REVIEWER'S REPORT

prepared by Dr.habil. Alexander Alexandrov Dreischuh, Professor at the Faculty of Physics of Sofia University "St. Kl. Ohridski", corr. member of Bulgarian Academy of Sciences (BAS), on the materials submitted for the competition for the academic position "Professor" at the Institute of Optical Materials and Technologies "Academician Malinovski" - BAS in Professional field 4.1. Physical sciences, scientific speciality "Electrical, magnetic and optical properties of condensed matter".

The competition for the academic position of Professor was announced in the State Gazette, issue 35 of 10.05.2022 and on the website of the Institute of Optical Materials and Technologies of BAS (IOMT-BAS; https://iomt.bas.bg/процедури).

General presentation of the submitted materials

By Order № РД-15-464/08.07.2022 of the Deputy Director of IOMT-BAS Prof. Nikola Malinovski I have been appointed a member of the Scientific jury of the competition. The only candidate in it is Assoc. Prof. Dr. Lian Lyubenov Nedelchev from IOMT-BAS. Assoc. Prof. Nedelchev has submitted all the necessary documents for participation in the competition for the academic position "Professor", required by the document Regulations on the conditions and procedure for the acquisition of scientific degrees and for the occupation of academic positions at IOMT-BAS, in addition to the Regulations on the conditions and procedure for the acquisition of scientific degrees and for the occupation of academic positions at BAS (last amended and supplemented on April 18, 2019). The full list of publications of Assoc. Prof. Nedelchev includes a total of 96 articles in specialized scientific journals (including 18 from quartile Q1, 12 from quartile Q2, 10 - from Q3, 19 - from Q4 and 13 with SJR impact-rank). Results with his co-authorship have been summarized into 110 conference contributions, 2/3 of them - presented at international scientific forums, the rest - at national forums. The number of noticed independent citations of his publications is 346, forming h-index h=13.

In the present competition the candidate Assoc. Prof. Lian Nedelchev participates with a total of 21 scientific papers (7 - according to indicator B.4, equivalent to a habilitation thesis/papers; 14 - according to indicator Г.7, not included in the habilitation papers), as well as with 1 useful model, protected since 2021. Of the overall 21 articles, 16 are published in journals with Q-factors, 5 - in journals with impact-rank. The number of independent citations of these papers is 70. For my review I am accepting all of them. My assessment that the applicant fully meets the national requirements, the requirements in the Act for the Development of the Academic Staff (ZRAS)-BAS and the regulations for the implementation of the Act for the Development of the Academic Staff (ZRAS) at IOMT-BAS is based on the data in the table presented below.

Group of sub-indicators	Required according to the Regulations for the Implementation of the ZPAS in IOMT-BAS	Scientific metrics for the candidate
A	PhD thesis – 50 pts.	**50 pts.**
Б	Thesis for awarding Dr.rer.nat.habil. – 0 pts.	**0 pts.**
В	Habilitation thesis - scientific publications that are refereed and indexed in world-known databases of scientific information (Web of Science and Scopus) - 100 pts.	Q1: 1 x 25 pts. = 25 pts. Q2: 2 x 20 pts. = 40 pts. Q4: 2 x 12 pts. = 24 pts. SJR: 2 x 10 pts. = 20 pts. **TOTAL: 109 pts.**
Г	Г7: Not included in the habilitation thesis - publications in Web of Science and Scopus Г9: Patents and useful models Total required - 220 pts.	Q1: 1 x 25 pts. = 25 pts. Q2: 7 x 20 pts. = 140 pts. Q3: 2 x 15 pts. = 30 pts. Q4: 1 x 12 pts. = 12 pts. SJR: 3 x 10 pts. = 30 pts. 1 x 25 pts. = 25 pts. **TOTAL: 262 pts.**
Д	Citations in world-renowned databases. Total required - 120 pts.	70 (based on В and Г) x 2 pts. = 140 pts. **TOTAL: 140 pts.**
E	Sum of indicators 13 to the end of the list Doctoral students National projects International projects National project management Project funds attracted Published university textbook 150 pts. required in total	 50 pts./2 = 25 pts. 4 x 10 pts. = 40 pts. 2 x 20 pts. = 40 pts. 2 x 20 pts. = 40 pts. 24 pts. 40 pts./1 = 40 pts. **TOTAL: 209 pts.**

In my opinion, the documents are informative, comprehensive, and are precisely prepared,.

General characteristics of the candidate's scientific, applied and pedagogical activities

In 1997 Mr. Nedelchev completed his higher education at the Faculty of Physics at Sofia University "St. Kliment Ohridski" as a Master of Physics with a specialization in laser physics. In the period 1997-2001 he was a PhD student at IOMT-BAS in the scientific specialty of the present competition. In 2004 he was awarded a PhD by the Higher Testimonual Committee. In the meantime (2001-2002) he worked as a researcher for company "OptiLink" and for the Riso National Laboratory (Roskilde, Denmark). From 2003 to 2011, he was a research fellow at IOMT. From 2009 to 2021, he was also an Associate Professor at the University of Telecommunications and Post (before 2015 - College of Telecommunications and Post), where he held senior positions including this of a Director of Research and Dean of the Faculty of Telecommunications and Management. Since 2011, he has held the academic position of "Associate Professor" in the field of "Optical Metrology and Holography" of IOMT-BAS. He is Head of the Laboratory "Holography" at the Department "Optical Metrology and Holography" and (since March 2022) - Scientific secretary of the Institute.

The activities of the candidate in the competition are both scientific and pedagogical. From the data regarding the teaching engagements of Assoc. Prof. Nedelchev it is evident that at the University of Telecommunications and Posts he has lectured in 7 courses in Physics, Fundamentals of Electronics, Electronics, Fundamentals of Electro-Technics, Higher Mathematics, Management Information Systems, and Integrated Management Information Systems. He has supervised two Ph.D. students (one already successfully defended his degree, the other - dismissed with the right to defend). He has supervised the development of master's theses, but I cannot specify their number. He has been a lecturer in 4 international Erasmus Student Schools held in Leipzig (Germany), Valencia (Spain), Debrecen (Hungary), and Sofia.

Besides the mentioned scientific metrics, further evidence of the fruitful and successful scientific and applied work of the candidate in the competition Assoc. Prof. Lian Nedelchev is that he has led two research projects funded by the National Science Fund (NSF, Bulgaria; 2013 and 2019), that he participated in the teams of two international projects with a partner institute from South Korea, and that he has participated in the teams of 4 national scientific projects funded by the NSF (Bulgaria).

Main scientific and applied contributions

In general, the scientific and applied activities of Assoc. Prof. Nedelchev are devoted to problems related to the analysis of the photoanisotropic properties of azo-polymer thin films and azo-polymer nanocomposites, as well as to the creation of highly efficient polarization holographic gratings and photo-induced chiral structures. Without any claim to completeness, I would like to mention that photoanisotropic materials are a subject of considerable scientific interest for the creation of polarization-selective optical elements, for reversible optical information recording, for polarization multiplexing, and for the creation of all-optical switches, just to mention a few. In this sense, the research topic of the candidate in the competition is more than relevant.

The first thematic group of his studies Assoc. Prof. Nedelchev summarized as experimental optimization and numerical modelling of photo-induced birefringence in thin films of azo-polymers and azo-dyes and study of the reversibility of the birefringence [A1-A4]. In [A1], results of studies on the kinetics of the birefringence induced by five different lasers in thin films of amorphous azo-polymer PAZO are reported. The recording time required for the birefringence to reach 80% of its maximum value was measured, as well as the stability of the photoinduced birefringence (namely, the residual birefringence after a 15-min relaxation relative to its maximum value). It has been found [A1] that the optimal wavelength of the effect-inducing laser for the experiments is 442 nm, which ensures a maximum birefringence $\Delta n_{max} = 0.081$ in the shortest time (10 s). From the spectral dependence of the data for the birefringence $\Delta n(\lambda)$ for PAZO, it is concluded that PAZO can be used to record polarization diffraction elements operating over the entire visible wavelength range. Data on the dynamics of the induced birefringence have also been published in

[A3] for vacuum-deposited aminoazobenzene derivatives. When recorded with a laser at a wavelength of 444 nm, an even higher maximum birefringence of 0.01 was obtained, but after some 200 s. In [A2], the reversibility of birefringence in an azopolymer synthesized at IOMT-BAS was investigated (cycles of recording with linearly polarized light/reading/erasing). It was found that a certain decrease in the contrast of photoinduced birefringence (~5%) is to be expected after repeated optical erasure of the recording with circularly polarized light, which is absent upon thermal erasure (which is, however, gradually slower). The reversibility of the birefringence in the PAZO polymer has also been investigated numerically ([A4], by Monte Carlo modelling), taking into account a large number of three-dimensionally oriented molecules. The resulting numerical data are estimated to be in a good agreement with the experimental data for recording with linearly polarized light and erasure with circularly polarized light.

The subject of the second group of works Assoc. Prof. Nedelchev defines as a study of pho-induced chiral structures in azo-polymers and azo-polymer nanocomposites and analysis of the influence of chirality on the efficiency of polarization holographic gratings [A5-A7]. The term "chirality" is generally used to say that an object (e.g., a molecule) cannot be superimposed on its mirror image by translation and/or rotation, i.e., the object is distinguishable from its mirror image. In [A5], the photoinduced chirality in thin films of the PAZO azopolymer and in samples of the same azopolymer doped with 21-nm-large TiO_2 nanoparticles is investigated. In front of the sample the polarization of the beam of a He-Cd laser (λ = 442 nm) is controllably varied from left circular to right circular. Maximum azimuth rotations of 33°/μm for PAZO and 46°/μm for the nanocomposite layer are retrieved from the experimental data [A5]. Investigations of the dynamics of chiral structure formation induced by polarized light in azo-polymer PAZO have been continued in thin films [A6], adding two more amorphous azo-polymers and one liquid crystal samples. The rotation kinetics of the azimuth of the polarization ellipse was investigated. It is shown that the formation of chiral structures occurs faster than the induction of linear birefringence (within 75 s to 10 s for PAZO and within 23 s to 2 s for P1-2 (amorphous polymer)), when changing the intensity from 25 mW/cm^2 to 300 mW/cm^2. The reversibility of chiral structures upon changing the sign of the input beam ellipticity has been experimentally demonstrated in [A6]. In [A7], the analyses are continued by investigating the influence of added TiO_2 nanoparticles (up to 3 wt.%; size ~20 μm) to the PAZO azopolymer. The results show that small concentrations of such nanoparticles lead to a (relatively small) increase in azimuth rotation (for a sample with 2 wt.% nanoparticles - 38°/μm, for an undoped sample - 37°/μm), while at higher concentrations the optical properties of the sample degrade.

In five other publications [B1-B5] Assoc. Prof. Nedelchev continued his research on the optical properties (including birefringence parameters) of azo-polymer nanocomposites containing nanoparticles of different chemical composition, size and shape. The base polymer used is again PAZO deposited in thin layers. The nanoparticles are golden spheres, [B1,B3], bioactive metal complexes based on copper ions and nickel ions [B2], goethite nanorods [B4], and chalcogenide nanoparticles with a chemical composition of $(GeTe_4)_{100-x}Cu_x$, where x=5, 10, 15 and 20 mol. % [B5]. The most significant increase of more than 25% in the induced birefringence compared to the undoped samples is found for the $(GeTe_4)_{85}Cu_{15}$ system [B5]. For the goethite nanoparticles [B4], a concentration dependence of the induced birefringence Δn_{max} is found with two pronounced peaks at nanoparticle concentrations1% and 10% relative to the azopolymer. When bioactive metal complexes based on copper and nickel ions are used, the highest value ($\Delta n_{max} = 0.093$) is reported for the nanocomposite layer with 1% nanoparticles based on nickel ions [B2]. When spherical gold nanoparticles are used, the optimal nanoparticle size and concentration are 20 nm and 2 a.u., respectively [B1]. Under these conditions, a maximum increase in photoinduced birefringence ($\Delta n_{max} = 0.087$) is achieved relative to the undoped sample ($\Delta n_{max} = 0.070$). In my opinion, the results present a valuable basis for optimizing the optical parameters of nanoparticle-doped PAZO azopolymer layers.

Some other works of Associate Professor Nedelchev [B6-B9, C1] are devoted to the study of polarization and surface reliefs recorded by polarization holography in azo-polymers and azo-polymer nanocomposites. The basic azo-polymer used is PAZO [B6-B8]. Using goethite nanorods, relief gratings with periods ranging from 0.86 μm to 2.51 μm are recorded [B6]. It is found that the highest diffraction efficiency of 53% for the two ±1st orders is reached at 10% nanoparticle concentration [B6]. The same performance for PAZO doped with bioactive complexes based on copper and nickel ions, but only in the +1st diffraction order, is 33.0% [B7], at a concentration of 1 wt%. When depositing layers doped with TiO_2 nanoparticles, it is found that layers deposited from methanol solution have higher values both of the induced birefringence and of the diffraction efficiency (typically over 25% versus typically around 12%, at an approximately 3 times higher surface relief) than those deposited from aqueous solution [B8]. In [B9], the azo-polymer used is not doped, but the thickness of the deposited layers is varied (from 470 nm to 2400 nm). The highest diffraction efficiency (in +1-st diffraction order more than 40% during recording and more than 30% after relaxation) is measured for a layer with a thickness of 2400 nm and a recording angle of 10° [B9]. I am positively impressed by the investigation of the topography of the recorded gratings by atomic force microscopy.

The registered protected useful model [C1] is also on this topic. In essence, it is a scheme for improving the properties of a polarization-dependent diffractive optical element - a polarization beamsplitter composed of a cover glass attached with a transparent adhesive to a photoanisotropic layer, whereby the formation of surface relief is suppressed. A 10-fold improvement in the polarization properties is achieved with the element compared to those of a grating recorded in an uncoated specimen.

As a last group of results [B10-B14], I would like to mention the studies on the monitoring of the drying process during the deposition of azopolymer layers and on the analysis of the mechanical properties of the layers. High sensitivity to micron changes in the optical paths of light beams reflected from rough surfaces or passed through turbid media under coherent illumination is the basis for the dynamic speckle analysis (DSA). In [B10], as a means of compressing data in DSA, the authors propose a "coarse" discretization of the raw spatially-varying intensity data. The raw data are recorded as time-correlated speckle maps of the object surface. Sequential processing of these patterns yields an "activity map" as a two-diimensional distribution of a statistical parameter at a given time and visualizes the rate of change at the particular site. However, this requires processing of a large number of two-dimensional images that reflect the process at different moments in time. In [B10,B11], an analysis of the drying process of aqueous solution of PAZO azo polymer at different substrate temperatures is published. The analysis is based on the dynamic speckle method. Two-dimensional activity maps using 256, 32, 16 and 8 sampling levels are obtained and compared. Calculation of the modified time-structure function has shown that coarser discretization, e.g., at 8 levels, also provides a correct estimate for the drying time of the polymer solution, but significantly reduces the volume of the data to be processed and the computation time. This technique, applied to a comparative analysis of water and methanol solvents, has shown [B12,B13] that, at the same temperatures, the drying time for methanol solutions is more than 20 times shorter than this of water solutions, and, moreover, the optical quality of the resulting layers is significantly better. In [B14], the micromechanical parameters stiffness and value of the elastic component of strain versus plastic component are determined for thin films of three azo-polymers synthesized in IOMT and for azo-polymer PAZO. The results show that it is of primary importance which polymer is liquid crystalline and which is amorphous one.

I would classify the results mentioned so far as obtaining and proving new facts and obtaining confirmatory facts about new materials for photonics, including materials of applied engineering value.

On the basis of what I have written, I have no hesitation in evaluating the quality of the scientific work of Assoc. Prof. Lian Nedelchev, with which he is participating in the procedure, as very high. The significance of the results is mainly scientific and applied scientific, with present and definite prospects for future applications. The quantitative indicators of the criteria for the academic position "Professor", specific to IOMT-BAS, are fully satisfied.

Evaluation of the personal contribution of the candidate

As I mentioned, in the current competition the candidate Assoc. Prof. Lian Nedelchev participates with a total of 21 scientific papers, 16 of which are in journals with impact-factors, 5 - in journals with impact-ranks, as well as with one protected useful model. Assoc. Prof. Nedelchev is a first author of 6 papers, second author of 4 papers and last author of another 3 papers, i.e. 13 times his name is leading among the names of the co-authors in the mentioned 21 publications. This is a clear indication for the significant contribution and leading role of Assoc. Prof. Nedelchev in obtaining these results.

Critical remarks and recommendations

I do not have any critical remarks and recommendations to the scientific publications and to the pedagogical activities of Assoc. Prof. Nedelchev. I believe that in the future his results will continue to receive international recognition.

Personal impressions

My personal impressions of the candidate in the competition are mostly from our discussions on specific scientific problems. These are impressions of an excellent professional. In more recent times, my contacts with him have been in his capacity of a Dean of the Faculty of Telecommunications and Management of the University of Telecommunications and Post - a Dean concerned with the development of the students of his Faculty.

CONCLUSION

The documents and materials submitted by Assoc. Prof. Dr. Lian Lyubenov Nedelchev comply with all the requirements of the Law for the Development of Academic Staff in the Republic of Bulgaria (ZRAS), the Regulations for the implementation of this law and the relevant regulations of BAS and IOMT - BAS. The candidate has submitted more than a sufficient number of scientific papers published in addition to the materials used in all previous competitions/procedures in which he has participated. The candidate's works contain a number of original scientific and applied contributions which have received international recognition. They have been published in refereed international journals with impact-factors and impact-ranks and have corresponding Q-factors. The scientific and pedagogical qualifications of Assoc. Prof. Nedelchev is undoubted.

The achievements of Assoc. Prof. Nedelchev in teaching and research fully comply with (and exceed) the specific requirements of the regulations for the implementation of the Law for the Development of Academic Staff at IOMT-BAS, adopted in addition to this Law.

After reading the materials and scientific works submitted for the procedure, analyzing their significance and the scientific, applied scientific and applied contributions, herewith I give with full conviction my positive assessment and recommend the Scientific Jury to propose to the Scientific Council of the Institute of Optical Materials and Technologies at BAS to elect Assoc. Prof. Dr. Lian Lyubenov Nedelchev to the academic position "Professor" in Professional field 4.1 Physical Sciences, Specialty "Electrical, magnetic and optical properties of condensed matter".

06.09.2022 **REVIEWER: ....**

Prof. Dr.habil. Alexander Dreischuh