University of Chemical Technology & Metallurgy
Department of Physics , Thin Films Technology Lab
1756 Sofia, 8 Kl.Ohridsky blvd., Tel. +359 2 81 63 447 , Fax. +359 2 868 54 88
p.petkov@uctm.edu plamen.petkov@abv.bg

REVIEW

on a dissertation for the acquisition of the educational and scientific degree "Doctor" in the scientific field 4.1 "Physical Sciences", scientific specialty - "Electrical, magnetic and optical properties of the condensed matter".

Scientific organization: Institute of Optical Materials and Technologies "Acad. Yordan Malinovski" - BAS

Author of the Thesis : Blaga Hristova Blagoeva, MSc

Topic of the dissertation: "Photoanisotropic media for optical recording, sensitive in the visible and ultraviolet regions"

Reviewer: Plamen Kostadinov PETKOV, Professor, Doctor of Engineering, Department of Physics - University of Chemical Technology and Metallurgy

1. Brief biographical information about the dissertation candidate.

Blaga Blagoeva was born in Sofia in 1991. In 2010, she graduated from secondary school and in the same year enrolled in a bachelor's program at Sofia University - "Physics". After successfully graduating in 2014, she entered the Faculty of Physics - master's program "Quantum Electronics and Laser Technology". She received her master's degree in 2017 after a brilliant defense of her thesis on the topic "Thermal and Optically Abrasive Anisotropy in Azopolymers". Immediately after obtaining her bachelor's degree, the doctoral candidate devoted herself to applied holography. First as a technician, then as a physicist and currently as an assistant at IOMT- BAS scientific department "Optical Metrology and Holography". Having fallen into this academic environment, Blaga Blagoeva naturally continued in the third level of education – PhD student in the Laboratory "Holography", as a natural continuation of her master's thesis. Working actively in one of the best groups specialized in this scientific field, the PhD student accumulates sufficient experience, and during the regular doctoral studies, in parallel with conducting the experiment,she participated in several (15) scientific projects funded mainly by the National Science Foundation, the European Commission and the Bulgarian Academy of Sciences. She participated in 60 materials in 34 scientific forums, in half of them she eas the presenter. I was particularly impressed by the publication activity of the student, in the last 8 years she has prepared 40 publications, 33 of which are in journals with IF and SJR, and the dissertation itself is based on 9 scientific publications.

2. Relevance of the problem and general characteristics of the dissertation work.

The relevance of the scientific problem is absolutely beyond doubt. The development of new organic-based media for polarization recording of information is a scientific challenge and essentially a vast field for research. In polarization holography, in addition to the intensity and phase of the incident beams, their polarization is also resisted. Photoanisotropic media are

a class of materials often used for polarization optical applications. Clarifying the properties of photoanisotropic media is mainly aimed at optimizing their optical parameters on the one hand and on the other - improving the optical elements and devices in which they are a working medium.

The peer-reviewed dissertation can be defined as a complex study of the optical behavior of photoanisotropic media for polarization recording based on azopolymers sensitive in the visible and ultraviolet parts of the spectrum. The aim of the dissertation is formulated correctly, specifically and justified, which is also reflected in the correct formulation of the set work tasks related to the clarification of the birefringence Δn during recording and erasing; the spectral dependence of Δn induced in an azopolymer; Modeling and obtaining polarization diffraction optical elements.

The dissertation is written on 146 pages, contains 66 figures and illustrations and 12 tables. The scientific literature used extends to 223 sources, the majority of which are publications from the last 10 years. The dissertation has a classical structure - introduction, review, experimental part, conclusion and contributions, organized in 3 chapters, ending with extensive comments.

The first chapter is essentially a literature review dedicated to the properties of a number of azobenzenes used in holography. The molecular processes in some azo compounds, stilbenes and Schiff bases upon irradiation with polarized light are traced. In the course of these processes, linear and circular birefringence are induced in anisotropic materials. The optical parameters of the media, and specifically birefringence and their influence on the development of optical switches and polarization diffraction elements, are extensively discussed.

The second chapter is devoted to the layer formation and characterization of thin layers of the materials considered in the dissertation – the azopolymers P1, P1-2, P2, PAZO, stilbene-based polyimide PI-St, the azo dyes DR1, DR13, CAD-Q and CAD-N dispersed in a polymer PMMA matrix, as well as the Schiff bases SB-S and SB-N, also dispersed in PMMA. Particular attention is paid to the drying process of the spun layers, controlled by dynamic speckle analysis. The surface topography, microstructure and micromechanical characteristics of some of them are studied. The photoanisotropic parameters of the materials when irradiated with linearly polarized laser light with a wavelength from the visible and ultraviolet part of the spectrum are considered and compared.

In the third chapter, results are presented regarding the implementation of some polarization-selective optical elements and structures. The possibility of implementing an optical switch based on the obtained supramolecular chiral structures in some of the studied materials, namely the azopolymers PAZO, P_1, P_{1-2} and P_2, and the azo dyes DR1 and DR13, is presented. For PAZO and P_{1-2}. The influence of the laser light intensity on the process of formation of chiral structures is determined. The possibility of changing the direction of the chiral structures in PAZO and P_{1-2} by changing the sign of the ellipticity of the polarization of the input radiation is shown. In the last two sections of the dissertation, the creation of diffraction optical elements is described; polarization holographic gratings in the azopolymer PAZO; method for improving the polarization properties of an optical element, representing a circularly polarized beam splitter. At the end of the chapter, the possibility of modeling the diffraction efficiency of a surface relief recorded in PAZO, at different spatial frequencies, profile and height of the relief is shown. Based on a literature analysis and own research, a table is presented regarding the values of birefringence, dichroism and diffraction efficiency of thin layers of azo dyes in a polymer matrix. This database would facilitate researchers in selecting the different dyes as a medium for optical recording.

The results presented in this way clearly show the author good knowledge, which gives her the opportunity to complete the dissertation work with correctly formulated

conclusions from the conducted experiment and scientific contributions, not only as a foundation, but with opportunities for preparing final optical elements.
She can independently interpret scientific results from the field of condensed matter physics and in particular the behavior of azopolymers as polarization recording media. The national requirements for acquiring the ONS "Ph Doctor" have been exceeded more than twice, and in addition, Assist. Blagoeva is a member of the Evaluation Group of the National Education Agency.

The abstract of the dissertation work has been prepared in accordance with the established standards and requirements of the Regulations for the Acquisition of Scientific Titles and Holding Academic Positions of IOMT - B A S and correctly reflects the achieved results and scientific contributions reflected in the dissertation work.

3. Scientific contributions of the dissertation.

In my opinion, the main scientific contributions of the dissertation correlate with the author's claims. They are formulated clearly, accurately and maximally synthesized, which suggests a good physical culture. The contributions can be attributed to purely scientific - accumulation of new facts and enrichment of scientific knowledge, and to those of a certain applied nature. Summarized briefly, they look as follows:
- For the first time, a spectral dependence of the birefringence induced in the azopolymer PAZO has been shown. On this basis, the polarization diffraction elements recorded in it would work in a wide spectral range;
- The parameters of the birefringence in some of the studied photoanisotropic media have been optimized: the optimal concentration of the azo dye DR1 in PMMA for the maximum value of the birefringence; the optimal wavelength for optical recording in PAZO
- birefringence at 355 nm (ultraviolet range) was also induced in different media: the polymers PAZO and PI-St, the azo dyes CAD-Q and CAD-N, as well as the Schiff bases SB-S and SB-N.
- An original method for optimizing the polarization properties of an optical element - a circularly polarized beam splitter is proposed. This polarization beam splitter with improved properties could be used in the construction of a spectral polarimeter.
- The influence of the solvent and the drying kinetics of spun PAZO layers on the quality of the layers obtained from the solutions and on the parameters of surface relief gratings recorded in this azopolymer is studied.
- For the first time, supramolecular chiral structures have been observed in the azopolymers PAZO and P_{1-2}, acting as an optical switch (the direction of the chiral structure changes when the sign of the ellipticity of the incident light changes).

4. Assess the degree of personal participation of the PhD student.

The personal participation of the PhD student in conducting and analyzing the experiment is indisputable to me. The basis for this statement is given to me by the long-standing scientific contacts with the Holography Laboratory, as well as my personal observations at IOMT in connection with the implementation of a joint project with the UCTM, on the subject of the PVP. In addition, the position of the PhD student in publications in authoritative scientific journals. And finally, the declarations of both scientific supervisors legally answer this question. Obviously, Assistant Blagoeva has made significant efforts to enter deeply into the theoretical issues of the group, as can be seen from the attached report on the implementation of the tasks set in the individual plan. From the materials provided to me and from personal impressions of the work of the team, I come to the conclusion that the presented dissertation work is definitely the personal work of the student, as naturally, the

research was planned and carried out under the expert guidance of the scientific supervisors, and let's not forget the consultations with a leading scientist, which is undoubtedly Prof. Stoykova.

5. Publications on the dissertation.

The main results of the research on the dissertation are the subject of nine scientific publications in specialized journals, distributed as follows: one article in Photochemistry & Photobiology A - Q1; one article in Thin Solid Films - Q2; one article in Photochemical and Photobiological Sciences - Q2; one article in Journal of Physics: Conference Series – SJR; two articles in OSA Imaging and Applied Optics Congress – SJR; two articles in SPIE publications – SJR and one in Journal of Physics and Technology.

More than 80% of the published articles are in journals with a high impact factor or rank, which is also a prerequisite for the many citations noted, as well as a good certificate for the qualities of the conducted experiment reflected in the dissertation work. Parts of the dissertation work have been reported in 16 national and international scientific forums, and Blagoeva has participated in them with oral reports.

The high publication activity of the student (mainly in the last years of the doctoral study), as well as the already noted 14 citations (only on the articles from the dissertation), are an unambiguous assessment of the relevance of the scientific problem on the one hand and the quality of the research conducted, on the other. I would definitely like to emphasize the contribution of the dissertation to expanding fundamental knowledge in this field of science covering Condensed Matter Physics, Quantum Optics, Wave Process Theory and Materials Science.

CONCLUSION

In terms of its volume and quality, the dissertation fully meets the recommended requirements reflected in the Regulations for the Application of the ZRASRB and the Regulations of the IOMT - BANS for the Acquisition of Scientific Degrees and Holding of Academic Positions. Based on the above, reflecting the undeniable scientific contributions of the dissertation, the importance of the results obtained in the field of photoanisotropic media for optical recording of information, the good reception of the experimental results by specialists in this scientific field, as well as the good preparation of the PhD student in the field of condensed matter physics and wave processes, I recommend with conviction to the members of the Scientific Jury to vote positively for the award of the educational and scientific degree "Philosophy Doctor" in scientific field 4.1 "Physical Sciences" - scientific specialty "Electrical, Magnetic and Optical Properties of Condensed Matter" to **MSc.-Phys. Blaga Hristova Blagoeva.**

Lozen, 20.12.2024 г.

Reviewer:

/Prof. Dr. Pl.Petkov/