduced surface relief profile was observed [10]. The polarization holographic recording was modeled theoretically and compared with the experimental data, and a good match was obtained [6].

I would summarize the ***main contributions out of the habilitation thesis*** as follows:

- The optimal parameters of the polarization recording in azopolymers (poly [1- [4- (3-carboxy-4-hydroxyphenylazo) benzenesulfonamido] -1,2-ethanediyl, sodium salt]) synthesized in IOMT, as well as those commercially available, leading to the highest birefringence (Δn) and lowest response time have been determined [publications № 9, 11, 14, 18, 19 of the list of publications]. For this purpose the optical and thermal reversibility of the recording [9] have been studied, as well as the dependence of Δn on different recording parameters, such as the temperature at which the recording is performed [11], the thickness of the films used as recording media [14], the wavelength of the laser radiation used for recording [19]. The stability of the recording over time has also been tested [18]. It was found that:
    - Illumination with circularly polarized light erases the recording in all studied azopolymers, while thermal reversibility is observed only in the azopolymers synthesized in IOMT. On the contrary, the recording in the commercially available azopolymer is stable up to 300 °C [9];
    - With temperature increase from 25°C to 100°C both the response time and the photoinduced birefringence decrease [11];
    - The film thickness in the range 50-2500 nm does not influence the values of Δn but the response time considerably increases for films thicker than 500 nm [14];

- The photoinduced birefringence decrease with the increase of the wavelength of recording from 390 nm to 700 nm [19];
- The stability of the birefringence in the LC (liquid crystal) polymer is considerably higher than in the amorphous one [18].

- It has been shown that newly synthesized azo and azo-azomethine dyes incorporated into a PMMA matrix and deposited in the form of thin films by vacuum evaporation can be used as reversible recording media controlled by light [1,5];

- The photoinduced anisotropy in dyes *Alizarin Yellow R* and *Mordant Pure Yellow* incorporated in gelatin matrix was studied. For the first time it has been demonstrated that *cis*-form of *Mordant Pure Yellow* is anisotropic. It has been proposed that it reorients into direction perpendicular to the polarization of the recording light [21] ;

- "*Host – guest*" nanocomposites were developed through vacuum co-evaporation using three sources - ODA (4,4-*oxydianiline*) and PMDA (*pyromellitic dianhydride*) as "*host*" and dye *perylene bis azo-imide* as "*guest*". An enhancement of photoresponse was observed compared to pure dyes [2] ;

- The optical constants and thickness of interface layer between silicon substrate and sputtered Ta_2O_5 (undoped and Hf, Al and Ti - doped) were determined by genetic algorithm used for minimization of discrepancies between calculated and measured reflectance spectra [15, 20];

- Numerical algorithms for analysis of dynamic laser speckle patterns were developed and applied for monitoring of ingoing processes of physical or biological activity within the object [papers № 4, 8, 12, 13 from the publications list].

Significance of the results obtained and personal contribution of the candidate

I am confident that the results obtained and the contributions of Dr. Nazarova are significant for the fields of materials science, holography and in particular polarization holographic recording. As one proof of the significance of the results obtained, I will mention that the total number of papers co-authored by Dr. Nazarova is 91 (71 of which with IF or SJR), which shows a very high publication activity. Her works have been cited more than 130 times, which is an evidence of the interest attracted by the scientific community to the results obtained.

According to the personal contribution of Dr. Nazarova, I can definitely state that it is indisputable and beyond any doubt. I have known Dr. Nazarova since the time she started as a PhD student at CLOSPI and I have witnessed her scientific career. I have already mentioned that she is one of the initiators and the main driving force of the idea related to the doping of azopolymers with nanoparticles and their use as media for polarization recording, which was laid as a basis for the theses of two PhD students working under her co-supervision.

Critical remarks

I have no critical remarks on the applicant's documents or on the reports of the contributions presented by the applicant.

Conclusion

Based on the materials presented in the competition and my personal observations and impressions, I can without any hesitation to conclude that Assoc. Prof. Dr. Dimana Nazarova is highly qualified scientist and well-established expert in the field of wave physics. She has also teaching and administrative experience and good project activity. The results obtained and their contributions are significant. Dr. Nazarova fully meets the minimum national requirements, as well as those of BAS and IOMT. Her scientific indicators in "Group E" significantly exceed the minimum requirements.

Based on all written above, I strongly recommend the respected Scientific Jury to support the application and propose to the Scientific Council of IOMT - BAS, Associated Professor Dr. Dimana Ilieva Nazarova to be selected for the academic position "Professor" in the professional field 4.1. Physical sciences.

August 11th 2020

/Prof. Dr. Tsvetanka Babeva/