REVIEW

for a competition for occupying the academic position "Professor" in professional field 4.1. Physical sciences, scientific specialty "Electrical, magnetic and optical properties of condensed matter", announced in SG No. 35 of 10th May 2022 by Institute of Optical Materials and Technologies (IOMT) - BAS

Applicant: **Dr. Lian Lyubenov Nedelchev**, associated professor at IOMT - BAS

Reviewer: **Dr. Tsvetanka Babeva**, professor at IOMT - BAS

1. Brief biographical record of the applicant

The sole applicant in the competition is Dr. Lian Lyubenov Nedelchev, associated professor at the Institute of Optical Materials and Technologies IOMT-BAN. In 1997, he graduated as a Master in Laser Physics at the Faculty of Physics of Sofia University "St. Kliment Ohridski" and began full-time PhD studies at the Central Laboratory for Optical Storage and Processing of Information (CLOSPI) - BAS, where he also worked as a physicist. During the period of February 2001 - December 2002 he worked as a researcher at Optilink JSC and Rizzo National Laboratory, Roskilde, Denmark. After his return, he continued to work at CLOSPI - BAS as a research assistant. In 2004, he obtained his PhD degree with a thesis titled "*Photoinduced processes in azobenzene-containing polymers and their applications*". In 2009, he obtained his habilitation and was awarded the scientific title "Associated Professor" inthe scientific specialty "Electrical, magnetic and optical properties of condensed matter" by the Higher Attestation Commission. In the period February 2009 - August 2021, he was a lecturer at the High School of Telecommunications and Posts (before 2015 - College of Telecommunications and Posts) and worked part-time as an associate professor at IOMT. Currently, Assoc. Professor Nedelchev is a full-time associated professor at IOMT.

2. General description of the presented materials

The documents submitted by the applicant correspond to the requirements of the ŽRASRB, PPZRASRB and the Regulations for the conditions and procedures for acquiring scientific degrees and occupying academic positions in IOMT - BAS. A very good impression is made by the careful description and arrangement of the presented materials, which characterize the applicant as an organized scientist paying attention to details.

In the competition, Dr. Nedelchev submitted 21 scientific papers published in refereed scientific journals with an impact factor (IF) and SJR and a utility model. Some papers have been published in high IF scientific journals such as *Journal of Photochemistry and Photobiology A: Chemistry* (IF = 5.141), *Optics Communications* (IF = 2.335), *Photonics* (IF=2.536), *Applied optics* (IF=1.905), which indicates good

scientific quality. The distribution by quartiles is as follows: **2** publications in journals of the category Q1, **9** in Q2, **2** in Q3, **3** in Q4, **5** publications in journals with SJR.

As the equivalent of a habilitation thesis, Dr. Nedelchev has presented 7 thematically related works dedicated to the theoretical and experimental study of photoinduced birefringence and chirality of azopolymer thin layers and nanocomposites. I would like to point out with great satisfaction that the habilitation report presented by Dr. Nedelchev fully meets the requirements of the ŽRASRB, which unfortunately is not often found in such competitions. The report includes an introduction, comprehensively describing major scientific contributions and a bibliography, in which the papers participating in the competition are clearly distinguished from the other papers of the applicant, as well as from the papers of other authors.

From the presented materials, it can be seen that the applicant not only meets **the minimum national requirements,** as well as those of BAS and IOMT – BAS but also exceeds them:

group A – 50 points (out of at least 50 pts.) gained from PhD thesis

group V – 109 points (out of at least 100 pts.): papers No.A1 to No.A7 (Q1-1 paper, Q 2 - 2, Q 4 – 2 and 2 papers with SJR)

group G – 262 points (out of at least 220 pts.): papers with No. B1 to No. B14 and 1 utility model (Q1-1 paper, Q 2 - 7, Q3-2, Q 4 -1 and 3 papers with SJR)

group D – 140 points (out of at least 120 pts.): Dr. Nedelchev participated in the competition with 70 citations

group E – 209 points (out of at least 150 pts.): co-supervisor of a PhD student successfully defended his thesis (25 pts.), participation in a national scientific or educational project (4 projects x 10 pts.), participation in an international scientific or educational project (2 projects x 20 pts.), team leader of 2 national scientific or educational projects (2 projects x 20 pts.), funds raised (24 pts.), published university textbook (40 pts.)

All publications and citations of the applicant, included in the current competition, were not used either in acquiring the PhD degree or in awarding the academic position "Associated Professor". It makes a very good impression the fact that these materials were not used in the similar competition in 2020 for the academic position of "professor" in the same department at IOMT, in which I was a reviewer.

I do not detect any plagiarism in the submitted materials.

3. General characteristics of the basic scientific, applied scientific and teaching activities of the applicant

Dr. Nedelchev's research activity is in the field of research and developing of photoanisotropic materials and optimization of their properties for application in diffraction optics, photonics and optoelectronics and fully corresponds to the topic of the

announced competition. Dr. Nedelchev works on modern problems in the field of polarization holography, photoinduced birefringence in azopolymers and azopolymer organic-inorganic structures, holographic recording of diffractive optical elements.

For his entire research career, Dr. Nedelchev has co-authored 96 scientific papers, 78 of them are published in journals indexed in WoS and/or Scopus. Dr. Nedelchev is also part of a team that registered at the end of 2020 a utility model of a system for improving polarization parameters of a holographic diffraction optical element - circular polarization beam splitter. Dr. Nedelchev presented his results at 62 scientific forums in the country and abroad, where he co-authored 30 talks and 80 poster presentations. For the past 9 years, Dr. Nedelchev was project leader of 2 research projects and participated in 6, 2 of them were internationally funded.

Dr. Nedelchev has more than 10 years of active teaching. He was a lecturer at the High School of Telecommunications and Posts, where he delivered lectures in physics, fundamentals of electronics, fundamentals of electrical engineering, advanced mathematics, etc. He was also a lecturer at international student schools under the Erasmus program held in Germany, Spain and Bulgaria. Dr. Nedelchev is the co-supervisor of two doctoral students, one of them successfully defended in May 2022. He is also a supervisor of graduate students and interns under the "Student Internships" program.

Regarding administrative experience, without of any doubts I could say that Dr. Nedelchev has good administrative record. He was the director of the Scientific Research Directorate at High School of Telecommunications and Posts (2014-2015), dean of the Faculty of Telecommunications and Management (2015 - 2019) and a member of the Academic Council and the Scientific Council of the School. Currently, Dr. Nedelchev is a member of the Scientific Council of IOMT, the chairman of the IOMT scientific colloquium, and from March 2022 he is the Scientific Secretary of IOMT.

4. Basic scientific and applied scientific contributions

The main contributions of the research, presented as the **equivalent of a habilitation thesis,** are related to numerical modeling and experimental optimization of the photo induced processes of anisotropy and chirality in azopolymers and azopolymer nanocomposites. The contributions can be summarized as follows :

- The kinetics of the photoinduced birefringence (Δn) were studied for PAZO (poly[1-[4-(3-carboxy-4-hydroxyphenylazo)benzene sulfon amido]- 1,2– ethanediyl, sodium salt]) at 5 different wavelengths selected in the absorption band of the polymer [publ. No. A1] and at two wavelengths for vacuum-deposited thin films of two types of the 4-aminoazobenzene azo dye [publ. No. A3]. The optimal wavelength of the largest Δn and the fastest response is established. By studying the spectral dependence of Δn in the range 400-800 nm, it has been shown that PAZO layers are suitable for production of achromatic polarization diffraction elements [publ. No. A1].

- Repeatedly reversible polarization recording has been successfully realized in an azopolymer synthesized in IOMT. It was found that the process of photoinduced anisotropy is completely reversible when erasing the recording by heating at 90°C, while if optical erasing by irradiation with circularly polarized light is implemented a slight decrease in the maximum value of Δn is observed with increasing the number of writing / erasure cycles [publ. No. A2].

- A numerical method for modeling the processes of induction, relaxation and optical erasure of birefringence has been developed. The method is based on Monte Carlo simulation and involves a large number (over 400,000) of 3D oriented azo molecules. A good agreement of the simulated birefringence kinetics with the experimentally obtained for the PAZO polymer was obtained [publ . No. A4].

- The parameters of photoinduced chiral structures were studied for 4 different azo polymers layer (PAZO and 3 polymers synthesized in IOMT) [publ. No. A 6] and PAZO doped with titanium dioxide particles of size 20 nm with different concentrations in the range 0-3 wt.% [publ. Nos. A5 and A7] and the influence of the intensity and wavelength of the pumping radiation on these parameters was followed [publ. No. A6]. The reversibility of the recording of chiral structures was demonstrated and their formation was found to be much faster than the process of photo induced linear anisotropy [publ. No. A6]. It is shown that doping the azopolymer with a small amount of TiO_2 nanoparticles (about 2 wt .%) enhances the induced chirality [publ. Nos. A5 and A7] .

The main contributions of the studies **outside the habilitation work** are related to:

I. Development of azopolymer nanocomposites with improved properties suitable for polarization holographic recording:

- Thin-film nanocomposite (less than 1 micron in thickness) with improved properties suitable for polarization holographic recording have been developed. The films comprise an azopolymer matrix with embedded Au nanoparticles [publ. No. B1], bioactive metal complexes based on copper and nickel ions (Cu(II) 3-amino-5,5'-dimethylhydantoin and Ni(II) 3-amino-5,5'-dimethylhydantoin) [publ. No. B2], chalcogenide glasses of the Ge - Te - Cu system [publ. No. B5] and goethite nanorods [publ. No. B4]. The influence of particle size, concentration and shape on the photoinduced anisotropy and diffraction efficiency of polarization gratings recorded in doped azopolymers was investigated. The optimum values of particle size and concentration at which an improvement is obtained compared to undoped samples were determined. The hypothesis was formulated that the increase in photoanisotropy observed in azopolymer composites is mainly due to the free volume around the nanoparticles, favoring the reorientation of the azochromophores.

- A method has been developed for calculating the effective refractive index of composite materials consisting of a matrix with incorporated nanoparticles. The method is based on calculating the amplitude of the EM wave scattered by the particle under the assumption of no aggregation and multiple scattering [publ. No. B3].

II. Study and optimization of surface relief gratings obtained by means of polarization holographic recording

- It has been shown that surface relief gratings with a large amplitude can be recorded simultaneously with volume polarization gratings in azopolymer composites with an optimized composition [publ. Nos.B6,B7,B8]. When doped with goethite nanoparticles, a surface relief of about 300 nm is achieved for gratings with a period in the range 0.86-2.5 μm [publ. No. B6]. For doping with bioactive complexes based on Cu and Ni ions and TiO_2 particles, a surface relief in the range of 500 - 600 nm is achieved at a grating period of 1.33 μm [publ. Nos. B7, B8].

- The influence of the thickness of the azopolymer layer and the spatial frequency of grating on the diffraction efficiency and the surface relief was investigated [publ. No. B9]. Dependences of the diffraction efficiencies in +1 and –1 order on the ellipticity of the reading beam were obtained [publ. No. B9].

- A utility model has been registered offering a system for improving the polarization properties of a beam splitter by suppressing the formation of surface relief by means of a cover glass attached via an optically transparent adhesive to the photoanisotropic layer. A 10-fold improvement in polarization properties was achieved compared to those of a grating recorded in an uncoated sample [utility model No. C1].

III.Application of dynamic speckle analysis for monitoring the drying process of azopolymer layers

- The possibility of reducing the amount of data needed to build the activity map in the intensity-based dynamic speckle analysis was investigated [publ. Nos. B10, B11]. Algorithms have been developed for coarse quantization of speckle data for large and small speckle contrast or asymmetric and symmetric intensity distribution in speckle images [publ. Nos. B10, B11]. The developed approach was applied to experimental data obtained during polymer drying at different temperatures [publ. No. B12], an azo polymer deposited using two solvents of different volatility [publ. No. B13] and in three polymers synthesized in IOMT [publ. No. B14].

5. Significance of the obtained results and personal contribution of the applicant

I am confident that significant results have been obtained that contribute substantially to the field of photoanisotropic media and also have the potential for practical application. As a confirmation I will mention the already registered utility model and the strong publication record of the applicant. Dr. Nedelchev's works have been cited more than 350 times, which is a evidence of the scientific society's interest in the results obtained.

According to the personal contribution of Dr. Nedelchev, I can say without any doubts that it is essential. I have known Lian since the time he started as a PhD student at CLOSPI and I have had the pleasure of working with him few times. Dr. Nedelchev together with Prof. Nazarova, started and developed the topic related to doping of azopolymers with nanoparticles and their application as media for polarization

holographic recording, which was laid as the basis of the topics of the dissertation works of their two doctoral students.

6. Critical notes and recommendations.

I have no critical remarks, neither to the submitted documents, nor to the presented reference of the scientific contributions.

CONCLUSION

The sole applicant in the competition Associated Professor Dr. Lian Lyubenov Nedelchev has submitted sufficient material which fully meets the minimum national requirements and those of BAS and IOMT - BAS for awarding the academic position "Professor". The scientific research activities of the applicant are related to research and development of photoanisotropic materials and their optimization for modern applications, such as diffraction optics, photonics and optoelectronics. The results obtained are original and visible in the international scientific society. They could contribute positively on the knowledge in aforementioned fields. Dr. Nedelchev has extensive teaching and administrative experience and strong publication and project record.

On the basis of the above, I give my positive assessment and strongly recommend to the honorable Scientific Jury to support the application and to propose to the Scientific Council of IOMT - BAS to award Dr. Lian Lyubenov Nedelchev the academic position "Professor" in professional field 4.1.Physical sciences.

Sofia, 05.09.2022

Reviewer:

Prof. Dr. Tsvetanka Babeva