Questionnaire
Summary of the main activities of a research institute of the Slovak Academy of Sciences

Period: January 1, 2016 - December 31, 2021

1. Basic information on the institute:

1.1. Legal name and address

Institute of Electrical Engineering SAS
Dúbravská cesta 9
841 01 Bratislava

1.2. URL of the institute web site www.elu.sav.sk

1.3. Executive body of the institute and its composition

Directoriat	Name	Year of birth	Years in the position, from - to
Director	RNDr. Vladimír Cambel, DrSc.	1956	2013 -
Deputy director	doc. Ing. Fedor Gömöry, DrSc.	1952	2016
Deputy director	Ing. Milan Ťapajna, PhD.	1977	2017 -
Deputy Director for Infras	Ing. Ján Fedor, PhD.	1976	2013 -
Scientific secretary	Ing. Milan Ťapajna, PhD.	1977	2016
Scientific secretary	RNDr. Marianna Španková, PhD.	1969	2017 -

Add more rows for any changes during the evaluation period

1.4. Head of the Scientific Board

RNDr. Dagmar Gregušová, DrSc. 2014 -

1.4.1 Composition of the International Advisory Board

Prof. Jaroslav Fabian – University Regensburg, Germany
Prof. Martin Kuball – University of Bristol, UK
Dr. Valentin Novosad – Argonne National Laboratories, Illinois, USA
Prof. Alvar Sanchez – Universitat Autonoma de Barcelona, Spain

1.5. Basic information on the research personnel

1.5.1. Fulltime equivalent work capacity of all employees (FTE all), FTE of employees with university degrees engaged in research projects (FTE researchers)

2016		2017		2018		2019		2020		2021		2016-2021	
FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	FTE all	FTE researchers	average FTE all per year	average FTE researchers per year
89,17	56,77	87,81	56,20	87,83	55,79	81,45	51,57	78,59	51,74	81,49	56,34	**84,39**	**54,74**

1.5.2. If applicable, add also a short information on the merger of the institute in the evaluation period. You can also add rows in the above table corresponding to the founding institutes

1.6. Basic information on the funding of the institute

1.6.1. Institutional salary budget, other salary budget[1], non-salary budget[2]

Salary budget	2016	2017	2018	2019	2020	2021	average
Institutional salary budget *[millions of EUR]*	1,421	1,583	1,598	1,749	1,960	1,928	**1,707**
Other salary budget *[millions of EUR]*	0,572	0,530	0,492	0,389	0,430	0,428	**0,473**
Total salary budget *[millions of EUR]*	1,993	2,113	2,089	2,138	2,390	2,356	**2,180**
Non-salary budget *[millions of EUR]*	0,789	0,751	0,809	0,828	0,779	0,749	**0,784**

1.7. Mission Statement of the Institute as presented in the Foundation Charter indicating the years when it was adopted and revised

1. Main activity of the Institute is the research and development in the field of electrical engineering, automatisation and controlling systems, physical sciences and nanotechnology aimed at physical and materials research of semiconductors and superconductors and on their applications.

2. The Institute offers consulting and expert services, related to the main activity, using its equipment and know-how for domestic and foreign customers, including leasing or sale of unique devices and equipment developed and produced in the Institute against a payment from domestic and foreign customers.

3. The Institute provides production, storing, distribution and sale of cryogenic media, mostly for the use of institutes of SAS as well as for domestic and foreign customers.

4. The Institute provides scientific education of new researchers in the scientific fields falling into the domain of its scientific activity within generally valid legal framework. The Institute offers an involvement of its employees in educational process at universities.

5. The Institute provides publications of research results by means of periodical and non periodical press. Publishing of periodical and non periodical press obeys decisions of the Presidium of SAS.

The Institute is authorized for education of new researchers (PhD study) in the research fields 5.2.48 Physical engineering, 4.1.3 Physics of condesed matter and acoustic, 5.2.13 Electronics and Photonics. The Institute realizes tuition and education of researchers for needs of SAS research institutes and other institutions.

The Institute is a co-publisher of the Journal of Electrical Engineering.

[1] Salary budget originating outside the regular budgetary resources of the organization, e.g. from the project funding.
[2] Includes Goods and Services and PhD fellowships

1.8. Summary of R&D activity pursued by the institute during the evaluation period in both national and international contexts. Describe the scientific importance and societal impact of each important result/discovery. Explain on general level – the information should be understandable for a non-specialist (recommended 5 pages, max. 10 pages for larger institutes with more than 50 average FTE researchers per year as per Table 1.5.1.)

The research activity of the Institute of Electrical Engineering SAS (IEE) is framed by its **mission** published in the **Long-term reserch strategy** document. Our mission is twofold:

1. To develop concepts of novel devices and structures based on new effects, which appear in semiconductor heterostructures, thin metal/oxide/ferromagnetic films and thin-film sandwiches, combined also with 2D materials.
2. To solve fundamental problems related to the application of superconductors in electric power devices and extremely light-weight superconductor coils and motors, their modelling and advanced characterization.

A high-quality reserch is supported by state-of-the-art technologies for thin-films and superconductor fabrication available at the institute. It includes thin film technologies for oxides, semiconductors, 2D materials, and metals and technologies for light superconductors wires processing and coils assembly. It also includes The instrumentation also includes clean-room facility and number of diagnostic tools for advanced materials and device characterization.
Reserch strategy document also defines the **main research topics** together with **classes of success** defined by the leading reserchers themselfs. These topics are regularly (annualy) evaluated by the international Advisory board (AB) and IEE Scientific board (SB), where overall performance (meeting the classes of success) and impact of the pursued reserch is monitored. Underperforming reaserch topics are identified and are either given special support or de-emphisised by the management measures (funding from institutional projects such as Structural funds, reserchers relocation). Then, the Reserch strategy document is updated accordingly.
At the beginning of the evaluation period, following main reserch topics were defined:

1. 2D materials
2. Magnetic effects at nanoscale
3. III-N heterostructure electronic devices
4. III-V nanostructures
5. Ionizing radiation detectors and X-ray optics
6. Oxide and especially perovskite oxide layers
7. Superconductor power applications
8. Advanced composite superconductors

In the following we describe the importance and main reserch achievments in the aforementioned topics. Note that more technical description (including references to relevant reserch works) will be given in part 2.1.9.
2D materials based on transition metal dichalcogenides (TMDs) are currently an object of intensive research in solid-state physics and material science. They are assumed as a perspective material for applications in electronics and optoelectronics as well as basic research, owing to their interesting properties including various topological phases, Weyl and Dirac electrons. Exploring these exciting properties for potential applications requires development of reliable methods for growing large-area thin films. Since 2015, we have focused on so-called thermally assisted conversion (TAC), when a thin film of a transition metal is exposed to vapours of a chalcogenide (S, Se and Te). Since then, we have shown that even a simple experimental set-up can prepare continuous layers as thin as 2 nm of a TMD material. The TAC has a relatively sizeable parametric space as most of the growth parameters can be varied, providing thin layers of different properties. For instance, for MoS2, we showed how the alignment of the thin layers on a substrate could be systematically controlled. Even though this property has been known, systematic research is missing. Parallel to that, we showed that experimental techniques of grazing-incidence wide-angle X-ray scattering and polarised Raman spectroscopy could reliably capture the structure and alignment of the thin TMD layers.

We have also continued with preparing thin layers of other TMD materials. Our $PtSe_2$ samples have shown charge-carrier mobilities comparable to the results reported from other laboratories for thin layers prepared by TAC. A completely new is our finding that thin-film stoichiometry controls carrier mobility. We have also demonstrated that $PtSe_2$ can be grown on a superconducting substrate of NbN without significantly affecting its electronic properties.

In reserch devoted to **magnetic effects at nanoscale**, we focus on the activities that bring closer towards realization of magnetic devices based on noncolinear magnetic textures, for instance, magentic memories or signal processing devices. Noncolinear magnetic spin structures, such as, vortices, skyrmions or bimerons can form spontanously in thin ferromagnetic films with sizes below the fabircation resolution and could be used as reconfigurable nanochannels for spin wave processing units or elements of modern memory devices. In our research we focus on their control at nanoscale, more scpecifically: stability, nucleation and transport process.
The theoretical research part is focused on the development of the micromagnetic methods, such as: calculation of energy barriers, finding lowest energy path for transition among different magnetic states or optimizing the frequency domain calculations of the spin wave spectra for non-collinear 3D magnetic states. In order to image noncolinear states at nanoscale, the experimental part of the group is systematically working on developing new techniques and methodologies with improved spatial and magnetic field resolution (switching-magnetization MFM, dual-tip MFM, dual-cantilever MFM, low temp. MFM, vortex core MFM tip, Hall-probe mapping).

III-N semiconductors are probably the most versatile and promising semiconductor family, consisted of artificial compounds made of GaN, AlN and InN. This is mainly due to a wide choice for the direct energy gap, providing full colour spectrum from IR down to UV light in optoelectronics applications, possibility to create quantum wells (QW) with numerous possible combinations and large polarization charges having applications in electronic devices, huge material ruggedness, chemical stability and large electron velocity suitable for RF and power devices and resilient sensors. Even though we already witness a large commercial success of III-N semiconductors in LED lighting, the electronics branch only expects the great day to come. This is particularly because of still immature stage of the III-N material systems, providing several exciting challenges for a scientific research. The previous and present problems of III-N semiconductors somehow relate to its unique properties. Counting large number of defects due to lack of large scale substrates providing strain-free growth, difficult processing because of the ceramic-like nature of surfaces, insolubility and instability of the growth by mixing different III-N compounds, deep nature and low activation efficiency of Mg acceptor (p) doping, and many other technological and physical issues which are a subject of intense research. Nevertheless, if III-N electronics becomes matured and theoretical limits are met; this will lead to unprecedented energy savings worldwide in many power applications like Electric Vehicles. Similarly, newly suggest III-N material systems and QWs can boost future technologies such as 6G wirless communication systems. In our work we have focused on R&D of following III-N-based electronic devices and scientific topics: (i) Enhancement (E)-mode transistors for power and digital applications, (ii) gate insulation and oxide/semiconductor interface, (iii) vertical power transistors and (iv) ultra-fast transistors employing InN channel.

In the field of **III-V nanostructures**, the reserch has been focused on four main applications. First, metal-organic vapor-phase epitaxy (MOVPE) was used for growth of high density GaP nanocones. Our results showed that by an appropriate combination of a high density of gold seeds and an optimized growth temperature, it is possible to obtain a nanostructured surface with very limited free spaces between the nanocones. Next, we continued the reserch on GaP nanocones covered by Ag nanoparticles for surface enhanced raman scattering (SERS). In order to increase relatively low SERS enhancement attributed to very high interparticle distance reported previously, we investigated structures with very small interparticle distances (under 5 nm) with the aim to allow for the interaction of plasmons creating the “hot spots” for Raman signal enhancement. Deposition of Ag nanostructures by RF sputtering resulted the SERS enhancement as high as 10^6. To allow a realistic extinction data recovery we developed method for polishing of finished nanocone samples without destroying of nanocones. In the following, we aimed the edge controlled growth of MoS_2 and $PtSe_2$ on GaP nanocones. Using the nanocone-structured GaP substrate grown by MOVPE, a thin Mo layer was deposited by DC magnetron sputtering and transformed into MoS_2 by sulfurization process. Electrical and optical characterization confirmed GaP/MoS_2 PN heterojunction formation. It was found that planar GaP/MoS_2 heterojunction generated lower photocurrent compared to the GaP/MoS_2 heterojunction that formed on the nanocone-structured

GaP substrate. The results support theoretical assumptions that edge rich substrates can help to increase the quality of deposited 2D materials. Finally, we developed techniques to prepare electronic devices based on nanomembranes with a two-dimensional electron gas (2DEG) attached to various materials by means of van der Waals forces. Different III-V 2DEG heterostructures were grown on GaAs substrates with 500-nm thick AlAs separation layer. The heterostructure nanomambranes (thickness of 130 and 50 nm) were separated from the substrate by wet etching and transferred onto sapphire substrates. Selected nanomembranes on sapphire were processed to prepare high-electron-mobility transistors (HEMTs).

Ionizing radiation is everywhere around us and is produced by natural or artificial sources. Since it is not directly perceptible to the human senses, we need **detectors or sensors**. There are several types of sensors with which we can characterize different types of ionizing radiation (□-particles, electrons, neutrons, X-rays and gamma rays and others). We deal with sensors based on various types of semiconductor compounds. Currently, the most used semiconductor materials are silicon (Si), germanium (Ge) and CdTe resp. CZT (CdZnTe). However, these sensors have certain limitations. For example, Si sensors are unsuitable for detection of X-rays with energies above 25 keV, because Si is a light element with low density. Ge-based sensors are only able to operate at liquid nitrogen temperatures, because the band gap of Ge is 0.66 eV. CZT sensors do not suffer the previous drawbacks, yet, they often show a polarizing effect, where after a short time the detection parameters of a sensor are degraded and it is necessary to turn it off. The radiation resistance of sensors is also an important parameter, as ionizing radiation generally has degrading effects.

Based on our research, the above-mentioned sensors also have insufficient radiation resistance. We prepare and optimize ionizing radiation sensors based on GaAs and SiC, which are characterized by more than two orders of magnitude higher radiation resistance. They are able to work for a long time in an environment with a high value of ionizing radiation. They are also able to operate at elevated temperatures and especially SiC-based sensors can operate up to several hundred of degrees Celsius, as shown by our measurements. We are currently focusing on the preparation of pixel 2D arrays, which can be used in digital X-ray imaging in combination with crystal optics, whose task is to manipulate X-rays. Using diffraction, we can enlarge or reduce the area of the beam, whereby we can achieve enlarging or reducing the X-ray image.

Oxide and especially perovskite oxide layers are the subject of current research in the field of spin electronics, sensors as well as basic research. As part of our topic, we focused on several areas. We studied the growth of $La_{0.67}Sr_{0.33}MnO_3$ (LSMO) and $YBa_2Cu_3O_7$ (YBCO) films deposited on different substrates, mainly on GaN and Si substrates with buffer layers. After optimizing the system of buffer layers (YSZ, CeO_2 and $Bi_4Ti_3O_{12}$) on the so-called SOI (Si-SiO_2 -Si) substrates and preparation of the final LSMO layer, we managed to realize test MEMS structures of uncooled detectors for THz region, working on the bolometric principle (conversion of THz radiation into a change in electrical resistance). The microbolometers were successfully tested at PTB Berlin by THz radiation up to 1.4 THz. Some of their electrical properties have been presented recently. Next, we also focused on preparation and study of superconductor (YBCO)/ferromagnet (LSMO) heterostructures with the aim to study long range proximity effect. We have investigated the triplet component of Cooper pairs (pairs with parallel spins of electrons) in lateral superconductor/ferromagnet/superconductor nanojunctions fabricated using focused ion beam. In the next study, we will focus on increasing the number of magnetic inhomogeneities in nanojunctions, which should increase the proportion of the triplet component. Finally, we focused on modification of superconducting properties of structures (microbridges) on the base of YBCO by applying electron irradiation with energy 30 keV using commercial scanning electron microscope. The energy of incident electrons is able to disrupt the configuration of oxygen chains in the orthorhombic structure of YBCO, which affect the superconducting properties of CuO_2 planes. We have created a model structure- bridges contaning channels (irradiated by electrons) with suppressed superconductivity enabling coherent vortex motion. As a result, we can observe a quasi - Josephson effect, Shapiro step. In interaction with applied microwave radiation the model structure can be used in metrology. Recently, we have performed experiments to modify the superconducting properties of YBCO structures by applying long chiral molecules to their surface, which is also promising in case of LSMO structures.

One of the main challenges of the 21st century is the reduction of greenhouse emissions in order to avoid (or minimize) future climate catastrophe. **Superconductor power applications** can play a major role in green electric power generation (such as wind turbines or fusion high-power plants),

electric grid improvements required for renewable sources (high voltage cables and fault-current limiters), and efficiency (electric or hybrid aircrafts). In addition, superconducting magnets are necessary for basic research, such as high-field magnets for materials science or accelerators for particle physics. REBCO superconductors ($REBa_2Cu_3O_{7-x}$ where RE represents a rare earth element, usually Y, Gd or Eu) present the advantage of high critical current temperature (around 90 K) and excellent performance at high magnetic fields, presenting the highest engineering current density above 20 T. These materials also present the best performance at the temperatures and magnetic fields that are interesting for motors for aviation or sea transport (20-40 K and 1-3 T), especially if powered by liquid hydrogen. In our department, we have made significant contributions to all these fields within EU Horizon 2020 projects (EUROfusion, FastGRID, ASuMED, superEMFL, ARIES, I.FAST) and national funding. In addition, we also worked on magnetic invisibility and shielding, which can be applied to study the effect of life beings to the low magnetic fields in space, among other uses. Our research involves numerical modelling of all these applications by either our own software or commercial one; as well as the construction of experimental proof-of-concept demonstrators, and the measurement of their physical properties (electric, magnetic, thermal, and mechanical; and their interplay). Thus, our Institute has become a key participant in EU framework projects with high impact in their field.
In the field of **advanced composite superconductors**, we focussed on the so-called internal magnesium diffusion (IMD) process, which allows us to obtain the highest transport current densities for MgB_2 wires important for all possible applications. In addition, we studied possibilities to reduce AC losses in MgB_2 wires and cables and also developed low mass MgB_2 wires attractive for wind power turbines, airborne engines and space applications. These activities have followed the topics of several EU projects aimed to high power superconducting wind turbines (e.g. SUPRAPOWER) for which high current density, low AC losses and minimized mass are very important. The topic of MgB_2 superconductors is actual and interesting due to its high critical temperature ~38 K allowing to use it in cryogen-free conditions (without liquid He). In addition, MgB_2 is actually the lightest superconducting material suitable for the long-length production by Powder-in-tube (PIT) method in the form of filamentary wires with much lower price than for high-temperature REBCO conductors. PIT method has limited current density due to usual porosity of MgB_2 filaments, which can be few times increased by diffusion IMD process allowing to create a porous-free MgB_2 filaments. Therefore, IMD process was studied, optimized and improved for future advanced MgB_2 superconductors. But, the uniformity of long-lengths MgB_2 wires made by an internal magnesium diffusion process is still worse than for PIT method and it should be farther studied and improved.

2. Partial indicators of main activities:

2.1. Research output

2.1.1. Principal types of research output of the institute: basic research/applied research, international/regional (in percentage)

basic research/applied research – 90%/10%,

international/regional (ratios in percentage) 100%/0%

2.1.2 List of selected publications documenting the most important results of basic research. The total number of publications should not exceed the number of average FTE researchers per year. The principal research outputs (max. 10% of the total number of selected publications, including Digital Object Identifier – DOI if available) should be underlined. Authors from the evaluated organizations should be underlined.

2016

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2. ŤAPAJNA, Milan - HILT, O. - BAHAT-TREIDEL, E. - WÜRFL, H.-J. - KUZMÍK, Ján. Gate reliability investigation in normally-off p-type-gan cap/AlGaN/GaN HEMTs under forward bias stress. In *IEEE Electron Device Letters*, 2016, vol. 37, p. 385 - 388. (2015: 2.528 - IF, Q1 - JCR, 1.607 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents, 85 citations). https://doi.org/10.1109/LED.2016.2535133

3. HUDEC, Boris - HSU, C.-W. - WANG, I-T. - LAI, W.-L. - CHANG, C.-C. - WANG, T. - FRÖHLICH, Karol - HO, C.-H. - LIN, C.-H. - HOU, T.-H. 3D resistive RAM cell design for high-density storage class memory - a review. In *Science China Information Sciences*, 2016, vol. 59, art. no. 061403. (2015: 0.885 - IF, Q3 - JCR, 0.357 - SJR, Q2 - SJR, karentované - CCC). (2016 - Current Contents, INSPEC, WOS, SCOPUS, 29 citations). https://doi.org/10.1007/s11432-016-5566-0

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6. KAČMARČÍK, Jozef - PRIBULOVÁ, Zuzana - SAMUELY, Tomáš - SZABÓ, Pavol - CAMBEL, Vladimír - ŠOLTÝS, Ján- HERRERA, E. - SUDEROW, H. - CORREA-ORELLANA, A. - PRABHAKARAN, D. - SAMUELY, Peter. Single-gap superconductivity in ß-Bi2Pd. In *Physical Review B*, 2016, vol. 93, art. no. 144502. (2015: 3.718 - IF, Q1 - JCR, 2.377 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents, WOS, SCOPUS, 22 citations). https://doi.org/10.1103/PhysRevB.93.144502

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Carbon, 2017, vol. 111, p. 54-61. (2016: 6.337 - IF, Q1 - JCR, 2.091 - SJR, Q1 - SJR, 106 citations). https://doi.org/10.1016/j.carbon.2016.09.064

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2.1.3 List of monographs/books published abroad

Chapters in monographs

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4. Ťapajna, M. and Koller, C.: Reliability Issues in GaN electronic devices. In Nitride semiconductor technology: power electronics and optoelectronic devices. Weinheim: Wiley-VCH, 2020, p. 199-253. ISBN 978-3-527-34710-0.

5. Hulman, M.: Raman spectroscopy of graphene. In Graphene: properties, preparation, characterization, and applications. Elsevier, 2021, p. 381-412. ISBN 978-0-08-102848-3.

2.1.4. List of monographs/books published in Slovakia

2.1.5. List of other scientific outputs specifically important for the institute, max. 10 items for institute with less than 50 average FTE researchers per year, 20 for institutes with 50 – 100 average FTE researchers per year and so on

1. Biennial Report IEE SAS 2015 – 2016. Eds. M. Ťapajna et al. Bratislava: IEE SAS 2017, 90 p.
2. Biennial Report IEE SAS 2017 –2018. Eds. M. Španková et al. Bratislava: IEE SAS 2019, 109 p.
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2.1.6. List of patents, patent applications, and other intellectual property rights registered abroad

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4. Kuzmík, J.: Vertical GaN transistor with insulating channel and the method of forming the same. Appl. EP3714489/2020

2.1.7. List of patents, patent applications, and other intellectual property rights registered in Slovakia

1. Sojková, M. and Chromik, Š.: The way of patterning of Tl-based superconducting thin films. Patent no. 288436

2. Chromik, Š., Talacko, M. a Španková, M.: Method for preparation of manganite La-Sr-Mn-O films with high onset temperature transition to ferromagnetic state. Patent no. 288749/2016.

3. Korytár, D., Svorada, M., and Zápražný, Z.: Machining method and tool for machining of the inner walls of channels in brittle materials in the nanometer range. Patent Appl. No. PP 50023-2019

4. Cambel, V., Šoltýs, J., Tóbik, J., Fedor, J., Precner, M., Feilhauer, J., Ščepka, T., Dérer, J., Bublikov, K., and Vetrova, I.: A method of fabricating a magnetic force microscopy tip, a tip made by this method, and a method of scanning a magnetic field using the tip. Patent Appl. No. PP 50030-2019

5. Chromik, Š., Talacko, M., Španková, M., and Jung, G.: Method of preparation of channels with suppressed superconductivity in $YBa_2Cu_3O_{7-x}$ microstrip using electron beam irradiation. Patent Appl. No. PP PP 50006-2020.

6. Hrkút, P., Čaplovič, I., Novák, I., and Gaži, Š.: Device for uniform surface processing of powders in plasma. Patent no. 288857

7. Zápražný, Z. and Maco, M.: Compound refractive lenses and method for their production. Patent Appl. No. PP 50014-2021

8. Zaťko, B. and Dubecký, F.: Large area detector of ionizing radiation and particles with its support, method of preparation and connection comprising large area detector. Patent Appl. No. PP 50017-2021

9. Zaťko, B. and Dubecký, F.: Large area detector of ionizing radiation and particles with its support, method of preparation and connection comprising large area detector. Appl. PUV50028-2021

2.1.8. Narrative on the most important research outputs of the institute – especially focused on their importance for society (3-5 pages)

The most important results are summarized below, structured by the reserch topics introduced in section 1.8. Also, the references to the reserch works listed in section 2.1.2 are given.
The thermally-assisted conversion (TAC) method is our preferred method for growing thin layers of **2D TMDs materials**. However, the technique we started with was also pulsed laser deposition (PLD). We showed that very thin layers with a reasonable quality could be prepared with this technique [Chromik ASS'17]. On the other hand, using TAC, we were able to control very precisely the alignment of the MoS_2 layer with respect to the substrate [Sojkova RSC Adv'19]. This possibility might be beneficial for some applications in the chemistry of small organic molecules or low-friction coatings for MEMS applications. Within a framework of national and international collaborations, we showed that organic molecules tend to align according to the orientation of the underlying MoS_2 substrate [Hagara PCCP'20, Mrkyvkova JPC'21]. In Ref. [Hulman JPCc'21], the importance of polarised Raman spectroscopy is demonstrated to capture the thin layer alignment quickly and efficiently. Synchrotron experiments presented in [Shaji JPCc'21] showed how the MoS_2 layers grow in real-time.
Regarding the **electrical properties of prepared 2D materials**, the values of charge carrier mobility measured in our thin $PtSe_2$ layers were comparable to those achieved by other groups for samples prepared by TAC [Sojkova ASS'21]. In addition, we found out for the first time that the mobility can be tuned by the stoichiometry of the thin layer [Hrda RSC Adv'21]. A first heterostructure made of PtSe2 and superconducting NbN was reported in Ref. [Sojkova APL'21]. An NbN layer acting as a substrate maintained its electronic properties even after PtSe2 deposition. Optical properties of very thin (2 nm) $PtSe_2$ layers were presented in [Pribusova ACS Omega'21], with the optical conductivity calculated in a broad frequency range.

In the field of **Magnetic effects at nanoscale**, we focused on the methods to control of noncolinear magnetic states [Vetrova APL'21, Zelent NanoBasel'21, Ognev ACS nano'20, Feilhauer PRb'20, Li npj CM'20 1-5]. For instance, we investigated, both numerically and experimentally the interaction between the MFM tip and magnetic sample that host magnetic skyrmions [Vetrova APL'21, Zelent NanoBasel'21, Ognev ACS nano'20]. We found that skyrmoins can form spontanously in nanoelements formed in multilayer systems hostind Dzyaloshinskii–Moriya interaction, e.g., ultrathin films with Pt/Co/Au. We have studied the dependance of the size of the nano disk in relation to the size of the magnetic domain and found magnetic skyrmions when these sizes are comparable [Vetrova APL'21]. Further we domonstred that other noncolinear magnetic states form in larger disks, for instanc, horse-shoe or labytinth domain structure. We found that the noncolniear magnetc state can be ereased by performing a scan with high momentum MFM tip, if the sample posses a pinning sites that block the movement of the domains. Both experimental and numerical studie confirmed this conclusions [Zelent NanoBasel'21]. In the same publicatoin, with numerical study we demonstrated that the skyrmion can be induced in ultrathin nanodisks using a magnetic force microscopy tip. We found that the local magnetic field generated by the magnetic tip significantly affects the magnetization state of the nanodisks and leads to the formation of skyrmions. Micromagnetic simulations explain the evolution of the magnetic state during magnetic force microscopy scanning and confirm the possibility of skyrmion formation. Our results demonstrate that the formation of the horseshoe magnetic domain is a key transition from random labyrinth domain states into the skyrmion state. We showed that the formation of skyrmions by the magnetic probe is a reliable and repetitive procedure. Our findings provide a solution for skyrmion formation in nanodisks.

Enhancement-mode (E-mode) transistors are specific by a positive threshold voltage, e.g. conduct current only upon positive bias applied on the gate. In **III-N heterostructure electronic devices**, E-mode devices can be utilized either in logic integrated circuits (IC), combining E- and depletion (D)-mode transistors, or for safe operation of the power switching transistors. Our group has designed a new class of E/D-mode ICs based on InAlN/GaN QWs [Blaho SST'16, Blaho APL'17], and for the first time, investigated reliability of p-GaN HEMTs [Tapajna EDL'16]. Gate insulation is an issue because of difficulties to prepare native oxide on III-N surface. Besides, oxide/III-N interface is believed to supply electrons to QWs. We have shown that electrons are truly provided by surface donors [Tapajna APS'17] however, source injection must be considered additionally in E-mode InAlN/GaN transistors [Gucmann PSSa'18]. New class of power electronics is represented by vertical structures, providing controlled avalanche and high switching efficiency. Design of structures is complex because of necessity of p-type doping. Therefore, for the first time, we proposed and demonstrated vertical structures with semi-insulating channel [Sichman MSSP'21, Stoklas TED'21]. Finally, we studied potential of InN for ultra-fast electronics. We demonstrated that InN/InAlN QWs can provide a new type of devices [Chauhan JAP'19, Hasenohrl PSSa'20] while InN possess the highest electron speed from all solid-state materials [Kuzmik AIP'21].

In the field of **III-V nanostructures,** We performed a systematic investigation of nanocone growth using metal organic vapour phase epitaxy (MOVPE) [Laurencikova ASS'17]. Our results showed that by an appropriate combination of a high density of gold seeds and an optimized growth temperature it was possible to obtain a nanostructured surface with very limited free spaces between the nanocones [Novak ASS'18]. Then, the optimized parameters were used for preparation of nanostructures for surface enhanced Raman scattering (SERS) [Laurencikova ASS'18] and MoS_2 and $PtSe_2$ experiments. The SERS enhancement was estimated to be as high as 10^6 for the nanocone (NC) sample decorated with Ag nanoparticles of a nominally 5 nm thick Ag layer. To allow a realistic extinction data recovery we developed method for polishing of finished nanocone samples without destroying of nanocones [Novak ASS'20]. For preparation of GaP (NC)/MoS_2, a thin Mo layer was deposited on GaP substrate by DC magnetron sputtering followed by sulfurated at 700 ^oC. Electrical and optical characterization gave evidence that a PN heterojunction formed between GaP and MoS_2 during the sulfuration process. The planar GaP/MoS_2 heterojunction were found to generat lower photocurrent compared with the GaP/MoS_2 heterojunction formed on the nanocone-structured GaP substrate. The results support theoretical assumptions that edge rich substrates can help to increase the quality of deposited 2D materials. Finally, we developed techniques to prepare electronic devices based on nanomembranes with a two-dimensional gas attached to various materials by means of van der Waals forces [Gregusova Materials '21]. We prepared 2DEG AlGaAs/InGaAs/GaAs and InGaP/AlGaAs/InGaAs/GaAs structures with sheet electron concentrations of about 2.10^{12} cm^{-2} on GaAs substrates overgrown

with 500 nm AlAs. We separated the structures from the substrate by etching the AlAs layer in a HF:H_2O solution and transferred them as 130 and 50 nm thick nanomembranes, respectively, onto sapphire substrates.
GaAs and SiC-based **ionizing radiation sensor**s have several advantageous properties over standard semiconductor materials. We have long been involved in the preparation and optimization of sensors based on semi-insulating GaAs material. Its advantage lies in low price and a good technological base. Our research shows also high stability and radiation resistance. In the case of degradation by high-energy electrons, the sensors show more than 100 times resistance to Si and CdTe sensors [Sagatova ASS'17, Sagatova ASS'21]. The parameters of the sensors can be influenced by a suitable choice of contact metallization. It is important that the leakage current of the structures is as low as possible and a high charge carrier collection is achieved [Dubecky ASS'19]. GaAs sensors are also promising in digital X-ray imaging, which is why we have prepared pixel sensors for an X-ray camera based on the Medipix reading chip. The first results showed high-quality imaging capabilities of the radiation camera [Kubanda JI'19]. We also used this camera to characterize silicon membranes, which we are preparing at our workplace [Zaprazny JI'21]. These membranes are one of the components of crystal optics, which are used for targeted treatment and manipulation of X-rays [Korytar AO'18, Zaprazny JAMT'19]. SiC-based detectors have radiation resistance is up to 1000 times higher than in the case of Si sensors, which predestines them for work in a radiation-inhospitable environment. Their energy resolution is high and comparable to the best commercial sensors [1, Osvald ASS'20, Zatko ASS'21].
In the reserch topic on **oxide and especially perovskite oxide layers,** we can highlight the results presented in [Spankova Vacuum'16], showing epitaxial growth of $La_{0.67}Sr_{0.33}MnO_3$ (LSMO) films deposited on $SrTiO_3$, $LaAlO_3$, $La_{0.26}Sr_{0.76}$ $Al_{0.61}Ta_{0.37}O_3$ and MgO substrates. LSMO films exhibited high Curie temperature T_C and metal-insulator transition temperature T_{MI} in temperature range 405–450 K. In the works [Lalinsky PE'16, Ryger JIMTW'21] we described fabrication and properties of uncooled antenna-coupled microbolometer, used for broadband detection of terahertz electromagnetic spectrum (1.4 THz). Optimal working temperature of the detectors was about 65 °C. The works [Strbik ASS'17] and [Gal SNM'19] presents properties of superconductor/ferromagnet/superconductor nanojunctions consisting of perovskite YBCO and LSMO films created using focused ion beam. The obtained results indicates a presence of long range triplet component of Cooper pairs in the LSMO and qualitative agreement with the theoretical model. In the work [Chromik ASS'17] the effects of low energy 30 keV electron irradiation of superconducting YBCO bridges were investigated. Depending on the fluency of the electron irradiation, it was possible to observe a suppression or improvement of superconducting properties of the bridges. Raman analyses revealed changes in Cu-O chains in the YBCO orthorhombic structure. In [Talacko JMSME'21] we presented a model structure containing a bridge in which channels with suppressed superconductivity were created using electron irradiation, exhibiting a quasi-Josephson effect when interacting with microwave radiation. The aging of such structures was also investigated.
We achieved several significant results regarding **power and magnet applications of superconductivity**, published in 68 articles. We developed a novel type of high-current cable with REBCO tapes on a round tube where coolant can flow, usually liquid nitrogen or helium [Souc SuST'17]. This is one of the cable options for the magnets confining the plasma in the DEMO fusion reactor [Zani TAS'16]. Regarding computer modelling, we were the first to predict the screening currents in a REBCO high-magnetic-field magnet for material research [Pardo SuST'16], enabling our participation to the Horizon2020 project superEMFL. Modelling on the REBCO superconducting stator of an aircraft propulsion motor showed that the energy dissipation is much lower than expected [Pardo TAS'19]. We also predicted the decay of generated magnetic field from superconducting stacks of tapes [Kapolka TAS'20], which act as rotor powerful magnets, for up to 2 million magnetic field cycles [Dadhich SciRep'20]. This is 5 orders of magnitude higher than the previous state of the art but represent only around 33 minutes of flight. For alternative rotors made of REBCO superconducting windings, we modelled REBCO magnetic flux pumps for their contact-less direct-current powering [Ghabeli SciRep'21] using a fast parallel-computing method that we developed [Pardo JCP'17]. Within the Horizon2020 project FastGRID, aimed to construct a REBCO fault-current limiter for reliable power grids with renewable sources [Tixador TAS'19], we developed an experimental a set-up to measure the tape response during an undesired pulse of voltage in the power network (or fault) [Buran SuST'19], performed numerical modelling [Gomory SuST'21], and developed a high-thermal capacity layer to avoid heat damage [Tixador TAS'19].

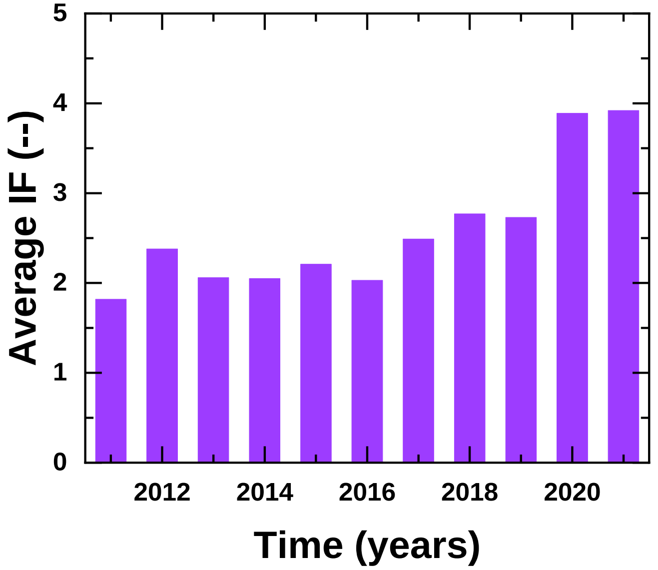
Other significant research aimed at improving Nb layers for superconducting radio-frequency particle accelerators [Ries SuST'21] (ARIES Horizon2020 project) and magnetic cloacking and shielding [Souc APL'16].
In the field of **advanced composite superconductors**, we can highlight the development of ultralight superconducting wire composed of the lightest elements (Mg, B, Ti and Al) used for MgB_2 wire [Kovac SuST'17, Kovac SuST'16, Kovac SciRep'18, Kovac SuST'18]. Utilization of fast creation of MgB_2 phase by diffusion process [Kovac SuST'16] combined with our experiences with pure Ti as barrier material and also successful testing of $Al+Al_2O_3$ (developed by the Institute of Materials and Machine Mechanics of SAS) for the outer sheath of wire [Kovac SuST'17] allowed to made ultralight superconducting MgB_2 wire [Kovac SciRep'18], and low AC loss cables [J Kovac SuST'18]. In addition, utilization of $Al+Al_2O_3$ sheath for MgB_2 wire offers the possibility of creation of very thin Al_2O_3 layer insulation which is applicable for superconducting coils heat treated after winding process and resulting in very high current density in low mass coils [Kopera SuST'19], which is attractive especially for wind power turbines and airborne engines.

2.1.9. Table of research outputs

Papers from international collaborations in large-scale scientific projects (Dwarf team, ALICE Collaboration, ATLAS collaboration, CD Collaboration, H1 Collaboration, HADES Collaboration, and STAR Collaboration) have to be listed separately

Scientific publications	2016			2017			2018			2019			2020			2021			total			
	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. / one million total salary budget	number	No. / FTE researches	No. /1 million total salary budget	number	averaged number per year	av. No. / FTE researches	av. No. / one million total salary budget
Scientific monographs and monographic studies in journals and proceedings published abroad *(AAA, ABA)*		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000	**0**			
Scientific monographs and monographic studies in journals and proceedings published in Slovakia *(AAB, ABB)*		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000	**0**			
Chapters in scientific monographs published abroad *(ABC)*	3	0,053	1,505		0,000	0,000		0,000	0,000		0,000	0,000	1	0,019	0,418	1	0,018	0,425	**5**	**1,667**	**0,030**	**0,765**
Chapters in scientific monographs published in Slovakia *(ABD)*		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000	**0**			
Scientific papers published in journals registered in Current Contents Connect *(ADCA, ADCB, ADDA, ADDB)*	53	0,934	26,591	77	1,370	36,446	55	0,986	26,322	49	0,950	22,918	53	1,024	22,177	68	1,207	28,867	**355**	**59,167**	**1,081**	**27,143**
Scientific papers published in journals registered in Web of Science Core Collection and SCOPUS not listed above *(ADMA, ADMB, ADNA, ADNB)*	34	0,599	17,058	11	0,196	5,207	17	0,305	8,136	15	0,291	7,016	13	0,251	5,440	6	0,106	2,547	**96**	**16,000**	**0,292**	**7,340**
Scientific papers published in other foreign journals (not listed above) *(ADEA, ADEB)*	2	0,035	1,003	2	0,036	0,947	2	0,036	0,957	2	0,039	0,935		0,000	0,000		0,000	0,000	**8**	**2,000**	**0,037**	**0,918**
Scientific papers published in other domestic journals (not listed above) *(ADFA, ADFB)*		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000	**0**			
Scientific papers published in foreign peer-reviewed proceedings *(AECA)*		0,000	0,000		0,000	0,000		0,000	0,000	1	0,019	0,468		0,000	0,000		0,000	0,000	**1**	**1,000**	**0,018**	**0,459**
Scientific papers published in domestic peer-reviewed proceedings *(AEDA)*		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000		0,000	0,000	**0**			
Published papers (full text) from foreign scientific conferences *(AFA, AFC)*	1	0,018	0,502	1	0,018	0,473		0,000	0,000	12	0,233	5,612	2	0,039	0,837	1	0,018	0,425	**17**	**3,400**	**0,062**	**1,560**
Published papers (full text) from domestic scientific conferences *(AFB, AFD)*	15	0,264	7,526	22	0,391	10,413	18	0,323	8,615	9	0,175	4,209	7	0,135	2,929	13	0	6	**84**	**14**	**0**	**6**

Although the number of publications has not been dramatically increased during the evaluated period compared to the previous one, we succeeded in an effort to increase the quality of the research outcomes. This can be documented by an increase in averaged impact factor (IF) of our papers shown in the figure below. As can be inferred from this graph, average IF has increased from about 2 (in 2012-2015) up to 4 at the end of evaluated period 2016-2021. Such increase correlates well with the recommendations given by the AB. First, AB encouraged the management to further support selected topics. Second, the topic leaders to publish their work in journals with higher IF (targeting the class of success defined by themselves). Finally, the topic leaders were advised to strengthen inter- and multidisciplinary research. We believe these recommendations have been taken seriously by the leaders and implemented into reasonable extent.



2.2. Measures of research outputs (citations, etc.)

2.2.1. Table with citations per annum (without self-citations)

Citations of papers from international collaborations in large-scale scientific projects (Dwarf team, ALICE Collaboration, ATLAS collaboration, CD Collaboration, H1 Collaboration, HADES Collaboration, and STAR Collaboration) are listed separately

Citations, reviews	2015		2016		2017		2018		2019		2020		total		
	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	No. / FTE researchers	number	averaged number per year	av. No. / FTE researchers
Citations in Web of Science Core Collection (1.1, 2.1)	1 003	17,67	1 129	20,09	1 261	22,60	1 203	23,33	1 376	26,59	1 287	22,84	**7 259**	**1 209,83**	**22,10**
Citations in SCOPUS (1.2, 2.2) if not listed above	67	1,18	86	1,53	85	1,52	63	1,22	78	1,51	68	1,21	**447**	**74,50**	**1,36**
Citations in other citation indexes and databases (not listed above) (3.2,4.2)		0,00		0,00	1	0,02		0,00	1	0,02		0,00	**2**	**1,00**	**0,02**
Other citations (not listed above) (3.1, 4.1)	7	0,12	41	0,73	13	0,23	4	0,08	13	0,25	4	0,07	**82**	**13,67**	**0,25**
Reviews (5,6)		0,00		0,00		0,00		0,00		0,00		0,00	**0**		

2.2.2. List of 10 most-cited publications published any time with the address of the institute, with number of citations in the assessment period (2015 – 2020)

KUZMÍK, Ján. Power electronics on InAlN/(In)GaN: prospect for a record performance. In *IEEE Electron Devices Letters*, 2001, vol. 22, p. 510-512. (2001 - Current Contents).
Citations: 203

GÖMÖRY, Fedor - SOLOVYOV, Mykola - ŠOUC, Ján - NAVAU, C. - CAMPS, J.P. - SANCHEZ, A. Experimental realization of a magnetic cloak. In *Science*, 2012, vol. 335, p. 1466-1468. (2011: 31.201 - IF, Q1 - JCR, 14.238 - SJR, Q1 - SJR, karentované - CCC). (2012 - Current Contents).
Citations: 151

GRILLI, F. - PARDO, Enric - STENVALL, A. - NGUYEN, D.N. - YUAN, W. - GÖMÖRY, Fedor. Computation of losses in HTS under the action of varying magnetic fields and currents. In *IEEE Transactions on Applied Superconductivity*, 2014, vol. 24, p. 8200433. (2013: 1.324 - IF, Q2 - JCR, 0.431 - SJR, karentované - CCC). (2014 - Current Contents).
Citations: 118

FULAJTÁROVÁ, K. - SOTÁK, T. - HRONEC, M. - VÁVRA, Ivo - DOBROČKA, Edmund - OMASTOVÁ, Mária. Aqueous phase hydrogenation of furfural to furfural alcohol over Pd-Cu catalysts. In *Applied Catalysis A: General*, 2015, vol. 502, p. 78-85. (2014: 3.942 - IF, Q1 - JCR, 1.335 - SJR, Q1 - SJR, karentované - CCC). (2015 - Current Contents).
Citations: 113

HRONEC, M. - FULAJTÁROVÁ, K. - VÁVRA, Ivo - SOTÁK, T. - DOBROČKA, Edmund - MIČUŠÍK, Matej. Carbon supported Pd-Cu catalysts for highly selective rearrangement of furfural to cyclopentanone. In *Applied Catalysis B: Environmental*, 2016, vol. 181, p. 210-219. (2015: 8.328 - IF, Q1 - JCR, 2.326 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents).
Citations: 99

GOLDACKER, W. - GRILLI, F. - PARDO, Enric - KARIO, A. - SCHLACHTER, S. - VOJENČIAK, Michal. Roebel cables from REBCO coated conductors: a one-century-old concept for the superconductivity of the future. In *Superconductor Science and Technology*, 2014, vol. 27, art. no. 093001. (2013: 2.796 - IF, Q1 - JCR, 0.873 - SJR, karentované - CCC). (2014 - Current Contents, WOS, SCOPUS).
Citations: 98

VARGA, M. - IZSÁK, Tibor - VRETENÁR, Viliam - KOZAK, H. - HOLOVSKY, J. - ARTEMENKO, A. - HULMAN, Martin - SKÁKALOVÁ, V. - LEE, D.S. - KROMKA, A. Diamond/carbon nanotube composites: Raman, FTIR, and XPS spectroscopic studies. In *Carbon*, 2017, vol. 111, p. 54-61. (2016: 6.337 - IF, Q1 - JCR, 2.091 - SJR, Q1 - SJR, karentované - CCC). (2017 - Current Contents).
Citations: 96

HOTOVÝ, I. - HURAN, Jozef - SPIESS, L. - HAŠČÍK, Štefan - REHACEK, V. Preparation of nickel oxide thin films for gas sensors applications. In *Sensors and Actuators B : Chemical*, 1999, vol. 57, p. 147-152. (1998: 1.130 - IF, karentované - CCC). (1999 - Current Contents).
Citations: 83

KUZMÍK, Ján - JAVORKA, P. - ALAM, A. - MARSO, M. - HEUKEN, M. - KORDOŠ, Peter. Determination of channel temperature in AlGaN/GaN HEMTs grown on sapphire and silicon substrates using DC characterization method. In *IEEE Transactions on Electron Devices*, 2002, vol. 49, p. 1496-1498. ISSN 0018-9383.
Citations: 71

ŤAPAJNA, Milan - KUZMÍK, Ján. A comprehensive analytical model for threshold voltage calculation in GaN based metal-oxide-semiconductor high-electron-mobility transistors. In *Applied Physics Letters*, 2012, vol. 100, 113509. (2011: 3.844 - IF, Q1 - JCR, 2.814 - SJR, Q1 - SJR, karentované - CCC). (2012 - Current Contents)
Citations: 71

2.2.3. List of 10 most-cited publications published any time with the address of the institute, with number of citations obtained until 2020

KUZMÍK, Ján. Power electronics on InAlN/(In)GaN: prospect for a record performance. In *IEEE Electron Devices Letters*, 2001, vol. 22, p. 510-512. (2001 - Current Contents). ISSN 0741-3106. Dostupné na: https://doi.org/10.1109/55.962646
Citations: 508

GLOWACKI, B.A. - MAJOROŠ, Milan - VICKERS, M. - EVETTS, J.E. - SHI, Y. - MCDOUGALL, I. Superconductivity of powder-in-tube MgB2 wires. In *Superconductor Science and Technology*, 2001, vol. 14, p. 193-199. (2000: 1.250 - IF, Current Contents - CCC). (2001 - Current Contents, WOS, SCOPUS). ISSN 0953-2048.
Citations: 320

GÖMÖRY, Fedor. Characterization of high-temperature superconductors by AC susceptibility measurement : Topical Review. In *Superconductor Science and Technology*, 1997, vol. 10, p. 523-542. (1996: 1.447 - IF, Current Contents - CCC). (1997 - Current Contents, SCOPUS). ISSN 0953-2048.
Citations: 226

GÖMÖRY, Fedor - SOLOVYOV, Mykola - ŠOUC, Ján - NAVAU, C. - CAMPS, J.P. - SANCHEZ, A. Experimental realization of a magnetic cloak. In *Science*, 2012, vol. 335, p. 1466-1468. (2011: 31.201 - IF, Q1 - JCR, 14.238 - SJR, Q1 - SJR, Current Contents - CCC). (2012 - Current Contents). ISSN 0036-8075. Dostupné na: https://doi.org/10.1126/science.1218316
Citations: 221

HOTOVÝ, I. - HURAN, Jozef - SPIESS, L. - HAŠČÍK, Štefan - REHACEK, V. Preparation of nickel oxide thin films for gas sensors applications. In *Sensors and Actuators B : Chemical*, 1999, vol. 57, p. 147-152. (1998: 1.130 - IF, Current Contents - CCC). (1999 - Current Contents).
Citations: 165

DOBROČKA, Edmund - OSVALD, Jozef. Influence of barrier height distribution on the parameters of Schottky diodes. In *Applied Physics Letters*, 1994, vol. 65, p. 575.
Citations: 156

KUZMÍK, Ján - JAVORKA, P. - ALAM, A. - MARSO, M. - HEUKEN, M. - KORDOŠ, Peter. Determination of channel temperature in AlGaN/GaN HEMTs grown on sapphire and silicon substrates using DC characterization method. In *IEEE Transactions on Electron Devices*, 2002, vol. 49, p. 1496-1498. ISSN 0018-9383.
Citations: 140

PLECENIK, Andrej - GRAJCAR, M. - BEŇAČKA, Štefan - SEIDEL, P. - PFUCH, A. Surface characterization of high-Tc superconductors using YBa2Cu3Ox/Au and Bi2Sr2CaCu2Oy/Au point contacts. In *Physical Review B*, 1994, vol. 49, no. 14, p. 10016. (1993: 3.159 - IF, Current Contents - CCC). (1994 - Current Contents). ISSN 1550-235X.
Citations: 138

GRILLI, F. - PARDO, Enric - STENVALL, A. - NGUYEN, D.N. - YUAN, W. - GÖMÖRY, Fedor. Computation of losses in HTS under the action of varying magnetic fields and

currents. In *IEEE Transactions on Applied Superconductivity*, 2014, vol. 24, p. 8200433. (2013: 1.324 - IF, Q2 - JCR, 0.431 - SJR, Current Contents - CCC). (2014 - Current Contents).
Citations: 128

FULAJTÁROVÁ, K. - SOTÁK, T. - HRONEC, M. - VÁVRA, Ivo - DOBROČKA, Edmund - OMASTOVÁ, Mária. Aqueous phase hydrogenation of furfural to furfural alcohol over Pd-Cu catalysts. In *Applied Catalysis A: General*, 2015, vol. 502, p. 78-85. (2014: 3.942 - IF, Q1 - JCR, 1.335 - SJR, Q1 - SJR, Current Contents - CCC). (2015 - Current Contents).
Citations: 113

2.2.4. List of 10 most-cited publications published during the evaluation period (2016-2021) with the address of the Institute, with number of citations obtained until 2021

VARGA, M. - IZSÁK, Tibor - VRETENÁR, Viliam - KOZAK, H. - HOLOVSKY, J. - ARTEMENKO, A. - HULMAN, Martin - SKÁKALOVÁ, V. - LEE, D.S. - KROMKA, A. Diamond/carbon nanotube composites: Raman, FTIR, and XPS spectroscopic studies. In *Carbon*, 2017, vol. 111, p. 54-61. (2016: 6.337 - IF, Q1 - JCR, 2.091 - SJR, Q1 - SJR, karentované - CCC). (2017 - Current Contents).
Citations:144

HRONEC, M. - FULAJTÁROVÁ, K. - VÁVRA, Ivo - SOTÁK, T. - DOBROČKA, Edmund - MIČUŠÍK, Matej. Carbon supported Pd-Cu catalysts for highly selective rearrangement of furfural to cyclopentanone. In *Applied Catalysis B: Environmental*, 2016, vol. 181, p. 210-219. (2015: 8.328 - IF, Q1 - JCR, 2.326 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents).
Citations:122

ŤAPAJNA, Milan - HILT, O. - BAHAT-TREIDEL, E. - WÜRFL, H.-J. - KUZMÍK, Ján. Gate reliability investigation in normally-off p-type-gan cap/AlGaN/GaN HEMTs under forward bias stress. In *IEEE Electron Device Letters*, 2016, vol. 37, p. 385 - 388. (2015: 2.528 - IF, Q1 - JCR, 1.607 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents).
Citations:85

HALIM, J.** - PALISAITIS, J. - LU, j. - THÖRNBERG, J. - MOON, E.J. - PRECNER, Marián - EKLUND, P. - PERSSON, P.O.A. - BARSOUM, M.W. - ROSEN, J. Synthesis of two-dimensional Nb1.33C (MXene) with randomly distributed vacancies by etching of the quaternary solid solution (Nb2/3Sc1/3)2AlC MAX phase. In *ACS Applied Nano Materials*, 2018, vol. 1, iss. 6, p. 2455-2460. (2018 - MEDLINE).
Citations: 59

HASHIZUME, T.** - NISHIGUCHI, K. - KANEKI, S. - KUZMÍK, Ján - YATABE, Z. State of the art on gate insulation and surface passivation for GaN-based power HEMTs. In *Materials science in semiconductor processing*, 2018, vol. 78, p. 85-95. (2017: 2.593 - IF, Q2 - JCR, 0.634 - SJR, Q2 - SJR, karentované - CCC). (2018 - Current Contents).
Citations:49

KOSTIUK, Dmytro - BODIK, Michal - ŠIFFALOVIČ, Peter - JERGEL, Matej - HALAHOVETS, Yuriy - HODAS, Martin - PELLETTA, Marco - PELACH, Michal - HULMAN, Martin - ŠPITÁLSKY, Zdenko - OMASTOVÁ, Mária - MAJKOVÁ, Eva. Reliable determination of the few-layer graphene oxide thickness using Raman spectroscopy. In *Journal of Raman Spectroscopy*, 2016, vol. 47, no. 4, p. 391-394. (2015: 2.395 - IF, Q2 - JCR, 1.020 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents).
Citations:34

MRUCZKIEWICZ, Michal - KRAWCZYK, M. - GUSLIENKO, K.Y. Spin excitation spectrum in a magnetic nanodot with continuous transitions between the vortex, Bloch-type skyrmion, and Néel-type skyrmion states. In *Physical Review B*, 2017, vol. 95, art. no. 094414. (2016: 3.836 - IF, Q2 - JCR, 2.339 - SJR, Q1 - SJR, karentované - CCC). (2017 - Current Contents, WOS, SCOPUS).
Citations:32

HUDEC, Boris - HSU, C.-W. - WANG, I-T. - LAI, W.-L. - CHANG, C.-C. - WANG, T. - FRÖHLICH, Karol - HO, C.-H. - LIN, C.-H. - HOU, T.-H. 3D resistive RAM cell design for high-density storage class memory - a review. In *Science China Information Sciences*, 2016, vol. 59, art. no. 061403. (2015: 0.885 - IF, Q3 - JCR, 0.357 - SJR, Q2 - SJR, karentované - CCC). (2016 - Current Contents, INSPEC, WOS, SCOPUS).
Citations:29

MRUCZKIEWICZ, Michal - GRUSZECKI, P. - ZELENT, M. - KRAWCZYK, M. Collective dynamical skyrmion excitations in a magnonic crystal. In *Physical Review B*, 2016, vol. 93, no. 174429. (2015: 3.718 - IF, Q1 - JCR, 2.377 - SJR, Q1 - SJR, karentované - CCC). (2016 - Current Contents, WOS, SCOPUS).
Citations:28

PRECNER, Marián - POLAKOVIČ, T. - QIAO, Q. - TRAINER, D. - PUTILOV, A.V. - DI GIORGIO, C. - CONE, I. - ZHU, Y. - XI, X.X. - IAVARONE, M. - KARAPETROV, Goran**. Evolution of metastable defects and its effect on the electronic properties of MoS2 films. In *Scientific Reports*, 2018, vol. 8, no. 6724. (2017: 4.122 - IF, Q1 - JCR, 1.533 - SJR, Q1 - SJR, karentované - CCC). (2018 - Current Contents, WOS, SCOPUS). Citations:26

2.2.5. List of most-cited authors from the Institute (at most 10 % of average FTE researchers per year) and their number of citations in the assessment period (2015– 2020). The cited papers must bear the address of the institute

1. J. Kuzmík 1215
2. F. Gömöry 936
3. E. Dobrocka 754
4. E. Pardo 752
5. J. Šouc 715
6. P. Kováč 612

2.2.6. List of most-cited authors from the Institute (at most 10 % of average FTE researchers per year) and their number of citations obtained until 2020. The cited papers must bear the address of the Institute

1. J. Kuzmík 2276
2. F. Gömöry 2073
3. P. Kováč 1743
4. K. Fröhlich 1332
5. J. Šouc 1232
6. E. Dobrocka 1130

2.2.7. List of most-cited authors from the Institute (at most 10 % of average FTE researchers per year) and their number of citations obtained until 2021 of their papers published during the evaluation period (2016– 2021). The cited papers must bear the address of the Institute

1. E. Dobročka 307
2. M. Hulman 244
3. J. Kuzmík 217
4. F. Gömöry 170
5. M. Mruczkiewicz 166
6. E. Pardo 163

2.3. Research status of the institute in international and national context

- **International/European position of the institute**

2.3.1. List of the most important research activities demonstrating the international relevance of the research performed by the institute, incl. major projects (details of projects should be supplied under Indicator 2.4). Max. 10 items for institute with less than 50 average FTE researchers per year, max. 20 for institutes with 50 – 100 average FTE researchers per year and so on

1. Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER, 7thFP-Collab./308793
2. European development of superconducting tapes - EUROTAPES, 7thFP-Collab./NMP3-LA-2012-280432
3. Highly Safe GaN Metal-Oxide-Semiconductor Transistor Switch - SAFEMOST, International Visegrad Fund
4. Implementation of activities described in the Roadmap to Fusion during H2020 through a Joint programme of the members of the EUROfusion consortium, H2020-Euratom/633053
5. Cost effective FCL using advanced superconducting tapes for future HVDC grids - FASTGRID, H2020-721019
6. Advanced superconducting motor experimental demonstrator - ASuMED, H2020-723119
7. Accelerator research and innovation for european science and society - ARIES, H2020-730871
8. The atomic-layer 3D plotter - ATOPLOT, H2020-950785
9. Superconducting magnets for the European Magnet Field Laboratory - SuperEMFL, H2020-951714
10. Innovation Fostering in Accelerator Science and Technology - I.FAST, H2020-101004730
11. Filamentized high temperature superconductor tapes for fusion - EUREKA Eurostars 2 - E115264

2.3.2. List of international conferences (co)organised by the institute

11th International Conference on Advanced Semiconductor Devices And Microsystems ASDAM 2016, Nov. 13-16, 2016, Smolenice

13th International Conference on Advanced Semiconductor Devices And Microsystems ASDAM 2020, Oct. 11-14, 2020, Smolenice - in relation to worsening the COVID-19 pandemic situation in the region of Central Europe was cancelled

2.3.3. List of edited proceedings from international scientific conferences

ASDAM 2016: 11th International Conference on Advanced Semiconductor Devices and Microsystems. Eds. Š. Haščík, J. Dzuba, G. Vanko. IEEE, 2016. 251 s. ISBN 978-1-5090-3083-5

ASDAM 2020: 13th International Conference on Advanced Semiconductor Devices and Microsystems. Eds. T. Izsák, G. Vanko. IEEE, 2020. 171 s. ISBN 978-1-7281-9776-0

2.3.4. List of journals edited/published by the institute and information on their indexing in WOS, SCOPUS, other database or no database, incl. impact factor and other metrics of journals in each year of the assessment period

WOS, SCOPUS
Journal of Electrical Engineering - co-published with STU

IF	2016	0.483
	2017	0.508
	2018	0.636
	2019	0.686
	2020	0.647
	2021	

- **National position of the institute**

2.3.5. List of selected activities of national importance

1. CEMEA – Building a centre for advanced material application SAS, ASFEU
2. 2D materials beyond graphene: monolayers, heterostructures and hybrids, APVV
3. Semiconductor nanomembranes for hybrid devices, APVV
4. Transistors with InN channel for THz microwaves and logic, APVV
5. Skyrmions in ferromagnetic nanoobjects, APVV
6. Magnetic cloaks from superconductor/ferromagnet composites, APVV
7. Modification of YBCO thin film structures using low energy electron beam processing for superconducting electronics, APVV
8. Superconducting coils made of uniform MgB_2 wires with tubular filaments, APVV
9. Vertical GaN MOSFET for power switching applications, APVV
10. Research of radiation resistant semiconductor detector for nuclear energies, APVV
11. Fabrication, physics and correlated states in metallic 2D transition metal dichalcogenides, APVV
12. Robust spin waves for future magnonic applications, APVV
13. High temperature superconducting coils in motors for electric and hybrid aircrafts, APVV
14. Modern electronic devices based on ultrawide bandgap semiconducting Ga_2O_3 for future high-voltage applications, APVV

2.3.6. List of journals (published only in the Slovak language) edited/published by the institute and information on their indexing in WOS, SCOPUS, other database or no database, incl. impact factor and other metrics of journals in each year of the assessment period

- **Position of individual researchers in the international context**

2.3.7. List of invited/keynote presentations at international conferences, as documented by programme or invitation letter

1. Vávra, I. and Hronec, M.: Nanoporous metallic films for catalysis. 16th Joint Vacuum Conf. Portorož 2016.

2. Vojenčiak, M., Šouc, J., Gömöry F., Mozola, P.,van der Laan, D., Kario, A., Nast, R., and Goldacker, W.: Theoretical and experimental study of a CORC cable AC loss and cooling concepts. ICSM 2016 - 5th International Conference of Superconductivity and Magnetism. Fethiye (Turecko) 2016.

3. Cambel, V., Precner, M., Fedor, J., Šoltýs, J., Tóbik, J., Ščepka, T., and Karapetrov, G.: Exploring magnetic state of ferromagnetic nanostructures. 7th Inter. Conf. Nanomater.: Application & Properties '2017. Zatoka (Ukrajina) 2017.

4. Dobročka, E., Hasenöhrl, S., Chauhan, P., and Kuzmík, J.: Non-conventional scans in highresolution X-ray diffraction analysis of epitaxial systems. 5th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN V). Florence 2017.

5. Gömöry, F., Solovyov, M., and Šouc, J.: Two-shell superconductor/ferromagnetic cloaks for shielding of magnetic fields. 30th Inter. Symp. on Supercond. - ISS 2017. Tokyo 2017.

6. Gregušová, D., Kúdela, R., Stoklas, R., Gucmann, F., Pohorelec, O., Blaho, M., Brytavskyi, I.V., and Rosová, A.: III-V-based high electron mobility transistor properties influenced by a capping layer modified heterostructure surface. 5th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN V). Florence 2017.

7. Kuzmík, J.: GaN-based normally-off HEMTs for switching and logic applications. 3rd Intensive Discussion on Growth of Nitride Semiconductors (IDGN-3). Tohoku Univ. 2017.

8. Mruczkiewicz, M.: Spin excitations in ultrathin films with Dzyaloshnskii-Moriya interaction: Nonreciprocal spin waves and skyrmion dynamics. Workshop MagIC 2017 Magnetism, Interactions and Complexity: a multifunctional aspects of spin wave dynamics. Poznań 2017.

9. Novák, J., Laurenčíková, A., Hasenöhrl, S., Eliáš, P., Kováč, J., Sojková, M., and Kováč, J.jr.: Nanorods and nanocones for advanced sensor applications. 5th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN V). Florence 2017.

10. Ťapajna, M., Gregušová, D., Fröhlich, K., and Kuzmík, J.: Current Understanding and Challenges of Metal-Oxide-Semiconductor Gated GaN HFETs. 6th Inter.Symp. Organic Inorganic Electronic Mater. Related Nanotechnol. - EM-NANO 2017. Fukui 2017.

11. Mikolášek, M., Fröhlich, K., Ťapajna, M., Hušeková, K., Novak. P., Racko, J., Rehacek, V., Ondrejka, P., Chymo, F., and Harmatha, L.: Perspective silicon and metal oxide based structures for photoelectrochemical water splitting. 5th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN V). Florence 2017.

12. Šagátová, A., Zaťko, B., Nečas, V., Dubecký, F., Tu, L.A., Sedlačková, K., Boháček, P., and Zápražný, Z.: From single GaAs detector to sensor for radiation imaging camera. 5th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN V). Florence 2017.

13. Fröhlich, K., Kundrata, I., Blaho, M., Precner, M., Ťapajna, M., Hudec, B., Wang, I.-T., Lai, W.-L., Chang, C.-C., Hou, T.-H., Klimo, M., Šuch, O., and Škvarek, O.: Resistive switching structures for memory and logic applications. In 13th Inter. Conf. on Solid State Chemistry. Pardubice 2018.

14. Gömöry, F., Ghabeli Juybari,A., Adámek, M., and Šouc, J.: Characterization of the local critical current fluctuation along the length in industrially produced CC tapes. In Workshop on Coated Conductors for Applications 2018. Vienna 2018.

15. Chromik, Š., Talacko, M., Bareli, G., Camerlingo, C., Španková, M., Rosová, A., Bar, I., and Jung, G.: The influence of substrate and aging on properties of YBCO strips exposed to electron irradiation. In: 10th Inter. Conf. Solid State Surfaces Interfaces Conf. - SSSI 2018. Smolenice 2018.

16. Korytár, D., Zápražný, Z., Jergel, M., Ferrari, C., Halahovets, Y., and Dobrovodský, J.: Surface quality, subsurface damage and mechanisms of material removal in nanomachining of brittle materials. In: 10th Inter. Conf. Solid State Surfaces Interfaces Conf. - SSSI 2018. Smolenice 2018.

17. Mruczkiewicz, M.: Skyrmion and spin wave dynamics in ultrathin filmswith Dzyaloshinskii-Moriya interaction. In 2018 IEEE 8th Inter. Conf. on Nanomaterials: Applications & Properties. Odessa 2018.

18. Mruczkiewicz, M.: Skyrmion and spin wave dynamics in ultrathin films with Dzyaloshinskii-

Moriya interaction. In 3rd Inter. Advanced School on Magnonics 2018. Kyjev 2018.

19. Novák, J.: Nanorods and nanocones prepared by low pressure vapour phase epitaxy. In 17th Joint Vacuum Conf. - JVC-17. Olomouc 2018.

20. Novák, J., Laurenčíková, A., Eliáš, P., Hasenöhrl, S., Sojková, M., Kováč, J.jr., and Kováč, J.: Electrical and photovoltaic characteristics of MoS_2/GaP p-n junctions. In: 10th Inter. Conf. Solid State Surfaces Interfaces Conf. - SSSI 2018. Smolenice 2018.

21. Pardo, E., Kapolka, M., Grilli, F., and Reis, T.: Multi-physics variational methods for magnet and power applications. In: 6th Inter. Workshop on Numerical Modelling of High Temp. Supercond. Caparica 2018.

22. Vojenčiak, M., Tixador, P., Escamez, G., Pop, C., Calleja, A., Bauer, M., Angeli, G., Lacroix, C., Saraf, A., Hänisch, J., Dutoit, B., and Pekarčíková, M.: Cost effective FCL using advanced superconducting tapes for future HVDC grids – overview of European project FASTGRID. In 31st Inter. Symp. on Supercond. - ISS 2018. Tokyo 2018.

23. Hudec, B., Chang, C.-C., Wang, I-T., Fröhlich, K., and Hou, T.-H.: Three-dimensional integration of ReRAMs. In IEEE Nano 2018. Cork 2018.

24. Chromik, Š., Talacko, M., Bareli, G., Camerlingo, C., Španková, M., Rosová, A., Bar, I., and Jung, G.: Preparation, structural and electrical properties of YBCO strips with channels created by electron irradiation. In: 6th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN VI). Florence 2019.

25. Dobročka, E., Španková, M., Sojková, M., Chromik, Š., Hasenöhrl, S., and Novák, J.: Structural characterization of textured thin films with various degree of complexity. In: 6th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN VI). Florence 2019.

26. Ghabeli, A., Pardo, E., Solovyov, M., and Šouc, J.: Modeling and measurement of the voltage signal in HTS flux pumps. In: EUCAS 2019. Glasgow 2019. Poster.

27. Gregušová, D., Blaho, M., Pohorelec, O., Stoklas, R., Eliáš, P., Dobročka, E., and Kúdela, R.: GaAs nanomembranes in device technology. In: 6th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN VI). Florence 2019.

28. Kapolka, M., Kováč, J., and Pardo, E.: 3D modeling and measurements of a multi-tape pancake coil with coupling currents. In: EUCAS 2019. Glasgow 2019. **Poster**.

29. Kováč, P., Hušek, I., Kopera, L., Kováč, J., Melišek, T., Rosová, A., Gelušiaková, B., and Berek, D.: Superconducting wires, cables and coils with minimized mass. In: EUCAS 2019. Glasgow 2019. Poster.

30. Kuzmik, J.: GaN-based normally-off HEMTs for switching and logic applications. In: ISPlasma2019/IC-PLANTS2019. Nagoya 2019.

31. Kuzmik, J.: GaN-based normally-off HEMTs for switching and logic applications. In Materials Research Meeting 2019 (MRM2019) Yokohama 2019.

32. Novák, J., Laurenčíková, A., Eliáš, P., Hasenöhrl, S., Kováč, J.jr., Kováč, J., Urbancová, P., and Pudiš, D.: Winned nanoparticle structures for surface enhanced raman scattering. In: 6th Inter. Conf. "Progress in Applied Surface, Interface and Thin Film Science - Solar Renewable Energy News " (SURFINT-SREN VI). Florence 2019.

33. Grilli, F., Benkel, T., Hänisch, J., Lao, M., Reis, T., Berberich, E., Wolfstädter, S., Schneider, C., Miller, P., Palmer, C., Glowacki, B., Climente-Alarcon, V., Smara, A., Tomkow, L., Teigelkötter, J., Stock, A., Büdel, J., Jeunesse, L., Staempflin, M., Delautre, G., Zimmermann, B., van der Woude, R., Perez, A., Samoilenkov, S., Molodyk, A., Pardo, E., Kapolka, M., Li, S., and Dadhich, A.: Superconducting motors for aircraft propulsion: the advanced superconducting motor experimental demonstrator project. In: 32th Inter. Symp. on Supercond. - ISS 2019. Kyoto 2019.

34. Ťapajna, M., Gregušová, D., Fröhlich, K., and Kuzmík, J.: Present state of InAlN/GaN MOS gate technology. In 11th International Conference on Nanomaterials - Research & Application - NANOCON 2019. Brno 2019.

35. Tóbik, J., Ščepka, T., Feilhauer, J., Karapetrov, G., Šoltýs, J., Fedor, J., Vetrova, J., Cambel, V., Precner, M., Mruczkiewicz, M., and Bublikov, K.: Magnetic nanostructures and their dynamics. In: 9th Inter. Conf. on Nanomater.: Applications & Properties '2019 - NAP 2019. Odesa 2019.

36. Fröhlich, K., Mikolášek, M., Sahoo, P.P., Hušeková, K., Ondrejka, P., Řeháček, V., and Harmatha, L.: Preparation and performance of photoanode with thin RuO_2- and IrO_2-RuO_2-based oxide electrocatalysts for water splitting. In Inter. Conf. Functional Materials and Nanotechnologies FM&NT-2020. Vilnius 2020. On-line.

37. Gömöry, F.: Use of electromagnetic potentials for the modeling of critical states in superconductors. In Applied Superconductivity Conference 2020 Virtual Conference.

38. Gömöry, F. and Šouc, J.: Effect of inhomogeneities on critical currents and stability of coated conductors. In: 33th International Symposium on Superconductivity - ISS. Tsukuba 2020.

39. Pardo, E., Kováč, J., Kopera, L., Ries, R., Grilli, F., Berberich, E., and Reis, T.: AC loss in the REBCO stator of a 1 MW motor for aviation. In: 33th International Symposium on Superconductivity - ISS. Tsukuba 2020.

40. Pardo, E., Dadhich, A., Li, S., Kapolka, M., Solovyov, M., Mošať, M., Kováč, J., and Šouc, J.: Modeling and measuring the cross field demagnetization of REBCO stacks and bulks for millions of cycles. In ASC 2020 Virtual Conference.

41. Ainslie, M., Grilli, F., Queval, L., Pardo, E., Perez Mendez, F., Mataira, R., Morandi, A., Ghabeli, A., Bumby, C., and Brambilla, R.: A new benchmark numerical model: the high-Tc superconducting dynamo. In ASC 2020 Virtual Conference.

42. Grilli, F., Benkel, T., Hänisch, J., Reis, T., Berberich, E., Wolfstädter, S., Schneider, C., Miller, P., Palmer, C., Glowacki, B., Climente-Alarcon, V., Smara, A., Tomkow, L., Teigelkötter, J., Stock, A., Büdel, J., Jeunesse, L., Staempflin, M., Delautre, G., Zimmermann, B., van der Woude, R., Perez, A., Samoilenkov, S., Molodyk, A., Pardo, E., Kapolka, M., Li, S., and Dadhich, A.: REBCO coated conductors are ready to take off. In SuperFOx 2020. Santa Margherita Ligure.

43. Gregušová, D., Pohorelec, O., Ťapajna, M., Blaho, M., Gucmann, F., Stoklas, R., Hasenöhrl, S., Laurenčíková, A., Šichman, P., Haščík, Š., and Kuzmík, J.: Polarization engineering in GaN-based normally-off transistors. In: 2021 Inter. Meeting for Future of Electron Devices. Kansai Virtual 2021.

44. Gömöry, F., Šouc, J., and Mošať, M.: Formation of hot spots in coated conductors during static and dynamic DC loading. In: 16th European Conference on Applied Superconductivity - EUCAS 2021. Moskva, virtual. Poster.

45. Solovyov, M., Kucharovič, M., Pardo, E., and Gömöry, F.: Demagnetizing of magnetic cloak

by use of dynamic magnetoresistance. In: 16th European Conference on Applied Superconductivity - EUCAS 2021. Moskva, virtual.

46. Varga, M.: Diamond nanostructures and composites for optics and photonics. In: 13th International Conference on Nanomaterials - Research & Application In: NANOCON 2021, Brno.

2.3.8. List of researchers who served as members of the organising and/or programme committees

RNDr. V. Cambel, DrSc. - 9th Inter**.** Conf**.** on Nanomaterials: Applications & Properties 2019, Odesa

doc. RNDr. E. Dobročka, CSc. - SURFINT-SREN III 2017, **2019,** Florence

Ing. J. Fedor, PhD. - 17th Joint Vacuum Conf**.** 2018, Olomouc

Ing. K. Fröhlich, DrSc. - 20th Workshop on Dielectrics in Microelectronics 2018, Berlin

doc. Ing. F. Gömöry, DrSc. - 25th Inter**.** Conf**.** on Magnet Technology 2017, Amsterdam
- Applied Superconductivity Conf**.** 2018, Seattle
- Coated Conductors for Applications Workshop 2018, Wien
- EUCAS 2019, Glasgow
- 26th Inter**.** Conf**.** on Magnet Technology 2019, Vancouver
- Applied Superconductivity Conf**.** 2020, Virtual
- 23th Inter**.** Conf**.** on Magnet Technology 2021, Fukuoka (virtual)

RNDr. D. Gregušová, DrSc**.** - SURFINT-SREN III 2021, Florence

Ing. Š. Chromik, DrSc. - SURFINT-SREN III 2021, Florence

Ing. J. Kuzmík, DrSc. - 12th Topical Workshop on Heterostructure Microelectr. 2017 Kirishima (Japan)
- Inter**.** Symp**.** Compound Semicond**.** 2019, Nara (Japan)
- TWHM 2019, Toyama (Japan)

doc. Ing. J. Novák, DrSc. - MOVPE 2017, Paris
- 18th Europ. Workshop on Metal-Organic Vapour Phase Epitaxy 2019, Litva
- SURFINT 2019 Florencia

Ing. J. Osvald, DrSc. - ICSMD 2018, Ardahan (Turecko)

Mgr. E. Pardo, PhD. - Inter**.** Workshop on HTS Modelling 2018, Caparica (Portugal)

Ing. G. Vanko, PhD. - MEMS 2017, Barcelona

2.3.9. List of researchers who received an international scientific award

doc. Ing. F. Gömöry, DrSc. - Van Duzer price 2016 from IEEE for the best article in IEEE
Mgr. E. Pardo, PhD. Transactions on Applied Superconductivity for the year 2014

Ing. T. Ščepka, PhD. - 3rd place **-** The best contribution of young scientists award **-** SURFINT-SREN 2019

Ing. F. Gucmann, PhD. - Outstanding reviewer for Nanotechnology IOP publisher 2021

Mgr. M. Soloviov, PhD. - Outstanding reviewer for Superconductivity IOP publisher 2021

- ## Position of individual researchers in the national context

2.3.10. List of invited/keynote presentations at national conferences, as documented by programme or invitation letter

1. Gregušová, D., Blaho, M., Haščík, Š., Ťapajna, M., and Kuzmík, J.: Semiconductor surface

processing for GaN-based normally-off transistors. Solid State Surfaces and Interfaces - SSSI 2016. Piešťany 2016.

2. Chromik, Š., Sojková, M., Hulman, M., Vretenár, V., Dobročka, E., Rosová, A., Machajdík, D., and Kobzev, A.P.: The preparation and properties of MoS_2 two dimensional system prepared by different deposition methods. Solid State Surfaces and Interfaces - SSSI 2016. Piešťany 2016.

3. Novák, J.: Environmental applications of Gallium Phosphide based nanowires. Solid State Surfaces and Interfaces - SSSI 2016. Piešťany 2016.

4. Novák, J.: GaP nanowires – properties and applications. 20th Slovak - Czech - Polish Optical Conf. Wave Quantum Aspects of Contemp. Optics. Jasná 2016.

5. Pinčík, E., Kobayashi, H., Brunner, R., Mikula, M., Vojtek, P., Takahashi, M., Zábudlá, Z., Imamura, K., Greguš, J., and Kučera, M.: About optical properties of catalytic black silicon and porous silicon formed by the standard electrochemical process. In: 10th Inter. Conf. Solid State Surfaces Interfaces Conf. - SSSI 2018. Smolenice 2018.

6. Jergel, M., Halahovets, Y., Maťko, I., Šiffalovič, P., Majková, E., Korytár, D., and Zápražný, Z.: Surface finishing of X-ray crystals optics after nanomachining. In: 10th Inter. Conf. Solid State Surfaces Interfaces Conf. - SSSI 2018. Smolenice 2018.

7. Precner, M., Polakovič, T., Qiao, Q., Trainer, D.J., Putilov, A.V., Di Giorgio, C., Cone, I., Zhu, Y., Xi, X.X., Iavarone, M., and Karapetrov, G.: Evolution of metastable defects and its effect on the electronic properties of MoS_2 films. In: 24th Konferencia slovenských fyzikov. Žilina 2019.

8. Chromik, Š., Sojková, M., Španková, M., Hulman, M., Rosová, A., Dobročka, E., Gregor, M., Vanko, G., and Pécz, B.: The preparation and properties of MoS_2 two dimensional system prepared by different methods. In 11th Inter. Conf. Solid State Surfaces Interfaces Conf. - SSSI 2020. Smolenice 2020.

9. Chromik, Š., Španková, M., Dobročka, E., Vanko, G., Hutár, P., Vojteková, T., Gregor, M., Cordier, Y., and Pécz, B.: MoS_2 two dimensional system prepared by PLD method on different substrates. In: Progress in applied surface, interface and thin film science – solar renewable energy news 2021 - SURFINT – SREN VII. Smolenice - virtual 2021.

10. Zaťko, B., Hrubčín, L., Šagátová, A., Boháček, P., Ivanov, O.M., Sekáčová, M., Kováčová, E., Gurov, Y.B., and Skuratov, V.A.: Study of the pulse height defect of 4H-SiC Schottky barrier detectors in heavy ion detection. In: 26th International Conference Applied Physics of Condensed Matter - APCOM 2021. Štrbské Pleso 2021.

2.3.11. List of researchers who served as members of organising and programme committees of national conferences

Ing. D. Korytar, CSc. - SSSI 2018**,** Smolenice
doc. Ing. J. Novák, DrSc. - SSSI 2020 Virtual
- SURFINT 2021 Smolenice
- ADEPT 2017, Podbanske, ADEPT 2019, Štrbské pleso

Ing. J. Osvald, DrSc. - ASDAM 2018
Ing. G. Vanko, PhD. - ASDAM 2016, 2018 Smolenice

2.3.12. List of researchers who received a national scientific award

Ministry of Education, Science, Research and Sport SR
Ing. P. Kováč, DrSc. - The Best Scientific Team 2020

Cena Literárneho fondu za 3-ročný ved. ohlas - LITA
Ing. J. Kuzmík, DrSc. 2016

Student of Slovakia in category Electrical Engineering (Junior Chamber International) - ABB
Ing. M. Blaho, PhD. 2017
Ing. M. Kapolka, PhD. 2018
Mgr. P. Šichman 2021

Young Physicists Competition - Slovak Physical Society
Ing. M. Precner, PhD. 2019

STU
Mgr. B. Zaťko, PhD.
Osobné poďakovanie dekana
Oceňovateľ: FEI STU, Bratislava
Opis: Osobné poďakovanie dekana fakulty pri príležitosti 80. výročia výchovy inžinierov elektrotechniky a informatiky

Rector STU Medal 2021
Ing. M. Mošať, PhD. -

SAS
Prize for the high-cited publication
doc. Ing F. Gömöry, DrSc., Mgr. M. Soloviov, PhD., Ing. J. Šouc, CSc. 2018

Young Scientists Competition
Ing. M. Blaho, PhD. 2018
Ing. M. Precner, PhD. 2019

Competition of Young PhD Students
MSc. A. Dadhich, PhD.

2.4. Research grants and other funding resources

(List type of project, title, grant number, duration, total funding and funding for the institute, responsible person in the institute and his/her status in the project, e.g. coordinator "C", work package leader "W", investigator "I". Add information on the projects which are interdisciplinary, and also on the joint projects with several participating SAS institutes)

- **International projects**

2.4.1. List of major projects of Framework Programmes of the EU (which pilar), NATO, COST, etc.

Add information on your activities in international networks

Framework Programmes of the EU

Project title: Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER
Project number: Collab./308793
Duration month/year-month/year: 01/2012 – 12/2016
Total funding (EUR): 3 891 058,46
Funding for Organisation (EUR): 108 960
Responsible person and role: Ing. P. Kováč, DrSc., I

Project title: European development of superconducting tapes - EUROTAPES

Project number: Collab./NMP3-LA-2012-280432
Duration month/year-month/year: 09/2012 – 02/2017
Total funding (EUR): 13 499 939
Funding for Organisation (EUR): 374 493
Responsible person and role: doc. Ing. F. Gömöry DrSc., W

HORIZON2020

Project title: Implementation of activities described in the Roadmap to Fusion during Horizon2020 through a Joint programme of the members of the EUROfusion consortium
Project number: Euratom/633053
Duration month/year-month/year: 01/2014 – 12/2021
Total funding (EUR):
Funding for Organisation (EUR): 57 132
Responsible person and role: doc. Ing. F. Gömöry, DrSc., I(third party)

Project title: Cost effective FCL using advanced superconducting tapes for future HVDC grids
Project number: 721019
Duration month/year-month/year: 01/2017 – 06/2020
Total funding (EUR): 7 248 235
Funding for Organisation (EUR): 399 947
Responsible person and role: doc. Ing. F. Gömöry, DrSc., W

Project title: Advanced superconducting motor experimental demonstrator
Project number: 723119
Duration month/year-month/year: 05/2017 – 05/2020
Total funding (EUR): 4 007 476
Funding for Organisation (EUR): 286 210
Responsible person and role: Mgr. E. Pardo, PhD., W

Project title: Accelerator research and innovation for european science and society
Project number: 730871
Duration month/year-month/year: 05/2017 – 04/2021
Total funding (EUR): 10 000 000
Funding for Organisation (EUR): 90 000
Responsible person and role: Mgr. E. Seiler, PhD., W

Project title: The atomic-layer 3D plotter
Project number: 950785
Duration month/year-month/year: 05/2020 – 05/2022
Total funding (EUR): 2 980 675
Funding for Organisation (EUR): 351 250
Responsible person and role: Ing. K. Fröhlich, DrSc., I

Project title: Superconducting magnets for the European Magnet Field Laboratory
Project number: 951714
Duration month/year-month/year: 01/2021 – 12/2024
Total funding (EUR): 2 904 356
Funding for Organisation (EUR): 548 750
Responsible person and role: Mgr. E. Pardo, PhD., I

Project title: Innovation Fostering in Accelerator Science and Technology
Project number: 101004730
Duration month/year-month/year: 05/2021 – 05/2025
Total funding (EUR): 10 000 000
Funding for Organisation (EUR): 60 000
Responsible person and role: Mgr. E. Seiler, PhD., I

Other

Type of project: International Visegrad Fund
Project title: Highly Safe GaN Metal-Oxide-Semiconductor Transistor Switch - SAFEMOST
Project number: Collab./NMP3-LA-2012-280432
Duration month/year-month/year: 10/2015 – 10/2018
Total funding (EUR):
Funding for Organisation (EUR): 75 000
Responsible person and role: Ing. J. Kuzmik, DrSc., C

Type of project: EUREKA
Project title: Filamentized high temperature superconductor tapes for fusion
Project number: Eurostars 2 - E115264
Duration month/year-month/year: 10/2021 – 05/2024
Total funding (EUR):
Funding for Organisation (EUR): 32 241
Responsible person and role: doc. Ing. F. Gömöry, DrSc., W

COST

Project title: Nanoscale Superconductivity
Project number: 4141/12
Duration month/year-month/year: 10/2012 – 10/2016
Responsible person and role: RNDr. V. Cambel, DrSc., MC Member

Project title: Advanced X-ray spatial and temporal metrology
Project number: MP 1203
Duration month/year-month/year: 11/2012 – 11/2016
Responsible person and role: Ing. D. Korytár, CSc., MC Member

Project title: Exchange on Ionic Liquids - EXIL
Project number: CM 1206
Duration month/year-month/year: 05/2013 – 05/2017
Responsible person and role: Ing. P. Lobotka, CSc., MC Member

Project title: Enhanced x-ray tomographic reconstruction: experiment, modeling, and algorithms
Project number: MP 1207
Duration month/year-month/year: 05/2013 – 05/2017
Responsible person and role: Ing. Z. Zápražný, PhD., MC Member

Project title: Hooking together European research in atomic layer deposition - HERALD
Project number: MP 1402
Duration month/year-month/year: 12/2014 - 12/2018
Responsible person and role: Ing. K. Fröhlich, DrSc., MC Member

Project title: Towards Oxide-Based Electronics
Project number: MP 1308
Duration month/year-month/year: 02/2016 – 04/2018
Responsible person and role: Ing. Š. Chromik, DrSc., MC Member

Project title: Ultrafast opto-magneto-electronics for non-dissipative information technology
Project number: CA17123
Duration month/year-month/year: 10/2018 – 10/2022
Responsible person and role: Dr. M. Mruczkiewicz, MC Member

Project title: High-tehigh-temperature superconductivity for accelerating the energy transitionmperature superconductivity for accelerating the energy transition
Project number: CA 19108

Duration month/year-month/year: 01/2021 – 12/2024
Responsible person and role: Mgr. E. Pardo, PhD., MC Member

Project title: European Network for Innovative and Advanced Epitaxy
Project number: CA 20116
Duration month/year-month/year: 11/2021 – 11/2025
Responsible person and role: Ing. J. Kuzmik, DrSc., MC Member

- **National projects, incl. international projects with only national funding**

2.4.2. List of ERA-NET projects funded from SAS budget

Type of project: ERA-NET RUS
Project title: Terahertz spintronics and magnonics of ferro- and antiferromagnets
Project number: 177550
Duration month/year-month/year: 07/2018 – 07/2021
Total funding (EUR):
Funding for Organisation (EUR): 64 583
Responsible person and role: Dr. M. Mruczkiewicz, I

Type of project: FLAG-ERA
Project title: Epitaxial transition metal dichalcogenides onto wide bandgap hexagonal superconductors for advanced electronics
Project number: III/2019/884/ETMOS
Duration month/year-month/year: 04/2020 – 04/2023
Total funding (EUR):
Funding for Organisation (EUR): 75 000
Responsible person and role: Ing. S. Chromik, DrSc., I

2.4.3. List of projects of the Slovak Research and Development Agency, APVV

Project title: Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER
Project number: 308793
Duration month/year-month/year: 01/2012 – 12/2016
Total funding (EUR):
Funding for Organisation (EUR): 12 644
Responsible person and role: Ing. P. Kováč, DrSc., C

Project title: Colloidal aspects of nanoscience for innovative processes and materials
Project number: CM1101
Duration month/year-month/year: 01/2012 – 12/2016
Total funding (EUR):
Funding for Organisation (EUR): 70 000
Responsible person and role: Ing. P. Lobotka, DrSc., C

Project title: Photonic structures for integrated optoelectronics
Project number: 0395-12
Duration month/year-month/year: 10/2013 – 12/2016
Total funding (EUR): 73 711
Funding for Organisation (EUR): 50 069
Responsible person and role: doc. Ing. J. Novák, DrSc., I

Project title: Transistors on the base of progressive materials for high temperatures
Project number: 0455-12
Duration month/year-month/year: 10/2013 – 09/2016
Total funding (EUR): 249 761
Funding for Organisation (EUR): 184 761

Responsible person and role: Ing. G. Vanko, PhD., I

Project title: European development of superconducting tapes - EUROTAPES
Project number: NMP3-LA-2012-280432
Duration month/year-month/year: 09/2012 – 02/2017
Total funding (EUR):
Funding for Organisation (EUR): 47 587
Responsible person and role: doc. Ing. F. Gömöry, DrSc., C

Project title: Nanomagnets for future nonvolatile memories and high-frequency applications
Project number: 0088-12
Duration month/year-month/year: 10/2013 – 03/2017
Total funding (EUR): 249 780
Funding for Organisation (EUR): 150 000
Responsible person and role: RNDr. V. Cambel, DrSc., C

Project title: Research and development of silicon carbide thin film technologies for applications in solar cells and thin film devices
Project number: 0443-12
Duration month/year-month/year: 10/2013 – 03/2017
Total funding (EUR): 248 106
Funding for Organisation (EUR): 158 154
Responsible person and role: Ing. J. Huran, CSc., C

Project title: Magnetic field shaping by a combunation of superconducting and ferromagentic materials
Project number: 0623/12
Duration month/year-month/year: 10/2013 – 03/2017
Total funding (EUR):
Funding for Organisation (EUR): 162 300
Responsible person and role: doc. Ing. F. Gömöry, DrSc., C

Project title: Exchange on Ionic Liquids - EXIL
Project number: CM1206
Duration month/year-month/year: 10/2013 – 03/2017
Total funding (EUR):
Funding for Organisation (EUR): 35 000
Responsible person and role: Ing. P. Lobotka, CSc., C

Project title: Broadband MEMS detector of terahertz radiaton
Project number: 14-0613
Duration month/year-month/year: 07/2015 – 06/2018
Total funding (EUR): 239 719
Funding for Organisation (EUR): 159 720
Responsible person and role: Ing. T. Lalinský, DrSc., I

Project title: Resistive switching structures for pattern recognition
Project number: 14-0560
Duration month/year-month/year: 07/2015 – 06/2018
Total funding (EUR): 220 000
Funding for Organisation (EUR): 120 000
Responsible person and role: Ing. K. Fröhlich, DrSc., C

Project title: Investigation of design and manufacturing methods for coils from round high-temperature superconducting conductor
Project number: 14-0438
Duration month/year-month/year: 07/2015 – 06/2018
Total funding (EUR): 249 939

Funding for Organisation (EUR): 179 865
Responsible person and role: Ing. J. Šouc, CSc., C

Project title: Ultra light composite superconductor based on Mg, B, Ti and Al
Project number: 14-0522
Duration month/year-month/year: 07/2015 – 06/2018
Total funding (EUR):
Funding for Organisation (EUR): 207 745
Responsible person and role: Ing. P. Kováč, DrSc., C

Project title: Universal nanorod platform for interdisciplinary applications
Project number: 14_0297
Duration month/year-month/year: 07/2015 – 06/2018
Total funding (EUR): 249 150
Funding for Organisation (EUR): 144 735
Responsible person and role: doc. Ing. J. Novák, DrSc., C

Project title: 2D materials beyond graphene: monolayers, heterostructures and hybrids
Project number: 15-0693
Duration month/year-month/year: 07/2016 – 12/2019
Total funding (EUR): 249 300
Funding for Organisation (EUR): 114 502
Responsible person and role: Dr. rer. nat. M. Hulman, C

Project title: Epitaxial transition metal dichalcogenides onto wide bandgap hexagonal superconductors for advanced electronics
Project number: 15-0243
Duration month/year-month/year: 07/2016 – 12/2019
Total funding (EUR): 220 250
Funding for Organisation (EUR): 170 250
Responsible person and role: Ing. R. Kúdela, CSc., C

Project title: Transistors with InN channel for THz microwaves and logic
Project number: 15-0031
Duration month/year-month/year: 07/2016 – 07/2019
Total funding (EUR): 250 000
Funding for Organisation (EUR): 220 000
Responsible person and role: Ing. J. Kuzmik, DrSc., C

Project title: Advanced materials and smart structures for progressive applications in electrical engineering, electronics and other fields based on micro- and nano-sized ferrite particles
Project number: 15-0257
Duration month/year-month/year: 07/2016 – 06/2020
Total funding (EUR): 250 000
Funding for Organisation (EUR): 30 000
Responsible person and role: Mgr. M. Soloviov, PhD., I

Project title: GaN-based normally-off high power switching transistor for efficient power converters
Project number: DO7RP0021
Duration month/year-month/year: 01/2016 – 12/2016
Total funding (EUR):
Funding for Organisation (EUR): 5 429
Responsible person and role: Ing. J. Kuzmik, DrSc., C

Project title: Silicon oxynitride-based photoluminiscent ceramic materials
Project number: 14-0385
Duration month/year-month/year: 07/2015 – 06/2019
Total funding (EUR): 240 985

Funding for Organisation (EUR): 48 000
Responsible person and role: Ing. K. Fröhlich, DrSc., I

Project title: Research of the nanomachining technology for active surfaces of the new generation of the X-ray optics
Project number: 14-0474
Duration month/year-month/year: 07/2015 – 06/2019
Total funding (EUR):
Funding for Organisation (EUR): 100 000
Responsible person and role: Ing. Z. Zápražný, PhD., I

Project title: GaN Monolithic Integrated Circuits
Project number: 15-0673
Duration month/year-month/year: 07/2016 – 07/2019
Total funding (EUR): 250 000
Funding for Organisation (EUR): 75 000
Responsible person and role: Ing. J. Kuzmik, DrSc., I

Project title: Skyrmions in ferromagnetic nanoobjects
Project number: 16-0068
Duration month/year-month/year: 01/2017 – 12/2020
Total funding (EUR): 250 000
Funding for Organisation (EUR): 130 000
Responsible person and role: RNDr. V. Cambel, DrSc., C

Project title: Magnetic cloaks from superconductor/ferromagnet composites
Project number: 16-0418
Duration month/year-month/year: 07/2017 – 12/2020
Total funding (EUR):
Funding for Organisation (EUR): 249 936
Responsible person and role: doc. Ing. F. Gömöry, DrSc., C

Project title: Modification of YBCO thin film structures using low energy electron beam processing for superconducting electronics
Project number: 16-0315
Duration month/year-month/year: 07/2017 – 12/2020
Total funding (EUR): 249 360
Funding for Organisation (EUR): 150 000
Responsible person and role: Ing. S. Chromik, DrSc., C

Project title: Photonic nanostructures prepared by 3D laser lithography for biosensing
Project number: 16-0129
Duration month/year-month/year: 07/2017 – 12/2020
Total funding (EUR): 245 549
Funding for Organisation (EUR): 78 686
Responsible person and role: doc. Ing. J. Novák, DrSc., I

Project title: Tribological properties of 2D materials and related nanocomposites
Project number: 17-0560
Duration month/year-month/year: 08/2018 – 07/2022
Total funding (EUR): 249 599
Funding for Organisation (EUR): 60 002
Responsible person and role: Dr. rer. nat. M. Hulman, I

Project title: Real-time grow studies of hybrid van der Waals heterostructures
Project number: 17-0352
Duration month/year-month/year: 08/2018 – 07/2022
Total funding (EUR):

Funding for Organisation (EUR): 24 566
Responsible person and role: Dr. rer. nat. M. Hulman, I

Project title: Superconducting coils made of uniform MgB_2 wires with tubular filaments
Project number: 18-0271
Duration month/year-month/year: 07/2019 – 11/2021
Total funding (EUR):
Funding for Organisation (EUR): 223 676
Responsible person and role: Ing. P. Kováč, DrSc., C

Project title: Vertical GaN MOSFET for power switching applications
Project number: 18-0054
Duration month/year-month/year: 07/2019 – 07/2022
Total funding (EUR): 249 999
Funding for Organisation (EUR): 175 999
Responsible person and role: Ing. J. Kuzmik, DrSc., C

Project title: Research of radiation resistant semiconductor detector for nuclear energies
Project number: 18-0243
Duration month/year-month/year: 07/2019 – 12/2022
Total funding (EUR): 249 516
Funding for Organisation (EUR): 150 438
Responsible person and role: Mgr. B. Zaťko, PhD., C

Project title: Radiation harder sensor for X-ray imaging of higher quality
Project number: 18-0273
Duration month/year-month/year: 07/2019 – 06/2023
Total funding (EUR): 249 851
Funding for Organisation (EUR): 100 571
Responsible person and role: Mgr. B. Zaťko, PhD., I

Project title: Fabrication, physics and correlated states in metallic 2D transition metal dichalcogenides
Project number: 19-0365
Duration month/year-month/year: 07/2020 – 07/2023
Total funding (EUR): 249 036
Funding for Organisation (EUR): 125 130
Responsible person and role: Dr. rer. nat. M. Hulman., C

Project title: Robust spin waves for future magnonic applications
Project number: 19-0311
Duration month/year-month/year: 07/2020 – 07/2023
Total funding (EUR): 196 000
Funding for Organisation (EUR): 133 998
Responsible person and role: Dr. M. Mruczkiewicz, C

Project title: High temperature superconducting coils in motors for electric and hybrid aircrafts
Project number: 19-0536
Duration month/year-month/year: 07/2020 – 07/2023
Total funding (EUR):
Funding for Organisation (EUR): 249 837
Responsible person and role: Mgr. E. Pardo, PhD., C

Project title: Advanced Microcantilevers from Wide Bandgap Materials
Project number: DS-FR-19-0051
Duration month/year-month/year: 03/2020 – 12/2021
Total funding (EUR):
Funding for Organisation (EUR): 10 000

Responsible person and role: Ing. G. Vanko, PhD., C

Project title: Long-range proximity effect in superconductor / ferromagnet heterostructures
Project number: 19-0303
Duration month/year-month/year: 07/2020 – 12/2023
Total funding (EUR): 200 000
Funding for Organisation (EUR): 80 000
Responsible person and role: Ing. S. Chromik, DrSc., I

Project title: Modern electronic devices based on ultrawide bandgap semiconducting Ga2O3 for future high-voltage applications
Project number: 20-0220
Duration month/year-month/year: 07/2021 – 07/2025
Total funding (EUR): 249 954
Funding for Organisation (EUR): 129 975
Responsible person and role: Ing. F. Gucmann, PhD., C

Project title: Topologically nontrivial magnetic and superconducting nanostructures
Project number: 20-0425
Duration month/year-month/year: 07/2021 – 12/2024
Total funding (EUR): 298 000
Funding for Organisation (EUR): 55 200
Responsible person and role: Ing. J. Šoltýs, PhD., I

Project title: Evolution of colour centres in diamond and their properties towards quantum detection
Project number: 20-0398
Duration month/year-month/year: 07/2021 – 12/2024
Total funding (EUR):
Funding for Organisation (EUR):
Responsible person and role: Ing. M. Varga, PhD., I

Project title: Nano-optical probes and sensors integrated on optical fiber
Project number: 20-0264
Duration month/year-month/year: 08/2021 – 12/2024
Total funding (EUR):
Funding for Organisation (EUR): 97 470
Responsible person and role: doc. Ing. J. Novák, DrSc., I

Project title: Optimization of round high-temperature supercnoducting cable for pulse magnetic field
Project number: 20-0056
Duration month/year-month/year: 07/2021 – 07/2025
Total funding (EUR): 249 774
Funding for Organisation (EUR): 100 030
Responsible person and role: doc. Ing. F. Gömöry, DrSc., I

Project title: Photonic Lab-on-a-Chip: investigation and development of plasmonic sensor platform for immediate detection of composites in solutions
Project number: 20-0437
Duration month/year-month/year: 07/2021 – 12/2024
Total funding (EUR):
Funding for Organisation (EUR): 104 119
Responsible person and role: doc. Ing. J. Novák, DrSc., I

2.4.4. List of projects of the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education, VEGA (for funding specify only total sum obtained from all VEGA grants in particular year)

Project title: Insulated gate technologies for high-performance III-As and III-N transistors
Project number: 2/0105/13
Duration month/year-month/year: 01/2013 – 12/2016
Responsible person and role: RNDr. D. Gregušová, DrSc., C

Project title: Advanced AlGaN/GaN HEMT and MISHEMT transistors for high temperature electronics and sensors
Project number: 2/0167/15
Duration month/year-month/year: 01/2013 – 12/2016
Responsible person and role: Ing. J. Osvald, DrSc., C

Project title: Advanced nanostructures for application in optoelectronic devices
Project number: 2/0098/13
Duration month/year-month/year: 01/2013 – 12/2016
Responsible person and role: doc. Ing. J. Novák, DrSc., C

Project title: New technologies of nanoparticles preparation
Project number: 2/0129/15
Duration month/year-month/year: 01/2013 – 12/2016
Responsible person and role: Ing. I. Vávra, CSc., C

Project title: Growth of thin films using Atomic Layer Deposition
Project number: 2/0138/14
Duration month/year-month/year: 01/2014 – 12/2017
Responsible person and role: Ing. K. Fröhlich, DrSc., C

Project title: Theoretical study of conductance and persistent currents in low-dimensional mesoscopic systems: effects of interaction, disorder, and band structure
Project number: 2/0200/14
Duration month/year-month/year: 01/2014 – 12/2016
Responsible person and role: doc. RNDr. M. Moško, DrSc., C

Project title: Thermodynamic properties of the micro-magnetic objects
Project number: 2/0180/14
Duration month/year-month/year: 01/2014 – 12/2016
Responsible person and role: Ing. J. Tóbik, PhD., C

Project title: Perspective thin films and structures for electronic applications
Project number: 2/0120/14
Duration month/year-month/year: 01/2014 – 12/2017
Responsible person and role: Ing. Š. Chromik, DrSc., C

Project title: Micro-electromechanical (MEMS) energy harvesting system for applications in medicine
Project number: 1/0712/14
Duration month/year-month/year: 01/2014 – 12/2016
Responsible person and role: Ing. G. Vanko, PhD., I

Project title: Superconducting coils made of cabled REBCO conductors
Project number: 2/0126/15
Duration month/year-month/year: 01/2015 – 12/2017
Responsible person and role: Ing. M. Vojenčiak, PhD., C

Project title: Advanced nanostructures for application in optoelectronic devices
Project number: 2/0178/15
Duration month/year-month/year: 01/2015 – 12/2017
Responsible person and role: Dr. rer. nat. M. Hulman, C

Project title: High quality active surfaces for new generation of X-ray crystal optics elements
Project number: 2/0004/15
Duration month/year-month/year: 01/2015 – 12/2017
Responsible person and role: Ing. Z. Zápražný, PhD., I

Project title: Cantilever based sensors
Project number: 2/0183/15
Duration month/year-month/year: 01/2015 – 12/2018
Responsible person and role: Ing. J. Šoltýs, PhD., C

Project title: Composite superconductor MgB_2 made by internal Mg diffusion
Project number: 2/0129/16
Duration month/year-month/year: 01/2016 – 12/2018
Responsible person and role: Ing. M. Kulich, PhD., C

Project title: Detection of ionizing particles using sensors base on semi-insulating GaAs and 4H-SiC for high energy physics
Project number: 2/0152/16
Duration month/year-month/year: 01/2016 – 12/2019
Responsible person and role: Mgr. B. Zaťko, PhD., C

Project title: Investigation of advanced materials and structures for photoelectrochemical applications
Project number: 1/0651/16
Duration month/year-month/year: 01/2016 – 12/2019
Responsible person and role: Ing. J. Huran, CSc., I

Project title: Surface processing of semiconductors as the way towards new III-As and III-N electronic devices
Project number: 2/0109/17
Duration month/year-month/year: 01/2017 – 12/2020
Responsible person and role: RNDr. D. Gregušová, DrSc., C

Project title: Advanced nanostructures prepared by sophisticated MOVPE technology
Project number: 2/0104/17
Duration month/year-month/year: 01/2017 – 12/2020
Responsible person and role: doc. Ing. J. Novák, DrSc., C

Project title: Physical problems of MISFET and MISHFET structures based on III-V and III-N semiconductors
Project number: 2/0112/17
Duration month/year-month/year: 01/2017 – 12/2020
Responsible person and role: Ing. J. Osvald, DrSc., C

Project title: 2D materials and ionic liquids in microelectronics and sensors
Project number: 2/0149/17
Duration month/year-month/year: 01/2017 – 12/2020
Responsible person and role: Mgr. M. Sojková, PhD., C

Project title: High temperature characterization, integration and reliability of MEMS pressure sensors based on AlGaN/GaN
Project number: 2/0150/17
Duration month/year-month/year: 01/2017 – 12/2019
Responsible person and role: Ing. G. Vanko, PhD., C

Project title: Design and preparation of high-temperature superconducting tapes joints using lead-free solders and characterization of their properties
Project number: 2/0151/17

Duration month/year-month/year: 01/2017 – 12/2020
Responsible person and role: doc. Ing. F. Gömöry, DrSc., I

Project title: Edge states and Landau levels in electronic artificial graphene
Project number: 2/0162/18
Duration month/year-month/year: 01/2018 – 12/2020
Responsible person and role: Mgr. J. Feilhauer, PhD., C

Project title: Thin film structures for energy applications
Project number: 2/0136/18
Duration month/year-month/year: 01/2018 – 12/2021
Responsible person and role: Ing. K. Fröhlich, DrSc., C

Project title: Advanced III-N devices for energy and information transfer
Project number: 2/0012/18
Duration month/year-month/year: 01/2018 – 12/2021
Responsible person and role: Ing. J. Kuzmík, DrSc., C

Project title: Magnetic interaction of superconducting and ferromagnetic layers: modelling, characterization and applications
Project number: 2/0097/18
Duration month/year-month/year: 01/2018 – 12/2020
Responsible person and role: Mgr. E. Seiler, PhD., C

Project title: Perovskite thin films and structures for modern electronics and sensorics
Project number: 2/0117/18
Duration month/year-month/year: 01/2018 – 12/2021
Responsible person and role: RNDr. M. Španková, PhD., C

Project title: Application of the metadynamics algorithm to micromagnetism
Project number: 2/0150/18
Duration month/year-month/year: 01/2018 – 12/2021
Responsible person and role: Ing. J. Tóbik, PhD., C

Project title: Advanced monochromators with added functionality of the beam conditioning for X-ray metrology and X-ray imaging
Project number: 2/0092/18
Duration month/year-month/year: 01/2018 – 12/2020
Responsible person and role: Ing. Z. Zápražný, PhD., I

Project title: Study of magnetic effects at nanoscale
Project number: 2/0160/19
Duration month/year-month/year: 01/2019 – 12/2021
Responsible person and role: Ing. J. Šoltýs, PhD., C

Project title: GaN-based heterostructure as a promising UV sensor for space application
Project number: 2/0114/19
Duration month/year-month/year: 01/2019 – 12/2022
Responsible person and role: Ing. J. Stoklas, PhD., C

Project title: Growth and characterization of a material from the group of transition metal dichalcogenides: titanium diselenide
Project number: 2/0131/19
Duration month/year-month/year: 01/2019 – 12/2022
Responsible person and role: Ing. M. Precner, PhD., C

Project title: Advanced MgB2 superconductor without diffusion barrier
Project number: 2/0140/19

Duration month/year-month/year: 01/2020 – 12/2021
Responsible person and role: Ing. P. Kováč, DrSc., C

Project title: Radiation resistant semiconductor sensors for utilization in harsh environment
Project number: 2/0084/20
Duration month/year-month/year: 01/2020 – 12/2023
Responsible person and role: Mgr. B. Zaťko, PhD., C

Project title: Contact engineering for advanced materials and devices
Project number: 2/0068/21
Duration month/year-month/year: 01/2021 – 12/2024
Responsible person and role: RNDr. D. Gregušová, DrSc., C

Project title: Transport of magnetic skyrmions in antidot lattices: Effect of temperature and combination of transport mechanisms
Project number: 2/0177/21
Duration month/year-month/year: 01/2021 – 12/2023
Responsible person and role: Mgr. J. Feilhauer, PhD., C

Project title: Low-loss superconducting CORC-like cable from REBCO conductors
Project number: 2/0036/21
Duration month/year-month/year: 01/2021 – 12/2023
Responsible person and role: Mgr. E. Seiler, PhD., C

Project title: Fabrication, characterization, and doping of ultra-thin layers of transition metal dichalcogenides
Project number: 2/0059/21
Duration month/year-month/year: 01/2021 – 12/2024
Responsible person and role: Mgr. M. Sojková, PhD., C

Project title: Electronic and optoelectronic devices based on ultra-wide bandgap Ga2O3 semiconductor
Project number: 2/0100/21
Duration month/year-month/year: 01/2021 – 12/2024
Responsible person and role: Ing. M. Ťapajna, PhD., C

Project title: High-performance curved X-ray optics prepared by advanced nanomachining technology
Project number: 2/0041/21
Duration month/year-month/year: 01/2021 – 12/2023
Responsible person and role: Ing. Z. Zápražný, PhD., C

Project title: Thermal stabilization of high-temperature superconducting tapes for fault current limiters
Project number: 2/0205/21
Duration month/year-month/year: 01/2021 – 12/2023
Responsible person and role: doc. Ing. F. Gömöry, DrSc., I

Year	Funding
2016	132 398
2017	137 906
2018	141 658
2019	138 205
2020	141 422
2021	142 014

2.4.5. List of projects supported by EU Structural Funds

Project title: Building a centre for advanced material application SAS
Project number: 313021T081
Duration month/year-month/year: 07/2019 – 07/2023
Total funding (EUR): 29 444 664
Funding for Organisation (EUR): 172 845
Responsible person and role: Ing. M. Ťapajna, PhD., I

2.4.6. List of other projects funded from national resources

Type of project: SASPRO
Project title: Design and Fabrication of Diamond-on-GaN Hybrid Structures for MEMS
Project number: 0068/01/01
Duration month/year-month/year: 06/2015 – 05/2018
Total funding (EUR):
Funding for Organisation (EUR): 171 473
Responsible person and role: Mgr. M. Babchenko, PhD., C

Type of project: SASPRO
Project title: Waves in exotic spin textures
Project number: 1244/02/01
Duration month/year-month/year: 01/2016 – 12/2018
Total funding (EUR):
Funding for Organisation (EUR): 151 552
Responsible person and role: Dr. M. Mruczkiewicz, C

Type of project: SASPRO
Project title: Pinning in commercial coated conductors
Project number: 1633/03/01-b
Duration month/year-month/year: 01/2016 – 12/2018
Total funding (EUR):
Funding for Organisation (EUR): 204 581
Responsible person and role: Mgr. E. Seiler, PhD., C

Type of project: SASPRO
Project title: Thermo-electrical stability of superconductors in unconventional cooling conditions
Project number: 0061/01/01
Duration month/year-month/year: 01/2016 – 12/2018
Total funding (EUR):
Funding for Organisation (EUR): 184 950
Responsible person and role: Ing. M. Vojenčiak, PhD., C

Type of project: Bilateral
Project title: Development of new designed transparent conductive electrodes for organic electronics - TRANSCOE
Project number:
Duration month/year-month/year: 02/2017 – 01/2020
Total funding (EUR):
Funding for Organisation (EUR): 70 833
Responsible person and role: Ing. K. Fröhlich, DrSc., C

Type of project: SAS-MOST JRP
Project title: An individual stimulating system with 3D nano-structure carbon/graphene based transducer and wireless heater for automated tiny insects behavior monitoring
Project number: JRP 2017/1
Duration month/year-month/year: 01/2018 – 12/2020
Total funding (EUR):
Funding for Organisation (EUR):

Responsible person and role: Ing. G. Vanko, PhD., C

Type of project: SAS-ERC /2018/576 PHOTONOMETA
Project title: Topological spin waves
Project number: ERC /2018/576
Duration month/year-month/year: 03/2019 – 05/2019
Total funding (EUR): 12 000
Funding for Organisation (EUR): 12 000
Responsible person and role: Dr. M. Mruczkiewicz, C

Type of project: MoRePro
Project title: TMD/diamond heterostructures: Fabrication, characterization and applications
Project number: 19MRP0010
Duration month/year-month/year: 08/2020 – 08/2024
Total funding (EUR): 177 612
Funding for Organisation (EUR): 64 399,28
Responsible person and role: Ing. M. Varga, PhD., C

Type of project: SASA-SAS
Project title: Topological transition-metal dichalcogenides: prediction, synthesis and properties
Project number: 21-020
Duration month/year-month/year: 04/2021 – 12/2022
Total funding (EUR):
Funding for Organisation (EUR):
Responsible person and role: Dr. rer. nat. M. Hulman, C

Type of project: SK-AT-20-0020
Project title: The preparation and atomic-scale characterization of ultrathin films of TMD materials
Project number: 20-0020
Duration month/year-month/year: 04/2021 – 12/2022
Total funding (EUR): 5 000
Funding for Organisation (EUR): 5 000
Responsible person and role: Dr. rer. nat. M. Hulman, C

Type of project: SAV-CNR
Project title: Optimization of the scalable growth of transition metal dichalcogenide thin films and novel heterostructures for application in electronics and advanced sensors
Project number: 0061/01/01
Duration month/year-month/year: 01/2021 – 12/2022
Total funding (EUR): 6 000
Funding for Organisation (EUR): 6 000
Responsible person and role: Mgr. M. Sojková, PhD., C

Type of project: SAV-CNR
Project title: PULSEd laser deposition of 2D semiconductors on nitrides for advanced electronics
Project number:
Duration month/year-month/year: 01/2021 – 12/2022
Total funding (EUR): 6 000
Funding for Organisation (EUR): 6 000
Responsible person and role: RNDr. M. Španková, PhD., C

Type of project: DoktoGranty
Project title: Systematic investigation of Ohmic contacts for devices based on rhombohedral gallium oxide (alfa-Ga_2O_3)
Project number: APP0234
Duration month/year-month/year: 01/2021 – 12/2021
Total funding (EUR): 2 000
Funding for Organisation (EUR): 2 000

Responsible person and role: Mgr. F. Egyenes, C

2.4.7. List of projects funded from private funds

2.4.8. List of projects funded from other competitive funds

2.5. PhD studies and educational activities

2.5.1. List of accredited programmes of doctoral studies, period of validity, source of funding

- Electronics and Photonics with Slovak University of Technology, Bratislava 2004 -
- Physical Engineering with Slovak University of Technology, Bratislava 2004 -
- Physics of condensed matter and acoustics with Comenius University, Bratislava 2004 -

2.5.2. Summary table on doctoral studies (number of internal/external PhD students at the end of the year; number of foreign PhD students, number of students who successfully completed their theses during the year, number of PhD students who quit the programme during the year*)*

PhD study	2016			2017			2018			2019			2020			2021		
Number of potential PhD supervisors	33			34			35			35			35			41		
PhD students	number, end of year	defended thesis	students quitted	number, end of year	defended thesis	students quitted	unumber, end of yea	defended thesis	students quitted	number, end of year	defended thesis	students quitted	number, end of year	defended thesis	students quitted	number, end of year	defended thesis	students quitted
Internal total	8	3		16			20	1		19	2		21			18	6	
from which foreign citizens	1			3			5			5			5			5		
External				1			1			1			3			3		
Other supervised by the research employees of the institute																		

2.5.3. PhD carrier path – Information on the next career steps of the PhD graduates who received their degree from the institute

7 continue on the Institute (Blaho, Ščepka, Dadhich, Hutár, Kujovič, Mošať, Ries)

2 researches abroad

Prerna Chauhan - Research Center for Applied Sciences, Academia Sinica, Taiwan

Asef Juybari - Karlsruhe Institute of Technology, Germany

2.5.4. Summary table on educational activities

Teaching	2016	2017	2018	2019	2020	2021
Lectures (hours/year)*	31	13	11	19	4	10
Practicum courses (hours/year)*	7	7	5	46	20	0
Supervised diploma and bachelor thesis (in total)	11	7	4	5	9	7
Members in PhD committees (in total)	10	3	3	8	3	7
Members in DrSc. committees (in total)	1	1	4	2	2	1
Members in university/faculty councils (in total)	2	2	2	2	2	2
Members in habilitation/inauguration committees (in total)	3	1	1	1	0	0

2.5.5. List of published university textbooks

2.5.6. Number of published academic course books

2.5.7. List of joint research laboratories/facilities with universities

2.5.8. Supplementary information and/or comments on doctoral studies and educational activities – focused on what changes have occurred since the last evaluation in 2016

2.6. Societal impact

2.6.1. The most important case studies of the research with direct societal impact, max. 4 for institute with up to 50 average FTE researchers per year, 8 for institutes with 50 – 100 average FTE researchers per year and so on. Structure: Summary of the impact; Underpinning research; References to the research; Details of the impact; Sources to corroborate the impact. One page per one case study

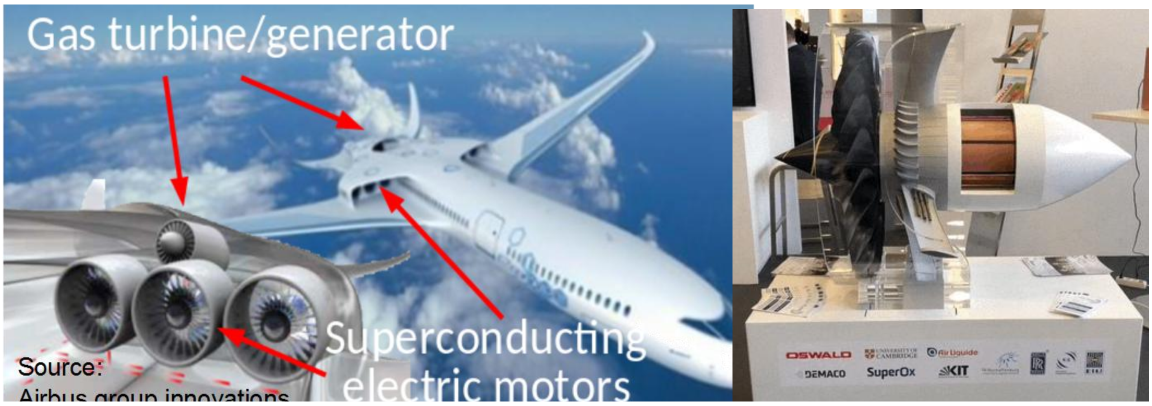
As a reserch institute dedicated to technical sciences, our main societal impact stems from the transfer of the gained knowledge, expertise, or developed technology to industrial partners. Apart from contracted reserch, EU Framework and H2020 programmes are excellent example of such transfer of knowledge, as their aim is to strengthen entire added-value chain for development and exploitation of new technologies. Further, high competitiveness and well-defined objectives of these projects ensure pursuing of excellent reserch focused on relevant societal needs in highly-competent international teams. Last but not least, they provide wide-spread dessimination of the resesrch results. Therefore, in this part, the main focus is given to description of our involvment in implementation of the selected H2020 and FP7 programme projects. Most important collaboration with industrial partners is also described.

As detailed below, most of the projects dealt with utilization of superconducting wires and cables for devices used in rebewable power generation (wind turbines, fussion reactors), efficient power distribution (HVDC, current limiter), and transportation (superconducting motor). All these topics have a potential to tackle the grand challenges connected to CO2 emission lowering. Other projects dealt with accelerator development necessary for medical application (ARRIES, I.FAST). Finally, we were involved also in project developing 3D printer employing atomic layer deposition method (ATOPLOT), allowing e.g. mask-less preparation of electronic devices.

1. **H2020 project ASuMED: Advanced superconducting motor experimental demonstrator**

Funding for IEE: 286 210 EUR (4 776 226.25 EUR whole project).

Air traffic is expected to grow worldwide after the Covid crisis, causing a significant increase in the global emissions. Thus, the ACARE Flightpath 2050 from the EU seeks reductions of CO2 by 75 %, NOx and particulates by 90 %, and noise by 65 %. Distributed electric propulsion can achieve these goals thanks to both higher efficiency and, more importantly, the possibility to drastically improve the overall aircraft aerodynamics. Both batteries and fuel-based turbine generators can provide the electric power. If fuel is used, it could be either conventional petrol-derived kerosene or liquid hydrogen, which could come from renewable sources. The goal of the Horizon 2020 project ASuMED is to construct a 1 MW full superconducting experimental motor, to be tested in laboratory conditions. The consortium contains both industrial and academic partners, being Oswald Elektromotoren GmbH (coordinator), Rolls-Royce PLC, the University of Cambridge, and Karlsruhe Institute of Technology, among others. The project also had Airbus in the Advisory Board. The full superconducting motor of ASuMED uses stacks of high-temperature REBCO tapes in the rotor as strong permanent magnets and REBCO windings as efficient stator. A few important results from our institute are the following. First, we developed a computer software to model the cross-field demagnetization of the superconducting permanent magnets in the rotor (made of REBCO stacks of tapes) for the relevantly high number of tapes (100) and up to 2 million cycles. Such high number of cycles is essential, since typical ripple magnetic fields (or “noise” magnetic fields) of 1000 Hz frequency reach 2 millions of cycles in just 33 minutes of flight. We also developed strategies to reduce the energy loss in the stator below 0.04 % of the total power, being the motor highly efficient. As well, we built an experimental set-up and measured the energy loss of one coil down to 25 K (-249^{o} C) by means of solid nitrogen, achieved by a cryocooler.



The ASuMED Horizon2020 project built an experimental full superconducting electric motor for commercial aviation. Left: a hybrid electric aircraft concept from Airbus. Right: an ASuMED real-scale model for dissemination purposes.

2. H2020 project SuperEMFL – Superconducting magnets for the European Magnet Field Laboratory

Funding for EIU SAV: 188 817.50 EUR (2 904 356.25 EUR whole project).

New materials can provide solutions to important technological problems, such as renewable energy, next-generation data storage, and quantum technologies. Many areas of material research require high magnetic fields to analyze their properties, such as structure and composition. Superconducting magnets can provide the highest stable magnetic fields on earth with low energy consumption. Indeed, the European Magnetic Field Laboratory is nowadays able to provide stable magnetic fields of up to around 37 T but in resistive magnets, which consume up to around 20 MW of power (average power for more than 15 000 houses). The goal of this project is to achieve these or higher magnetic fields with novel superconducting magnets, which consume negligible power at stable operation. This not only saves energy but also enables continuous running of the magnet for long periods, improving the quality and quantity of the high-magnetic-field experiments. The roles of our Institute are to: (a) develop and provide multi-physics numerical modelling (electromagnetic, electro-thermal, and magneto-mechanical) by our in-house software; (b) measurement under high magnetic fields of the critical current of the high-temperature superconducting tape that the magnet will be made of.

3. **H2020 project FASTGRID – Cost effective FCL using advanced superconducting tapes for future HVDC grids**

Funding for ElU SAV: 399 947.50 EUR (8 602 250.54 EUR whole project).
High voltage direct current (HVDC) super-grids are attractive solution for the transmission of bulk power of renewable electricity over long distances. Their protection is still an issue and superconducting fault current limiters (SCFCL) offer attractive perspectives. However, the actual superconducting tapes are not yet properly designed for operation at high voltages (>100 kV): The electric field developed during the current limitation is still too low (approximately 50 V/m for 50 ms) and the limiter requires too long lengths of tape. The European project FASTGRID aimed at improving the properties of the REBCO tapes to enhance significantly (by 2–3 times) the electric field limit and so the economical SCFCL attractiveness. Several approaches were simultaneously investigated.
IEE in collaboration with the Faculty of Materials and Technologies, Slovak University of Technology the shunt solution developed consisted of a ceramic in epoxy matrix coating. Extensive modelling of the fault event was developed and used also in the optimization of the solution that used metal as the shunt layer. Validated at laboratory scale, the metal shunt technology was implemented in long lengths with an industrial process by the project partner THEVA Dunschichttechnik (Ismaning, Germany).

4. **H2020 projects ARIES (Accelerator research and innovation for european science and society) and I.FAST (Innovation Fostering in Accelerator Science and Technology)**

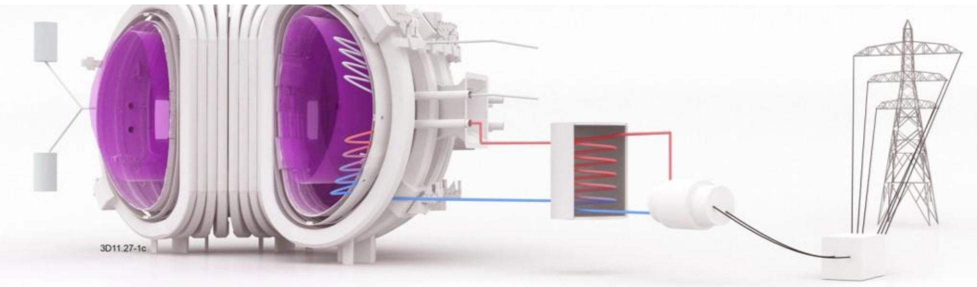
Funding for ElU SAV: 90 000 and 60 000 EUR (10 269 542 and 10 608 500 EUR for the whole projects). The I.FAST project continues most of the activities from ARIES.
Accelerator technologies developed for particle accelerators have many scientific, societal and industrial applications. These include research in other domains (novel chemicals and materials studies with synchrotron and photon sources), energy and environment (cleaning of flue gases of power plants, replacing aging nuclear reactors with accelerator-driven systems), healthcare (treatment of cancer with particle beams, production of radioisotopes and medical imaging devices such as PET scanners), industrial applications (ion implantation, material processing, seed treatment), material identification (non-destructive testing, cargo screening) etc.
Development of compact proton accelerators at about 10 MeV energy will facilitate the production of radioisotopes for the Positron Emission Tomography (PET) next to the scanners in hospitals, with the advantage of increasing availability and decreasing cost by shortening the isotope supply chain, making the use of short-living isotopes possible also for hospitals far from the production centre, and of reducing the impact on the environment of isotope production by avoiding the large transport losses. The development of accelerators for ^{99}Tc aims at reducing the use of nuclear reactors for the production of SPECT isotopes (Single Photon Emission Computed Tomography), lowering its environmental impact and shortening the supply chain, increasing flexibility and reducing dependence from possible shortage. The development of special accelerators for alpha particles will make possible a large-scale production of alpha emitters for modern brachytherapy techniques that are considered as the next frontier of nuclear medicine.
The improvement of accelerators used to produce photons or neutrons as probes to study molecules and materials will greatly impact the fields of science making use of these facilities such as life sciences, condensed matter, energy research, engineering materials and geosciences, environmental science, material science, cultural heritage. Moreover, these improvements will be beneficial for the industrial domains using such machines, notably the pharmaceutical industry.
A common requirement for medical and industrial applications is to reduce the volume and weight of accelerators, together with their cost. High field, and therefore more compact, cyclotron accelerators and gantries would be a real breakthrough making hadron therapy centres for cancer treatment smaller, cheaper and hence more accessible to city hospitals or less wealthy countries.
One of the key elements on the way towards more effective, compact and cheaper accelerators is the improved performance of the superconducting radio frequency accelerating cavities (SRF). Conventional technology based on bulk Niobium is very close to its theoretical peak performance. IEE has been contributing to the activities aimed at development of innovative SRF cavities, based on superconducting thin film coatings deposited on a copper substrate-cavity. Different materials

and deposition technologies were explored for the superconducting coatings, in a single layer as well as in multilayer configurations. The development now continues with participation of industrial partners and is focused on construction of prototype SRF cavities with superconducting thin film coating on the inner walls.

5. **H2020 project EUROfusion – Implementation of activities described in the Roadmap to Fusion during Horizon2020 through a Joint programme of the members of the EUROfusion consortium**

Funding from EU for our institute 40 000 EUR.

The DEMO reactor is expected to be the first application of fusion for electricity generation in the near future. To this aim, conceptual design activities are progressing in Europe (EU) under the lead of the EUROfusion Consortium in order to drive on the development of the major tokamak systems. The European DEMO has arrived to the end of the pre-conceptual design phase with the Gate Review in 2020, in which all DEMO subsystems have been reviewed by panels of independent experts. The magnet and conductor design studies are accompanied by the experimental tests on both LTS and HTS prototype samples, covering a broad range of DC and AC tests.
IEE SAS participated in the HTS-related R&D activities dealing with consolidating the knowledge of the conductor inventory undergoing fast improvement in the current carrying capability and the resistivity against mechanical and thermal cycling. First models of cabled conductors were manufactured and tested. With our participation in these activities the expertise in the field of thermonuclear fusion is built in Europe and in particular in Slovakia.



The EUROfusion project aims to develop green ultra-high-power electric power generation plants, which could replace both fossil-fuel-based and nuclear fission power plants.

6. **H2020 project AtoPlot – The atomic-layer 3D plotter**

The project ATOPLOT was funded by Fast Track to Innovation program of the Horizon 2020. The program supports actions undertaking innovation from the demonstration stage to market uptake. The ATOPLOT project aims to bring to market a disruptive technology that enable ultra-precise hybrid (additive and subtractive) processing for rapid prototyping of micro- and nano-devices. The project offers opportunity to participate in development of unique devices and processes in close cooperation with companies.
The overall objective of the ATOPLOT project was to bridge the current stage of development of the innovative atomic layer deposition (ALD) technology and the unique ATLANT3D Nanofabricator system, bringing to market a fast and cost-effective micro-/nanofabrication process relevant to several industries, e.g. micro-electro-mechanical systems (MEMS) & sensors, photonics, optics and radio-frequency devices. The unique system allows for precise selective area and material deposition and removal on a variety of substrates, including polymers. It delivers conformal coatings, 2D patterns and 3D structures at the micro- and nanoscale. Features obtained are all customizable and can be adapted to several industrial and research applications.
The ATLANT3D Nanofabricator technology is a prototyping tool in the form of an all-in-one micro-/nanoscale 3D printing system that replaces several machines and facilities and works faster than conventional methods, thus making it applicable for rapid prototyping. The result is a reduction of equipment investment, maintenance, infrastructure costs per year, and a significant reduction in production risks and failures, as well as negative effects on environment and human health. The innovation also disrupts the design possibilities through an increase of resolution, obtainable

geometries, and number of applicable materials. Furthermore, there are no other 3D printer with the same capabilities as ATLANT3D Nanofabricator. It stands out from competition especially due to improved resolution (down to 100 nm) and flexibility to use new materials, while costing less than the closest competitor. In sum, ATLANT3D Nanofabricator enables rapid prototyping, vastly more experimenting, shorter time to market and lower barriers for companies and researchers already working in this field, as well as those for whom micro-/nanoprototyping is currently not feasible.
In Europe, nanotechnologies (such as micro- and nanofabrication) are classified as one of six key enabling technologies (KETs). KETs include micro- and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics and advanced manufacturing technologies. It is supposed that KET will increase industrial innovation to address societal challenges and will create advanced and sustainable economies. More so, the KETs are responsible for European growth potentials between 10-20% every year. Subsequently, an enormous amount of jobs depends on the continued technological progress of nanotechnologies in Europe. Just as examples, the semi-conductor ecosystem alone is responsible for employing approx. 250,000 people, where 800,000 people work on the integration of components into systems, applications and services across Europe, and more than 2,500,000 are employed in the complete components value chain.
Beyond the purely economic potential, ATOPLOT delivers societal and environmental benefits, as well. ATOPLOT delivers a sustainable micro-/nanofabrication solution that tackles a number of sustainable development goals (SDGs), namely: SDG7: affordable and clean energy; SDG8: decent work and economic growth; SDG9: industry, innovation and infrastructure; SDG12: responsible production and consumption by drastically reducing prototyping costs (up to 92%), delivery time and associated risks; and avoiding waste material in the production process by lowering the amount of raw materials needed and the energy consumption associated with its extraction.
We believe that outputs of ATOPLOT will accelerate innovation and allow novel European companies to access the market. The ATLANT3D Nanofabricator manufacturing relies primarily on EU suppliers, contributing to the generation of new jobs directly at ATOPLOT project partners and indirectly upstream in the entire value-chain.

7. EU FP7 project SUPRAPOWER - Superconducting, reliable, lightweight, and more powerful offshore wind turbine

Funding for ElU SAV: 108 960 EUR (5 152 069.37 EUR whole project).
The project (12/2012 – 5/2017) was conceived to provide an important breakthrough in offshore wind industrial solutions by designing an innovative, lightweight, robust and reliable 10 MW class offshore wind turbine based on an MgB_2 superconducting generator, taking into account all the essential aspects of electric conversion, integration and manufacturability. SUPRAPOWER project overall objectives were:

- To reduce the head mass, size and cost of offshore wind turbines by means of a compact superconducting generator.
- To maximize the power conversion and wind response of the wind turbine by means of dedicated control systems/procedures.
- To facilitate the development of the offshore wind potential and support its drastic increase.

The main role of IEE was in improvements of MgB_2 wire related to the enhancements of the critical current because this drives the coil design and the amount of wire needed to reach the magnetic field in the generator. A further study was also related to the mechanical characteristics (critical bending radius, stress strain behaviour) because these are related to the handling of the wire during the manufacturing process of the coil and also affects the design of the coil and of the generator.

8. Collaboration with GSI Darmstadt

External contract. Funding from our Institute: 80 000 EUR.

GSI Darmstadt (Germany) and external partners are currently developing a new cable for fast-ramped accelerator magnets. This cable, based on helically arranged coated conductor tapes, is

very similar to the CORT/CORC design that has been one of the main research topics under investigation at IEE SAS. On the request of GSI we have performed two studies:
Assessment of the possibility of replacing the current NbTi superconductor, cooled by liquid helium to 4 K, by high-temperature conductors operating at higher temperature, was the object of the first study. Main motivation here is that such conductor modification should reduce significantly the energy consumption of the accelerator. In spite of not finding a feasible solution in this step, the collaboration aimed at tackling the problem is continuing within the EU project I.FAST.
GSI also sponsored the study exploring the possibility of using the CORT/COCR cable in other fields than the particle acceleration. we performed thorough literature survey of HTS cable use in different fields of energy, transport, medicine and physics. Based on the conclusion of this stage it was decided to elaborate further the possibility of using CORT conductor in the Resistive Superconducting Fault Current Limiter. Main advantage of such conductor is its simple adaptability to higher operating currents while keeping uniform the distribution of currents among parallel tapes. As conclusion of this Study the research necessary for developing the concept to the stage of verification in laboratory environment has been formulated.

2.6.2. List of the most important studies and/or other activities commissioned for the decision-making authorities, the government and NGOs, international and foreign institutes (title, name of institution, contract value, purpose (max 20 words))

2.6.3. List of contracts and research projects with industrial and other commercial partners, incl. revenues (study title, name of institution, contract value, country of partner, purpose (max 20 words))

Title: Research Parnership Agreement (Modelling of 40 MVA Superconducting Transformer
Partner: Robinson Research Institute, Victoria Univesity of Wellington (Research Inst., New
Zealand); Fabrum Solutions Ltd. (Comp., New Zealand); SuperPower Inc. (Comp., USA)
Duration: 2016
Revenues (€): 13 759

Title: Merania magnetických vlastností podložiek supravodivých pások
Partner: THEVA Dünnschichttechnik GmbH, Germany
Duration: 2016
Revenues (€): 750

Title: Demagnetization correction of magnetic measurements of high-permeability materials
Partner: FOESTER GmbH, Germany
Duration: 2016-2017
Revenues (€): 17 100

Title: Modelling of the current distribution and AC loss in HTS coil for motors
Partner: OSWALD Elektromotoren GmbH, Germany
Duration: 2016-2017
Revenues (€): 9 850

Title: Custom design, production and testing of cold finger for Femtosecond Electron Diffraction system
Partner: Drexel University, Department of Physics, Philadephia, USA
Duration: 2019
Revenues (€): 7 200

Title: Feasibility study of coating stencil mask
Partner: IMS Nanofabrication GmbH, 2345 Brunn am Gebirge, Austria
Duration: 2019
Revenues (€): 4 000

Title: Reparation two AFM scanners for LT MFM
Partner: University of Salerno, Italy
Duration: 2019
Revenues (€): 2 000

Title: RF cleaning, annealling and sputtering of Ti/Pt-Pd layers on membranes for electron litography
Partner: IMS Nanofabrication GmbH, Austria
Duration: 2019
Revenues (€): 6 390

Title: Producton and delivery of 3x3 sensors of ionizing radiation based on 4H-SiC semiconductor developed for research purpose of the laboratory
Partner: Nuclear Physics Institute CAV, Řez, Czech Republic
Duration: 2019
Revenues (€): 6 000

Title: Measurement of resistivity of highly-resistive SiC samples
Partner: RHP Technology GmbH, Austria
Duration: 2020
Revenues (€): 1 800

Title: Hall sensors for cryogenic temperatures
Partner: European X-Ray Free-Electron Laser Facility (XFEL) GmbH, Germany
Duration: 2020
Revenues (€): 4 700

Title: Performance of high temperature superconducting tapes
Partner: GSI Darmstadt, Germany
Duration: 2020
Revenues (€):50 000

Title: HTS Energy Applications Study
Partner: GSI Darmstadt, Germany
Duration: 2021
Revenues (€):80 000

2.6.4.1 List of intangible fixed assets (internally registered IP (confidential know-how), patent applications, patents granted, trademarks registered) denoting background IPR

2.6.4.2 List of licences sold abroad and in Slovakia, incl. revenues (background IPR identification, name of institution, contract value, country of partner, purpose (max 20 words))

2.6.5. Summary of relevant activities, max. 300 words (describe the pipeline of valorization in terms of Number of disclosure, Number of registered IP internally, number of CCR/LIC contracts and their respective summary values, the support you are receiving in specific points internally at the institute, at SAS, externally – also the limitations and drawbacks.

2.7. Popularisation of Science (outreach activities)

The Institute attaches crucial importance to popularizing scientific results. The main events amongst our popularization activities were the annual Day of Open Doors. The aim of the activity was to make young people interested in the study of electrical engineering and physics. Thanks to our long-term contacts with teachers from colleges and technical schools we welcomed 200 to 300 students each year. In 2020-2021, we could only organize a virtual open day. Several workplaces focused on material science, microelectronics and superconductivity are prepared every year for this event, and almost half of the institute‘s scientists are involved in it. European Researcher’s Night belongs to the most popular public event in which our Institute also participates in the form of hands-on experiments or demos, e.g. how to use an ordinary pencil to prepare the thinnest material in the world – graphene, or to prepare a semiconductor device with micrometer dimensions and test how a transistor works in practice, etc. Since press and telecommunication media can play a major role in forming the public’s opinion about science and scientists we tried to promote our results mainly on Slovak National Television and Broadcast (interviews and articles about research in superconductors and electrotechnics).

2.7.1. List of the most important popularisation activities, max. 20 items

1. Every year Open Day 2016 - 311 visitors,
2017- 316 visitors,
2018 - 260 visitors,
2019 - 200 visitors,
2020/2021 - 21 - virtual

2. Every year European Researchers' Night 2016 – 2021- from 2 to 3 stages

3. Participation on Science Slam - 2019, 2020

Next 17 most important activities

No.	Employer	Title	Type	Date	Description
1.	F. Gömöry, J. Šouc, M. Vojenčiak, M. Soloviov, E. Pardo, M.Kapolka	Mágia supravodičov	National TV 20 min.	Oct. 1, 2016	Video about research in the superconductivity application group (youtube https://www.youtube.com/watch?v=ZQJLvh0T7Lo)
2.	P. Kováč	Superconductors and superconductive wind power turbines	National Broadcast 5 min.	May 31, 2016	Interview about innovative supercoducting wire
3.	F. Gömöry	Nočná pyramída	National Broadcast 1 hour	March 27, 2017	Interview about research on superconductors
4.	T. Ščepka	Veda nás baví	Elementary School	Jan-March 2017	Voluntarily interest group
5.	J. Šoltýs	Cesta k povolaniu	Intetnet EDUCTECH.sk	Sept. 11, 2017	Interview (https://www.eductech.sk/novinky/cesta-k-povolaniu-ucarila-mi-vona-taviaceho-sa-cinu/)
6.	J. Šoltýs	Slovenský vedec - Ján Šoltýs	Internet - CVTI	June 6, 2017	Interview (youtube https://www.youtube.com/watch?v=H0ima4rcYSM)
7.	V. Cambel, M. Ťapajna	Elektrotechnika mení náš svet	National Broadcast	Nov. 11, 2018	Interview

			1 hour		
8.	F. Gömöry	Pán Ervín (89) nám predviedol patentovaný vynález	National TV 3 min.	April 4, 2018	Consultation to inventor
9.	M. Vojenčiak, M. Mošať	Misie na Mars	High School	May 18, 2018	Lecture
10.	J. Brndiarová	Čo je grafén a ako ho vedci našlli pomocou izolepy	Newspaper SME-tech	April 18, 2019	The artical about graphen
11.	F. Gömöry, M. Soloviov	Skús pokus	Middle Schol	Nov 4, 2019	Competition
12.	F. Gömöry	gen.sk	National TV 20 min.	Jan 24, 2016	Video - biography
13.	P. Kováč	Slovenskí vedci vyvinuli najľahší supravodivý kábel na svete	National newspaper Pravda	July 31, 2019	Interview about innovative supercoducting wire
14.	E. Pardo	Vedci SAV vyvinuli najľahší supravodivý kábel	National TV 5 min.	July 31, 2019	Interview about innovative supercoducting wire
15.	M. Ťapajna	GaN technológie pre 5G mobilné siete	Technological festival IXPO	April 28, 2019	
16.	M. Ťapajna	Nové technológie pre 5G siete	Veda v centre (CVTI)	Febr. 27, 2020	youtube https://www.youtube.com/watch?v=2vsEdVYe4I0
17.	M. Ťapajna	Bez 5G by bol prenos dát v blízkej budúcnosti energeticky neudržateľný	Podcast CVTI	May 5, 2021	youtube https://www.youtube.com/watch?v=RSZCaewxRgw

2.7.2. Table of outreach activities according to institute annual reports

Outreach activities	2016	2017	2018	2019	2020	2021	total
Articles in press media/internet popularising results of science, in particular those achieved by the Organization	5	7	5	8	3	0	28
Appearances in telecommunication media popularising results of science, in particular those achieved by the Organization	3	1	2	3	0	3	12
Public popularisation lectures	4	4	6	4	2	0	20

2.8. Background and management. Infrastructure and human resources, incl. support and incentives for young researchers

2.8.1. Summary table of personnel

2.8.1.1. Professional qualification structure (as of 31 December 2021)

	Degree/rank				Research position		
	DrSc./DSc	CSc./PhD.	professor	docent/ assoc. prof.	I.	II.a.	II.b.
Male	9	40		4	9	31	12
Female	2	6		1	2	5	1

I. – director of research with a degree of doctor of science/DrSc.

II.a – Senior researcher

II.b – PhD holder/Postdoc

2.8.1.2. Age and gender structure of researchers (as of 31 December 2021)

Age structure of researchers	< 31		31-35		36-40		41-45		46-50		51-55		56-60		61-65		> 65	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Male	16,0	10,0	10,0	7,2	10,0	10,0	6,0	6,0	3,0	3,0	3,0	3,0	2,0	2,0	9,0	7,5	16,0	8,9
Female	3,0	0,3	2,0	1,8	2,0	2,0	1,0	1,0	0,0	0,0	0,0	2,0	1,0	1,0	4,0	4,0	2,0	1,2

A – number

B – FTE

2.8.2. Postdoctoral fellowships (list of positions with holder name, starting date, duration. Add brief information about each fellow's career path before and after receiving PhD degree, etc.)

2.8.2.1. MoRePro and SASPRO fellowships

SASPRO

Mgr. Babchenko Oleg, PhD. 2015 - 2018
Ing. Vojenčiak Michal, PhD. 2015 - 2018
Dr. Mruczkiewicz Michal 2016 - 2018
Mgr. Seiler Eugen, PhD. 2016 - 2018

MoRePro

Ing. Varga Marian, PhD. 2020 - 2024

2.8.2.2. Stefan Schwarz fellowships

Ing. Jaroslav Dzuba, PhD. 2016
Ing. Michal Blaho, PhD. 2017
Ing. Filip Gucman, PhD. 2019

2.8.2.3. Postdoctoral positions from other resources (specify)

2.8.3. Important research infrastructure introduced during the evaluation period with the information about the sources of funding *(max. 2 pages)*

2.9. Supplementary information and/or comments on all items 2.1 – 2.8 (max. 2 pages in total for the whole section)

3. *Implementation of the recommendations from the previous evaluation period*

Management of the IEE SAS - Global view on the evaluation period

Here we summarize management steps introduced in the evaluation period that reflect the recommendations of the International Panel as well as recommendations of our Advisory Board (AB), created in 2017. All of them are in agreement with the Strategic Plan of the IEE SAS.

The management steps carried out took into account local IEE SAS conditions (generation exchange, investments into new and old infrastructure, special rules during Covid pandemic times, gender issues, etc.) and global challenges (climate changes, artificial intelligence and quantum technologies, chip crisis and introduction of automation Industry 4.0, the development of electromobility, energy saving, etc.).

These serious challenges were reflected by the management steps of the director's team, and partially by the research topics solved at the IEE SAS. The topics are higly relevant: Superconductivity can be used for efficient production, transmission and transformation of energy, but also in wind turbines and aircraft engines. Power GaN components promise energy savings in its conversion (AC/DC, DC/DC) as well as high-frequency fast internet components. GaAs surface radiation detectors are promising in medicine, 2D materials represent a promising successor to silicon, and micromagnetism and spintronics promise a significant reduction in the energy consumption of storage media. Quantum technology is promising for the communication coding in EU and Slovakia.

According to this, we believe the scientific orientation of the Institute is excellent. In the evaluation period we not only improved the scientific results (namely the quality of published papers), but also started new topics – quantum technologies, memristors for neuromorphic computation, and Ga_2O_3 semiconductor films growth and characterization. We have started collaborations with Slovak and EU companies, which promises fast application of our research outputs (GaAs array detectors, SiC detectors, memristors, ALD plotters). We hired more than 10 post-doctoral employees (post-docs) and increased the number of PhD students up to 20. The Institute provides education in thin-film technology, nanotechnology and quantum technology so that it is able to train specialists for the upcoming era. We improve the soft skills of students, train them in structural analysis, technology and in Academic writing.

In the evaluation period, we have started fundamental changes in the personnel structure - a large proportion of the scientists are getting retired. Great news for the Institute is our success in attracting high-quality young scientists, many of them returned to Slovakia after long-term stays aboard. It is important for us they selected the IEE SAS for their future work. Indeed, the new generation have started to play a dominant role at the Institute, as they successfully applied for national and international projects. Comparing the age of principal investigators (PI) of projects implemented at IEE SAS, the average PIs' age was 60 years in 2015, while 7 years later (in 2021), it dropped to 54 years. In 2021, eight new young PI were successful in the project competition including H2020 projects. Therefore, we do not worry about the scientific future of the Institute.

How we see IEE SAS after the evaluation period, after the last 6 years?

The IEE SAS is a assuccesful, open, dynamic, and international research and education Institution.

Successsful – high number of national/international projects, patents, collaborations, high-level papers
Open – open labs for others, open and tolerant for different views, nations, genders
Dynamic – opens new topics, closes not perspective ones, attracts returning reserchers and gives them the space for research work
International – many international projects and scientists including department/group leaders
Research/Education – many PhD students (20), extra education courses, talks, soft skills – academic writing.

We are sure that the success of the IEE SAS achieved in the evaluation period is based on 3 pillars:

- We have seriously *implemented advices of the International Pannel* from the last evaluation
- We *created the Advisory Board* and implemented advises of their members
- The *IEE SAS internal rules* support active, successful and young scientists.

We describe now all the steps introduced by the Institute to implement the advices of the International Pannel in the previous evaluation period. In the following, the International Panel suggestions are given in blue for clarity followed by description of the managment measures in black.

Implementation of the advices of the International panel

Training of PhD Candidates, Careers of Post-Doctoral Fellows and Empowerment of the Next Generation of Researchers

a) *SAS is recommended to ensure high standards of PhD supervision.*

Two main steps were accepted to ensure high standards of PhD supervision:

- The highly respected person, Dr. D. Gregušová, was elected as an Institute garant of PhD studies. She is at the same time the chief of the Scientific Board of the IEE SAS.

- The Scientific Board accepted the rule that only best scientist (based on internal evaluation) can be PhD supervisors –they must regularly publish papers, lead projects, attend international conferences, etc.

b) *SAS is recommended to include to the PhD curricula teaching of general skills, such as laboratory/project management, research integrity/ethics, scientific writing/presenting*

IEE SAS introduced several courses for PhD students and pos-tdocs. Most of them were visited also by students from external research institutes and universities:

Course	**Led by**	**Year**
Diagnostics of materials	Dobročka, Šoltýs, Ťapajna, Rosová	2019, 2021
Statistics, quantum mechanics	Moško	2019, 2021
Technology of devices	Gregušová	2019, 2021
Courses of nanotechnology	Moško, Lobotka	2020, 2021
Academic writing	*L. Bachárová*	*2021*

The course Academic writing was led by excellent internationally-recognized scientist L. Bachárová, the **Editor of the Journal of Electrocardiology. She** deals with the academic writing more than 20 y. (http://electrocardiology.sci.utah.edu/member-highlights/43-interview-bacharova.html).

In 2021, we established the Gender and Ethic Commision at the IEE SAS which solves tasks about research integrity/ethics at the institute. More details about the commission is at our web http://www.elu.sav.sk/en/gender-equality-and-ethic/

c) *The SAS Research Institutes are recommended to enlarge the international networks of SAS.*

IEE SAS have started to search for new PhD students and postdocs via EuroAxcess system from 2019. From that moment, hundreds of students from third countries applied for position at the IEE SAS, best of them were accepted. In our Strategic plan we planed to increase the number of internation students/postdocs to 20% of the research stuff, which has been achieved by now (10 people).

Relationship between SAS and the Slovak Universities

During the evaluation period the IEE SAS improved its relationship with Slovak Universities by:

- Increased the number of common APVV projects
- Practical courses for Commenius University (CU) and Slovak Technical University (STU)
- Started a collaboration with CU and STU in the area of quantum technologies as a partners of Qute, consortium created by the Ministry of Education, Science, Research and Sport.
- The collaboration within consortium Qute led to the application for EU project (in 2022), winthin which the IEE SAS has to develop single-photon detector.

Diversity of Academic Staff

- *It is recommended that measures are taken for increasing the share of female researchers.*

We tried to set a balanced representation of both men and women in the IEE SAS during the period. The aim is not only to empower women, but also to inspire female students to embark on ambitious research careers. The IEE SAS has now following important women representatives:

- Scientific secretary — Dr. Marianna Španková — since 2017
- Chairwoman of the Scientific Board — Dr. Dagmar Gregušová — since 2013
- Garant of PhD studies at IEE SAS — Dr. Dagmar Gregušová — since 2021
- Representative of PhD students — Mgr. Jana Hrdá — since 2021
- Chairwomen of Trades — Dr. Michaela Sojková since 2018

This means that almost each second woman researcher is a representative for certain field at the institute, their positions became more important during the evaluation period.

We also compared the income of men and women at the institute with very positive result. There is no difference between these two groups for the same possitions. Due to our advanced evaluation process the salary differs for people of different activities which is not gender-sensitive.

We have introduced a rule that the evaluation of the scientists is postponed aftre their return from maternity leave by 1 year. Also, extra 200 € bonus is paid to all young scientists (36 y.). This period is prolonged by the period of maternity leave plus one year. These two rules help the adoptation process at the Institute for scientists after their return from maternity leave.

Academic Leadership and Sharing of Good Practice

- *SAS is recommended to organize management training for directors in seminars where their strategic thinking, governance and leadership skills can be improved*

The Presidium SAS organized two workshops on management training for directors in the period, where their strategic thinking, governance, and leadership skills were improved.

- *The Research Institutes are recommended to form stronger ties between each other, beyond the directorial level, between Institutes within a Section and across the Sections.*

The IEE SAS has improved the relations, we mention here 3 most important examples:

- Together with the Institute of Physics and Institute of Polymers we started collaboration on 2D materials (several national APVV projects), which resulted in 20 common papers (also high-ranking yournals).

- Together with the Institute of Materials and Machine Mechanics, we patented common idea of super light superconductor in 2017 (SUPERCONDUCTOR WIRE BASED ON MGB2 CORE WITH AI BASED SHEATH AND METHOD OF ITS PRODUCTION, PP50037-2017). We applied also for EU PCT patent in 2018 (EP 18737410.3), and the patent was granted in May 2022 (EP3625833A1).

- Together with the Institute of Experimental Physics we increased our collaboration in magnetism and condens matter physics, which resulted in several papers published in high-ranking yournals.

Strategy Foresight

- *It is recommended that Institutes engage in a long-term (5-10 years) strategy foresight exercise*

The IEE SAS prepared its Strategy plan, which is updated annualy based on the suggestions of our Advisory Board.

- *It is recommended to appoint an independent International Advisory Committee.*

The IEE SAS established international Advisory Board (AB) in 2017. It has strong position at the Institute, which is well-defined in the Organizational rules document. Members of the AB are high-ranked scientists from west-european countries and US:

Prof. Jaroslav Fabian – University Regensburg, Germany
Prof. Martin Kuball – University of Bristol, UK
Dr. Valentin Novosad – Argonne National Laboratories, Illinois, USA
Prof. Alvar Sanchez – Universitat Autonoma de Barcelona, Spain

AB comments management steps and scientific results presented at the annual end-year seminar. Based on the following discussion between management and Scientific board, we implement the suggestions within upcoming year in order to improve the overall IEE SAS performence. In this way, we can interactively improve our Strategy plan.

The establishment of the Advisory board we consider as one of the most important management steps done in the evaluation period. Most of the other strategy decisions follow the AB advice. It has to be mentioned that part of them is identical to the recommendations of the International panel in 2016. We believe we can conclude that all the AB ***suggestions improved the research quality*** of the institute, namely:

• Mission of the institute is now better defined
• The long term strategy in many of the research areas is now better defined
• We defined what is classed as success in each area of the IEE research
• The level of sharing of good practices across departments is improved
• We improved publication strategy, the mean impact of our papers increased to more than 4 in 2021
• Higher international visibility (int. Projects) was achieved, and more invited talks were presented
• We emphasised (2D materials) and de-emphasized (III-V nanostructures, oxides and perovskite films) selected research areas
• We increase the number of PhD students, pos-tdocs, and improved their education including soft skills
• We intensified the collaboration with universities (more APVV projects), started new collaboration with industry, improved patents (3 EU and 10 Slovak patents) in the evaluation period
• We have built a system of hunting (via EuroAxcess) and accepting new scientists -basic pos-tdoc positions are for two years, and each position can be repeated twice.

Multidisciplinary Research and Collaboration between Research Institutes, and with industry

We have started multidisciplinary research by collaboriation with other institutions such as CEMEA (new institute, battery research), Institute of Physics (2D materials) and Institute of polymers (2D materials). A newly established consorcium QUTE for quantum technology research also connects several SAS institutes and can be accounted as multidisciplinary (work on sensors, low temperature quantum technology, software, mathemathics). The next example is our common work on extra-light superconductors with the Institute of Materials and Machinery Mechanics (papers, EU patent). All these common projects are successful and speeded up our progress in mentioned fields.

We also improved the collaboration with small nanotechnology company *Danubia Nanotech Ltd*., which deals with preparation of graphene, graphene oxide and other 2D materials. In 2022 we published common paper in the journal Advanced Materials (IF 30), published online in 2021.

We have also started several fruitful colaborations with industry during the evaluation period. The most promising is the collaboration with company Bizzcom Ltd. in the field of resistive switching (we applied for common IPCEI and Structural fund projects). We also participated in the preparation of *The Slovak Strategy for microelectronics* document, which was formulated by the private companies and public institutions. The private companies read: *Bizzcom s.r.o.; Continiuum Technologies s.r.o.; Ctrl s.r.o.; K-Mlab (Ilmsens GmbH); Neuromorphic Europe o.z.; Tachyum s.r.o.; ON Semiconductor SK, a.s.; R-DAS, s.r.o.; SEMIKRON s.r.o.; and Powertec s.r.o.*

Redesign of Research Institutes

IEE SAS belongs to larger institutes of SAS with a lot of collaborations with other SAS Institutions. Therefore, our Scientific Board does not support the idea of creating a larger unit with selected SAS Institutes at the moment. However, the idea is regularly discussed inside the Institute, and in case of a positive view on the idea, we are ready to start discussions on merging IEE SAS with other Institutes**.**

Research Institutes' Names

The International panel recommended we change the name of the Institute of Electrical Engineering. However, our Scientific Board together with our Advisory Board believe that the name of our Institute should not be revisited, as it reflects most of the Institute's activities and represent a trademark in the EU.

Publication Practices and Incentives

We have reviewed our contribution on our Journal of Electrical Engineering, which is published by IEE SAS and STU. From 2022, we have stopped the financial support of this journal.

4. ***Research strategy and future development of the institute for the nextfive years*** (Recommended 3 pages, max. 5 pages)

Research strategy of the institute in the national and international contexts, objectives, and methods (including the information on when the strategy was adopted)

As already mentioned, the reserch strategy document defines the main research topics based on the regular evaluation by the international Advisory board (AB) and IEE Scientific board (SB). In the evaluation seminar at 2017, three underporforming reaserch topics were identified by our AB, namly 2D materials, III-V nanostructures, and Oxide and especially perovskite oxide layers. In the following discussion between SB and IEE menagmnet, it has been decided that while 2D material topic will recive special support by strethgtening of the reserch team, other two topics will be de-emphasised in the next period.
Meanwhile, several new reserch topics have started to form. Each of these new topics share a common feature of being led by young reserchers with international experiences, who returned or were re-integrated to IEE after post-docing abroad. Recently, a compact group focusing on **Ga_2O_3 ultra-wide bandgap semiconductors** has been formed with an aim to pursue R&D of Ga2O3 films grown by in-houce MOCVD technology for power electronic devices and UV photodetectore applications (key reserchers: M. Ťapajna and F. Gucmann, both spent almost 3 years as post-docs at Univeristy of Bristol, UK in the group of Prof. Kuball). Other new topic focuses on reserch R&D of **2D/3D heteroctructures** combining diamond and 2D materials. This topic is supported by highly-copetitive MoRePro project funded by SAS with an aim to support mobility and reintegration of high-quality Slovak reserchers working abroad (key reserchers M. Varga, T. Izsak). Next topic aims the **memristor** development for **neuromorphic computing**. This topics originates from our previous collaboration with NCTU (National Chiao Tung University, Hsinchu, Taiwan R.O.C.) and the 6-year-long affiliation of Dr. Boris Hudec. The reserch aim is to develop the memristor cross-bars and its integration with AD/DA converters and is driven by strong industrial partner involment (BIZZCOM, Continium Technologies, 3D Atlant Nanosystems). Finally, our institute is active in quantum computing topic together with other SAS institutions and universities in Slovakia. Althoug several devices based on quantum effects serve to us for several decades (laser, LED diodes, solar cells, computer chips), it is believed that the real potential of the quantum technologies starts only now, and it is based on individual control of quantum states of the systems. For this purpose, **IEE SAS will develope single-photon transistor** within the consortion QUTE (based by MIRRI, Ministry of Investment and Regional Development and Informatization of the Slovak Republic).

In the following, we will describe future plans in the topics defined in the updated reserch strategy documents as well as emergeing topics at IEE listed above:

2D metrials: In the future, we would like to shift our focus more on the physical properties of TMDs materials. They can be divided into different classes depending on their electronic properties. We will prefer those compounds which have a semimetallic electronic structure with octahedral or distorted octahedral (monoclinic) crystallographic lattices. In addition, some of the materials host elusive electronic phases, including Weyl and Dirac electrons or become topological insulators under certain conditions.

Heterostructures of TMDs and other materials, including superconductors or ferromagnets, are another research direction we would like to take. This field is rich in novel phenomena which benefit from effects induced by the proximity of two or more materials. The first steps have already been done with PtSe2 layers deposited on NbN.

Concerning the experimental methods needed for achieving the goals, we will develop spectroscopic techniques, including Raman and optical spectroscopy, in the broad range of frequencies from THz to UV. It is also essential to have access to low temperatures and magnetic fields. Electric transport measurements will also be used as a complementary technique.

Our strategy for the future includes further development of the research team by hiring new collaborators such as undergraduate and PhD students. In addition, financial support is essential, so we will steadily participate in national and international project calls.

Magnetic effects at nanoscale: In the next years we are going to continue the research related to the noncolinear magnetic states. In particular we will investigate the topological properties of spin waves in chiral magnonic crystals. For instance, we will investigate the unidirectional edge states in 2D arrays of magnonic elements. These type of waves are considered for computing application because of their robustness against the defects. Further, the topologcal magnonics creates interesting platform for investigation of fundamental topological effects, due to intrinisc nonreciprocity and nonlinearlity of spin waves.

In spite of several theoretical demonstrations of topological magnonics, the experimental confirmation is still missing. The main obstacles preventing experimental observations are: difficulty of nanofabrication of complex geometry, low coupling between elements, difficulty to control the ground state], low sensitivity of in-plane dynamical field component, high density of modes when scaling up of structures, or high damping in case of DMI-based concepts.

We are going to optimize numerically the magnonic crystal that posses the unidrectional edge states. One of the considered designs is composed of Py squares with side length of 200-300 nm, cut along diagonals and formed in rectangular lattice. The formation of the topological edge state can be realized when each square is in the closed domain state with the same chirality and finite perpendicular component of magnetization. The width of the cuts required to fabricate a magnonic crystal hosting unidirectional edge states is estimated to be approximately 10-30 nm. Helium Ion Microscope has an optimal resolution for etching of such structures. In collaboration with experimental laboratories (Leibniz-Institut für Höchstfrequenztechnik-Berlin, IEE SAS- Bratislava) we will fabricate and prepare a chiral magnetic crystal that can host unidirectional spin waves.

III-N heterostructure electronic devices: In coming period we plan continuation in already developed topics of (i) E/D-mode InAlN/GaN ICs, (ii) vertical power switches, (iii) InN-channel ultra-fast transistors, and initiate a new topic of (iv) p -channel transistors. With recent move of needed internet and communication band-width to W-band and above, replacement of conventional AlGaN/GaN QWs with InAlN/GaN ones becomes inevitable. Therefore we plan continuation in this topic, which in fact originated in SAS. Vertical transistors promise a huge energy savings and deployment in (Slovak) Electric Cars industry. Therefore we intend to develop 600 V-class vertical devices. InN-channel transistors can fill a THz frequency gap; we intend to demonstrate a first InN-based microwave transistor ever. Our recent know-how of growing GaN on GaN substrate can be utilised in post-CMOS ICs, combining electron and hole-type conduction. Homo-epitaxial growth is promising in increasing p-type doping efficiency in GaN.

Ionizing radiation detectors and X-ray optics: Pixel sensors based on semi-insulating GaAs show a great perspective in the field of digital X-ray imaging. However, they still require some optimization in terms of operating voltage and detection efficiency. Our research shows how to perform this optimization and pixel sensors can be fully competitive with the standardly used silicon resp. CdTe sensor. The use of these sensors would be mainly at high X-ray intensities. Its advantage is also a higher radiation resistance and thus many times longer operational life, which will also result in a reduction in the total operating costs. SiC-based sensors are also highly durable and stable. SiC is a broadband semiconductor, which predestines these sensors to work at high temperatures up to several hundred degrees Celsius. We are preparing to test and study these sensors at various temperatures up to 500 degrees. We also plan to use them as pixel sensors for the radiation camera. Here is a very promising area of so-called "particle tracking". It is important that the sensor has a fast response and high radiation resistance, which is met by SiC-based sensors. And especially in combination with the latest reading chip Timepix4, which reaches a time resolution of 200 ps, it opens up use in high energy physics and especially everywhere where it is necessary to monitor traces of ionizing radiation with high energy and time accuracy.

Superconductor power applications: The main topics of research in the next 5 years will be on round cables, motors for aviation, and high magnetic field magnets, all of them with already approved funding. We plan to study compact round cables for large bore magnets, such those for fusion and particle accelerators. We will put particular effort in cables made of filamented REBCO tapes in order to reduce screening currents, which cause dissipation and spurious magnetic fields. We will also work on applying these cables for power cables, which could transmit wind-generated electricity from off-shore stations to land. In this framework, we will also develop MgB_2 cables, in order to join forces with the “Advanced composite superconductors group”. For electric aircraft propulsion motors, we aim to develop fast parallel-computing modelling methods for the electromagnetic, electrothermal and magneto-mechanical properties of full superconducting machines. This will also include the charging process of the rotor windings by a flux pump. In addition, we will also measure the electromagnetic and electro-thermal quench properties of REBCO windings at low temperatures (between 20-40 K). Part of this know-how will also be applied to high magnetic field magnets. For that goal, we will also develop fast 3D multi-physics computer modelling methods.

Advanced composite superconductors: Our future work will be in the direction of in-length uniform MgB_2 wires and cables made by internal magnesium diffusion (IMD) process tested by coil windings made of unreacted wires (wind and react process). Uniform and high engineering current density superconducting MgB_2 wires will be developed by IMD process and tested by wind and react coils of small inner bore diameter ~ 50 mm cooled by solid nitrogen or water. Wind and react technique minimizes the stress in the conductor, but it requires high temperature insulation, which reduces fill factor and consequently also current density of the winding. Therefore, not insulated and/or metal-foil insulating coils will be done and tested. Next generation magnets employing filamentary MgB_2 wires are also interesting to work in persistent mode. Joints between superconducting wires are integral components of persistent mode magnets in which the persistent current switch isolates the magnet from the power supply used for the first charging. Therefore, development of reliable persistent mode jointing techniques will be important and remains an active field of research. The production of ‘persistent current joints’ requires a truly superconducting current path between the parent conductors, but its value has not be close to the critical current of used wire because the joins are placed in low magnetic field. MgB_2 superconducting wires are actually produced mostly by the powder-in-tube. The internal magnesium diffusion (IMD) techniques is determining the different conditions for joining process. Making and testing of superconducting joints between MgB_2 superconductors of variable configuration will be our important future activity allowing the persistent mode for MgB_2 coil operation.

Ga_2O_3 semiconductors: Recently, a great research effort has been devoted to ultra-wide bandgap semiconductors (AlN, Ga2O3, diamond) for the preparation of high-performance electronic components operating in the electric fields up to tens of kV. This newly established topic aims the research of epitaxial films growth and processing of electronic as well as optoelectronic devices based on Ga2O3. We developed epitaxial growth of different Ga_2O_3 polymorphs (α, β, ε) using in-house liquid-injection MOCVD system on sapphire substrates [Egyenes et al., Semicond. Sci Technol. 35 (2020) 115002]. Recently, we have succeeded to grow β- and ε-phase Ga_2O_3 epitaxial films in SiC substrates. Since Ga_2O_3 suffers from relatively low thermal conductivity, the main motivation is to improve the heat spreading by employing high-thermal conductivity substrate for future power devices. Our future goals are R&D of Ga_2O_3 power transistors grown on SiC as well as diamond templates. Further, we will aim epitaxial growth of heterostructures with $(Al_xGa_{1-x})_2O_3$ and $(In_xGa_{1-x})_2O_3$ barriers in order to prepare and study modulation-doped heterostructure transistors. We have also started activities toward processing of fully metal-oxide PIN junctions for photodetectors using NiO and Cu2O p-type films, as Ga_2O_3 p-type conductivity is hardly achievable. Here, Ga_2O_3 intrinsic films grown on n-type Ga2O3 substrates is targeted to process e.g. solar-blind or single-photon detectors.

2D/3D heterostructures: The authors greatly improved the manuscript. First, they used appropriate formula for the threshold voltage calculation, which is then used in other analytical formulae. Second, more physically sound statements are used in the DCT data interpretation, where they refer to changes in the sheet density due to changes in trap occupation rather than density of bulk traps. I am still concerned that the observed signature of traps in InAlN/GaN HEMTs on C-doped buffer may be related to surface or barrier traps, keeping in mind huge difference in capture cross-section between InAlN/GaN:C and AlN/GaN:C devices and well-known lower crystal quality of InAlN as compared to AlN barrier layer.

Memristors for neuromorphic computing: Memristor device research has been taking place at the Institute for the past decade, and the plans for the next 5 years are aligned to leverage that experience with the experience on building memristor-based neuromorphic computing systems that Dr. Boris Hudec gained during his stay at the NCTU (now NYCU) Taiwan, in group of prof. Tuo-Hung Hou. This research interest is driven also by an involvement of a strong industrial partner Bizzcom s.r.o., a local robotics company. IEE and Bizzcom have applied for funding from local funding agencies, and plan to develop a programmable hardware neural network (HNN) based on memristor cross-bar array, paired with a ADC/DAC interface platform, developed by Continium Technologies, a German/Slovak start-up company. The approach taken at IEE for memristor dielectric oxides (TiO_2, HfO_2) fabrication is atomic layer deposition (ALD), which offers unmatched film growth control, uniformity, and reproducibility. Based on the results achieved, the intended applications will include hardware security (physically unclonable function, smart hardware key) and/or pattern recognition (edge-AI). A new research approach being explored is to fabricate these HNN with hardware-embedded synaptic weights in terms of physical oxide thickness instead of memristor's state, using a unique technology of selective-area direct-write ALD (ALD 3D printer) with another IEE's industrial partner Atlant 3D Nanosystems from Denmark. The technology is patented (where IEE is a coassignee) and its development was supported by a recently finished H2020 Fast Track to Innovation project Atoplot (IEE was a partner). A project proposal leveraging the neuromorphic memristor HNN expertise with the use of this novel technology was just submitted for m-era.net 2022 Joint call where IEE, Atlant 3D Nanosystems and prof. Hou's group from NYCU are partners.

Quantum computing: Based on the experimental progress of manipulation and control of individual quantum states in quantum systems it is supposed that quantum effects and technologies will start so called second quantum revolution soon. Progress in quantum technologies, namely in quantum interference and non-local effects promise progress in medicine (diagnostics), in material science and green energy, in metrology ans navigation, artifitial intelligence, save communication on internet and other. EU scientific community reflected the quantum revolution and prepared strategic document ***Quantum Manifesto.*** In the document it is stressed that quantum technologies are the key-factor for the innovative industry and safety in EU. That is why the EU commission initiated also the call ***Quantun Technology Flagship*** to keep EU in the first rank of the world technology. Together with EU initiatives, universities and SAS institutes in Slovakia wish to be active in this topic, to participate in simulation of quantum systems, optimization of quantum measurements and preparation of quantum protocols. **IEE is ready to educate new generation of scientists and engineers in quantum technologies, to design and develop novel quantum devices including single-photon detector for cryptography communication and to participate on their testing in laboratory conditions.** All these activities will be coordinated by QUTE, i.e by the institution directly controlled by the Slovak government.

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