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STATEMENT

by Assoc. Prof. Christina Andreeva
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on dissertation thesis for awarding the educational and research degree "Doctor of Philosophy"
by Petar Kolev, PhD student at IOMT-BAS
entitles: „Sensors based on spectral polarimetric detection"
in the professional field 4.1. Physical sciences
(„Electrical, Magnetic, and Optical Properties of Condensed Matter")

The presented dissertation has been prepared in accordance with the requirements of the Rules and Regulations for acquiring scientific degrees and for holding academic positions at the Institute of Optical Materials and Technologies – BAS. The work is well structured and written, the description is logical and consistent. The dissertation is 106 pages long and consists of an Introduction, leading to the Relevance of the topic and the Goals and objectives of the dissertation, a Literature Review, two chapters dedicated to the experimental work, specifically Construction of a channel polarimeter and its application in sensors based on spectral polarimetric detection. The work ends with a Conclusion, a summary of the main contributions, a list of figures, a list of the author's publications included in the dissertation and his participation in scientific forums, references. The dissertation is based on four articles indexed in Web of Science and Scopus, two of which are in the first quartile, one in the second and one has an impact rank. The work has already received eleven citations, with the first publication receiving nine citations in two years. The results have been reported at nine conferences.

The introductory part discusses the main schemes of excitation of surface plasmon resonances (SPR), and includes a definition and comparison of the main parameters of the sensors based on them. The inclusion of conclusions in the definition of the parameters, as well as the detailed discussion of the advantages and disadvantages of the different approaches to excitation of SPR (with a prism or diffraction grating, with angular, spectral and phase detection), as well as ways to improve these parameters by applying the method of channel polarimetry, leaves an excellent impression.

The purpose of the work directly follows from the introductory part – development of a channeled spectrum polarimeter and its application in various types of sensors, specifically for pathogen detection, gas sensors for H_2 detection and magneto-optical sensors.

The second chapter provides a detailed description of the construction of the channeled spectrum polarimeter – from the calculation of the thicknesses of the phase plates, the fabrication of the selected phase retarders to the construction of the setup and the procedure for the orientation of the elements, with a substantiated comparison of the two sets of plates and their advantages, selection of optimal parameters of the structural elements, consistent with the accompanying measuring equipment. The accuracy and resolution of the measurement are determined.

The approbation of the phase measurement approach using the channeled polarimetry method is the subject of the third chapter of the dissertation, which describes the application of the developed channeled spectrum polarimeter for three types of sensors: biosensor and gas sensor based on surface plasmon resonance, and a magnetic field sensor.

Within the first approach, the sensor uses a bioreceptor immobilized on a gold-coated diffraction grating. The bioreceptor is a blood antigen against a protein that makes up the cell membrane of the bacterium *H. pylori*. A reduction in the detection limit by about 35% has been demonstrated by application of phase detection compared to amplitude detection, due to the improved signal-to-noise ratio. This makes possible to register binding reactions at concentrations of about 200 CFU/ml.

Increased sensitivity has also been demonstrated in the detection of hydrogen, for which tungsten trioxide is deposited on a gold-coated diffraction grating. Its reaction with hydrogen causes a change in the refractive index of the material, and in a small dynamic range (concentration of 40-50%), two orders of magnitude higher sensitivity has been achieved with respect to the conventional amplitude measurement. Model experiments in a large dynamic range show an improvement in sensitivity by about 25%.

The third type of sensor is magneto-optical and is based on the Faraday effect, associated with the rotation of the plane of polarization of light in a magnetic field. The channeled polarization method, applied for the first time to measure the magnetic field (or current) in a BSO crystal, allows determining the operating point of the initial state of polarization, control of its spectral position and temperature drift, and direct measurement of the phase shift caused by the Faraday effect, which also provides high temperature stability of the measurement.

Overall, I am very positively impressed by both the results obtained and the fact that the dissertation candidate demonstrates not only theoretical, but also excellent experimental and technical skills, which is rare.

Technical remarks:

1. There are inaccuracies in the translation from English to Bulgarian of certain terms, namely "Figure of Merit"; FWHM; "substrate", "reference signal". It would be good to provide an explanation of the RIU unit.
2. In Fig. 14 on p. 36 the X and Y axes are not shown, but the text describes the orientation relative to them. It would be good to also give labels in Figs. 20 and 22 (p. 48).

These terminological and grammatical inaccuracies do not hinder the understanding of the presentation and in no way reduce the quality of the dissertation work.

I have the following questions:

1. From the data in Table 11 on page 56, how was Option 3 selected as the most appropriate?

2. On page 66, Fig. 42, the results of amplitude and phase measurements of SPR for two concentrations of *H. pylori* are presented, but the concentrations are not indicated. What are they and are they comparable to standard concentrations in saliva in patients?
3. Again in relation to the biosensor – can you comment on the selectivity of the method? How would other types of bacterial infections be distinguished from *H. pylori*?
4. Could you comment on the sensitivity of magnetic field measurement using the channeled polarimetry method and the time for one measurement?

Conclusion

I am of the opinion that Petar Kolev's dissertation work has been developed at a high scientific level, meets and significantly exceeds the requirements of the Law on the Promotion of the Academic Staff of the Republic of Bulgaria and the Regulations for its implementation, as well as the Regulations of the Institute of Optical Materials and Technologies. The results are published in prestigious refereed journals with an impact factor, and citations have also been noted. Based on this, I strongly recommend that the Scientific Jury award the educational and scientific degree "doctor" to Petar Kolev in professional field 4.1. Physical Sciences, scientific specialty "Electrical, magnetic and optical properties of condensed matter".

Signature:

/доц. д-р Х. Андреева/

Date: 23.02.2026 г.