REVIEW

by competition for the academic position of "professor" in the section "Sensors and measuring technologies in robotics and mechatronics" by professional direction 5.2. "Electrical engineering, electronics and automation", (Sensors for magnetic field).

The competition was announced in the "State Gazette", no. March 26, 21, 2023 with candidate Eng. August Yordanov Ivanov, Eng. Ph.D., associate professor

Reviewer: Prof. Dr. Eng. Nikola Vichev Kolev, Doctor of Sciences, member of the jury, according to Order No. 70/31.05.2023 of the Director of the Institute of Robotics at the BAS.

1. General and biographical data

August Yordanov Ivanov was born in 1958 in Sofia and in 1976 he graduated from the 21 "Hristo Botev" high school, and in 1983 - Master's program at EMF of the Technical University, Sofia, majoring in "Hydraulics and Pneumatics". In 1983 he started working at the Technical University, and in 1985 he started working as a design engineer, and then as an assistant at the Institute of Robotics at the BAS (then the Institute of Technical Cybernetics and Robotics). In 2000, he defended a dissertation for the educational and scientific degree "doctor" on the topic "New types of magnetic field microsensors using the Hall effect". From 2006 to 2016 he was the main assistant, and from 2017 he was an associate professor at the Institute of Robotics.

His total work experience in the specialty is 38 years, having qualified in: nano- and micro-sensors and technologies, robotics and mechatronics, intelligent sensor-information architectures, production automation and electrical measuring instruments and technologies. Assoc. Professor Ivanov has significant administrative and management experience as a participant and manager of over 40 scientific projects and contracts, of which: 4 with the Ministry of Science and Education, 3 with the National Institute of Scientific Research, 5 national, 6 international, 6 under operational programs, 8 with external contractors for the transfer of new technologies. He is the head of the thematic group "Integrated and robotic mechatronic systems". He is a member of the Union of Scientists in Bulgaria and the Scientific and Technical Unions, as well as a member of the Bulgarian Robotics Society. He is a member of the Committee for Academic Property and the Council for Social Cooperation at the BAS, as well as the Committee for Cooperation with CERN at the MES.

He is a manager of a thematic group “Integrated and robotic mechatronic systems”of the Institute of Robotic of the BAS.

He is a member of the editorial boards of "Complex Control Systems" and of the Scientific Journal "Problems of Engineering Cybernetics and Robotics". Since 2018 and until now, Assoc. Professor Ivanov has been the director of the Institute of Robotics and a long-time member of the Scientific Council of the Institute. He is the organizer and head of the non-contact automation and atomic force microscopy laboratories at the Institute, as well as deputy. Chairman of the Innovation Council. He speaks English and Russian. He was the supervisor of two doctoral students before defense. Prof. Ivanov submitted his documents for the competition within the legal deadline.

2. General description of the presented materials

The candidate in the competition for the academic position "professor" Assoc. Prof. Ivanov has submitted the following materials: application to the Deputy Director of IR; resume; copies of diploma for the educational and scientific degree "Doctor", certificate of internship; a list of systematized publications with the qualities of a monographic work, lists of scientific works in specialized scientific publications; separate copies of the scientific publications for participation in the competition; author reference for citations of his works; author reference for scientific and scientific-applied contributions; reference for participation and leadership in national and

international scientific and educational projects; certificate of patents and certificate of compliance of the applicant's materials with the minimum requirements for candidates for the academic position of "Professor", according to the Annex from PUZAD of the BAS.

3. **General characteristics of the candidate's scientific research and applied scientific activity**

The candidate in the competition, Associate Professor Ivanov, has worked in the field of nano- and micro-sensors, robotics and mechatronics, intelligent sensor-information systems and architectures, production automation and in the field of electrical measuring instruments and technologies. He has submitted for review systematic monograph-quality materials on the topic "New generation of multi-purpose sensor elements", which include 16 scientific papers, including patents and patent applications.

Separately, Associate Professor Ivanov presented lists of 29 scientific works after the habilitation and 22 patents and 7 applications, including those included in the lists of works from the monograph category, issued after the habilitation as an associate professor and outside of the dissertation publications for the scientific and educational degree "doctor". The monograph-quality publications complement the existing knowledge in the field of sensors and magnetometry through new methods for their application. The total number of scientific works in publications that are referenced and indexed in world-famous databases with scientific information are 29 in number.

The list of documented participation of the candidate in scientific research and implementation projects and contracts includes 42 numbers, of which 11 are international, 4 of FNI and MO, 21 national projects of BAS and 6 contracts representing the development of sensors, devices and systems, ending with implementations.

Prof. Ivanov's scientific works have been published in magazines: "Compte Rendus de l, ,Academie", "Sensors and Actuators, Elsevier" and in the scientific editions of the international conferences "Proceedings at the Eurosensors" (Paris, France; Graz, Austria; Lecce, Italy); Proceedings of the IEEE and Electronica and others. In the citation list, 50 citations of the candidate's publications by scientists from the country and abroad (Germany, Italy, China, Russia, Poland, USA, India, Thailand, etc.) are noted.

The complex nature of the developments with which Assoc. Prof. Ivanov participated in the competition forced him to work in a team, and therefore his works and patents after habilitation are collective. The scientometric report on the candidate's activities in the competition shows that, with a minimum requirement of 600 points for a Professor at the BAS, Assoc. Prof. Ivanov has exceeded the required minimum points for all positions.

Assoc. Prof. Ivanov has received numerous awards from world exhibitions and international exhibitions, as well as numerous diplomas for his contribution to the development of innovations at the Institute of Robotics.

The review of the candidate's documents, Assoc. Professor Ivanov, shows that the procedural and legal requirements arising from the ZRASRB (Art. 29, para. 1), the Regulations thereto (Art. 60) and the Regulations on the terms and conditions for holding academic positions have been complied with of the Institute of Robotics at the BAS.

4. **Basic scientific and scientific-applied contributions**

First, we will examine and evaluate the contribution elements of scientific works and patents that are included in the list of scientific works with the qualities of a monographic work. The contributions cover 16 publications, of which 15 are subject to review, as well as patents and author's certificates, and number 1 from the list of scientific works is not reviewed because it was published in 2011 in the period before the habilitation for associate professor. Of these, 10 are in

journals with an impact factor, including refereed and indexed in the global rating system. The contributing elements of scientific and applied research on the topic "New generation of multi-purpose sensor elements" presented below, contribute to the expansion of existing knowledge in the field of sensors and, above all, magnetometry and galvanomagnetism. The achieved results are within the scope of a fruitful international collaboration of the Institute of Robotics with European institutes and laboratories, above all with collectives from the Federal Republic of Germany and the Grenoble Technology Center, France. Also, in the laboratory complex of the National Center of Competence "Quantum Communication, Intelligent Systems for Security and Risk Management - QUASAR" some of the experimental studies were carried out.

I accept the submitted contributions of the candidate in the competition, which are described at length and present them systematically as follows:

1. A regularity has been established in sensors, resulting in the occurrence of a linear magnetic potential on one side of the Hall elements, and a non-linear potential on the opposite surface, which is due to a magnetically controlled surface current in the conductive materials in combination with the peculiarities of the shape of the sensor structure [Works: 2; 3; 4; Patent 11, Patent Applications 12, 13];

2. A new regularity in the magnetoelectric properties of the surface of conductive materials, including semiconductors, has been theoretically substantiated and experimentally investigated, which consists in managing the scattering of current carriers by the strength and direction of the magnetic field when their concentration in the near-surface layers changes, which results in impact on the sensitivity, linearity and reproducibility of the output characteristics of magnetic field sensors over a wide temperature range [Papers: 5; 7; 8];

3. A family of multidimensional silicon microsystems for measuring the magnetic field has been created, the advantages of which are maximally simplified construction, high spatial resolution, removed influence of parasitic disturbances and substantial sensitivity [Papers: 6; 9];

4. The magnetically controllable surface current in Hall sensors with in-plane and orthogonal magnetosensitivity is established and it is proved that the Hall voltage consists of two components summing additively. A model of this phenomenon has been developed and tested for various silicon and semiconductor sensor structures [Paper: 14];

5. The phenomenon "Emission of particles under uniaxial pressure of solid structures" was discovered and a previously unknown regularity was established in inhomogeneous systems - rocks and concrete, resulting in the generation of microparticles under the influence of high uniaxial deformations, and it was proved that the quantities emitted particles, regardless of their size, are reproducible for a specific scale and grow simultaneously with the uniaxial pressure, where constant monitoring of particles serves for early warning and prediction of pre-emergency and emergency events in critical infrastructure [Papers: 15; 16];

6. An innovative solution to the principle of electromagnetic induction is proposed, as the charging generator is a hollow cylindrical body of small dimensions made of non-magnetic material, along which a multi-layer induction coil is permanently installed, in the inner area of which there is a small cylindrical magnet, which moves freely along the length of the cylindrical body in opposite directions. The two terminals of the induction coil are connected to the battery. The applicability of the new system is in the control of the movement of animals, together and separately - cattle (cows and buffaloes), horses, donkeys, etc., collecting express information about them such as biometric indicators, etc., including finding them at losing the terrain or in the forest massifs. [Work: 10];

7. A semiconductor vector magnetometry method was developed for measuring more than one non-electrical parameter – magnetic field and temperature using the same conversion region in the silicon substrate for the measurement of more than one non-electrical parameter, and a new class of sensor microsystems with amperometric output for simultaneous and independent measurement of the direction and value of the magnetic field, and of the temperature of the environment, using for the first time the "Diode Hall effect" phenomenon. These converters are characterized by increased noise immunity to parasitic effects, high sensitivity and signal-to-noise ratio, and thermal stability. [Work: 10].

I support the contribution elements of the works, beyond those with monograph qualities. The texts in the contributions formulated by Assoc. Prof. Ivanov are verbose, and therefore I offer the following summaries of the contributions from this section:

1. It has been established that a magnetically controllable surface current occurs in conductive Hall structures in a wide temperature range when a supply current is passed through the structures and a magnetic field is applied perpendicular to it, and the surface current depends linearly on both the strength of the magnetic field and the supply current at mixed type conductivity [Paper 14, Patents: 1; 2; 3;14];

2. A family of multidimensional silicon vector magnetometers has been developed, containing a minimum number of contacts, registering simultaneously and independently the 2D and 3D components of the magnetic field, and the advantages of the new technical solutions are maximally simplified construction, high resolution of the individual output channels, reduced parasitic interchannel influence, and substantial magnetic susceptibility[Papers: 15, 16, 17, 18, 19, 20; Pat: 1, 2, 3];

3. A theoretical model was developed, interpreting the experimental results of the discovered regularities – "magnetically controlled surface current" in conductive materials and anomalies in the behavior of "the potentials of semiconductor structures in a magnetic field" [Papers 21, 22, 23, 24, 25, 26, 27, 28; Pat. 18, 19];

4. Essentially new aspects of the Hall effect have been proven, consisting in the additional current carriers from the Lorentz force on the corresponding boundary surface, which are mobile and not statically located, as well as from the different density of surface charges forming the Hall electric field from the deflected electrons on one side and from the uncompensated positive donor ions on the opposite side, as well as from the additional voltage drop on the opposite interfaces from the flow of the magnetically controlled surface currents [Papers: 29, 30; Pat: 10, 12, 14].

5. A new regularity was experimentally discovered in the behavior of individual Hall potentials, consisting in the generation of a linear potential from the magnetic field on that side of the structures, from which the Lorentz force takes the current carriers, and a linearly increasing potential after a certain value of the induction on the opposite surface with the increased concentration of electrons [Papers: 29, 30 and Patents 8, 11, 14];

6. A method for measuring more than one non-electrical parameter – magnetic field and temperature – with the same area in silicon structures was developed and tested [Papers 1, 2, 3, 4];

7. New three-component (3-D) vector magnetometers have been constructed, using the functional integration of Hall microsensors with parallel and orthogonal axis of sensitivity, measuring simultaneously and independently the three spatial components of the magnetic field, which are distinguished by high spatial resolution minimized parasitic influence between the three sensor channels, low level of inherent noise, long-term stability of the parameters, equalized

conversion characteristics of the x- and y-channels from the used structural symmetry. [Papers 5, 6, 7];

8. A new sensor mechanism was discovered in Hall microsystems, allowing by injection of non-essential carriers with only 0.1% of the supply current to increase the magnetic sensitivity by more than 50%, and the practical significance of this regularity is in the reduction of dissipated power, increased accuracy and the low noise level. [Papers 8, 9];

9. It has been established experimentally in sensor electronics the occurrence of a magnetically controlled surface current in conductive structures when a supply current is passed through the structures and a magnetic field is applied perpendicular to it, provided that the surface current depends linearly, both on the strength of the magnetic field and from the supply current, reversing its direction if one of these input parameters changes its polarity. [Papers:15, 16, 17, 18, 19, 20];

10. A family of multidimensional silicon vector magnetometers has been developed, containing a minimum number of contacts, registering simultaneously and independently the 2D and 3D components of the magnetic field, and the advantages of the new technical solutions are maximally simplified construction, high resolution of the individual output channels, reduced parasitic interchannel influence, and substantial magnetic susceptibility[Papers: 15, 16, 17, 18, 19, 20];

11. A theoretical model was developed, interpreting the experimental results of the discovered regularities - magnetically controlled surface current in conductive materials and anomalies in the behavior of the potentials of semiconductor structures in a magnetic field [Papers: 21, 22, 23, 24, 25, 26, 27, 28];

12. Essentially new aspects of the Hall effect have been proven, consisting in the additional current carriers from the Lorentz force on the corresponding boundary surface, which are mobile and not statically located, as well as from the different density of surface charges forming the Hall electric field from the deflected electrons on one side and from the uncompensated positive donor ions on the opposite side, as well as from the additional voltage drop on the opposite interfaces from the flow of the magnetically controlled surface currents [Papers: 29, 30].

5. Significance of contributions for science and practice

The significance of the created sensors, methods and devices is indisputable, because completed technical developments are offered, some of which have been approved for patents and implemented in practice in the implementation of scientific projects and contracts.

The works of the candidate in the competition are prepared qualitatively, with a broad literary justification, an analytical part and a conclusion, and have the character of in-depth publications.

6. Critical notes and recommendations

1. I have not critical notes to the materials of the protzedure.
2. I recommend that Dr. Ivanov to prepare and publish a monograph based on the accepted developments so that they find wider recognition.

7. Personal impressions and opinion of the reviewer

I know Prof. Ivanov from our joint participation in scientific juries and from my interest in sensors and sensor systems with Hall structures. I positively assess the results of Assoc. Professor Ivanov's developments, included in the scientific publications and those included in contracts with external and internal applicants, as well as the accumulated knowledge and experience at the Institute of Robotics at the BAS.

I note that the candidate in the competition has not proven plagiarism in the scientific works in accordance with the statutory procedure (Art. 24. paragraph 5 of the ZRASRB).

I have no publications in common with Assoc. Professor Ivanov and I am not a person related to him in the sense of paragraph 1, item 5 of the Additional Regulations of ZRASRB.

CONCLUSION

Based on familiarization with the competition materials presented by the candidate in the competition (biography, scientific works, patents, participation in projects and contracts, their significance, the scientific and scientific-applied contributions contained in them) participation in the administrative-management activity, I find to reasonably propose to the Scientific Jury to make a positive decision on the election of Assoc. Prof. Dr. Eng. August Yordanov Ivanov as a Professor, and to propose to the Scientific Council of the Institute of Robotics that he be elected and hold the academic position of "Professor" in the "Sensors section and measuring technologies in robotics and mechatronics" by professional direction 5.2. "Electrical engineering, electronics and automation", (Sensors for magnetic field).

Sofia
20.06.2023

Reviewer: Prof. Dr. Eng. Nikola Kolev, Dr.Sci.