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REVIEW

on the competition for academic position occupation **"Professor"** in the field of higher education **4.** Natural sciences, mathematics and informatics, professional direction **4.1.** Physical sciences, scientific specialty "Electrical, magnetic and optical properties of condensed matter", at the Institute of Optical Materials and Technologies "Acad. Yordan Malinovski "- BAS, announced in State Gazette no. 35/10.05.2022

Candidate: Associate Professor Dr. Liyan Lyubenov Nedelchev

Reviewer: Prof. Dr. Plamen Kostadinov PETKOV, Department of physics, University of Chemical Technology and Metallurgy

1. Application data.

The documents submitted by the candidate in the competition correspond to the requirements of the national law and the regulations for its application and the Regulations for the terms and conditions for acquiring scientific degrees and occupying academic positions in IOM T - B A S. The candidate has submitted a complete list of his scientific publications - 96 items, articles in refereed publications - 92 items; articles in non-refereed publications - 4 and 110 participations with posters and oral reports at scientific forums. For participation in the competition, Dr. Nedelchev submitted a list of 21 Bulgarian and foreign scientific publications, one utility model and 110 reports at international scientific forums, 31 of which were oral presentations. A total of 7 other documents (in the form of official notes and certificates from an employer, project manager, funding organization or project contractor and other relevant evidence) supporting the applicant's achievements are also presented. The attached documents thus provide an opportunity for an objective assessment of the candidate's teaching and scientific activity.

2. Applicant data.

Liyan Nedelchev was born in the city of Sofia in 1973. In 1991, he completed his secondary education at NPMG "Acad. Lubomir Chakalov" with honors, and since the autumn

of the same year he has been student at the Faculty of Physics of Sofia University "St. Kliment Ohridski". In 1997, he completed the five-year study and graduated in the specialty "Laser Physics", brilliantly defending his diploma thesis on the topic: "Laser refractometer with an interferometric device for measuring angles". In March of the following year, after a successful competition, he was enrolled in full-time doctoral studies at CLOSPI - BAS. After graduation, he joined the same laboratory as a research physicist, section "Holographic Metrology". He defended his doctoral dissertation on the topic: "Photoinduced processes in azobenzene-containing polymers and their application" in 2004, and from the same year he was elected a research associate. In the period 2001 – 2003, he specialized in Optilink Inc. and Rizo National Laboratory, Roskilde, Kingdom of Denmark, again in the field of azo-benzenes, as media for optical recording of information. In 2009, he moved to the main job as an associate professor in the College of Telecommunications and Posts, which grew in 2015 to the Higher School of Telecommunications and Posts. During his stay at HSTP, the candidate was a teacher of several basic physical disciplines for HSTP, and in the period 2015-2019 he was dean of the Faculty of Telecommunications and Management. Without severing ties with the Academy, Assoc. Prof. Nedelchev continues to actively work at IOMT-BAS, where he is currently head of the "Holography" lab, member of the Scientific Council and Scientific Secretary of the Institute.

3. General characteristics of the scientific works and achievements of the candidate.

The candidate's research interests are definitely in the field of Condensed Matter Physics, focusing his research on modeling and optimization of photoinduced birefringence in azobenzenes and creation of polarization optical elements. The materials for the competition fully meet the minimum national requirements, which the candidate exceeds about 1.3 times (in group "B" - 109 pts, in group "D" - 262 pts, in group "D" - 140 pts and in group "E" - 209 pts). The total number of independent citations of these articles is more than 70, with the Hirsch index (h-index) being 12. The distribution of scientific articles by quartiles is also very good and meets the requirements of IOMT - BAS: - Q1 - 3 pcs [A1, B11, C1]; - Q2 - 9 pcs. [A5, A6, B1, B6, B7, B8, B9, B10, B14]; - Q3 - 2 pcs. [B2, B3] and Q4 - 3 pcs. [A2, A3, B5]; SJR – 5 pcs. [A4, A7, B4, B12, B13].

The habilitation's experimental results are due to the participation in national and international scientific research projects financed mainly by the Ministry of Education and National Science Found, in which he is a participant in 6 of them and the leader of 2 projects. During the implementation of the projects, Assoc. Prof. Nedelchev shows himself as a

talented experimenter and undoubtedly a leading specialist in the lab. "Holography", and this judgment of mine is the result of the author's position in the peer-reviewed articles. The scientific works submitted by the candidate do not repeat those from previous procedures, both for the acquisition of the position "Docent" and for the acquisition of the degree "Doctor". Having read the scientific publications submitted for the competition, I declare with conviction that there is no evidence, signal or suggestion of plagiarism in accordance with the law.

In conclusion, the scientific production not only meets, but also exceeds the minimum national requirements (according to Art. 2b, paras. 2 and 3 of national law) and, accordingly, the additional requirements of IOMT - BAS for occupying position "Professor" in the scientific field and professional direction at the contest.

4. Characteristics and assessment of the candidate's teaching activity.

Assoc. Prof. Nedelchev definitely has teaching talent and almost ten years of experience in working with students. The submitted service note certifies an average annual workload of over 330 hours, which is an excellent certificate. On the other hand, the fact that Associate Professor Nedelchev has prepared three basic courses - "Physics", "Fundamentals of Electronics" and "Electronics" for students from various specialties of the Higher School cannot be ignored. Regardless of his involvement as director of of the "Research Activity" Directorate, Dean of the Faculty of Telecommunications and Management, Member of the Academic Council and the Scientific Council, the candidate publishes a textbook on "Physics" - as a main subject for VU. As an additional activity, I will only mention the delivery of lectures on "Higher Mathematics" and "Electrical Engineering", as well as activities with graduates. This fact gives me reasons to evaluate the pedagogical activity of Associate Professor Nedelchev as extremely impressive.

5. Content analysis of the applicant's scientific and scientific-applied achievements contained in the materials for participation in the competition.

Research results have a decidedly scientific-applied nature and can be classified as obtaining new data and proving existing hypotheses with new means. The main contributions can be systematized as follows:

1. Experimental optimization and numerical modeling of the photoinduced birefringence in thin layers of azo polymers and azo dyes - A method is proposed for determining the thickness of thin layers by absorption spectrum and comparing it with the spectrum of a standard. The method has been successfully used to determine thicknesses in the 400-900 nm range and the results have been verified profilometrically and

interferometrically with excellent agreement. Birefringence kinetics $\Delta n(t)$ were investigated and the maximum value ($\Delta nmax$), response time (τ) and stability (r) of birefringence for five wavelengths (355, 442, 491, 514 and 532 nm) were determined. from the absorption band of the azopolymer PAZO (poly[1-[4-(3-carboxy-4-hydroxyphenylazo)benzene sulfonamido]-1,2-ethanediyl, sodium salt]). The spectral dependence and reversibility of the birefringence $\Delta n(\lambda)$ for the same azopolymer in the entire visible spectrum (400-800 nm) was determined. It shows that layers of the azopolymer PAZO can be used to record polarization diffraction elements operating in a wide spectral range. Birefringence kinetics under 355 and 444 nm irradiation for vacuum deposited layers of the 4-aminoazobenzene azo dye Azo-d were obtained. At 444 nm a value of $\Delta nmax = 0.01$ was obtained. Numerical simulation was carried out by means of Monte Carlo modeling of the processes of induction, relaxation and optical erasure of birefringence.

2. Realization of photoinduced chiral structures in azopolymers and azopolymer nanocomposites - The kinetics of azimuth rotation were obtained for layers of the azopolymer PAZO, as well as for nanocomposite layers of the same polymer doped with 2% titanium dioxide nanoparticles (TiO_2 NPs) of medium size 21 nm under laser beam irradiation with ellipticity ranging from -1 (left circular polarization) to +1 (right circular polarization). From them, the maximum azimuth rotation values of 33°/μm for the azopolymer layer and 46°/μm for the nanocomposite layer were determined. The dependence of the diffraction efficiency on the azimuth of a linearly polarized sample beam was determined for polarization gratings recorded with two orthogonal linear polarizations of the light field. The parameters of photoinduced chiral structures were determined for layers of 4 azopolymers - PAZO and the azopolymers P1, P1-2 and P2 synthesized in IOMT. The obtained results confirm the theoretical model proposed by us earlier. The possibility of reversibly switching the direction of chirality by changing the sign of the ellipticity of the pumping radiation is demonstrated. The dependences of azimuth rotation and output ellipticity on input ellipticity were determined for chiral structures induced in nanocomposite samples of PAZO doped with TiO2 NP with concentrations of 0% (undoped sample), 1%, 2% and 3%.

3. Determination of the birefringence parameters for azopolymer nanocomposites containing different nanoparticles – The dependence of the PAZO – Au birefringence on the size of the NPs was determined and the optimal size and concentration of the NPs were determined, respectively 20 nm and 2 a.u., where a maximum increase in photoinduced birefringence ($\Delta nmax = 0.087$) is reached compared to the undoped sample ($\Delta nmax = 0.070$). Based on the obtained data on the dependence of the birefringence on the size of the doped

NPs, the hypothesis was formulated that the increase in Δn for these nanocomposites is due to a greater extent to the effect of the free volume around the nanoparticles than to the scattering of light by the NPs . The photoinduced birefringence parameters (maximum value, response time and time stability) were determined for a series of nanocomposite layers containing the azopolymer PAZO and bioactive metal complexes based on copper ions (CLP) and nickel ions (NLP) with concentrations of 0, 1, 2 and 5 wt. %. The highest value (Δnmax = 0.093) was reported for the nanocomposite layer with 1% NLP nanoparticles. The complex refractive index in a wide spectral range (320 – 800 nm) of a nanocomposite medium containing the azopolymer PAZO and gold nanoparticles with three different sizes and three different filling factors was determined. The dependence of the maximum photoinduced birefringence on the concentration of goethite nanorods in PAZO was determined. An unusual form of this dependence was found, namely two distinct peaks at concentrations of NPs relative to the azopolymer of 1% and 10%, which we believe is due to the two characteristic sizes of the nanorods. The reflection and absorption spectra, the band gap and the kinetics of photoinduced birefringence were determined for a series of composite layers obtained by doping the azopolymer PAZO with chalcogenide particles of chemical composition $(GeTe_4)_{100-x}Cu_x$, where x=5, 10, 15 and 20 mol %. The most significant increase in Δnmax compared to the undoped samples was found for the $(GeTe_4)_{85}Cu_{15}$ system, the increase being over 25%.

4. Preparation of polarization and surface-relief gratings in azopolymers and azopolymer nanocomposites - Polarization and relief gratings with a period in the range from 0.86 to 2.51 μm were obtained. The recording was performed in PAZO samples doped with goethite nanorods. It was found that the highest diffraction efficiency in total for both orders of 53% is reached for the sample with 10% concentration of NPs. The contributions of the bulk polarization and relief scalar grating to the overall diffraction efficiency are evaluated. Polarization diffraction gratings were recorded in nanocomposite layers of the azopolymer PAZO doped with bioactive complexes based on copper and nickel ions, and high values were achieved both of the diffraction efficiency in the +1 order - 33.0%, and of the height of the surface relief – 586 nm. The absorption spectra, as well as the kinetics of photoinduced birefringence and the diffraction efficiency during holographic recording, were determined for a series of samples containing PAZO and different concentrations of TiO_2 NPs. Polarization holographic gratings were recorded in undoped nanoparticle PAZO layers between 470 and 2400 nm thick at recording angles 2θ = 10°, 20° or 30°. The highest diffraction efficiency (over 40% in +1 order during recording and over 30% after relaxation)

was achieved for a layer with a thickness of 2400 nm and a recording angle of $2\theta = 10°$. A system for improving the polarization properties of a polarization diffraction optical element, representing a circular polarization beam splitter, is proposed. The system includes a cover glass attached with an optically transparent adhesive to the photoanisotropic layer. Thus, the formation of a surface relief, which adversely affects the polarization properties of the optical element, is suppressed. In an exemplary implementation of the system, a 10-fold improvement in polarization properties was achieved compared to that of a grating recorded in an uncoated sample;

5. Monitoring of drying and analysis of the mechanical properties of azopolymer layers - An analysis was performed, using the dynamic speckle method, of the drying process of an aqueous solution of the azopolymer PAZO at different substrate temperatures – 30, 40, 50 and 60°C. Two-dimensional activity maps were obtained using 256, 32, 16 and 8 quantization levels. The calculation of the modified time structure function shows that the coarser quantization (eg with 8 levels) also gives a correct estimate for the drying time of the polymer solution. At the same time, the use of fewer quantization levels significantly reduces the volume of processed data and computation time. The dynamic speckle technique is proposed for monitoring the drying process of azopolymer solutions for two different solvents – water and methanol, and the following substrate temperatures – 25, 30, 40 and 50°C for both solvents and 60°C for the aqueous one only. solution. The drying times for each of these cases were determined and it was shown that for the methanol solutions the drying time was more than 20 times less than that of the aqueous solutions at the same temperature, and also the optical quality of the resulting layers was significantly better. The main micromechanical parameters of thin films of three azopolymers synthesized in IOMT (P1, P1-2 and P2) were determined and compared with the analogous parameters for the commercially available azopolymer PAZO. The results show that azopolymers P1 and PAZO have the highest hardness and P2 the lowest. Also, P2 is distinguished by several times lower value of the elastic component of deformation compared to the plastic one, compared to the other three polymers. These results are explained by the fact that P2 is a liquid crystalline polymer, while the others are amorphous. Using the method of dynamic speckle metrology, the polar correlation function (PCF) was calculated for three of the polymers (P1-2, P2 and PAZO), which is an indicator of the rate of changes taking place in the samples.

6. Critical notes and recommendations.

I have no critical remarks, but as for recommendations. I would recommend him to remain active in publishing.

7. Personal impressions of the candidate.

My first contact with Dr. Nedelchev dates back more than ten years, as a member of the NSF Physical Sciences Committee, and I was intrigued by the scientific topics presented in the project. Subsequent meetings were at conferences, general experiments, and evaluation of dissertation projects. Moreover, my personal impressions of the man and scientist Liyan Nedelchev are definitely magnificent.

CONCLUSION

After reading the materials and scientific works presented in the competition and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I confirm that the scientific achievements meet the requirements of ZRASRB, the Regulations for its application and the relevant Rules of the IOMT - BAS" for occupying the academic position "Professor" in the scientific field and professional direction of the competition. In particular, the candidate convincingly exceeds the minimum national requirements in the professional direction, as no plagiarism was found in the scientific works submitted for the competition.

Based on the above, I recommend the scientific jury to propose to the competent authority for the selection of the Institute of Optical Materials and Technologies "Yordan Malinovski" at the Bulgarian Academy of Sciences, to elect **Assoc. Prof. Dr. Liyan Lyubenov Nedelchev** to occupy the academic position **"Professor"** in a professional direction 4.1. "Physical Sciences" (Electrical, Magnetic and Optical Properties of Condensed Matter).

Albena, 03.09.2022

Prepared the review: ...

(Prof. Dr. Plamen Petkov)