



## REVIEW

on competition for awarding the academic position of "Professor" in professional field 5.2 Electrical Engineering, Electronics and Automatics, section "Sensors and Measurement Technologies in Robotics and Mechatronics (Magnetic Field Sensors)" for the needs of the Institute of Robotics, BAS – Sofia, announced in the "State Gazette", issue 26/21.03.2023

Candidate: Assoc. Prof. Avgust Jordanov Ivanov, Ph.D

Member of scientific jury: Prof. Anatoly Trifonov Aleksandrov, Ph.D (as per order №70/31.05.2023 of the Deputy Director of the Institute of Robotics at BAS – Sofia, Assoc. Prof. Aleksandar Krastev)

### 1. General description of candidate's scientific and applied research activity

Assoc. prof. Avgust Ivanov, Ph.D is the author of 59 scientific works. For his participation in the competition he has submitted 30 scientific works. The scientific works include habilitation thesis (Indicator B) – 10 scientific publications (11, 14-20, 25, 28) in editions referenced and indexed in world renowned data bases with scientific information (Scopus, Web of Science ) and two scientific works (10, 30) not referenced and indexed in world renowned data bases with scientific information (Scopus, Web of Science); 18 scientific publications under Indicator Г, 16 of which (1-6, 8, 9, 12, 13, 21-24, 26, 27) are published in editions referenced and indexed in world renowned data bases with scientific information (Scopus, Web of Science) (Indicator Г7), 2 publications (7, 29) in non-refereed journals with scientific reviewing or in edited volumes of collections (Indicator Г8); 22 patents and inventions and 7 patents applied for.

The publications can be categorized as follows:

- in foreign journals and editions with IF and/or SJR – 20 publications altogether (1-6, 8, 9, 11-20, 25, 28);
- in Scopus refereed foreign conferences – 1 publication (21);
- in Scopus-refereed Bulgarian conferences – 5 publications (22-26, 27);
- in non-refereed foreign journals – 3 publications (7, 29, 30);
- in non-refereed Bulgarian journals – 1 publication (10);

Twenty-nine of the publications are written in English and one in Bulgarian.

The candidate in the competition meets and even exceeds the minimal national requirements in regard to certain indicators. He has defended dissertation entitled "New varieties of magnetic field micro-sensors using Hall Effect" (Indicator A – 50 points) The candidate has submitted: Habilitation thesis – scientific publications (12 publications altogether) 10 of which are published in editions refereed and indexed in world renowned data bases with scientific information (Indicator B4-154 points), 2 publications in non-refereed editions and 4 patents and inventions; 18 scientific publications (Indicator Г – 221,62 points), 16 of which (Indicator Г7 – 209,95 points) in editions refereed and indexed in world renowned data bases with scientific information (Scopus, Web of Science), 2 publications (Indicator Г8 – 11,67 p.) in non-refereed journals with scientific reviewing or in edited volumes of collections. The candidate has 50 citations (Indicator Д - 373 points), of which 34 citations in scientific journals, refereed and indexed in world renowned databases with scientific information (Indicator Д 12 – 340 points), one citation in monographs and volumes of collections with scientific reviewing (Indicator Д13 – 3 points), 15 citations in non-refereed journals with scientific reviewing (Indicator Д 14 – 30 points). The candidate has (Indicator E – 1260 points): participation in 10 national research or educational projects (Indicator E 18 – 100 points); manager of 1 national research or educational project (Indicator E20 -20 points); funds raised under a project led by the candidate (Indicator E22 – 220 points); 7 patents or utility models applied for (Indicator E26 – 140 points) and 22 filed and granted applications for a utility model or patent or copyright registration (Indicator E27 – 880 points).



From the submitted reference record it becomes evident that Assoc. Prof. Avgust Ivanov, Ph.D has participated in 42 research and educational projects and contracts:

- projects under Operational Program "Science and Education for Smart Growth", Priority Axis 1 – "Research and Technological Development", procedure BG05M20P001-1.002 – 37 projects.

- project financed by EU Structural Funds – 5 projects.

## **2. Evaluation of candidate's pedagogical and teaching activity**

In the period from 1985 to 1992 Assoc. prof. Avgust Ivanov, Ph.D. was a design engineer at the Institute of Informatics at BAS, from 1994 to 2000 was an assistant professor at the Institute of Systems Engineering and Robotics at BAS, from 2000 to 2016 was a chief assistant professor at the Institute of System Engineering and Robotics at BAS, and since 2017 is an Associate Prof. at the Institute of Robotics at BAS. His main activities include: preparation of graduate students, masters students and doctoral students; dissemination of research results; development of multipurpose inventions and innovative solutions; organization and management of Centers of Competence under OP SESG; director of IR-BAS. He has more than 29 years of research and inventive activity in the fields of sensors, micro- and Nano-electronics, power engineering, control and measurement technologies, actuators and peripheries, robotics and mechatronics, atomic force microscopy. He is a Deputy-Head of the Center of Competence "Quantum communication, smart security systems and risk management" and the manager of a package at the Center of Competence "Personal medicine, 3D and telemedicine, robotic and minimally invasive surgery", administrative management of the Center of Competence "Smart, mechatronic, eco- and energy saving systems and technologies" (CoC SMEEST).

Assoc. prof. Avgust Ivanov, Ph.D. is a scientific supervisor of two doctoral students in higher education field 5., technical sciences, professional field 5.2 Electrical engineering, electronics and automation, scientific specialty "Application of the principles and methods of cybernetics in technical sciences." He is a member of 7 international and national professional scientific associations, committees, federations, societies, etc. He has received 11 diplomas and rewards. On the grounds of the above information, I assess the candidate's research and pedagogical preparation and activity as very good.

## **3. Main contributions**

I fully accept the contributions stated in the submitted works. They are of scientific and applied research character and are related to establishing totally new aspects in existing scientific problems and to obtaining conclusive facts in the field of sensorics and multidimensional magnetometry by using entirely new methods and means.

### *3.1. Contributions in publications equivalent to habilitation thesis in the thematic area "New generation of multifunctional sensor elements"*

The contributions include **16** publications, **10** of which in journals refereed and indexed in world renowned databases with scientific information, **4** patents and author's certificates and **2** publications in journals not refereed and indexed in world renowned databases with scientific information.

1. A previously unknown regular phenomenon in sensorics, has been experimentally detected consisting in the occurrence of a linear potential from the magnetic field on one side of the Hall elements and of a nonlinear potential on the opposite surface.
2. A universal nondestructive method for surface characterization of semiconductor materials has been developed [2-4, 11-13].
3. A new regularity in magneto-electrical properties of the surface of conducting materials, including semiconductor materials, has been experimentally investigated and theoretically interpreted. It consists in controlling, through the strength and direction of the magnetic field, the scattering of the current carriers by changing of their



concentration in the near-surface layers. Based on this phenomenon, a family of multipurpose microelectronic structures has been designed, including the simultaneous and independent measurement of the magnetic field vector components [5, 7, 8].

4. A family of multidimensional silicon microsystems for magnetic field measurement that has no analog in control and measurement technology has been developed, the main advantages of which are simplified design, high spatial resolution, elimination of the effect of the parasitic interference and increased sensitivity [6, 9].
5. The magnetically controlled surface current in Hall sensors with planar and orthogonal magnetic sensitivity has been experimentally investigated. It has been shown that Hall voltage consists of two components, one of which is known, and is generated by the Lorentz deviation and is compensated by the Hall field, while the other one has been identified for the first time – this is the voltage drop caused by the flow of the magnetically controlled surface current. A model of this phenomenon has been developed and significantly new aspects of the Hall mechanism have been demonstrated and explained [1, 14].
6. The phenomenon “Particle emission under uniaxial pressure of solid structures” has been identified and interpreted. A regular phenomenon has been experimentally observed in inhomogeneous systems – rocks and concretes, resulting in the generation of micro-particles under the influence of high uniaxial deformations. The amounts of emitted particles, regardless of their size, have been shown to be reproducible for a particular rock and increase simultaneously with uniaxial pressure. [15, 16].
7. An innovative solution for real-time control and monitoring of animals is proposed based on the principle of electromagnetic induction, which makes it possible to control the movement of animals, to collect immediate information about them, such as registration number, biometric indicators, etc., as well as to find them when lost. [10].

### *3.2. Contributions in publications apart from those equivalent to habilitation work*

- In the field of semiconductor vector magnetometry the principle of functional integration has been further developed and upgraded – the use of the same conversion region in the silicon substrate for the measurement of more than one nonelectrical parameter, for example the components of the magnetic field vector  $B_x$ ,  $B_y$  и  $B_z$ , their gradient, the temperature of the  $T$  crystal, etc. A new class sensor of microsystems with amperometric output has been developed for simultaneous and independent measurement of the direction and value of the magnetic field and the ambient temperature, using for the first time the Diode Hall Effect phenomenon. High sensitivity and improved signal-to-noise ratio has been achieved. [1-4].
- New three-component (3D) vector magnetometers using the functional integration of the Hall micro sensors with parallel and orthogonal sensitivity axis, measuring simultaneously and independently the three spatial components of the magnetic field have been designed, implemented and tested. They are characterized by high spatial resolution, minimized parasitic influence between the three sensor channels, low inherent noise level, long term stability of the parameters, equalized conversion characteristics of the  $x$ - and  $y$ - channels from the used structural symmetry. The new 3D sensors are promising for building scanners for magnetic micro-objects in biology and medicine, as well as in counter-terrorism, in electric vehicles to control energy consumption, in the positioning of objects in space, etc. [5-7].
- A novel sensor mechanism in Hall microsystems has been devised, investigated and interpreted allowing the injection of minority carriers with as little as 0,1 % of the supply current to increase magneto-sensitivity by more than 50%. The practical significance of this pattern lies in the reduction of power dissipation, increased accuracy and low noise level [8, 9].



- It has been experimentally observed that a magnetically controlled surface current occurs in conductive structures, including semiconductors, in a wide temperature range, when a supply current is passed through the structures and a magnetic field is applied perpendicular to it. The surface current depends linearly on both the magnetic field strength and the supply current, and its direction reverses if one of these input parameters changes its polarity [10-14].
- A family of multidimensional silicon vector magnetometers has been developed, containing a minimum number of contacts that simultaneously and independently register 2D and 3D magnetic field components. The benefits of the new technical solutions are maximum simplicity of design, high resolution of individual output channels, reduced parasitic inter-channel effect and significant magnetic sensitivity. Their practical applicability is in multifunctional sensor modules for robotics, robotic medicine, quantum communication, navigation, automotive industry, etc. [15-20].
- A theoretical model has been developed, interpreting the experimental results of the observed patterns – magnetically controlled surface current in conducting materials and anomalies in the behavior of the potentials of semiconductor structures in a magnetic field. Existing contradictions in the interpretation of the classical and quantum Hall effect have been removed. An innovative method for testing the surface quality of semiconductors has been formulated and demonstrated [21-28].
- Substantial new aspects of the Hall effect have been formulated by showing that: the additional current carriers from the Lorentz force on the respective boundary surface are mobile and determine the surface current; The Hall potentials and voltages are generated both by 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, and by the additional voltage drop across opposite interfaces from the flow of magnetically controlled surface currents. A new pattern in the behavior of the individual Hall potentials has been experimentally observed and interpreted, consisting in the generation of a linear potential by the magnetic field on the side of the structure from which the Lorentz force withdraws the current carriers, and of a linearly increasing potential after a certain value of the induction on the opposite surface with the increased electron concentration [29-34].

#### **4. Significance of contributions for science and practice**

An assessment of candidate's recognition in scientific circles is the list of citations provided in the documents submitted for participation in the competition. A list of 50 citations is presented, 34 of them are in scientific journals, refereed and indexed in world-renowned databases of scientific information. Publication 5 has been cited 8 times, and publications 11 and 12 have been cited 6 times each. The main research and engineering achievements and results in the transfer of technologies and methods are contained in the patents for inventions (29 patents) and in the results obtained from participation in projects (42 projects).

All of this gives me reason to conclude that the candidate is a well-known author who has made publications in high impact scientific forums in the thematic scope of this competition. The quantitative indicators of the criteria for awarding the academic position of "Professor" have been complied with and correspond to the national requirements and the Rules for academic staff development of the Institute of Robotics at the Bulgarian Academy of Sciences.

#### **5. Critical remarks and recommendations**

I have no particular remarks or objectives concerning the candidate's written work. I am of the opinion that it would be good to have a uniform numbering of scientific papers.

## **CONCLUSION**

In conclusion, I can give a highly positive assessment of the overall research and teaching activity of Assoc. prof. Avgust Ivanov, Ph.D., which completely meet the requirements for holding the academic position of "Professor". Sufficient and significant contributions have been made by the candidate.

Drawing upon the content of the materials submitted for participation in this competition, the topicality and significance of accomplished contributions, I propose to the esteemed jury that associate professor Avgust Jordanov Ivanov, Ph.D. be awarded the position of "Professor" in professional field 5.2 Electrical Engineering, Electronics and Automatics, section "Sensors and Measurement Technologies in Robotics and Mechatronics (Magnetic Field Sensors) for the needs of the Institute of Robotics at BAS – Sofia.

Date: 26.06.2023

MEMBER OF JURY:

/Professor A. Aleksandrov/