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

Period: January 1, 2012 - December 31, 2015

1. Basic information on the institute:

1.1. Legal name and address

Institute of Electrical Engineering SAS
Dúbravská cesta 9
841 04 Bratislava

Detached branche
Department of Microelectronics and Sensors
Vrbovská cesta 110
921 01 Piešťany

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

1.3. Executive body of the institute and its composition

Directoriat	Name	Age	Years in the position
Director	RNDr. Vladimír Cambel, DrSc.	59	3
Deputy director	doc. Ing. Fedor Gömöry, DrSc.	63	3
Scientific secretary	Ing. Milan Ťapajna, PhD.	38	3

Deputy director for infrasctructure Ing. Ján Fedor, PhD. 39 6

Until Sept. 2013
Director: Ing. Karol Fröhlich, DrSc.
Deputy director: RNDr. Vladimír Cambel, DrSc.
Scientific secretary: Mgr. Bohumír Zaťko, PhD.

1.4. Head of the Scientific Board

Ing. Ján Kuzmík, DrSc. 2011 - 2014
RNDr. Dagmar Gregušová, DrSc. 2014 -

1.5. Basic information on the research personnel

1.5.1. Number of employees with university degrees (PhD students included) engaged in research projects, their full time equivalent work capacity (FTE) in 2012, 2013, 2014, 2015, and average number of employees in the assessment period

	2012		2013		2014		2015		total		
	number	FTE	number	FTE	number	FTE	number	FTE	number	averaged number per year	averaged FTE
Number of employees with university degrees	59,0	48,620	56,0	51,020	59,0	52,710	60,0	49,820	**234,0**	**58,5**	**50,543**
Number of PhD students	17,0	14,920	17,0	12,560	18,0	13,670	16,0	11,820	**68,0**	**17,0**	**13,243**
Total number	76,0	63,540	73,0	63,580	77,0	66,380	76,0	61,640	**302,0**	**75,5**	**63,785**

1.5.2. Institute units/departments and their FTE employees with university degrees engaged in research and development

Research staff	2012		2013		2014		2015		average	
	No.	FTE	No.	FTE	No.	FTE	No.	FTE	No.	FTE
Institute in whole	59,0	48,620	56,0	51,020	59,0	52,710	60,0	49,820	**58,5**	**50,543**
Physics at Nanoscale	8,0	6,930	6,0	5,800	8,0	6,880	0,0	0,000	**7,3**	**6,537**
Superconductor Physics	12,0	9,970	14,0	12,250	14,0	12,900	0,0	0,0	**10,0**	**8,780**
Microelectronic Structures	6,0	4,750	5,0	4,670	5,0	4,650	0,0	0,000	**5,3**	**4,690**
Semiconductor Technology and Diagnostic	5,0	4,750	6,0	5,420	6,0	5,750	0,0	0,000	**5,7**	**5,307**
Optoelectronics	9,0	8,600	9,0	8,600	9,0	8,250	0,0	0,000	**9,0**	**8,483**
Superlattices	4,0	4,000	4,0	4,000	4,0	3,830	0,0	0,000	**4,0**	**3,943**
Cryoelectronics	6,0	3,520	6,0	5,070	6,0	4,860	0,0	0,000	**6,0**	**4,483**
Thin Oxide Films	9,0	6,100	0,0	0,0	0,0	0,0	0,0	0,000	**9,0**	**6,100**
Materials and Electronic Devices	0,0	0,0	6,0	5,210	7,0	5,590	0,0	0,000	**6,5**	**3,600**
Physics and Technolgy at Nanoscale	0,0	0,0	0,0	0,0	0,0	0,0	10,0	8,000	**10,0**	**8,000**
III-V Semiconductors	0,0	0,0	0,0	0,0	0,0	0,0	12,0	10,290	**12,0**	**10,290**
Superconductors	0,0	0,0	0,0	0,0	0,0	0,0	15,0	12,950	**15,0**	**12,950**
Microelectronics and Sensors	0,0	0,0	0,0	0,0	0,0	0,0	23,0	18,580	**23,0**	**18,580**

1.6. Basic information on the funding of the institute

Institutional salary budget and others salary budget

Salary budget	2012	2013	2014	2015	average
Institutional Salary budget *[thousands of EUR]*	914,402	915,757	916,163	957,185	**925,877**
Other Salary budget *[thousands of EUR]*	404,669	475,670	412,012	419,063	**427,854**

1.7. Mission Statement of the Institute as presented in the Foundation Charter

1. Main activity of the Institute is the research and development in the field of electrical engineering, automatization 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 Microelectronics. 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.

1.8. Summary of R&D activity pursued by the institute during the assessment period in both national and international contexts, (recommended 5 pages, max. 10 pages)

The research activities are organized in four Scientific Departments:

- Physics and technology at nanoscale;
- III-V semiconductors;
- Microelectronic devices and sensors (included detached branche);
- Superconductors.

The goal is to contribute to fundamental knowledge in solid state physics, materials science, theory of electromagnetism and microelectronics, to the development of new technologies and new microelectronic devices, as well as to the understanding of advanced superconducting devices. In the following paragraphs we discuss selected outstanding results achieved during the assessed period following the structure of Scientific Departments.

a) Physics and technology at nanoscale

Dynamics of magnetic vortices in ferromagnetic nanoelements with broken symmetry

We studied theoretically and experimentally magnetic effects in ferromagnetic nanoelements. Each nanomagnet can store two bits, polarity and chirality. The read/write process of the magnetic state is influenced significantly by the shape of the nanomagnet, and the simplest one appears for the objects with broken symmetry. Micromagnetic simulations show that all four ground states of the nanomagnet can be easily achieved by switching of the in-plane external field in the defined direction according the symmetry axes of the nanomagnet [Tóbik, **Phys. Rev.** B 86 (2012) 134433; Cambel, **J. Magnetism Magnetic Mater.** 336 (2013) 29]. In the theoretical part we explore the nature of the magnetic state in such nanoobjects. The dynamics of the magnetic state shows asymmetric time evolution, which we explain by a single-spin model [Tóbik, **Sci. Reports** 5 (2015) 12301]. Such simplified model opens a possible venue for controlling magnetic states of the future nanodevices in practical applications. In the experimental part we have: a) developed novel scanning method: dual-tip magnetic force microscopy with improved spatial resolution of the soft magnetic objects imagined [Precner,

Nanotechnol. 26 (2015) 055304]; b) explored magnetization reversal of the nanomagnet using micro-Hall probe magnetometry [Ščepka, **AIP Adv.** 5 (2015) 117205]. Our experiments agree with the results obtained by simulations.

Resistive switching in TiO_2- and HfO_2-based structures prepared by atomic layer deposition

Resistive switching in metal-insulator-metal structures is a challenging topic for application in future random access memories (RAM). In our papers we have shown that TiO_2 [Hudec, **Thin Solid Films** 563 (2014) 10] and HfO_2 [Jančovič, **Appl. Surf. Science** 312 (2014) 112] structures prepared using ALD technology are suitable for resistive switching phenomenon. To achieve bipolar resistive switching, one has to use electrode with different output work functions and affinity to oxygen, e.g. TiN and Pt. In the case of HfO_2 based structures, the resistive switching effect was observed also for ultrathin layers of thickness of ~2 nm. We have found that forming voltage of such structures depends on the HfO_2 thickness. Characterization of the structures using pulsed voltage (pulse length 1 μs) showed 10^8 switches with resistivity ratio higher than 10 for reading voltage of 0.2 V. Such characteristics show that HfO_2 based structures are perspective for future RAM memories.

Visualizing domain wall and reverse domain superconductivity

In magnetically coupled planar ferromagnet-superconductor (F/S) hybrid structures, magnetic domain walls can be used to spatially confine the superconductivity. In contrast to a superconductor in a uniform applied magnetic field, the nucleation of the superconducting order parameter in F/S structures is governed by the inhomogeneous magnetic field distribution. The interplay between the superconductivity localized at the domain walls and far from the walls leads to effects such as re-entrant superconductivity and reverse domain superconductivity with the critical temperature depending upon the location. Here we use scanning tunneling spectroscopy to directly image the nucleation of superconductivity at the domain wall in F/S structures realized with Co-Pd multilayers and Pb thin films. Our results demonstrate that such F/S structures are attractive model systems that offer a possibility to control the strength and the location of the superconducting nucleus by applying an external magnetic field, potentially useful to guide vortices for computing application. The work was done in collaboration with Temple University [Iavarone, **Nature Comm.** 5 (2014) 4766].

Fast highly-sensitive semiconductor gas sensor based on the nanoscale Pt–TiO_2–Pt sandwich

Development of fast highly-sensitive semiconductor gas sensors operating at room temperature, which would be compatible with semiconductor technology, remains a challenge for researchers. Here we present such sensor based on a nanoscale Pt–TiO_2–Pt sandwich. The sensor consists of a thin (~30 nm) nanocrystalline TiO_2 layer with ~10 nm grains, placed between the bottom Pt electrode layer and top Pt electrode shaped as a long narrow (width w down to 80 nm) stripe. If we decrease w to ~100 nm and below, the sensor exposed to air with 1% H_2 exhibits the increase of response (R_{air} / R_{H2}) up to ~10^7 and decrease of the reaction time to only a few seconds even at room temperature. It is shown theoretically, that the sensitivity increase is due to a nontrivial non-ohmic effect, a sudden decrease (by three orders of magnitude) of the electrical resistance with decreasing w for w ~ 100 nm. This non-ohmic effect is explained as a consequence of two nanoscale-related effects: the hydrogen-diffusion-controlled spatially-inhomogeneous resistivity of the TiO_2 layer, combined with onset of the hot-electron-temperature instability when the tiny grains are subjected to high electric field [Plecenik, **Sensors Actuators B** 207 (2015) 351].

Switching-magnetization magnetic force microscopy with high spatial resolution

Basic drawback of standard magnetic force microscopy (MFM) is its relative low spatial resolution (~ 20 nm). Improvement of the resolution is limited by the mixing of magnetic and van der Waals forces for scans closer than 20 nm above the sample. We have solved the problem by introducing a novel scanning method, so called Switching-magnetization MFM method. In the method, two scans of the sample are realized with opposite tip polarity, switched by the external magnetic field. Then the data addition of these scans gives van der Waals forces, and their difference gives magnetic image of the sample. The method separates atomic and magnetic forces in scans realized in close proximity above the sample (e.g. 5 nm). Therefore it improves the spatial resolution of the MFM method below 10 nm [Cambel, **Applied Phys. Lett.** 102 (2013) 062405].

Magnetization and vortex phase diagram in Cu_xTiSe crystals

Cu_xTiSe_2 is a recently found material in which compete superconductor (SC) and charge density wave states for interval $0.04 < x < 0.06$. We have extracted several important parameters from magnetization reversal characteristics of several crystals with various concentrations of Cu. Superconductive anisotropy is very low, close to 1.7, and independent of doping level. However, it is enhanced for weakly doped crystals. We assume that this is due to the competition between superconductivity and the charge density wave state. From the magnetization curves we have extracted also extremely low SC current densities, which is the consequence of very low intrinsic pinning. Surprisingly, the phase diagram of the SC vortices shows extremely wide liquid phase. This is non-typical result for a low-temperature superconductor with low anisotropy. This was explained as a consequence of above mentioned weak pinning [Barančeková Husaníková, **Phys. Rev. B** 88 (2013) 174501; Kačmarčík, **Phys. Rev. B** 88 (2013) 020507].

b) III-V semiconductors

InN-channel/InAlN-buffer high-electron-mobility transistors

Owing its highest electron saturated velocity among semiconductors, InN can be used for designing extremely fast transistors. However, InN-based microwave transistors represent a technological challenge due to high strain in InN when grown on GaN and because of electron accumulation on the InN surface. Here, we propose and theoretically analyze transistors with a strained InN channel. In our design, N-polar InN channel can be grown as a last semiconductor layer, insulated from the gate metal using a dielectric layer. In this way we expect to fill the “terahertz gap” between electron and photon devices [Kuzmík, **Semicond. Sci Technol.** 29 (2014) 035015]. In the following work we analyzed electrical and chemical properties of InN layers grown with different polarity and methods of removing electrons surface accumulation. Significant oxidation at the In-polar InN surface was found by X-ray photoelectron spectroscopy analysis. Similarly, we observed significant surface electron accumulation regardless of the oxide presence. On the other hand, if the InN was capped by four mono-layer of GaN, surface accumulation was fully removed. This effect is vital for manufacturing future ultra-fast InN transistors. [Kuzmík, **Appl. Phys. Lett.** 107 (2015) 191605].

Design and technology of normally-off GaN HFETs

There is a great effort towards development of normally-off GaN heterostructure-field-effect transistor (HFET) for switching applications. Among other concepts, insulated gate HFETs, i.e. MOS-HFETs represent an excellent candidate for this purpose as an appropriate selection of the gate dielectric can provide manipulation of the so-called surface donors, to allow the desired adjustment of the transistor’s threshold voltage (Vth). However, a complete analytical model for the calculation and technological adjustment of Vth was still missing in the literature. We proposed such a model together with separation of the relevant charges across the gate structure and explained the effect of the charges on MOS-HFET Vth [Ťapajna, **Appl. Phys. Lett.** 100 (2012) 113509]. Another concept for realizing normally-off GaN transistor is based on unique InAlN barrier-based devices. Demonstrated transistors open a way towards robust high-power switches as well as towards new generation of fast logic circuits. New technology is represented by a method of plasma etching of transistor access regions, which is highly selective and harmless to transistor performance [Jurkovič, **IEEE Electron Dev. Lett.** 34 (2013) 432].

Analysis of self-heating and trapping effects in high-power GaN HFETs

Self-heating and trapping effects in GaN switching transistors represent significant performance and reliability issues. Self-heating effects were studied in tailored normally-off GaN HEMTs with AlGaN and GaN buffer with or without Ar implantation into conductive SiC substrate prior to heterostructure growth. Our transient self-heating analysis indicated almost three-fold higher temperature rise in transistors with AlGaN buffer compared to devices employing GaN buffer. Surprisingly, transient self-heating was further increased in devices with AlGaN buffer with Ar implantation into SiC substrate that was attributed to changes in thermal conductivity of AlGaN buffer with Ar implanted into SiC. [Kuzmík, **J. Applied Phys.** 115 (2014) 164504]. To understand the effect of Ar implantation into SiC in more detail, trapping processes were characterized using drain current transient analysis. Our investigation revealed appearance of dominant trapping centres in the AlGaN buffer, while being negligible in those with GaN buffer, indicating impact of Ar implantation into SiC substrate on the density of in-grown defects.

Trapping processes in MOS-gated GaN switching transistor can cause Vth instabilities due to relatively high density of oxide/barrier interface states. We developed a technique capable to separate carrier capture-emission processes from traps located in the oxide bulk and its interface with III-N heterostructure. Original technique was used based on Vth-transient monitoring in the MOS-HFETs as a function of temperatures and monochromatic light exposure. Developed technique provides feed-back for technology optimization of highly-effective GaN switching MOS-HEMTs [Ťapajna, **Appl. Phys. Lett.** 102 (2013) 243509].

GaAs-based metal-oxide-semiconductor HFETs

The GaAs-based MOS-HFETs represent alternative devices to conventional Si MOS transistors. However, performance of GaAs MOS-HFETs is still hindered by a high density of surface/interface states. We studied GaAs MOSHFETs prepared with aluminium oxide as a passivation and gate insulator layer. The surface of GaAs was covered in-situ by a thin Al layer, which was subsequently oxidized at room temperature to obtain aluminium oxide. The GaAs-based MOS-HFETs yielded higher sheet charge density and saturation drain current compared to the untreated counterparts. Devices with 1.5 µm gate length showed current gain and unilateral power gain cut-off frequencies of 19 and 48 GHz, respectively [Kordoš, **Appl. Phys. Lett.** 100 (2012) 142113]. Next, InGaAs/GaAs MOS structures with double-layer insulator consisting of oxygen-plasma oxide covered by Al_2O_3 were processed and analyzed. Static measurements yielded saturation drain current of ~250 mA/mm. Carrier peak mobility of 4570 $cm^2V^{-1}s^{-1}$ sheet charge density of 2×10^{12} cm^{-2} were obtained. This demonstrates high capability of the developed procedure for GaAs-based MOS devices with oxidized GaAs surface covered by Al_2O_3 insulator [Gucmann, **Appl. Phys. Lett.** 105 (2014) 183504].

Radial pn junction on GaP/ZnO nanorod for photovoltaic applications

Nanowires (NW) exhibit unique electrical and optical properties due to lowered dimensions and related confinement effects. The GaP nanowires studied here were grown on the p-type GaP (111) substrate by a VLS technique using 30 nm colloidal gold particles as seeds. We applied a conventional field-effect transistor configuration to estimate a type of conductivity and carrier mobility of the prepared NWs. Structural properties were studied by means of SEM and TEM techniques [Novák, **Phys. Stat. Solidi (a)** 209 (2012) 2505]. In the following work, part of NWs was covered by a thin nanocrystalline Ga-doped ZnO layer (10 – 140 nm) deposited by RF sputtering. Deposition of thin ZnO layer on the GaP nanowire led to creation of radial PN junction in core-shell configuration. Electrical contacts were processed to individual GaP/ZnO NWs using electron beam lithography, evaporation and lift-off of metallic layers: Au/Zn (GaP core) and Au/Al (ZnO shell). Electrical and photocurrent measurement of the NWs confirmed that a radial pn heterojunction was formed between the GaP core and ZnO shell [Laurenčíková, **Appl. Surf. Sci.** 267 (2013) 60].

c) Microelectronic devices and sensors

Terahertz radiation detector

We have designed and fabricated detectors of THz radiation based on bolometric principle. Though THz band is very important for applications in medicine, detection of explosives, etc., there is still lack of proper devices for generation and/or detection of THz waves. Therefore, our microbolometer can be considered a substantial contribution to this field - it is miniature, has fast response, and works at room temperature, i.e., the bulky cooling can be omitted. In its construction, a long-term experience in fabrication of MEMS structures and deposition of thin film structures of complex materials by PLD technique is applied. The microbolometers were successfully tested at PTB Berlin by THz radiation up to 1.4 THz and its potential application at NIST (USA) is being negotiated. More sophisticated microbolometers with enhanced sensitivity up to 10 THz are the subject of a new APVV project TERAMEMS (2015-2018) [Chromik, **Applied Surface Sci** 312 (2014) 30]

Nanomachining with subsequent polishing of the active surfaces of crystal X-ray optics
The high-asymmetry diffraction producing beam magnification/compression in the grazing incidence/emergence mode requires a high quality of the crystal surface. We have applied advanced nanomachining using Single Point Diamond Turning (SPDT) to prepare the crystal surfaces. It leads to high shape accuracy, however, the surface roughness and subsurface defects are usually several times higher than the value achieved by chemical-mechanical process in planar semiconductor technology. Subsequently to the SPDT, several finishing methods, including conventional mechanical lapping, chemical polishing, and chemical-mechanical polishing have been tested. We have obtained the surface roughness (RMS) of ~0.3 nm without the subsurface damages after a fine 15-min polishing process with a polishing solution containing SiO_2 nanoparticles (20 nm). Reciprocal space mapping by high resolution X-ray diffractometry showed suppression of the so-called undesirable surface grating truncation rods. These results were achieved in collaboration with IP SAS, international cooperation with DESY Hamburg, MU Brno, IMEM CNR Parma and within the EU and national projects and are highly rated by several subscribers of the results [Zápražný, **Optical Engn.** 54 (2015) 035101].

Semiconductor pressure sensor for extreme conditions
We introduced prototypes of semiconductor MEMS piezoelectric pressure sensors applicable at extreme conditions of high temperatures and chemically aggressive ambient. The sensing part of the MEMS sensor consists of a 2-4 μm thick circular AlGaN/GaN membrane with integrated circular high electron mobility transistors on its surface. The sensing electrodes are optimally situated at locations with maximal changes of mechanical strain as a consequence of external pressure loading. The pressure sensor works based on originally proposed piezoelectric sensing principle employing the accumulation of induced charge on the gate electrodes of the HEMT device by membrane deflection. The introduced MEMS pressure sensor represents a new generation of sensors exploitable for pressure measurements in harsh environments and induced by hydrodynamic or acoustic activation as well as acceleration (pressure measurements in combustion engines and on wings of aircrafts, etc.) [Dzuba, **Applied Phys. Lett.** 107 (2015) 122102; Dzuba, **Micromech. Microengn.** 25 (2015) 015001; Vanko, **Microelectron. Engn.** 110 (2013) 260; Vallo, **Applied Surface Sci** 267 (2013) 159-163; Lalinský, **Microelectron. Engn.** 98 (2012) 578].

Spectrometric detector of heavy ions based on 4H-SiC
Semiconductor spectrometric detector based on high quality epitaxial layer of 4H-SiC material is suitable for detection and spectrometry of heavy charge particles and neutrons generated by various sources e.g. in reactors of nuclear fusion. We designed and realized original technology of detector preparation. The experimentally obtained spectrometric parameters overperform the best presented results published in the literature till now. Advantages of designed detector ioncludes: i) 4H-SiC semiconductor material of the diode detector is capable to operate reliably in wide range of temperature; ii) possibility of detection of different heavy ions up to energies of several 100 MeV; iii) high spectrometric resolution of 0.25% for 5.5 MeV alpha particles; iv) high resistance against radiation including neutrons; and v) possibility of the detector preparation with different active area and optimization for various heavy ions flux [Zaťko, **J. Instrument.** 10 (2015) C04009; Zaťko, **J. Instrument.** 9 (2014) C05041].

Phase contrast X-ray imaging of light weight samples
Weakly absorbing objects (such as biological, polymers, etc.) typically feature 1000 times stronger contrast in the X-ray region in the so-called phase-contrasted imaging mode as compared to the absorption imaging mode. This was the motivation for the X-ray microscopy setup we developed, which is based on an X-ray microfocus generator attaining a spatial resolution down to 3 μm with an average lateral coherence length of 0.3 to 13 μm and up to a 140-fold geometrical magnification. The X-ray imaging system allows phase contrast imaging of light-weight samples, e.g. biological samples, wood, plastics, paper, and so on. However, such a setup uses broad polychromatic radiation, therefore, the extracted quantities from the X-ray images, such as attenuation coefficient and the retrieved phase, are affected by beam

hardening effects and the X-ray images have usually a reduced contrast due to the presence of scattering. The use of monochromatic radiation will, therefore, be of benefit but at the cost of a significant photon flux loss. However, the recent developments of more intense laboratory X-ray sources using liquid anode in combination with collimation optics and high-efficient direct conversion integrating or single photon counting X-ray detectors allow us to employ the X-ray crystal optics for imaging applications in laboratory conditions in an efficient way. Such a setup will allow for quantitative scattering-free X-ray imaging [Zápražný, **J. Applied Crystall.** 46 (2013) 933].

The way of patterning of Tl-based superconducting thin films

The aim of the work was to find fast and effective way for the patterning of thin superconducting films based on thallium using wet etching. So far, some bi- and tri-carboxylic acids as succinic, oxalic, malonic, citric, adipic or tartaric acid were used successfully for the wet etching of the thin superconducting Tl- based films. However, the etching rate is very low (0.3 – 0.6 nm / s). Ethylenediaminetetraacetic acid (H4EDTA) and its sodium salts can be also used with etching rate of about 1 nm/s, however it is necessary to maintain the pH of the solution and nitrogen bubbling during etching process. The main drawbacks of these methods consist in forming a low etching rate and selective etching. The above mentioned issues can be solved by the use of etchant based on potassium iodide. The invention is used for the preparation of thin film structures of superconductors based on Tl using photolithography and wet etching. An aqueous potassium iodide solution, hydrochloric acid, and ascorbic acid is used as an etchant. The etching process is fast enough (about 15 nm/s), provides residues-free surface, and it avoids degradation of the superconducting properties [Sojková, **Applied Surface Sci** 312 (2014) 208].

Characterization of electrical transport of LSMO in ferro-metallic state

Approximations (presented by other authors) of temperature dependence of resistance (R(T)) for perovskite manganites described the experimental dependences only for temperatures below 150-300 K. The suggested new equation $R(T) = R_0+R_1T^2+R_2(T-T_0)^{4,5}$ connects three basic transport mechanisms known for manganites (in this case $La_{0.67}Sr_{0.33}MnO_3$ (LSMO)). The equation well describes the experimental data in ferroagnetic-metalic state up to a temperature of 350 K. It is significantly higher value than that in previous approximations. We introduce the term of T_0 which indicates the activation temperature of ferromagnetic term $\sim T^{4.5}$, so we are able to describe the abrupt increase of resistance at temperatures around 350 K. The main meaning of this equation stems in the possibility to recognize all three parts of the resistance at temperatures above 300 K, where the bolometric applications of LSMO thin films are expected [Štrbik, **J. Phys.: Conf. Ser.** 514 (2014) 012042; Štrbik, **Acta Phys. Polonica A** 126 (2014) 210].

d) Superconductivity

Dense MgB_2 superconducting layer made by diffusion process (IMD)

Microstructure of dense pore-free MgB_2 layers in single filament wires made by internal magnesium diffusion process (IMD) have been analysed. The superconducting layer consists of nearly pure MgB_2 phase with small volume fraction of nano-sized Mg and MgO precipitates and some of amorphous or nano-crystalline B-rich grains. Content of oxygen in IMD wires was significantly suppressed in comparison to powder-in-tube (PIT) technology. Thin Mg layers were observed on plate-shaped MgB_2 grain boundaries. Electrical measurements have shown high critical current densities in MgB_2 layer, which are promising for further improvements and also for possible applications [Rosová, **J. Alloys Comp.** 619 (2015) 726; Kováč, **Supercond. Sci Technol.** 28 (2015) 095014; Brunner, **J. Supercond. Novel Magn.** 28 (2015) 443].

AC loss modelling for HTS coils

Many superconducting applications are usually charged and discharged under a bias dc current, which may increase the ac loss. For their design, it is necessary to understand and predict the ac loss. The analysis is based on a numerical model that takes the interaction between magnetization currents in all turns into account. The studied example is a stack of 32 pancake coils with 200 turns each made of thin tape, such as ReBCO-coated conductor. We have found that the loss increases with the dc bias current. The instantaneous power loss is the largest in the initial rise of the ac current. In the following cycles, the power loss is higher in the current increase than in the decrease. The loss per cycle is the largest at the end pancakes. The presented model has a high potential to predict the ac loss in magnet-size coils, useful for their design [Pardo, **IEEE Trans. Applied Supercond.** 24 (2014) 4700105; Pardo, **Supercond. Sci Technol.** 26 (2013) 105017; Pardo, **Supercond. Sci Technol.** 25 (2012) 035003].

Low AC loss cable produced from transposed striated CC tapes
In this work we demonstrate that the use of striated tapes from coated conductors (CCs) significantly reduces the dissipation of a cable made of tapes wound helically on a round core when it is exposed to AC magnetic field. We compare the magnetization loss in two cable models of identical geometry: The reference cable was prepared from as-received tapes while the other one from the tapes striated to 5 filaments. The cable length was designed to reach two complete tape pitches. The AC loss was measured for cables without terminations as well as with low resistance terminations; the latter configuration simulates the conditions in a magnet winding. Our experiments have clearly shown the loss behaviour expected in the regime of uncoupled filaments. At AC fields of 0.1 T amplitude, the loss in the cable from striated tapes is five times lower than in the reference cable. Numerical models have explained the experimentally observed cable behaviour in the whole range of AC fields [Šouc, **Supercond. Sci Technol.** 26 (2013) 075020].

Magnetic cloak from superconducting/ferromagnetic composite
Both the superconducting (SC) and ferromagnetic (FM) materials in form of layers or shells have been widely used for magnetic shielding. Using the Maxwell equations, it was demonstrated that a properly designed cylindrical SC/FM bilayer shell can exactly cloak uniform static magnetic fields. This theoretical assumption was experimentally confirmed in a device with centimetre dimensions. Easily accessible commercial materials have been utilized for its manufacturing: FeNiCr transformer core sheet and coated conductor tape from high-temperature superconductor YBCO cooled by liquid nitrogen (77 K). Our results show that the right combination of materials with suitable geometry could yield shielding with no distortion of external applied field thus the magnetic invisibility in DC fields [Gömöry, **Science** 335 (2012) 1466] as well as in low-frequency AC fields [Šouc, **New J. Phys.** 15 (2013) 053019].

Incorporation of the research in the European Research Area

Several groups from the Institute have reached international recognition that resulted in invitations to participate in the projects funded by European Comission in the 7th Framewok Programme.

In the field of ***III-V semiconductors*** the project entitled "GaN-based normally-off high power switching transistor for efficient power converters" was launched in 2011. Eight partners from 5 European countries are involved in the project. The aim of the project is to develop highly efficient, thermally and electrically well performing GaN-based power switching devices on Si substrate. Aside from the academic partners, the project covered a full value added chain from epitaxy (AIXTRON, EpiGaN), device processing and packaging (Infineon) to system level integration (Emerson). The role of the Institute was to design and develop new explorative technologies for normally-off GaN-based devices. Our proposed technology of manipulating the transistor threshold voltage is based on semiconductor surface plasma oxidation and subsequent oxide deposition by atomic layer deposition. Using this procedure, we reached the threshold voltage as high as 1.6 V simultaneously with maintaining the current density as high as 0.5 A/mm. The technology was successfully transferred to Ferdinand Braun Institute, FBH Berlin [Gregušová, **Appl. Phys. Lett.** 104 (2014) 013506]. Further, together with FBH we also investigated the gate degradation upon electrical stress in the ON state. Using the appropriate statistic techniques, we extrapolated a safe operation area for the gate voltage guaranteeing 10-years-lifetime [Ťapajna, **IEEE Electron Device Lett.** 37 (2016) 385; Ťapajna, **Appl. Phys. Lett.** 107 (2015) 193506]. The project was successfully accomplished in 2015.

Department of Superconductors participated in research projects dealing with the technology of composite superconducting wires and with the application of high-temperature superconductors in the field of electric power.

Our expertise in energy dissipation in supercondcutors at time-varying magnetic field (AC loss) was essential in the design of an innovative device for future electrical grid in the project “Development and field testing of an efficient YBCO coated conductor based fault current limiter in electricity networks” that started in 2010 under the coordination of Nexans (France). Radical reduction of AC loss in stand-by mode in the prototype based on modules designed and manufactured at KIT Karlsruhe (Germany) according to our recommendations [Šouc, **Supercond. Sci Technol.** 25 (2012) 014005] was verified in 2013 by tests in an authorized laboratory RSE (Italy).

In the project “European development of superconducting tapes: Integrating novel materials and architectures into cost effective processes for power applications and magnets – EUROTAPES” coordinated from 2012 by ICMAB Barcelona (Spain), our scientists are responsible for the Work-package focused on novel architectures of supercondcuting wires and the study of AC losses. Activities are performed in close collaboration with University of Cambridge (UK), ENEA (Italy) and tape manufacturers THEVA and DNano (both Germany). Main role of our investigators is the analysis of AC loss in tapes prepared by innovative routes from high-temperature superconductors [Solovyov, **Supercond. Sci Technol.** 26 (2013) 115013], as well as the development of a round conductor with integrated cooling channel [Gömöry, **IEEE Trans. Applied Supercond.** 25 (2015) 8201004].

Our activities in the project “Superconducting, reliable, lightweight, and more powerful offshore wind turbine – SUPRAPOWER” coordinated by Tecnalia (Spain) (finished in 2015) were aimed at developing a composite wire containing mid-temperature superconductor MgB_2 in form of tiny filaments, in order to achieve reduced weight and low AC loss [Kováč, **Supercond. Sci Technol.** 26 (2013) 105028]. In the same time the wire must withstand mechanical stresses expected during the operation of electrical machine wound from such composite [Kováč, **IEEE Trans. Applied Supercond.** 22 (2012) 8400106]. Innovative way of arranging the starting materials has been proposed and experimentlay verified. It resulted in dramtically increased density of the superconducting phase [Kováč, **Supercond. Sci Technol.** 28 (2015) 095014]. In collaboration with the conductor manufacturer Columbus (Italy) alternative designs of composites with improved properties have been investigated and their limitations assessed [Kováč, **IEEE Trans. Applied Supercond.** 25 (2015) 6200607]

Within the framework of the European Fusion Development Agreement funded project “Development and qualification of HTSC conductors for fusion magnets” our team contributed to the progress in magnet technology based on high-temperature superconductors [Pardo, **Supercond. Sci Technol. 26** (2013) 105017, Gömöry, **IEEE Trans. Applied Supercond.** 23 (2013) 5900406]. Consortium of partners involved in this project, after its end in 2013, is continuing under new framework of the Horizion2020 Co-fund project “Implementation of activities described in the Roadmap to Fusion during Horizon2020 through a Joint programme of the members of the EUROfusion consortium”. Our researchers are involved in the Work-package “Magnet System Design”, subtask “Advanced Magnet Technology” focused on the development of cables transporting electrical currents over 50 000 A based on high-temperature superconducting tapes [Vojenčiak, **Supercond. Sci Technol.** 28 (2015) 104006].

Our scientists are involved in several COST Actions as the Management Committee members representing Slovakia. Networking allowed by this instrument is considerd a good opportunity for integration of our research activities in ERA.

SASPRO projects implemented at IEE SAS

The project is supported partially by Maria Curie fellowship and partially by SAS, and the idea is to attract young scientists from different countries as well as Slovak scientists working aboard, to work at SAS and strengthen its future prospects. The Institute received 4 SASPRO projects in the assessment period, two of them started in 2015, next two from 01/2016. The number of SASPRO post-doc positions documents well the international position of the Institute and supports the quest of the IEE management to attract scientists from different countries to our laboratories. We present here four received projects.

1) **M. Vojenčiak: Thermo-electrical stability of superconductors in unconventional cooling conditions**

From: 04/2015 To: 03/2018 Serial: SASPRO 0061/01/01

Superconductors are materials with strongly non-linear current-voltage characteristic. When the transported electrical current is below the critical value they exhibit zero resistance, while at higher currents their resistance is high. Latter regime is associated with energy dissipation and temperature increase; it can lead to the temperature excursion causing a damage of superconducting material. Stability of the superconducting wire describes how big is the margin against transition to non-superconducting state and whether it will be followed by a material degradation. In this project we investigate the stability in conditions representing the situation typical for two configurations: the fault current limiter and the cable for a coil winding.

2) **O. Babchenko: Design and fabrication of diamond-on-GaN hybrid structures for MEMS**

From: 05/2015 To: 04/2018 Serial: SASPRO 0068/01/01

The project is oriented on bilateral transfer of knowledge, design of hybrid electronic devices with efficient thermal management, e.g. AlGaN/GaN based devices passivated by diamond and/or diamond-based devices covered by metal oxides, manufacturing of such devices and their characterisation. It is expected that the successful project implementation will enable fabrication of hybrid high power electronic devices and/or micro-electro-mechanical systems potentially operating at high frequencies and/or high temperatures.

3) **M. Mruczkiewicz: Waves in exotic spin textures**

From: 01/2016 To: 12/2018 Serial: SASPRO 1244/02/01

The research project is focused on the theoretical investigation of collective excitations in various magnetic architectures and magnetic field configurations (spin textures). In particular, the dynamical properties of magnetic vortices and skyrmions will be studied in disks, nontrivial geometries, and ultrathin films. Possible mechanisms of excitations (e.g., current or external field) will be considered and the possibility of experimental verification of numerically studied structures will be evaluated. An important part of the work will be dedicated to the study of collective skyrmion modes, a topic of research that is completely unexplored yet. On the basis of the obtained results a logic device will be proposed.

1) E. Seiler: Pinning in commercial coated conductors

From: 01/2016 To: 12/2018 Serial: SASPRO 1633/03/01-b

The project will investigate pinning mechanisms in commercial ReBCO coated conductors coming from different industrial producers. Different manufacturing processes incorporate various kinds of pinning centres into functional superconducting layers of these conductors and as a consequence a very diverse mixture of pinning centres with dissimilar strength dependence on temperature and magnetic field can be found. Main focus will be on the temperature and magnetic field range interesting for applications in electric machinery (electric motors, generators, transformers, etc.) – temperatures 65 K to 77 K and fields 0 to 5 T. The aim is to identify which of the pinning mechanism is the most effective in the temperature and field domain of our interest and develope experimental techniques for its classification and description.

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 (ratios in percentage)

Basic research/applied research: 90%/10%

International/regional: 100%/0%

2.1.2 List of selected publications documenting the most important results of basic research. The total number of publications listed for the assessment period should not exceed the average number of employees with university degrees engaged in research projects. The principal research outputs (max. 5, including Digital Object Identifier - DOI) should be underlined

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60. **Rosová**, **A**., **Hušek**, **I**., **Kováč**, **P**., **Dobročka**, **E**., and **Melišek**, T.: Microstructure of MgB_2 superconducting wire prepared by internal magnesium diffusion process, J. Alloys Comp. **619** (2015) 726-732. (1 cit.) (IF 2.999)

61. **Tóbik, J**., **Cambel**, **V**., and Karapetrov, G.: Asymmetry in time evolution of magnetization in magnetic nanostructures, Sci Reports 5 (2015) 12301. (IF 5.578) DOI 10.1038/srep12301

62. **Precner**, **M**., **Fedor**, **J**., **Šoltýs**, **J**., and **Cambel**, V.: Dual-tip magnetic force microscopy with suppressed influence on magnetically soft samples, Nanotechnol. 26 (2015) 055304. (IF 3.821)

63. **Feilhauer**, J., Apel, W., and Schweitzer, L.: Merging of the Dirac points in electronic artificial graphene, Phys. Rev. B 92 (2015) 245424. (IF 3.736)
64. **Dzuba**, **J**., **Vanko**, G., Držík, M., **Rýger**, I., Kutiš, V., Zehetner, J., and **Lalinský**, T.: AlGaN/GaN diaphragm-based pressure sensor with direct high performance piezoelectric transduction mechanism, Applied Phys. Lett. 107 (2015) 122102. (IF 3.302)
65. **Kuzmík**, **J**., **Haščík**, **Š**., **Kučera**, **M**., **Kúdela**, **R**., **Dobročka**, E., Adikimenakis, A., Mičušík, M., Gregor, M., Plecenik, A., and Georgakilas, A.: Elimination of surface band bending on N-polar InN with thin GaN capping, Applied Phys. Lett. 107 (2015) 191605. (IF 3.302)
66. **Ťapajna, M**., Hilt, O., Bahat-Triedel, E., Würfl, H., **Kuzmík**, J., : Investigation of gate-diode degradation in normally-off p-GaN/AlGaN/GaN high-electron-mobility transistors. Applied Phys. Lett. 107 (2015) 193506. (IF 3.302)
67. **Gömöry**, **F**., **Soloviov**, **M**., and **Šouc**, J.: Magnetization loop modelling for superconducting/ferromagnetic tube of an ac magnetic cloak, Supercond. Sci Technol. 28 (2015) 044001. (IF 2.325)
68. **Kováč**, **J**., **Šouc**, **J**., **Kováč**, **P**., and **Hušek**, I.: Magnetization AC losses in MgB_2 wires made by IMD process, Supercond. Sci Technol. 28 (2015) 015013. (IF 2.325)
69. **Kováč**, **P**., **Kopera**, **Ľ**., **Melišek**, **T**., **Kulich**, **M**., **Hušek**, I., Lin, H., Yao, C., Zhang, X., and Ma, Y.: Electromechanical properties of iron and silver sheathed $Sr_{0.6}K_{0.4}Fe_2As_2$ tapes, Supercond. Sci Technol. 28 (2015) 035007. (IF 2.325)
70. **Pardo**, E., Staines, M., Jiang, Z., and Glasson, N.: Ac loss modelling and measurement of superconducting transformers with coated-conductor Roebel-cable in low-voltage winding, Supercond. Sci Technol. 28 (2015) 114008. (IF 2.325)
71. **Pitel**, **J**., **Kováč**, P., Tropeano, M., and Grasso, G.: Study of the potential of three different MgB_2 tapes for application in cylindrical coils operating at 20K, Supercond. Sci Technol. 28 (2015) 055012. (IF 2.325)
72. **Vojenčiak**, M., Kario, A., Ringsdorf, B., Nast, R., van der Laan, D., Scheiter, J., Jung, A., Runtsch, B., **Gömöry**, **F**., and Goldacker, W.: Magnetization ac loss reduction in HTS CORC® cables made of striated coated conductors, Supercond. Sci Technol. 28 (2015) 104006. (IF 2.325)
73. Magdolenova, Z., Drlickova, M., Henjum, K., Runden-Pran, E., Tulinska, J., Bilanicova, D., Pojana, G., Kazimirova, A., Barancokova, M., Kuricova, M., Liskova, A., Staruchova, M., Čiampor, F., **Vávra**, **I**., Lorenzo, Y., Collins, A., Rinna, A., Fjellsbo, L., Volkovova, K., Marcomini, A., Amiry-Moghaddam, M., and Dusinska, M.: Coating-dependent induction of cytotoxicity and genotoxicity of iron oxide nanoparticles, Nanotoxicology 9 (2015) 44-56. (9 cit.) (IF 6.411)
74. Plecenik, T., **Moško**, **M**., Haidry, A.A., Durina, P., Truchly, M., Grančič, B., Gregor, M., Roch, T., Satrapinsky, L., **Mošková**, **A**., Mikula, M., Kúš, P., and Plecenik, A.: Fast highly-sensitive room-temperature semiconductor gas sensor based on the nanoscale Pt-TiO_2-Pt sandwich, Sensors Actuators B 207 (2015) 351-361. (3 cit.) (IF 4.097)
75. Vagovič, P., **Korytár**, D., Cecilia, A., Hamann, E., Baumbach, T., and Pelliccia, D.: Laboratory-based multi-modal X-ray microscopy and micro-CT with Bragg magnifiers, Optics Express 23 (2015) 18391-18400. (IF 3.488)
76. Lobato, B., Vretenár, V., Kotrusz, P., **Hulman**, M., and Centeno, T.: Reduced graphite oxide in supercapacitor electrodes, J. Colloid Interface Sci 446 (2015) 203-207. (IF 3.368)

2.1.3 List of monographs/books published abroad

Chapters in monographs published abroad

1. **Gömöry**, **F**. : Electromagnetic modeling of high temperature superconductor (HTS) materials and applications. In: High temperature superconductors (HTS) for energy applications. Ed. Z. Melhem. Oxford: Woodlhead Publ. Ltd. 2012. ISBN 978-0-85709-012-6. P. 216-256.

2. **Šmatko**, **V**., Donchev, I., **Kováčová**, **E**., **Štrbik**, **V**., and Zyryn, S.: Surface modification for novel nanosensors creation. In: Nanodevices and Nanomaterials for Ecological Security, NATO Sci Peace and Security Series B: Physics and Biophysics. ISBN 978-94-007-4118-8. Dordrecht: Springer Science+Business Media 2012. P. 263-268.
3. **Korytár**, **D**., Vagovič, P., Ferrari, C., and Šiffalovič, P.: X-ray crystal optics based on Germanium single crystals In: Germanium: Characteristics, Sources and Applications. Ed. E.E. Feuerstein. New York: Nova Sci Publ. 2013. ISBN 978-1-62948-181-4. P. 105-140.
4. **Gömöry**, **F**.: Superconductor dynamics In: Proc.CAS-CERN Accelerator School: Superconductivity for Accelerators. Erice, Italy 2013. Ed. R. Bailey. Geneva: CERN, 2014. ISBN 978-92-9083-405-2. P. 477-495.
5. Kratošová, G., Dědková, K., **Vávra**, **I**., and Čiampor, F.: Investigation of nanoparticles in biological objects by electron microscopy techniques In: Intracellular Delivery II: Fundamentals and Applications. Eds. A. Prokop, Y. Iwasaki, A. Harada. Springer 2014. ISBN 978-94-017-8896-0. P. 165-187.
6. **Lobotka**, **P**. and **Kunzo**, **P**. : Carbon nanoparticles/polymer composites for sensing In: Handbook of Polymer Nanocomposites. Processing, Performance and Application. Vol. B: Carbon Nanotube Based Polymer Composites. Eds: K.K.Kar, J.K.Pandey, S.Rana. Berlin: Springer-Verlag 2015. ISBN: 978-3-642-45228-4. P. 577-601.

2.1.4. List of monographs/books published in Slovakia

Chapters in monographs published in Slovakia

1. Červeň, I., **Dobročka**, E., Fejdi, P. a Vančová, I.: Slovenská kryštalografická terminológia (Slovak crystallographic terminology). Bratislava: Veda 2014. ISBN: 978-80-224-1361-9. 208 s.

2.1.5. List of other scientific outputs specifically important for the institute, max. 10 items

1. Biennial Report IEE SAS 2011 – 2012. Eds. M. Ťapajna et al. Bratislava: IEE SAS 2013.
2. Biennial Report IEE SAS 2013 –2014. Eds. M. Ťapajna et al. Bratislava: IEE SAS 2015.

2.1.6. List of patents, patent applications, and other intellectual property rights registered abroad, incl. revenues

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

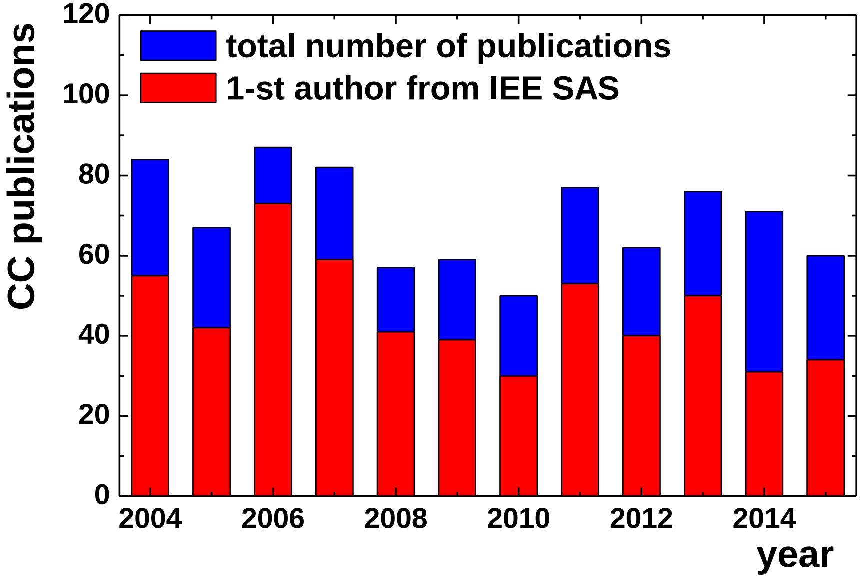
1. **Dzuba**, **J**., **Lalinský**, **T**., **Rýger**, **I**., **Vallo**, **M**., and **Vanko**, **G**.: MEMS pressure sensor with a high electron mobility transistor and a production method thereof. Patent Appl. No. PP 94-2013.
2. **Kuzmík**, **J**.: Enhancement mode III-N transistor with N-polarity and a production method thereof. Patent Appl. No. PP 67-2013.
3. **Sojková**, **M**. and **Chromik**, **Š**.: The way of patterning of thin superconducting films based on thallium. Patent Appl. No. PP 5030-2013.
4. **Sojková**, **M**. and **Chromik**, **Š**.: Stable sputtering target for the fabrication of the precursor films suitable for the preparation of high temperature superconductors based on thallium and mercury. Patent Appl. No. PP 50057-2014.
5. **Šouc**, **J**., **Gömöry**, **F**., **Vojenčiak**, **M**., **Soloviov**, **M**., **Kováč**, **J**., and **Štefánik**, S.: Superconducting coil and feeding superconducting cable. Patent Appl. No. PP50063-2015.

2.1.8. Table of research outputs (as in annual reports).

Scientific publications	2012			2013			2014			2015			total			
	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	averaged number per year	av. No. / FTE	av. No. / salary budget
Scientific monographs and monographic studies in journals and proceedings published abroad *(AAA, ABA)*	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	**0,0**	**0,0**	**0,000**	**0,000**
Scientific monographs and monographic studies in journals and proceedings published in Slovakia *(AAB, ABB)*	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	**0,0**	**0,0**	**0,000**	**0,000**
Chapters in scientific monographs published abroad *(ABC)*	1,0	0,016	0,001	2,0	0,031	0,002	1,0	0,015	0,001	1,0	0,016	0,001	**5,0**	**1,3**	**0,020**	**0,001**
Chapters in scientific monographs published in Slovakia *(ABD)*	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	**0,0**	**0,0**	**0,000**	**0,000**
Scientific papers published in journals registered in Current Contents Connect *(ADCA, ADCB, ADDA, ADDB)*	65,0	1,023	0,071	78,0	1,227	0,085	72,0	1,085	0,079	63,0	1,022	0,066	**278,0**	**69,5**	**1,090**	**0,075**
Scientific papers published in journals registered in Web of Science Core Collection and SCOPUS *(ADMA, ADMB, ADNA, ADNB)*	22,0	0,346	0,024	10,0	0,157	0,011	19,0	0,286	0,021	15,0	0,243	0,016	**66,0**	**16,5**	**0,259**	**0,018**
Scientific papers published in other foreign journals (not listed above) *(ADEA, ADEB)*	1,0	0,016	0,001	4,0	0,063	0,004	3,0	0,045	0,003	2,0	0,032	0,002	**10,0**	**2,5**	**0,039**	**0,003**
Scientific papers published in other domestic journals (not listed above) *(ADFA, ADFB)*	0,0	0,000	0,000	0,0	0,000	0,000	1,0	0,015	0,001	0,0	0,000	0,000	**1,0**	**0,3**	**0,004**	**0,000**
Scientific papers published in foreign peer-reviewed proceedings *(AEC, AECA)*	1,0	0,016	0,001	0,0	0,000	0,000	1,0	0,015	0,001	0,0	0,000	0,000	**2,0**	**0,5**	**0,008**	**0,001**
Scientific papers published in domestic peer-reviewed proceedings *(AED, AEDA)*	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	**0,0**	**0,0**	**0,000**	**0,000**
Published papers (full text) from foreign and international scientific conferences *(AFA, AFC, AFBA, AFDA)*	33,0	0,519	0,036	3,0	0,047	0,003	18,0	0,271	0,020	6,0	0,097	0,006	**60,0**	**15,0**	**0,235**	**0,016**
Published papers (full text) from domestic scientific conferences *(AFB, AFD, AFBB, AFDB)*	14,0	0,220	0,015	28,0	0,440	0,031	30,0	0,452	0,033	22,0	0,357	0,023	**94,0**	**23,5**	**0,368**	**0,025**

- **Supplementary information and/or comments on the scientific outputs of the institute.**

We present the graph showing how the number of CC papers produced by the Institute developed in recent 10 years. From the graph it is clear that the number of publications is almost constant in time, around 65. Decrease of the share of first-author papers is probably the result of growing international collaboration. We consider important the increase of papers quality, measured by the impact factors of journals in which our scientists publish the papers. It is constantly increasing in time, and in 2015 the average impact factor of our published papers was higher than 2.2.



This positive trend is probably linked to the rules (management) applied at the Institute. *Scientists are motivated to send manuscripts to journals with higher impact factors by the fact that the financial bonus paid to the authors linearly depends on the journals impact factor. Also, the quality of the publications (i.e. the impact of the journal) is taken into consideration as one of the indicators in the annual evaluation of individual scientists of the Institute. Another indicator is the number of citations received for the papers published in the past. Because the evaluation directly influences the salary of the scientist for the next period (year), these measures make a production of low quality or incremental papers unbeneficial.*

2.2. Responses to the research outputs (citations, etc.)

2.2.1. Table with citations per annum.

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) have to be listed separately.

Citations, reviews	2011		2012		2013		2014		total		
	number	No. / FTE	number	No. / FTE	number	No. / FTE	number	No. / FTE	number	averaged number per year	av. No. / FTE
Citations in Web of Science Core Collection (1.1, 2.1)	680,0	10,715	760,0	11,892	938,0	13,925	959,0	15,100	**3337,0**	**834,3**	**12,922**
Citations in SCOPUS (1.2, 2.2) if not listed above	77,0	1,213	81,0	1,267	54,0	0,802	88,0	1,386	**300,0**	**75,0**	**1,162**
Citations in other citation indexes and databases (not listed above) (3.2,4.2,9,10)	1,0	0,016	6,0	0,094	6,0	0,089	0,0	0,000	**13,0**	**3,3**	**0,050**
Other citations (not listed above) (3, 4, 3.1, 4.1)	4,0	0,063	11,0	0,172	5,0	0,074	2,0	0,031	**22,0**	**5,5**	**0,085**
Reviews (5,6)	0,0	0,000	0,0	0,000	0,0	0,000	0,0	0,000	**0,0**	**0,0**	**0,000**

2.2.2. List of 10 most-cited publications, with number of citations, in the assessment period (2011 – 2014).

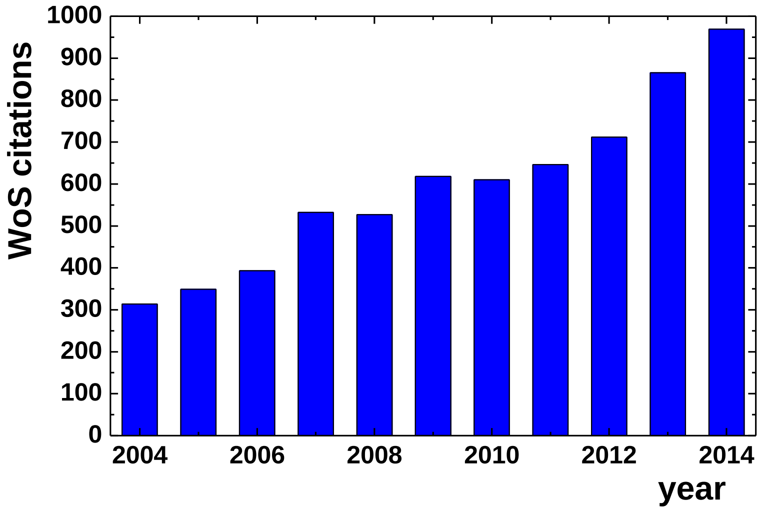
1. **Kuzmík**, **J**.: Power electronics on InAlN/(In)GaN: prospect for a record performance, IEEE Electron Devices Letters **22** (2001) 510-512. (SCI 164, SCOPUS 19)
2. **Gömöry**, **F**., **Solovyov**, **M**., **Šouc**, **J**., Navau, C., Camps, J.P., and Sanchez, A.: Experimental realization of a magnetic cloak, Science **335** (2012) 1466-1468. (SCI 69, SCOPUS 4)
3. **Gömöry**, **F**.: Characterization of high-temperature superconductors by AC susceptibility measurement, Topical Review, Supercond. Sci Technol. **10** (1997) 523. (SCI 44, SCOPUS 3)
4. **Kuzmík**, **J**., Pozzovivo, G., Ostermaier, C., Strasser, G., Pogany, D., Gornik, E., Carlin, J.-F., Gonschorek, M., Feltin, E., and Grandjean, N.: Analysis of degradation mechanisms in lattice-matched InAlN/GaN high-electron-mobility transistors, J. Applied Phys. **106** (2009) 124503. (SCI 39, SCOPUS 1)
5. **Kuzmik**, **J**.: InAlN/(In)GaN high electron mobility transistors: some aspects of the quantum well heterostructure proposal, Semicond. Sci Technol. **17** (2002) 540-544. (SCI 35, SCOPUS 4)
6. **Stoklas**, **R**., **Gregušová**, **D**., **Novák**, **J**., Vescan, A., and **Kordoš**, P.: Investigation of trapping effects in AlGaN/GaN/Si field-effect transistors by frequency dependent capacitance and conductance analysis, Applied Phys. Lett. **93** (2008) 124103. (SCI 33, SCOPUS 2)
7. Dobročka, E. and **Osvald**, **J**.: Influence of barrier height distribution on the parameters of Schottky diodes, Applied Phys. Lett. **65** (1994) 575. (SCI 33, SCOPUS 1)
8. **Plecenik**, **A**., Grajcar, M., **Beňačka**, **Š**., Seidel, P., and Pfuch, A.: Surface characterization of high-T_c superconductors using $YBa_2Cu_3O_x$/Au and $Bi_2Sr_2CaCu_2O_y$/Au point contacts, Phys. Review B **49** (1994) 10016. (SCI 33)
9. **Gömöry**, **F**., **Vojenčiak**, **M**., **Pardo**, **E**., **Solovyov**, **M**., and **Šouc**, **J**.: AC losses in coated conductors, Supercond. Sci Technol. **23** (2010) 034012. (SCI 32)
10. **Osvald, J**. and Horváth, Zs.J.: Theoretical study of the temperature dependence of electrical characteristics of Schottky diodes with an inverse near-surface layer, Applied Surface Sci **234** (2004) 349-354. (SCI 30, SCOPUS 1)

2.2.3. List of most-cited authors from the Institute (at most 10 % of the research employees with university degree engaged in research projects) and their number of citations in the assessment period (2011– 2014).

1.	Ing. J. Kuzmík, DrSc.	590
2.	doc. Ing. F. Gömöry, DrSc.	415
3.	Ing. K. Fröhlich, DrSc.	289
4.	Ing. J. Šouc, CSc.	287
5.	RNDr. D. Gregušová, DrSc.	283
6.	Ing. P. Kováč, DrSc.	264
7.	Ing. I. Vávra, CSc.	236
8.	Mgr. E. Pardo, PhD.	228

- **Supplementary information and/or comments on responses to the scientific output of the institute.**

The response to the scientific output of the IEE SAS is growing in time, in the last 10 years it improved by factor of 3 (see next Figure for WOS citations). In the assessment period, from 2011 to 2014, the number of citations increased 1.5 times. In the year 2014 the overall number of citations was above 1000 (WOS citations - 955, SCOPUS – 64). Average number of citations per scientist (FTE) was ~ 18 in 2014. The graph also shows that its slope within the assessment period is increased as compared to the slope in previous years.



We consider this positive feature as a consequence of several facts.
One is the **growing international collaboration**, in part carried by scientists that returned from postdoctoral or visiting scientist stays abroad. Our investigators are well established in their international communities and take active part in the developments in the concerned research fields. Pleasing is also the growth of foreign researchers interested to carry out a part of their project at the Institute under the tutorship of our scientists.
Positive impact of the ***improvement of the experimental equipment*** (Structural funds started to be implemented in 2009, several new technologies and diagnostic instruments were installed) is also a factor that contributed to better international visibility of our research.
In coherence with our ambition to be a respected international player also the ***management rules,*** as was mentioned in the comments on Institute outputs, emphasize the quality of research and in particular the quality of the journals in which IEE SAS scientists publish.

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

- ## 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.

IEE SAS successfully participated in the EU Framework Programme. From the list of the most cited publications, the most promising and successful research topics of the Institute in the assessed period were GaN-based devices and applied superconductivity. In both fields the groups from the Institute participated in the projects of the EU Framework Programme and belong to the top EU research teams. The major research projects within the assessed period include:

1. GaN-based normally-off high power switching transistor for efficient power converters - HiPoSwitch, 7^{th} FP project
2. Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER, 7^{th} FP project
3. Development qualification of HTSC conductors for fusion magnets, 7^{th} FP project

4. Development and field testing of an efficient YBCO coated conductor based fault current limiter for operation in electricity networks - ECCOFLOW, 7th FP project
5. European development of superconducting tapes: Integrating novel materials and architectures into cost effective processes for power applications and magnets - EUROTAPES, 7th FP project
6. Implementation of activities described in the Roadmap to Fusion during Horizon2020 through a Joint programme of the members of the EUROfusion consortium, Horizon2020-Euratom
7. Highly Safe GaN Metal-Oxide-Semiconductor Transistor Switch - SAFEMOST, International Visegrad Fund
8. Two IEE scientists (E. Pardo, F. Gömöry) were invited to participate in the international team comprising colleagues from KIT Karlsruhe, Tampere University of Technology, Los Alamos National Laboratory and University of Bath selected to produce an extensive Invited Paper covering the field of numerical modelling of superconductors [Grilli, **IEEE Trans. Applied Supercond.** 24 (2014)].
9. Institute is member of the European Energy Research Alliance (EERA), the association coordinating the efforts to develop more efficient and cheaper low carbon energy technologies and the public research pillar of the EU Strategic Energy Technology Plan (SET-Plan). Our scientists from the Department of Spercondcutors are involved in the Joint Programme “Energy Storage”.

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

1. 9th International Conference on Advanced Semiconductor Devices And Microsystems - ASDAM 2012, Nov. 11-15, 2012, Smolenice.
2. 4th International Workshop on Numerical Modelling of High Temperature Superconductors, May 11-05 2014, Bratislava.
3. 10th International Conference on Advanced Semiconductor Devices And Microsystems - ASDAM 2014, Oct. 20-22, 2014, Smolenice (co-organised with STU Bratislava)

2.3.3. List of edited proceedings from international scientific conferences.

1. ASDAM 2012: conference proceedings. Eds. Š. Haščík, J. Osvald. Piscataway: IEEE, 2012. 320 p. ISBN 978-1-4673-1195-3.
2. Superconductor Science and Technology - Special issue on Numerical Modelling of High Temperature Superconductors. Guest Editors E. Pardo, F. Sirois, F. Gömöry. 28 (2015) Iss. 5.

2.3.4. List of journals edited/published by the institute:

2.3.4.1. WOS (IF of journals in each year of the assessment period)

Journal of Electrical Engineering - co-published with STU

IF 2012 0.546

2013 0.42

2014 0.378

2.3.4.2. SCOPUS

Journal of Electrical Engineering - co-published with STU

2.3.4.3. other databases

2.3.4.4. not included in databases

- **National position of the institute**

2.3.5. List of selected projects of national importance

1. Center of Excellence for New Technologies in Electrical Engineering II, ASFEU
2. Center of competence for new materials, advanced technologies and power engineering, ASFEU
3. Development of HD video universal platform for application in broadcasting, education and research (HD Video), ASFEU
4. Effective control of production and consumption of energy from renewable sources, ASFEU
5. Centre of applied research of new materials and technology transfer, ASFEU
6. Towards next generation of III-N high-electron-mobility transistors, APVV
7. Metal-oxide-metal structures for resistive switching based memory cells, APVV
8. Growth of nanowires for photovoltaic applications, APVV
9. Advanced piezoelectric MEMS pressure sensors, APVV
10. Fine-filamentary superconducting MgB_2 wires for steady and alternating current windings, APVV
11. Proximity effect and electron transport in ferromagnet/superconductor nanostructures, APVV
12. Nanostructured materials for sensorics- IOLISEN, APVV
13. Nanomagnets for future nonvolatile memories and high-frequency applications, APVV
14. Research and development of silicon carbide thin film technologies for applications in solar cells and thin film devices, APVV
15. Magnetic field shaping by a combination of superconducting and ferromagentic materials, APVV
16. Broadband MEMS detector of terahertz radiaton, APVV
17. Resistive switching structures for pattern recognition, APVV
18. Investigation of design and manufacturing methods for coils from round high-temperature superconducting conductor, APVV
19. Ultra light composite superconductor based on Mg, B, Ti and Al, APVV
20. Universal nanorod platform for interdisciplinary applications, APVV

2.3.6. Projects of the Slovak Research and Development Agency (APVV) 31

2.3.7. Projects of the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education (VEGA) 32

2.3.8. Projects of SAS Centres of Excellence

2.3.9. National projects supported by EU Structural Funds 9

2.3.10. List of journals (published only in the Slovak language) edited/published by the institute:

2.3.10.1. WOS (IF of journals in each year of the assessment period)

2.3.10.2. SCOPUS

2.3.10.3. Other databases

2.3.10.4. Not included in databases

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

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

2012

1. **Fröhlich**, **K**., Hudec, B., Ťapajna, M., Hušeková, K., Rosová, A., Eliáš, P., Aarik, J., Rammula, R., Kasikov, A., Arroval, T., Aarik, L., Murakami, K., Rommel, M., Bauer, A.J.: TiO_2-based metal-insulator-metal structures for future DRAM storage capacitors. 222nd ECS Meeting. Honolulu, Hawai 2012.
2. **Gömöry**, **F**,. Solovyov, M., Pardo, E., Šouc, J., Seiler, E., and Frolek, L.: Numerical modeling of superconductor properties for AC loss calculation in electric power devices. Inter. Conf. Supercond. Magnetism - ICSM 2012. Istanbul 2012.
3. **Gömöry**, **F**., Šouc, J., Pardo, E., Seiler, E., Solovyov, M., Frolek, L., Skarba, M., Konopka, P., Pekarčíková, M., and Janovec, J.: AC loss in pancake coil made from 12 mm ReBCOtape. Applied Supercond. Conf. Portland 2012.
4. **Gömöry**, F.: Magnetic field shaping by a combination of coated conductor and ferromagnetic tapes. Inter. Conf. on Coated Conductors for Applications. Heidelberg 2012.
5. **Gömöry**, F., Šouc, J., Pardo, E., Kováč, J., Frolek, L., Solovyov, M., and Kováč, P.: AC losses in wires and tapes. Inter. Supercond. Symp. Tokyo 2012.
6. **Chromik**, **Š**., Štrbík, V., Dobročka, E., Beňačka, Š., Šmatko, V., Dujavová, A., Reiffers, M., Liday, J., Španková, M., Knoška, J., and Gaži, Š.: Significant increasing of onset temperature of FM transition in LSMO thin films. Progress in Applied Surface, Interface and Thin Film Sci 2012 - SURFINT-SREN III. Florence 2012.
7. **Kováč**, **P**., Hušek, I., Melišek, T., and Kopera, L.: Filamentary MgB_2 superconductors with titanium barriers. In: Inter. Conf. Supercond. Magnetism - ICSM 2012. Istanbul 2012.
8. **Novák**, **J**., Eliáš, P., Hasenöhrl, S., Vávra, I., Novotný, I., and Kováč, J.: ZnO/GaP Nanowires Prepared by Combination of MOVPE growth and RF sputtering. Progress in Applied Surface, Interface and Thin Film Sci 2012 - SURFINT-SREN III. Florence 2012.
9. **Pardo**, **E**., Šouc, J., and Kováč, J.: Optimization of the AC loss and generated magnetic field in windings made of coated conductor. Inter. Conf. Supercond. Magnetism - ICSM 2012. Istanbul 2012.
10. **Ťapajna**, **M**.: Effect of oxide/barrier interface traps on the electrical properties of GaN based MOS-HEMTs. Inter. Workshop on Semicond. Devices 2012. Sapporo 2012.

2013

11. **Chromik**, **Š**., Štrbik, V., Dobročka, E., Roch, T., Rosová, A., Lalinský, T., Vanko, G., Lobotka, P., and Ralbovský, M.: LSMO thin films with high metal-insulator transition temperature on buffered SOI substrates for uncooled microbolometers. Solid State Surfaces and Interfaces. Smolenice 2013.
12. **Kováč**, **P**., Hušek, I.,Melišek, T., and Kopera, L.: Low weight MgB_2 superconductor for possible aviation, space and wind power applications. The International Congress on Light Materials –Science and Technology (LightMAT2013). Bremen 2013.

2014

13. **Gömöry**, **F**., Solovyov, M., Šouc, J., Vojenčiak, M., and Švec, P.: Dissipation in superconductor/ferromagnet multilayers for AC magnetic cloaking. 4th Inter. Conf. Supercond. Magnetism - ICSM 2014. Antalya 2014.
14. **Gömöry**, **F**., Šouc, J., Vojenčiak, M., and Solovyov, M.: Manufacturing and properties of round cables from CC tapes. Inter. Conf. Superconductivity for Energy 2014. Paestum 2014.
15. **Gömöry**, **F**., Solovyov, M., and Šouc, J.: Layered superconductor/ferromagnet structures for magnetic field cloaking. 2014 MRS Spring Meeting & Exhibit. San Francisco 2014.
16. **Gömöry**, **F**., Šouc, J., Vojenčiak, M., and Solovyov, M.: Low loss cable from high-temperature superconducting tapes. CIMTEC 2014. 6th Forum on New Materials. 7th Inter. Conf. Science and Engineering of Novel Superconductors. Montecatini Terme 2014.
17. **Hulman**, **M**., Kotrusz, P., Vretenár, V., Vincze, A., and Skákalová, V.: The growth and characterisation of carbon nanostructures: graphene and graphene oxide. 15th Joint Vacuum Conf. Vienna 2014.

18. **Korytár**, **D**., Jergel, Ma., Šiffalovič, P., Mikloška, M., Demydenko, M., Zápražný, Z., Ferrari, C., Dobročka, E., and Vagovič, P.: Stochastic and deterministic technologies for X-ray crystal optics. 19th Polish-Slovak-Czech Optical Conference on Wave and Quantum Aspects of Contemporary Optics. Wojanów 2014.
19. **Kuzmík**, **J**.: Material aspects in developing normally-off GaN-based transistors. In: WOCSDICE-EXMATEC 2014. 38th European Workshop on Compound Semicond. Devices and Integrated Circuits and 12th Expert Evaluation & Control of Compound Semicond. Mater. and Technol. Delphi 2014.
20. **Kuzmík**, **J**.: Novel Indium-containing heterostructures for ultra-high speed transistors. Inter. Workshop on Nitrides Semicond. 2014. Wroclaw 2014.
21. **Lobotka**, **P**. et al.: Metallic nanoparticles prepared in ionic liquids. Colloquium of Metallurgy and Metallurgical Engineering - CMME 2014. Tále 2014.
22. **Novák**, **J**., Eliáš, P., Hasenöhrl, S., Laurenčíková, A., Vávra, I., and Novotný, I.: Preparation of nanowires under low pressure conditions. 15th Joint Vacuum Conf. Vienna 2014.
23. **Pardo**, **E**., Šouc, J., and Kováč, J.: AC loss in coated conductor coils in DC bias current. Electronic Materials and Applications 2014. Orlando 2014.
24. **Pardo**, **E**., Šouc, J., and Kováč, J.: Modelling and measurement of AC loss in coated conductor windings. CIMTEC 2014. 6th Forum on New Materials 7th Inter. Conf. Science and Engineering of Novel Superconductors. Montecatini Terme 2014.
25. **Solovyov**, **M**., Šouc, J., and Gömöry, F.: Magnetic cloak for low frequency AC magnetic field. Applied Supercond. Conf. 2014. Charlotte 2014. Invited poster.
26. **Vojenčiak**, **M**.: Application potential of round wires/cables made from CC tapes. Inter. Workshop on Coated Conductors for Applications 2014. Jeju 2014.

2015

27. **Dobročka**, **E**., Novák, P., Búc, D., Harmatha, L., and Murín, J.: X-ray diffraction analysis of residual stresses in textured ZnO thin films. Progress in Applied Surface, Interface and Thin Film Science (SURFINT-SREN IV). Florence 2015.
28. **Fröhlich**, **K**.: Atomic layer deposited films for next generation resistive switching memories. 13th Inter. Baltic Conf. on Atomic Layer Deposition - BALTIC ALD 2015. Tartu 2015.
29. **Chromik**, **Š**., Štrbik, V., Španková, M., Lalinský, T., Vanko, G., Lobotka, P.,Beňačka, Š., and Li, J.: Advanced perovskite thin films and structures for applications. Progress in Applied Surface, Interface and Thin Film Science (SURFINT-SREN IV). Florence 2015.
30. **Kuzmík**, **J**.: Indium-containing heterostructures for ultra-high speed transistors and logic. 11th Topical Workshop on Heterostructure Microelectronics. Takayama 2015.
31. **Osvald**, **J**.: Computational methods in semiconductor structure parameter analysis. Inter. Semicond. Sci Technol. Conf. 2015 - ISSTC 2015. Izmir 2015.
32. **Solovyov**, **M**., Šouc, J., and Gömöry, F.: Magnetic cloak for low frequency AC magnetic field. EUCAS 2015, Lyon.
33. **Ťapajna**, **M**., Gregušová, D., and Kuzmík, J.: GaN metal-oxide-semiconductor HEMTs: selected physical aspects and characterization. 47th Inter. Conf. on Solid State Devices and Mater. - ISSDM. Sapporo 2015.

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

1. Ing. K. Fröhlich, DrSc. - 17th Workshop on Dielectrics in Microelectronics 2012, Dresden
2. Ing. K. Fröhlich, DrSc. - 222nd ECS Meeting. Honolulu, Hawai 2012
3. doc. Ing. F. Gömöry, DrSc. - International Conference on Superconductivity and Magnetism - ICSM 2012, Istanbul
4. doc. Ing. F. Gömöry, DrSc. - International Workshop on HTS Modelling 2012, Barcelona

5. Ing. Š. Chromik, DrSc. - Progress in Applied Surface, Interface and Thin Film Science 2012 - SURFINT-SREN III, Florence
6. Ing. P. Kováč, DrSc. - International Conference on Superconductivity and Magnetism - ICSM 2012, Istanbul
7. Ing. J. Kuzmík, DrSc. - 5th International Conference on Micro - Nanoelectronics, Nanotechnologies and MEMS 2012, Heraklion
8. Ing. J. Kuzmík, DrSc. - Material and device issues of InAlN/GaN heterostructures. ASDAM 2012. Smolenice 2012.
9. doc. Ing. J. Novák, DrSc. - HETECH 2012, Barcelona
10. doc. Ing. J. Novák, DrSc. - Progress in Applied Surface, Interface and Thin Film Science 2012 - SURFINT-SREN III, Florence
11. Mgr. E. Pardo, PhD. - International Conference on Superconductivity and Magnetism - ICSM 2012, Istanbul
12. Mgr. E. Pardo, PhD. - International Workshop on HTS Modelling 2012, Bracelona
13. Ing. K. Fröhlich, DrSc. - E-MRS Spring Meeting 2013, Strasbourg
14. doc. Ing. F. Gömöry, DrSc. - 23th International Conference on Magnet Technology 2013, Boston
15. doc. Ing. F. Gömöry, DrSc. - EUCAS 2013, Genoa
16. Ing. J. Kuzmík, DrSc. - 40th International Symposium on Compound Semiconductors 2013, Kobe
17. doc. Ing. J. Novák, DrSc. - 15th European Workshop on Metalorganic Vapour Phase Epitaxy - EW-MOVPE 2013, Aachen
18. doc. Ing. J. Novák, DrSc. - 18th International Workshop on Heterostructure Technology HETECH 2013, Glasgow
19. doc. Ing. J. Novák, DrSc. - 19th International Vacuum Congress IVC-19 2013, Paris
20. Ing. G. Vanko, PhD. - SPIE Microtechnologies 2013. Smart Sensors, Actuators, and MEMS VI 2013, Grenoble
21. Ing. I. Vávra, CSc. - 19th International Vacuum Congress 2013, Paris
22. Ing. K. Fröhlich, DrSc. - 18th Workshop on Dielectrics in Microelectronics - WODIM 2014, Cork
23. doc. Ing. F. Gömöry, DrSc. - Applied Superconductivity Conference 2014, Charlotte
24. doc. Ing. F. Gömöry, DrSc. - International Conference on Superconductivity and Magnetism - ICSM 2014, Antalya
25. Ing. J. Kuzmík, DrSc. - 25th European Symposium on Reliability of Electron Devices 2014, Berlin
26. Ing. J. Kuzmík, DrSc. - International Workshop on Nitrides Semiconductors 2014, Wroclav
27. Ing. T. Lalinský, DrSc. - ASDAM 2014, Smolenice
28. doc. Ing. J. Novák, DrSc. - 17th International Conference on Metalorganic Vapor Phase Epitaxy 2014, Lausanne
29. Ing. J. Osvald, DrSc. - ASDAM 2014, Smolenice
30. Ing. J. Osvald, DrSc. - International Semiconductor Science and Technology Conference, ISSTC-2014, Istanbul
31. doc. Ing. F. Gömöry, DrSc. - Magnet Technology Conference 2015, Seoul
32. Ing. J. Kuzmík, DrSc. - 11th Topical Workshop on Heterostructure Microelectronics 2015, Takayama
33. Ing. J. Kuzmík, DrSc. - 6th International Symposium on Growth of III-Nitrides 2015, Hamamatsu

34. doc. Ing. J. Novák, DrSc. - 16th European Workshop on Metalorganic Vapour Phase Epitaxy 2015, Lund
35. In. J. Osvald, DrSc. - International Semiconductor Science andTechnology Conference 2015, Izmir
36. Ing. G. Vanko, PhD. - SPIE Microtechnologies 2015: Smart Sensors, Actuators, and MEMS 2015, Barcelona

- **Position of individual researchers in a national context**

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

2013

1. **Cambel**, **V**., Precner, M., Fedor, J., Šoltýs, J.,Tóbik, J., and Karapetrov, G.: Nanomagnetism – actual problems. In: 20. Konferencia slovenských fyzikov. Bratislava 2013.

2015

2. **Korytár**, **D**.,Zápražný, Z., Dobročka E.,Vagovič P., Baumbach, T., Cecilia, A., Hamann, E., Végsö, K., Šiffalovič, P., Jergel, M., Halahovets, Yu., Majková, E., Mikulík, P., Áč, V., and Ferrari, C.: Rtg kryštálová optika. 298. rozhovory: Krystalografie a rtg metody studia materiálů. Praha 2015.

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

1. Ing. P. Lobotka, CSc. - Nanoved 2013, Svit
2. doc. Ing. J. Novák, DrSc. - 1st International Conference on Advances in Electronic and Photonic Technologies - ADEPT 2013, Spa Nový Smokovec
3. Ing. I. Vávra, CSc. - Mikroskopie 2013, Lednice
4. Ing. I. Vávra, CSc. - Nanoved 2013, Svit
5. doc. Ing. J. Novák, DrSc. - 2nd International Conference on Advances in Electronic and Photonic Technologies - ADEPT 2014, Tatranská Lomnica

- **Supplementary information and/or comments documenting the international and national status of the Institute**

The improving position of the Institute in the international and national level can be documented by the fact that.

F. Gömöry received in 2014 the national “Scientists of the year” award for his research leading to new knowledge about the behavior of composite superconductor / ferromagnet in DC and AC magnetic fields.

J. Feilhauer and M. Soloviev are winners of the national “Young Physicists Competition” organized by the Slovak Physical Society in 2013 and 2014, respectively.

P. Kunzo is winner of the “Startup Awards 2013” (category Science) organized by Neulogy,a.s. in Slovakia.

SASPRO projects implemented at IEE SAS

The project is supported partially by Maria Curie fellowship and partially by SAS, and the idea is to attract young scientists from different countries as well as Slovak scientists working aboard, to work at SAS and strengthen its future prospects. The Institute received 4 SASPRO projects in the assessment period, two of them started in 2015, next two from 01/2016. The number of SASPRO post-doc positions documents well the international position of the Institute and supports the idea of the IEE management to attract scientists from different countries to our laboratories.

Invited talks, organization of international conferences

Within the assessed period the IEE SAS had 33 invited talks at international conferences and organized 3 international conferences.
The International Workshop of Numerical Modelling of High Temperature Superconductors became the most important conference specialized in the topic, with attendees from all around the globe. After the conferences in Lausanne, Cambridge and Barcelona, our institute organized the 4^{th} workshop in Bratislava in 2014 (http://www.elu.sav.sk/htsmod2014/). The proceedings, with head editor from the staff of the institute, were published as a special issue of Supercondor Science and Technology, with impact factor 2.7.
Twice the regular conference ASDAM (9^{th} International Conference on Advanced Semiconductor Devices and Microsystems - ASDAM 2012, Nov. 11-15, 2012, Smolenice) and ASDAM 2014, Oct. 20-22, 2014, Smolenice has been co-organized with STU Bratislava.
Together with Charles University (Prague) we organized the 9^{th} Autumn School on X-ray Scattering from Surfaces and Thin Layers, Sept. 25-28 2013, Smolenice.

National projects

IEE SAS belongs to successful organizations at national level. Within assessment period, IEE SAS solved 31 SRDA (APVV) projects, 22 of them coordinated by IEE and in 9 of them the IEE SAS was a partner. In each call, ***the success rate of the Institute was much higher than the average***. The Institute carried out also 32 VEGA projects in the assessed period.

Structural Funds

This scheme has played a crucial role in the improvement of the Institute infrastructure. We can honestly say that within the assessed period the Institute has transformed from weakly- to well-equipped research institution. Regarding the infrastructure, our laboratories have reached the standards of the Western Europe. IEE SAS coordinated 3 ERDF projects and was involved in 6 projects as a partner. The overall budget for instrumentation received by the Institute was almost 10 mil €. It was used for purchase of the equipment for thin-film growth, sample/device fabrication, and characterization. More detailed description of the instrumentation is described in following comments. But, it has to be mentioned, that building up new laboratories (namely those with new technologies) took a lot of energy and time of several scientists involved in the reconstruction. However, we believe that it was not a loss but a good investment that in the future will bring good scientific results published in highly-ranked papers.

Improved infrastructure should lead in the future to ***increased number of scientists from abroad interested in visits of the Institute for short- or even long-time period***, to work at the Institute, in our laboratories. We have observed such interest in last year – we have long term visitors from US, Japan, Turkey, Poland (SASPRO), and Ukraine (SASPRO), and open interest from Taiwan (for PhD study), and India. Such internationalization of the research should lead to further improvement of the scientific level of the Institute in the future.

2.4. Tables of project structure, research grants and other funding resources

- **International projects and funding**

2.4.1. Major projects within the European Research Area and other important project – Framework Programmes of the EU, ERA-NET, European Science Foundation, NATO, COST, INTAS, etc. (here and in items below please specify: 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”),

	Project title	Typ / Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	GaN-based normally-off high power switching transistor for efficient power converters - HiPoSwitch	7thFP-Collab./287602	09/2011 - 02/2015	164 400,00	I/Kuzmík
	Development qualification of HTSC conductors for fusion magnets	7thFP-Collab./FU-CT-2007-00051	01/2007 - 12/2013	1 046 697,00*	I(third party)/Gömöry
	Development and field testing of an efficient YBCO coated conductor based fault current limiter for operation in electricity networks - ECCOFLOW	7thFP-Collab./241285	08/2010 - 07/2013	139 840,00	I/Gömöry
	Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER	7thFP-Collab./308793	01/2012 - 12/2016	147 680,00	I/Kováč
	European development of superconducting tapes - EUROTAPES	7thFP-Collab./NMP3-LA-2012-280432	09/2012 - 02/2017	388 000,00	W/Gömöry
	Energy for a Green Society	ENIAC/270722-2	06/2011 - 05/2014	2 960,00	I/Novák
	Microwave and terahertz metrology for homeland security	EMRP/NEW07	06/2012 - 05/2015	18 000,00	I(third party)/Lobotka
	Hybrid energy storage devices and systems for mobile and stationary applications	COST MP1004	05/2011 - 05/2015		MC Member/Gömöry
	Composites of Inorganic Nanotubes and Polymers - COINAPO	COST MP0902	11/2009 - 11/2013		MC Member/Lobotka
	Nanoscale Superconductivity	COST 4141/12	10/2012 - 10/2016		MC Member/Cambel
	Advanced X-ray spatial and temporal metrology	COST MP1203	11/2012 - 11/2016		MC Member/Korytár
	Colloidal aspects of nanoscience for innovative processes and materials	COST CM1101	01/2012 - 01/2016		MC Member/Lobotka
2013	Exchange on Ionic Liquids - EXIL	COST CM1206	05/2013 - 05/2017		MC Member/Lobotka
	Enhanced x-ray tomographic reconstruction: experiment, modeling, and algorithms	COST MP1207	05/2013 - 05/2017		MC Member/Zápražný
2014	Implementation of activities described in the Roadmap to Fusion during Horizon2020 through a Joint programme of the members of the EUROfusion consortium	Horizon2020-Euratom/633053	01/2014 - 12/2018	60 000,00	I(third party)/Vojenčiak
	Hooking together European research in atomic layer deposition - HERALD	COST MP1402	12/2014 - 12/2018		MC Member/Fröhlich
2015					

All the sums are the total project costs for IEE SAS.

*** Real reimbursment for IEE SAS is 209 339 €**

2.4.2. Other international projects, incl. total funding and funding for the institute

Title: Highly Safe GaN Metal-Oxide-Semiconductor Transistor Switch - SAFEMOST

Type of project: International Visegrad Fund
Duration month/year-month/year: 10/2015 - 10/2018
Total funding: 125 000 €
Responsible person in the institute: Ing. Kuzmík Ján, DrSc.
Status in the project: Coordinator

2.4.3. Other important, international projects and collaborations without direct funding (max. 10 projects)

Inter-governmental agreement (MAD)

1. **Title:** Preparation and properties of superconducting, manganite and dielectric films for cryoelectronic structures
   Duration month/year-month/year: 01/2010 - 12/2012
   Responsible person in the institute: Ing. Štefan Chromik, DrSc.
   Partners: PAV, Poland

2. **Title:** Advanced M(N)EMS devices on the base of GaN-Diamond material
   Duration month/year-month/year: 01/2012 - 12/2014
   Responsible person in the institute: Ing. Gabriel Vanko, PhD.
   Partners: AS CR, Czech Republic

3. **Title:** InN heterostructures for ultra-high frequency transistors
   Duration month/year-month/year: 01/2013 - 12/2014
   Responsible person in the institute: Ing. Ján Kuzmík, DrSc.
   Partners: FORTH Crete, Greece

4. **Title:** Investigation of the proximity effect and spin injection in epitaxial bi-layer structures of ferromagnetic manganites and high temperature superconductors
   Duration month/year-month/year: 01/2012 - 12/2015
   Responsible person in the institute: RNDr. Vladimír Štrbík CSc.
   Partners: BAV, Bulgaria

5. **Title:** Perovskite heterostructures of nanometric thickness for sensors and spintronics
   Duration month/year-month/year: 01/2015 - 12/2017
   Responsible person in the institute: RNDr. Vladimír Štrbík CSc.
   Partners: BAV, Bulgaria

6. **Title:** Preparation and properties of superconducting, manganite and dielectric films for modern electronic applications
   Duration month/year-month/year: 01/2013 - 12/2015
   Responsible person in the institute: Ing. Štefan Chromik, DrSc.
   Partners: PAV, Poland

7. **Title:** Crystals for high energy X-ray optics and imaging and X-ray and gamma ray detectors
   Duration month/year-month/year: 01/2013 - 12/2015
   Responsible person in the institute: Ing. František Dubecký, CSc.
   Partners: IMEM-CNR, Italy

- ## National projects and their funding

2.4.4. Projects supported by the Slovak Research and Development Agency (APVV)

Role of the Institute e.g. coordinator “C”, investigator “I”.

	Project title	Typ/ Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	MOS HFET transistors based on III-N semiconductors for high temperature applications	LPP-0162-09	09/2009 - 08/2012	10 580,00	C/Novák
	Towards next generation of III-N high-electron-mobility transistors	0104-10	05/2011 - 04/2014	110 687,00	C/Kuzmík
	Metal-oxide-metal structures for resistive switching based memory cells	0509-10	05/2011-04/2014	130 774,00	C/Fröhlich
	Growth of nanowires for photovoltaic applications	0301-10	05/2011-04/2014	111 552,00	C/Novák
	Multifunctional detector arrays based on micromechanical structures	0199-10	05/2011 - 10/2014	63 616,00	I/Vanko
	Advanced piezoelectric MEMS pressure sensors	0450-10	05/2011-10/2014	87 441,00	C/Lalinský
	Fine-filamentary superconducting MgB_2 wires for steady and alternating current windings	0495-10	05/2011 - 04/2014	178 497,00	C/Kováč
	GaN-based normally-off high power switching transistor for efficient power converters - HiPoSwitch	DO7RP 0021-11	09/2011-02/2015	34 571,00	C/Kuzmík
	Progressive materials with competing order parameters	0036-11	07/2012-06/2015	46 777,00	I/Cambel
	Proximity effect and electron transport in ferromagnet/superconductor nanostructures	0494-11	07/2012-12/2015	138 150,00	C/Chromik
	Nanostructured materials for sensorics- IOLISEN	0593-11	07/2012-12/2015	168 661,00	C/Lobotka
	New semiconductor detectors of neutrons	0321-11	01/2012-12/2015	89 966,00	I/Zaťko
	Crystal elements of X-ray optics for beam compression and expansion	0308-11	07/2012-12/2015	80 000,00	I/Korytár
	Monolithic integration of depletion- and enhancement-mode InAlN/GaN HFET transistors	0367-11	07/2012-06/2015	60 000,00	I/Kuzmík
	Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER	DO7RP 0020-12	01/2012-12/2016	12 644,00	C/Kováč
	European development of superconducting tapes - EUROTAPES	DO7RP 0003-10	09/2012-02/2017	47 587,00	C/Gömöry
	Development and field testing of an efficient YBCO coated conductor based fault current limiter for operation in electricity networks - ECCOFLOW	DO7RP 0005-10	08/2010-07/2013	8 000,00	C/Gömöry
2013	Integration of superconducting and manganite films and structures with semiconducting substrate	SK-CN-0012-12	07/2013 - 12/2014	4 926,00	C/Chromik

	Photonic structures for integrated optoelectronics	0395-12	10/2013-12/2016	50 069,00	I/Novák
	Nanomagnets for future nonvolatile memories and high-frequency applications	0088-12	10/2013-03/2017	102 500,00	C/Cambel
	Research and development of silicon carbide thin film technologies for applications in solar cells and thin film devices	0443-12	10/2013-03/2017	114 699,00	C/Huran
	Transistors on the base of progressive materials for high temperatures	0455-12	10/2013-09/2016	121 090,00	I/Vanko
	Magnetic field shaping by a combunation of superconducting and ferromagentic materials	0623-12	10/2013-03/2017	128 196,00	C/Gömöry
2014					
2015	Silicon oxynitride-based photoluminiscent ceramic materials	14-0385	07/2015-06/2019	6 000,00	I/Fröhlich
	Broadband MEMS detector of terahertz radiaton	14-0613	07/2015-06/2018	27 870,00	C/Lalinský
	Resistive switching structures for pattern recognition	14-0560	07/2015-06/2018	20 000,00	C/Fröhlich
	Investigation of design and manufacturing methods for coils from round high-temperature superconducting conductor	14-0438	07/2015-12/2018	32 005,00	C/Šouc
	Ultra light composite superconductor based on Mg, B, Ti and Al	14-0522	07/2015-12/2018	35 121,00	C/Kováč
	Universal nanorod platform for interdisciplinary applications	14-0297	07/2015-12/2018	23 140,00	C/Novák
	Research of the nanomachining technology for active surfaces of the new generation of the X-ray optics	14-0474	07/2015-06/2019	12 500,00	I/Zápražný

2.4.5. Projects supported by the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education (VEGA) for each year, and their funding

VEGA	2012	2013	2014	2015
Number	16	16	18	19
Funding in the year (EUR)	119192	121158	112325	132727 [1]

- **Summary of funding from external resources**

[1] Excluding projects for the popularisation of science

2.4.6. List of projects supported by EU Structural Funds

Project title: Center of Excellence for New Technologies in Electrical Engineering II.
Project number: 26240120019
Duration month/year-month/year: 03/2010 - 02/2013
Funding for Organisation within 2012-2015: 598958
Role of Organisation: Coordinator

Project title: Development of HD video universal platform for application in broadcasting, education and research (HD Video)
Project number: ITMS26240220041
Duration month/year-month/year: 06/2010 - 05/2013
Funding for Organisation within 2012-2015: 246077
Role of Organisation: Investigator

Project title: Effective control of production and consumption of energy from renewable sources
Project number: ITMS 2624220028
Duration month/year-month/year: 05/2010 - 09/2014
Funding for Organisation within 2012-2015: 264371
Role of Organisation: Investigator

Project title: Center of competence for new materials, advanced technologies and power engineering
Project number: 26240220073
Duration month/year-month/year: 09/2011 - 11/2015
Funding for Organisation within 2012-2015: 1613794
Role of Organisation: Coordinator

2012

Project title: Research and development of advanced semiconductor material and substrates VGF GaP with 100 nm diameter for conversion of CO_2 into value addeed chemicals
Project number: ITMS 26220220172
Duration month/year-month/year: 06/2012 - 11/2015
Funding for Organisation within 2012-2015: 570669
Role of Organisation: Investigator

Project title: Research and development center for advanced X-ray technologies
Project number: ITMS 26220220170
Duration month/year-month/year: 06/2012 - 06/2015
Funding for Organisation within 2012-2015: 591956
Role of Organisation: Investigator

2013

Project title: University Science Park of STU Bratislava
Project number: ITMS 26240220084
Duration month/year-month/year: 02/2013 - 05/2015
Funding for Organisation within 2012-2015:
Role of Organisation: Investigator

Project title: Centre for applied research of new materials and technology transfer
Project number: ITMS 26240220088
Duration month/year-month/year: 09/2013 - 12/2015
Funding for Organisation within 2012-2015: 72677
Role of Organisation: Investigator

2014

Project title: Research centre ALLEGRO
Project number: ITMS 26220220198
Duration month/year-month/year: 10/2014 - 12/2015
Funding for Organisation within 2012-2015:
Role of Organisation: Investigator

2.4.7. Summary of external resources of the EU Structural Funds (ERDF/ESF)

Role of the Institute in the project, e.g. coordinator "C", work package leader "W", investigator "I".

Year	Project title	Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute
2012	Center of Excellence for New Technologies in Electrical Engineering II.	ITMS 26240120019	03/2010 - 02/2013	598 958,00	C
	Development of HD video universal platform for application in broadcasting, education and research (HD Video)	ITMS 26240220041	06/2010 - 05/2013	246 077,00	I
	Effective control of production and consumption of energy from renewable sources	ITMS 2624220028	05/2010 - 09/2014	264 371,00	I
	Center of competence for new materials, advanced technologies and power engineering	ITMS 26240220073	09/2011 - 11/2015	1 613 794,00	C
	Research and development of advanced semiconductor material and substrates VGF GaP with 100 nm diameter for conversion of CO_2 into value addeed chemicals	ITMS 26220220172	06/2012 - 11/2015	570 669,00	I
	Research and development center for advanced X-ray technologies	ITMS 26220220170	06/2012 - 06/2015	591 956,00	I
2013	Centre for applied research of new materials and technology transfer	ITMS 26240220088	09/2013 - 12/2015	72 677,00	I
	University Science Park of STU Bratislava	ITMS 26240220084	02/2013 - 05/2015	14 718,00	I
2014	Research centre ALLEGRO	ITMS 26220220198	10/2014 - 12/2015	31 528,00	I
2015					

External resources	2012	2013	2014	2015	total	average
External resources (milions of EUR)	1,315	2,201	0,871	2,555	**6,942**	**1,736**
External resources transfered to coooperating research institute (milions of EUR)	0,446	1,802	0,358	0,241	**2,847**	**0,712**

- **Supplementary information and/or comments on research projects and funding sources**

2.5. PhD studies and educational activities

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

5.2.48 Physical engineering 2004 -

5.2.13 Mikroelectronic 2004 -

4.1.3 Physics of condensed matter and acoustics 2004 -

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

PhD study	31.12.2012			31.12.2013			31.12.2014			31.12.2015		
Number of potential PhD supervisors	33			30			30			33		
PhD students	number	defended thesis	students quitted	number	defended thesis	students quitted	number	defended thesis	students quitted	number	defended thesis	students quitted
Internal	13,0	3,0	1,0	15,0	2,0	0,0	13,0	3,0	2,0	11,0	5,0	0,0
External	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other supervised by the research employees of the institute	0,0	0,0	0,0	0,0	1,0	0,0	0,0	2,0	0,0	0,0	1,0	0,0

2.5.3. Summary table on educational activities

Teaching	2012	2013	2014	2015
Lectures (hours/year)[2]	156	246	206	142
Practicum courses (hours/year)[2]	50	98	24	36
Supervised bachelor theses (in total)	6	4	4	4
Supervised diploma theses (in total)	6	5	2	3
Supervised PhD theses (in total)	18	18	17	16
Members in PhD committees (in total)	5	2	8	3
Members in DrSc. committees (in total)	2	0	5	1
Members in university/faculty councils (in total)	2	2	2	2
Members in habilitation/inauguration committees (in total)	0	2	0	2

[2]

2.5.4. List of published university textbooks

Janovec, J., Skarba, M., Grgač, P., **Gömöry**, **F**., Kusý, M., a Gogola, P.: Progresívne materiály a technológie Bratislava: STU 2012. ISBN 978-80-227-3648-0. 299 s.

2.5.5. Number of published academic course books

2.5.6. List of joint research laboratories/facilities with universities

- **Supplementary information and/or comments on doctoral studies and educational activities**

Policy of the Institue towards internationalization of all activities is reflected in PhD studies. Following PhD students carried out a part of their research work abroad:

P. Husaníková-Barančoková – Drexel University, Philadelphia, USA (1 year)

J. Kováč – CERN Geneva, Switzerland (several 1-2 week long visits)

B. Brunner – Vienna University of Technology, Austria (several visits, in total 9 months)

S. Zajkoska – Austrian Insitute of Techology, Vienna, Austria (6 months)

J. Brndiarová - Max-Planck Institute for Solid State Research, Stuttgart, Germany (2 months).

There was also interest from foreign students to collaborate with our scientists:

J. Viljamaa (after obtaining the Master degree from Tampere University of Technology, Finland) performed all her PhD study at IEE with successful defence in 2012.

N. Amaro (Fac. de Cienc. e Tecnol., Centre of Technol. & Syst., Quinta da Torre, Portugal) went for 3 months in 2013 to perform experiments and computations for his PhD work.

A. Pique (master student from Departament de Física, Universitat Autònoma Barcelona) spent 6 months in 2014 within ERASMUS framework preparing his diploma work

Y. Nagasaki came from NASA Ames laboratories, Moffat Fields, California (USA) for 3 months in 2015 to perform experiments helping him to complete his PhD thesis

R. Terzioglu (Sakarya University, Turkey) came in 2015 for 9-months stay to carry out experiments and analyses that will be used in his PhD thesis

IEE organizes the so-called “Journal Reading” seminar for PhD students, where the students regularly report on the recent papers published in high-quality journals and the presentation is followed by discussion (in English) focused on detail understanding and critical assessment of the presented research by the student.

Approximately every second year, IEE offers an intense course of lectures (about 40 hours in total in three weeks) for PhD students, focused on quantum mechanics, solid-state and mezoscopic physics (led by M. Moško).

In cooperation with FEI STU and FMFI UK, IEE organizes laboratory trainings for undergraduate students focused on solid-state device technology, processing, and characterization (6 lessons, 3 hours each). It typically includes demonstration of epitaxial and oxide growth (MOCVD, ALD), characterization of thin films and realization of planar device technology followed by electrical characterization performed by students. To formalize and strengthen these activities, IEE SAS and FEI STU signed ‘Agreement on Cooperation’ on 15/01/2014, wherein common education (for undergraduate and graduate students) and research activities (common laboratories) are defined.

A one-week course of applied superconductivity combining theoretical lectures and laboratory experiments is organized in the Deparment of Superconductors for bachelor and master students willing to complete their diploma work under the supervision of IEE researchers.

Due to continuous decrease in number of undergraduate students in technical sciences in Slovakia, it became challenging to attract sufficient number of PhD students. Therefore, in last five years we enhanced our activities towards attracting undergraduate as well as graduate students to work at IEE. Our activities include presentation of our results in students magazine OKO (distributed at Slovak University of technology), job fairs organized at STU, and panel

[2] Do not include time spent with bachelor, diploma or PhD students during their supervising

discussions focused on job possibilities for the graduate students (see popularization activities).

2.6. Social impact

2.6.1. List of the most important results of applied research projects. Max. 10 items

Type of project: 7th FP EU
Title: GaN-based normally-off high power switching transistor for efficient power converters - HiPoSwitch
Duration month/year-month/year: 09/2011 - 02/2015
Partners: EpiGaN, AIXTRON
Innovative design and technology of normally-off GaN transistors has been developed and transferred to Ferdinand-Braun Institut (Germany).

Type of project: 7th FP EU
Title: Superconducting, reliable, lightweight, and more powerful offshore wind turbine - SUPRAPOWER
Duration month/year-month/year: 01/2012 - 12/2016
Partners: Oerlikon-Leybold Vacuum GmbH, ACCIONA Windpower, Columbus Superconductor Spa
Novel architecture for composite superconductor developed.

Type of project: 7th FP EU
Title: Development and field testing of an efficient YBCO coated conductor based fault current limiter for operation in electricity networks - ECCOFLOW
Duration month/year-month/year: 08/2010 - 07/2013
Partners: RWE Rhein-Ruhr Netzservice GmbH, Endesa Distributión Eléctrica S.L., A2A RETI Elettriche S.p.A., Nexans, Vychodoslovenska energetika A.S (VSE)
Participation on design of Fault Current Limiter module, device manufactured by industrial partner Nexans (Germany, France).

Type of project: 7th FP EU
Title: European development of superconducting tapes - EUROTAPES
Duration month/year-month/year: 09/2012 - 02/2017
Partners: Bruker HTS GmbH, Nexans, THEVA, Oxolutia, DNano
Collaboration with European industries led to the development of competitive superconducting tapes.

Type of project: EMRP
Title: Microwave and terahertz metrology for homeland security
Duration month/year-month/year: 06/2012 - 05/2015
Partners: Rohde & Schwarz GmbH & Co. KG, SLT Sensor- und Lasertechnik GmbH
Terahertz radiation detector (bolometer) has been developed and manufactured in small series.

2.6.2. List of the most important studies commissioned for the decision-making authorities, the government and NGOs, international and foreign institutes

2.6.3. List of contracts and research projects with industrial and other commercial partners, incl. revenues

- **Contracts**

Title: Magnetization and AC losses in superconducting conductors and cables
Partner: CERN
Duration: 2012-2014
Revenues (€): 29769

Title: Magnetic measurement of susceptibility
Partner: University of Limerick
Duration: 2012
Revenues (€): 3500

Title: Modelling of 40 MVA Superconducting Transformer
Partner: Robinson Research Institute, Victoria University of Wellington
Duration: 2013-2015
Revenues (€): 20511

Title: Design and realization of photolitography contact masks with resolution below 50 um. Desing and realization of precise guiding mask holder for several photolitographic layers with positional precision below 20 um.
Partner: IMEM-CNR, Parma
Duration: 2014
Revenues (€): 725

Title: Preparation of thin oxide layers using ALD or other CVD like methods
Partner: Semikron, s.r.o., Vrbové
Duration: 2014
Revenues (€): 3000

Title: Development of exploratory InN-channel transistors
Partner: University of Oulu
Duration: 2015
Revenues (€): 9000

- **Research projects with industrial and other commercial partners**

Type of project: ASFEU
Title: Development of HD video universal platform for application in broadcasting, education and research (HD Video)
Duration month/year-month/year: 06/2010 - 05/2013
Partners: Monogram Technologies, spol. s r.o.

Type of project: ASFEU
Title: Center of competence for new materials, advanced technologies and power engineering
Duration month/year-month/year: 09/2011 - 05/2015
Partners: Monogram Technologies, spol. s r.o., Slovenské elektrárne, a.s., Geothermal Anywhwere, s.r.o., Západoslovenská energetika, a.s., ZSE Distribúcia, a.s., E.ON Slovensko, a.s., Siemens, s.r.o., MicroStep HDO, s.r.o., SCHRACK TECHNIK, s.r.o.

Type of project: ASFEU
Title: Research and development of advanced semiconductor material and substrates VGF GaP with 100 nm diameter for conversion of CO_2 into value addeed chemicals
Duration month/year-month/year: 02/2012 - 11/2015
Partners: Phostec s.r.o.

Type of project: ASFEU
Title: Research and development center for advanced X-ray technologies
Duration month/year-month/year: 06/2012 - 11/2014
Partners: Integra TDS, s. r. o.

2.6.4. List of licences sold abroad and in Slovakia, incl. revenues

2.6.5. List of most important social discourses under the leadership or with significant participation of the institute (max. 10 items)

Institute is acknowledged as excellent research institution in the field of electronics, electrical engineering, and materials research. During the period of assessment two important officials of domestic politics visited the Institute and discussed with scientists about general science policy issues:
2. 12. 2014 – Andrej Kiska, President of Slovakia
16. 12. 2014 – Juraj Draxler, Minister of Education, Science, Research and Sport

F. Gömöry served as the Chairman of Task Group appointed to elaborate the Regional Smart Specialization Strategy (RIS3) in the priority topic “Sustainable Energy”.
V. Cambel was appointed as a consultant for the Task Group in the priority topic “Materials Research and Nanotechnologies”. The documents approved in December 2015 define the strategy for national research infrastructure development in the programming period ending 2020.

2.6.6. Summary of relevant activities, max. 300 words

Institute research orientation provides good opportunity to utilize the EU Framework Programme as an excellent tool to develop cooperative links to industrial partners. In this way the results of research efforts of our scientists have been transferred to the producers of sensors, devices, and oher products.

Our knowledge of superconductor technology and expertise in numerical modeling were utilized in prestigious research contracts with CERN and with the Robinson Research Institute (Univ. of Wellington, New Zeeland).

2.7. Popularisation of Science (outreach activities)

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

1. Every year Open Day – in 2015 – over 400 visitors
2. Every year European Researchers' Night
3. 14 articles in University student journal OKO – during all period 2012-2015
4. Gömöry, F., Fröhlich, K.: Nočné dialógy, SRO (Night-time Dialogues, Slovak Radio) 13. 5. 2012
5. Gömöry, F.: SAV scientists' breakthrough, The Slovak Spectator Iss. 13, p. 2 (2012)
6. Gömöry, F.: Vedci z SAV zhotovili obal, ktorý je schopný skryť predmety pred magnetickým poľom, SRO (Slovak scientists produced a cover able to hide objects from magnetic field) cloak, Slovak Radio) 27. 3. 2012
7. Lalinský, T. and Vanko, G.: www.bulletins-electroniques.com 25.9.2012
8. Dobročka, E.: Excursion in Rtg laboratory (Bruker) for students of TU Vienna. 19.9.2013
9. Gömöry, F.: Veda v CENTRE: Kvapalný dusík a supravodivý materiál, ako ich vieme využiť? Lecture. (Science in the CENTRE: Liquid nitrogen and superconductors, what use could be of it?, Slovak Centre of Scientific and Technical Information). 27.6.2013
10. Kováč, P.: Supravodivosť v službe medicíny a energetiky, STU Bratislava. (Lecture Superconductivity helping medicine and energy supplies) 19. 4. 2013
11. Kunzo, P.: Predstavujeme finalistov Startup Awards.SK v kategórii veda: Gas sensor. Science.sk (Presenting of finalists of Startup Awards.SK) 21.11. 2013
12. Pitel, J.: EURATOM - fúzia. Lecture - EURATOM-Fusion information day of HORIZONT 2020, STU 21. 11. 2013
13. Šmatko, V. and Kováčová, E.: Popoludnie s vedou pod beckovským hradom. Klub AMAVET, ZŠ J.M.Hurbana, Beckov (Afternoon with science under Beckov castle - lecture for elementary school)
14. Dobročka, E.: Excursion in Rtg laboratory (Bruker) for students of University Nitra. 25. 3. 2014
15. Gömöry, F.: Neplánovaný výskum magnetického plášťa neviditeľnosti, TEDxBratislava (Unintended research of the magnetic invisibility cloak) 4. 7. 2015

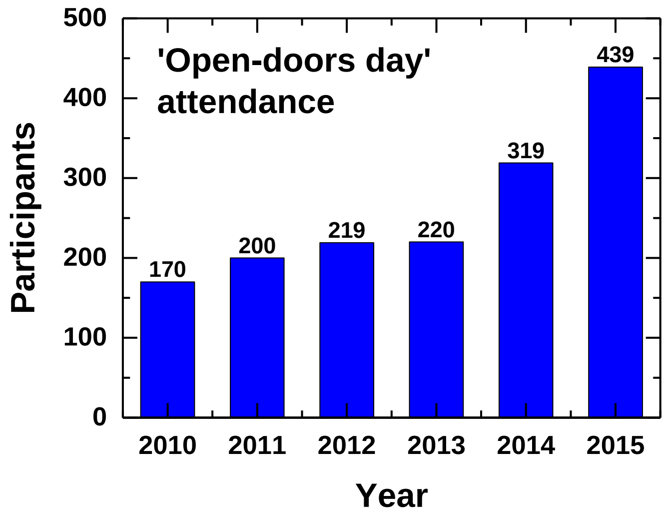
16. Ťapajna, M., Hušeková, K., Jančovič, P., Seifertová, A., and Dobročka, E.: Open Day of IEE SAS. Rádio_FM 11.11.2014
17. Gömöry, F.: Slovenský neviditelný plášť, ČT24 (Slovak invisibility cloak, Czech TV) 24. 1. 2015
18. Novák, J.: NanostĺpikovÝ lesík a antireflexia (Nanord forrest and antireflection). Green business Revue (2015), Iss. 1, p. 51
19. Ťapajna, M.: OZ. Nexteria Career vision. Lecture High School C. S. Lewisa v Bratislave 13. 10. 2015
20. Vanko, G.: Veda na dosah, TV ta3 (Science on touch, Slovak TV) 9. 6. 2015

2.7.2. Table of outreach activities according to institute annual reports

Outreach activities	2012	2013	2014	2015	total
Articles in press media/internet popularising results of science, in particular those achieved by the Institute	12	3	0	14	29
Appearances in telecommunication media popularising results of science, in particular those achieved by the Institute	15	3	1	3	22
Public popularisation lectures	4	9	3	6	22

- **Supplementary information and/or comments on popularisation activities, max. 300 words**

The most important event amongst our popularization activities was the annual ‘Open Doors Day’. The aim of the activity is to encourage young people in continuing their university study in technical and natural sciences. Several demonstration stands focused on material science, microelectronics, and superconductivity are prepared every year in this event, and almost half of the institute’s researchers are being involved. The interest from the schools’ side can be well documented from the number of attendees (shown in the figure below) that increases every year. Since 2014, the interest increased strongly also due to establishing the ‘Week of the Science and Technology’ event (2^{nd} week of November) organized at the SAS level.



Overall number of popularisation activities was over 70 in the assessed period. The improvement as compared with the previous period was namely due to our paper published in Science (Gömöry, Science 2012, topic - Magnetic cloak), which was subsequently discussed in all media in Slovakia. This example clearly shows that the best and easiest publicity of science is based on exciting scientific results.

Presidium of SAS awarded the team of F. Gömöry by the Prize for Popularization in the year 2012.

2.8. Background and management. Human resources and implementation of recommendations from previous assessment

2.8.1. Summary table of personnel

Personnel	2012	2013	2014	2015
All personnel	115,0	115,0	110,0	114,0
Research employees from Tab. Research staff	59,0	56,0	59,0	60,0
FTE from Tab. Research staff	48,620	51,020	52,710	49,820
Average age of research employees with university degree	48,2	48,8	50,1	49,9

2.8.1.1. Professional qualification structure (as of 31.12. 2015) FEMALE

FEMALE	AGE								
Number of	< 30	31 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	> 65
DrSc. / prof.	0	0	0	0	0	0	1	0	0
II.a / Assoc. prof.	0	0	0	0	1	1	0	0	0
Other researchers PhD./CSc.	0	1	1	0	0	0	0	0	0
doc. / Assoc. prof.	0	0	0	0	0	0	0	0	0

2.8.1.2. Professional qualification structure (as of 31.12. 2015) MALE

MALE	AGE								
Number of	< 30	31 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	> 65
DrSc. / prof.	0	0	0	0	0	0	3	6	2
II.a / Assoc. prof.	0	3	5	2	1	0	4	4	5
Other researchers PhD./CSc.	5	3	3	0	0	0	0	1	0
doc. / Assoc. prof.	0	0	0	0	0	0	1	3	1

2.8.2. Postdoctoral and mobility scheme

2.8.2.1. Postdoctoral positions supported by national and international resources

2.8.2.2. Postdoctoral positions supported by external funding

APVV, EU Structural Funds

Mgr. M. Soloviov, PhD. (2012-2013)
Mgr. E. Pardo, PhD. (2012-2015)
Ing. M. Kulich, PhD. (2014-2015)
Mgr. A. Laurenčíková, PhD. (2011-2015)
Ing. G. Vanko, PhD. (2012-2015)
Ing. Z. Zápražný, PhD. (2012-2015)
Ing. F. Gucmann, PhD. (2015)
Mgr. J. Kováč, PhD. (2015)

2.8.2.3. SAS stipends and SASPRO stipends

Mgr. E. Seiler, PhD.
Ing. M. Vojenčiak, PhD.

2.8.2.4. Internal funding - the Slovak Academy of Sciences Supporting Fund of Stefan Schwarz

Mgr. M. Soloviov, PhD.
Ing. M. Vojenčiak, PhD.
Ing. R. Stoklas, PhD.
Ing. K. Čičo, PhD.

2.8.3. Important research infrastructure *(max. 2 pages)*

IEE SAS Research Infrastructure

Research infrastructure has been developed to serve the research at the Institute. It can be divided into three main branches: (i) Technological line for semiconductors, (ii) diagnostic line for semiconductors, and (iii) technological and power testing line for superconductors.

Technological line for semiconductors includes:

- **MOCVD laboratory** for growth of epitaxial layers, heterostructures, and low dimensional structures in GaAs and GaP (Aixtron AIX-200 R&D) and GaN material systems (Aixtron CCS flip top MOCVD) for transistor and photocathode structures;
- **Laboratory of pulsed laser deposition (PLD)** dedicated to deposition of high-quality thin superconducting films and multilayer structures;
- **Atomic layer deposition (ALD) laboratory** for deposition of thin oxide films with atomic level precision on 2D a 3D substrates for transistor and resistive switching applications;
- **Metal deposition laboratory** for evaporation of materials by two independent electron guns and AC and DC sputtering of metallic, insulating, and magnetic materials;
- **Nanostructure laboratory** for micro- and nano-patterning, 3D structure nanostructure formation, and analysis of layered (FEI Quanta 3D Dual microscope);
- **Laboratory for 2D materials** for 2D material preparation by Vapour Transport Method in a three-zone furnace using powders of Ti, Se, Cu, and I;
- **Plasma etching laboratory** for etching of semiconductors based on GaN, GaAs, SiC and dielectrics using CF4 and SF6 gases (Oxford Plasmalab 100 Inductively Coupled Plasma (ICP));
- **Clean room facility** for planar technology equipped with a Karl Suss MJB3 aligner, optical microscopes, deionized water source, and two chemical boxes;

- **Technology laboratory in Piešťany** equipped with two high vacuum evaporation systems, clean room facility for photo-lithographic processing and chemical boxes.

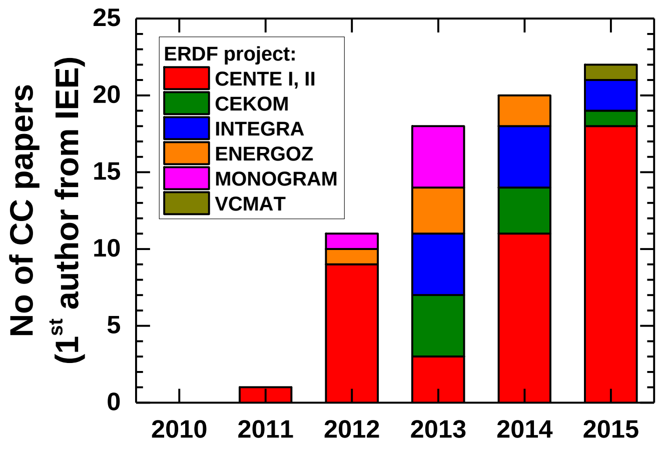
The Diagnostic line for semiconductors includes:

- **X-ray Laboratory** for X-ray diffraction and reflectivity, texture analysis, stress analysis, and reciprocal space mapping equipped with diffractometer Bruker D8 DISCOVER with rotating Cu anode operating at 12 kW;
- **Laboratory for X-ray optics and imaging techniques** for free-space propagation imaging, phase contrast, and computerized tomography equipped with micro-focus X-ray sources Hamamatsu, X-ray camera miniFDI (Photonic Science) and rotary table (Newport);
- **Raman spectroscopy laboratory** equipped with Raman system (WiTEC) with three lasers (355, 532 and 785 nm), confocal microscope, CCD cameras for each laser line, spectrometer for luminescence measurements in the optical and NIR range up to 2.2 μm;
- **Scanning techniques laboratory** for topography imaging (FEG 250 high resolution SEM), analysis of surface roughness, magnetic measurements (NT-MDT NTegra SPM equipped with MFM, EFM, SFM and KPM), and electron beam lithography (FEI Inspect F50 SEM) equipped with Elphy Quantum lithography software (Raith) and laser interferometric measuring system for precise stage positioning;
- **Laboratory for electrical characterization of semiconductor** structures for on-wafer measurements using current- and capacitance-voltage measurements (Keithley 4200 SCS, Agilent 4284A LCR Meter, and Xe lamp with grating monochromator;
- **Laboratory for DC, low frequency, and microwave characterization** of superconducting films and weak links in temperature range 4.2-300 K and magnetic field using various systems (lock-in, sweep oscillator, noise meter, network analyzer);
- **Laboratory of MEMS device characterization** for precise electro-thermo-mechanical characterization of MEMS devices in wide temperature range (77 - 1000 K) and using a chemical gas chamber;
- **Optical laboratory** for optical characterization of semiconductor materials and hetero-structures (photoluminescence, photoreflectance, photoconductivity, transmittance, spectral response) in the 4-300 K range;

Technological and power testing line for superconductors includes:

- **Laboratory of composite superconductors** is equipped for complete manufacturing of composite wirers and cables, rotary swaging, drawing and rolling techniques, heat treatments of powders, metals, and composite wires in oxygen atmosphere, vacuum, or in the inert gas;
- **Laboratory of physical property measurements** for electrical and magnetic characterization of superconductors, magnetic materials, and semiconductors at variable temperatures (2.7 – 300 K) and external magnetic fields (up to 14 T);
- **Laboratory of electric transport testing** is equipped with range of DC sources (up to 2500 A) for analysis of superconducting wires or electrical devices arranged in cryostats at cryogenic temperatures and magnetic fields up to 8.5 T;
- **Laboratory of electromagnetic measurements** for analysis of AC losses in superconducting wires exposed to external magnetic fields with frequencies renging from DC to 200 Hz and amplitude up to 100 mT at variable temperatures from 15.5 K to room temperature.

Roughly 65% of the equipment listed above has been purchased during implementation of the ERDF projects and all this equipment are primarily used for research at the Institute. This can be documented by number of CC papers (1^{st} author form IEE) acknowledging one of the ERDF project shown in the figure below. First ERDF project (CENTE I) has been implemented in 2009 and since then, the number of the papers reached a level of 23 in 2015. Keeping in mind average number of the 1^{st} author publications per year during the assessed period (~42), more than 50% of original research has been facilitaded by the research infrastructure obtained by ERDF projects.



IEE SAS research infrastructure is also available for researchers outside IEE and SAS. Here, three types of access to the equipment are considered: (i) Equipment available at IEE is used by outside users, (ii) IEE's employee is responsible for equipment shared among several institutes, and (iii) IEE's employee conducts technology/diagnostic for outside users. Most relavant outside users are listed in the Table below.

Laboratory	Users outside IEE SAS	Access/Activity
Scanning techniques lab. (SEM, EBL)	II SAS	Regular access to equipment
Nanostructure lab. (FIB)	ICA SAS; FMT SUT Trnava	Regular access to equipment
Lab. for electrical charact. of semicond.	FMSI Univ. of Žilina (UoŽ)	Regular access to equipment
X-ray lab.	IP SAS; IMMM SAS; II SAS; IMR SAS; FEI SUT; Univ. of Trenčín; Int. Laser Center	Performing XRD and XRR analysis for outside users (40%) and maintenance on shared equipment (IP SAS, II SAS, IMS SAS, IMMM SAS)
Raman spectroscopy lab.	IP SAS	Shared with IP SAS
Metal deposition lab. (AYA), Clean room facility, Lab. for phys. property meas. (PPMS)	IEP SAS Košice; Univ. Grenoble Alpes	Preparation and characterization of Hall probes
Lab. of PLD, Clean room facility, Plasma etching lab.	Slovak Inst. of Metrology	Preparation of THz detectors
Lab. for 2-D materials, Metal deposition lab. (AYA), Clean room facility	Drexel Univ. (USA); Temple Univ. (USA); IEP SAS Košice; Univ. Grenoble Alpes	Preparation of $TiSe_2$ films
ALD lab., Clean room facility	FMSI UoŽ	Preparation of structures for complementary resistive switching
ALD lab., Clean room facility , Metal deposition lab. (AYA)	FEI SUT	Preparation of structures for water splitting
MOCVD lab., Optical lab.	FEI UoŽ	Preparation and optical characterization of photonic structures

It is worth mentioning that IEE serves as a local distributor of liquid nitrogen (LN). In 2015, 130,000 litres of LN was provided to 76 customers, while only 5,500 litres was used by IEE.

2.8.4. Description of how the results and suggestions of the previous assessment were taken into account

Comments, objections to organization's activities in form of suggestions and specific tasks which must be performed by organization before next regular evaluation, etc.

a. Knowledge transfer into industrial sector has to be improved

Our collaboration with industry was mainly oriented on European industry partners through common international project (as listed in the part 2.3.1) or through Contracts and Research projects with industrial and other commercial partners as listed in the chapter 2.6.3., and was during the assessed period improved.

In the last period we have developed technology of the switching GaN transistor for power applications, which was later on fabricated by Ferdinand Braun Institute in Germany. Second example is the detector of terahertz radiation tested in Germany - the tests proved that the detector works up to 1.4 THz. Our nanomachining of crystals is important for new generation of x-ray optics – company Bruker is highly interested in our results and we started intense communication for future nanomachining for them. Also our micro–Hall probes are attractive for Japan company Nippon Steel - the results of the first meeting with their representatives are very encouraging, the company wants to test their cables using our micro-Hall probes. We have patented polymer sensor for hydrogen and in 2012 we got gold medal on International patent fair in Taipei, Taiwan, in competition of 2000 patents.

In the field of superconductors (SC) we have developed together with company Nexans (Germany, France) the first model of the cable from the second generation of high temperature superconductors. With the same company we were developing the prototype of short-circuit current limiter. At the moment we are members of consortium led by ICMAB, Barcelona, in which we are responsible for improved architectures of SC tapes for companies Bruker, Theva, and Dnano. We collaborate with the producer of composite SC, with company Columbus (Italy) on the development of light wires for wind turbines under leadership of company Tecnalia (Spain). SC motor of the same power can be realized only with 1/3 of the mass as compared to „classical motor". This is very important for wind turbines, and interesting also for future aircrafts. After successful finishing of the project it will be possible to use the developed technology for SC production. We deal also with computer modelling of 1 MW and 40 MW SC transformers, which are realized by New Zeeland company in collaboration with University in Wellington.

Based on these facts we conclude that the knowledge transfer into industrial sector was improved during the assessed period.

b. The Institute has to look for applications which match better the needs of industry in the country

Reasearch projects mentioned in chapter 2.6.3. include also Structural-fund projects with several Slovak companies involved. The projects established higher level of the collaboration between the Institute and Slovak companies and represent important step towards better matching of Institute activities and the needs of industry in the country. Nevertheless it is still much easier to find industry partner aboard than in Slovakia. Why it is like that?

It has to be stressed here that Slovakia is a specific country in both fields, in R&D and industry as well. The industry is dominated by big foreign companies (Volkswagen, KIA, Peugeot, Samsung, Enel, etc.) or traditional Slovak companies nowadays owned by foreign companies (Slovnaft, Easten Slovakian Steel Company, SlovAlko, Biotika,...). Foreign Companies prefer to control their R&D in mother countries – our attempt to contact few of them was not succesfull in the past. On the other hand, for small Slovak companies it is too risky to introduce high-tech technologies and to support financially their own R&D.

The situation in R&D is as follows, the government supports science at Slovak Academy of Sciences and at some Universities. The system of scientific institutions is not so well structures as e.g. in Germany, where the basic research is coved by Universities and Max-Planck Institutes, and applied research by Fraunhofer and Ferdinand Braun Institutes, with many companies sustaining their own R&D and often collaborating intensively with the governmental Institutes.

Currently the support of science from Slovak government is low, but the expectations are huge – high quality science, application of the results in Slovak companies, high level patenting, edification, and education of experts for companies that often do not use high-technology. It is impossible to handle all these tasks with current budget and man-power, without additional support for IPR, IT, etc. The most important duty of the Institutes is to realize high-level science and applied research. So, if high-tech companies aboard are ready to realize our ideas, we prefer them before national one's that do not offer additional support mentioned above.

Nevertheless, we have visited several small companies in Slovakia within the assessed period and discussed the future collaboration. The companies include Semikron s.r.o. Vrbové, EVPU Nová Dubnica, Sylex s.r.o. Bratislava, Elcom s.r.o., Monogram Technologies a.s., and other. The potential of the Institute is in theoretical calculation and modeling, in thin films-coatings preparationin, application of MEMS sensors and detectors for harsh envinronment, and in x-ray detectors for medicine.

Another step towards better collaboration with industry is the reduction of the number of Scientific Departments - 8 Departments of the Institute were transformed into 4 in 2015. This important change should help also the collaboration with Slovak companies - previous small Departments couldn't easily find enough time and space for intensive collaboration with the industry. Our ambition is that each Department will have at least one collaboration with Slovak industry.

c. ***Special care should be given to use the new equipment effectively, both from the point of view of managing them personally and finding some new attractive and useful research problems.***

The management of the Institute accepted internal rules which guarantee personal responsibility for the research instruments and their wide use by all users that have interest (also those outside of the Institute). Each of the instrument has a person who is responsible for its correct and effective exploitation, and the person has financial bonus for such service. The person controls the equipment regularly, is responsible for service, and in the case of damage organizes its reparation which has to be fast and cheap. The Institute together with the Departments that the instrument uses support its service and reparation financially. Such rules guarantee that the new equipment is used effectively.

The existence of the new equipment itself generated new attractive problems that started to be solved at the Institute experimentally (GaN based heterostructures – growth using MOCVD, structures for resistive switching prepared by ALD, samples for micromagnetometry using SEM with electron lithography, LSMO layers for THz detectors by PLD, lithography at nanoscale for different nanostructures, precise measurements at high magnetic fields and at low temperatures using PPMS, etc.).

New equipments strengthened the scientific level of the Institute. The Institute's research is now very well equipped in thin film technologies – in semiconductor epitaxial thin films and heterostructures, technology of 2D materials as well as oxide and metallic thin films and their combinations.

- **Supplementary information and/or comments on management, research infrastructure, and trends in personnel development**

Management - Research teams are organised in research departments. In 2015 previous eight Departments were transformed into four. First motivation for the change was the fact that several Departments had only 3-4 people with University degree – such small Deparments cannot work effectively and address challenging probles on European and even national level. Another reason for this radical step was to reduce the number of research topics addressed at the Institute, to concentrate the man-power on selected problems in which is the Institute successful, and to improve the overall efficiency of the work at the Institute.
The new Departments represent now sufficiently independent units that should be able to apply for projects at national and international level. The leaders of the Departments manage the research activities and are responsible for scientific outputs and overall scientific activity of the scientists of their Department.
The Institute continues in the organization of annual internal evaluation of the Departments, as well as research activity of individual researches in order to evaluate their individual contribution to the results of the Institution.
Research infrastructure and trends in personnel development - Improved infrastructure should lead in the future to increased number of scientists from abroad interested in visits of the Institute for short- or even long-time period, to work at the Institute and improve our research. In last year we had long term visitors from US, Japan, Turkey, Poland, and Ukraine, and expression of interest from Taiwan, and India. Such internationalization of the research should lead to further improvement of the scientific level of the Institute in the future.
Next important feature in the personnel development is the focus on young researchers. The Institute is active in stabilizing them at the Institute, and actively is searching for high-quality

students, PhD students, and posc docs. For this are important our activities in teaching at universities and in student practical training at the Institute.

3. Research strategy and future development of the institute for the next five years (2016-2020) **(**Recommended 3 pages, max. 5 pages)

3.1. Present state of the art in both the national and the international contexts

3.2. Research strategy of the institute in the national and the international contexts, objectives and methods

Concept of R&D activity of the Organisation for the next four years (max. 5 p.)

Ambition of the Institute is to strenghten its position as internationally distinguished research institution in the fields of electrical engineering, solid state physics, microelectronic and materials research. We strongly believe that excellent knowledge of fundamental physics, material science including applications in sensors and detectors, and theory of electromagnetism are necessary to carry out internationally competitive research in these fields with possible applications in the domains of energy, ICT, safety, and medicine. On the other hand, understanding of industrial processes and trends is necessary for a success in research in the engineering disciplines.

Scientific Board elected by the academic community of the Institute is the body authorised to judge the quality of scientific research and formulate recommendations for improvement. It cooperates with the Institute's management in developing the rules for evaluation of scientific productivity. The restructuring of scientific activities and establishing of four Departments as well as their research focus was approved by the Board as follows:

Physics and technology at nanoscale incorporates activities in 2D materials including graphene and graphene oxide, theory and experiment of resisting switching effect, and effect in nanomagnets including magnetic field imaging.

Activities in **III-V semiconductors** include growth of the heterostructures, processing and testing of fabricated high-power and high frequency transistors. The topic is oriented mostly on GaN based transistors and represents one of the most successful topics solved at the Institute.

Microelectronic devices and sensors represent important part of the Institute activities with possible applications in industry, automobiles, in medicine and in the field of security. Main representatives of the sensors and detectors prepared at the institute are MEMS-based sensor of pressure, terahertz detector, and crystal optics with GaAs radiation detectors.

Superconductors develope new composite wires in the form of filamentary wires and laboratory models/devices using advanced superconductors are investigated with the goal to provide new solutions for electric power (cables, electromagnets, limiters, magnetic cloaks).

i. Present state of of the art in both the national and the international contexts

New **thin film technologies** differ from those used in the past. The difference is coupled to new materials which show unique properties. Here belongs artificial semiconductor GaN, nowadays used for effective lightening (GaN LED diodes), and research teams (including our) are intensively working on its exploitation at high temperatures and in harsh environment. Also 2D materials including graphene and graphene oxide promise interesting applications in IT and sensor-based technologies, medicine, safety, mobility, and other. Next change in the functionality of the devices is connected with lowering of their dimensions. Nowadays, the dimensions approach the edge when quantum properties start to play significant role (energy levels, tunnelling, Coulomb blockade effect, etc.). Quantum properties can be used to improve the device properties (i.e. semiconductor lasers, scanning tunnelling microscope), but often they limit device properties. In skyrmion memories a new principle – spin-orbit interaction – is used to write bits effectively using extremely low energy. Important changes in material properties show also thin films of known materials governed by the interaction of the thin film with substrate – i.e. thin TiO_2 film represents an active layer of the device – a fast hydrogen detector or an element of resistive switching memory, which is a hot candidates for the future high-density memories.

We see that the research of new materials is driven by the development of new technological processes in which the thin film technologies play the key role. It is important to understand the theory of transport in thin films and in nanodevices including quantum effects. The technologies operated by the Institute include atomic layer deposition (ALD), metal organic chemical vapour deposition (MOCVD) for III-V heterostructures, pulsed laser deposition (PLD), vapour transport method for 2D materials, and evaporation/sputtering equipments for thin metallic films – all the techniques are inevitable for micro- and nano-electronics research and/or industrial applications. The techniques together with high-precision electron beam lithography and high-quality dry etching systems represent reproducible, versatile and capable systems for the control of microstructures at nanometer scale. Their further development is a prerequisite for novel structures and devices.

At the Institute, **advanced patterning techniques** (focused ion beam, electron beam, and atomic force microscope lithography) are used to define sub-micrometer structures of new devices. The Institute continues in research that utilizes high permittivity oxides which were introduced to novel microelectronic devices to increase their performance. We study magnetic memory elements, modify tips and cantilevers to improve scanning probe microscopy systems, introduce novel micro- electro- mechanical systems (MEMS) for various applications, develop semiconducting detectors of X-ray radiation, and high-electron mobility transistors (HEMT) based on III-N heterostructures. III-Nitride-based HEMTs are top candidates for a new generation high-power and high-frequency amplifiers due to strong piezoelectric and spontaneous polarization phenomena creating high density of a two-dimensional electron gas in a heterostructure quantum well. That is why we obtained substantial results in the field of high-power and high frequency AlGaN/GaN HEMT amplifier. We suppose a high application potential of the proposed devices and sensors in microelectronics, automotive industry, energy management and in the inspection of the quality of environment. For the novel structures and devices also the methodology of characterization and testing (at high-frequency, low temperatures, HR TEM etc.) is needed and available at SAS.

In our research of **superconductors for power applications** the techniques for filamentary wires manufacturing, structural characterization, and low temperatures measurements are used. This is because the electric wire with diameter typically around 1 mm with isotropic properties is what the electrical engineers expect from material scientists. Interesting research challenges are present for mid-temperature superconductors MgB_2 and iron pnictides, both materials having ceramic structure. Making a wire from MgB_2 requires incorporation of superconductor in form of continuous powder filaments in a suitable metallic matrix. Long-term expertise in the field of metallurgical processing of variable composites allowed our scientists to contribute continuously to rapid development of these advanced conductors. MgB_2 is relatively cheap and scalable superconductor with already started industrial production. Main problems are still in high porosity and brittleness of superconducting filaments. Alternative way of preparing highly dense MgB_2 by the diffusion of Mg into B attracted lot of interest recently. First wires made from pnictides suffered from heavy granularity, the ways to overcome this problem are intensively studied in many groups. Having all the necessary equipment for metallurgical processing and thermal treatment of such composites, the investigation of manufacturing technology of these composites is the natural choice of our materials scientists.

The most promising superconducting wire cooled by liquid nitrogen is the metallic tape covered by ~1 μm film of high-temperature superconductor $RE\mathrm{Ba_2Cu_3O_7}$ (*RE* is one of the rare-earth elements, currently Y or Gd are preferred). Production of such composite in lengths exceeding several hundreds of meters is beyond the capability of our Institute. However, our researchers are strongly involved in the collaboration with tape producers assisting them with characterization and modelling tasks. In the FP7 project Eurotapes we provide highly valued feedback to the companies THEVA and DNano by performing particular experimental tests and sophisticated interpretation of behaviour observed on short samples of the development-stage tapes. Numerical modelling with help of commercial codes as well as home-made programs is in continuous process of improving the models in order to cover better all the complexity of electromagnetic phenomena met in superconducting composites, and our scientists are one of the leading groups in this topic.

Important innovations in the sector of electric power engineering and energy are currently taking place due to superconductors. There is a potential to strongly improve the performance/efficiency of traditional electrical devices and to enable new functions (e.g. transmission of large quantity of energy over long distances, network fault protection, energy storage), thus playing an important role in the low carbon energy scenario and environment protection. Electric machines (generators, turbines, transformers) with windings from superconductors are smaller, lighter and more effective that the classical ones. Optimising the design with help of thorough knowledge of various processes (electromagnetic, thermal, mechanical) taking place during the operation of superconducting devices is a pre-requisite for delivering the solutions that are also economically competitive. Our scientists have significant competences in this regard, and are regularly invited to cooperate with industrial partners on the development of innovative superconducting devices. In particular the topic of energy dissipation at time varying electrical current or magnetic field (commonly called AC loss) is our strong expertise because of original results achieved in various aspects of design, experimental testing as well as theoretical modelling methods.

One of activities involving superconductors are the construction of biggest particle accelerators and the building of devices for thermonuclear fusion. Our Institute has close links to CERN (research contract carried out in the period of assessment, new European project submitted) and is involved in activities of the EUROFusion consortium within Horizon2020, in both cases investigating the possibilities of making large magnets from new superconductors.

ii. Objectives of the Concept

In general, our research strategy is oriented towards continuous production of scientific knowledge that is new on global scale in the fields of electrical engineering, solid state physics, microelectronics, material science and related disciplines and contributes to face the societal challenges in energy supply, information and communication technologies, medicine, environment protection, transport, etc. Basic indicators of performance in this regard are:

- Publishing of results in high quality journals, presentations at international conferences
- Participation in international collaborations, in particular Horizon2020 programme
- Leadership in national projects
- Technology transfer to industry on international and national level
- Hosting of foreign scientists.

Horizontal activities supporting the scientific research are the education of young researchers in PhD programs and an improvement of research infrastructure. Adequate part of our efforts should address also the popularization of the science. Motivating role of the Institute’s management in all these tasks is essential.

iii.Detailed description of the research activities for the next period

2D materials and thin films – The topics **2D materials** includes the preparation of ultrathin (<10 nm) films and monolayers of materials from the group of transition metal dichalcogenides (TMDC). For the preparation, we use mostly a pulse laser deposition (PLD) method and sulfurization / selenization of thin films of transition metals. The layers will be studied with regard to their thickness, crystallinity, and homogeneity. Thin layers of TMDC materials including their heterostructures will be used for fabrication of a variety of electronic devices such as photodetectors and transistors. **Superconducting and dielectric films, and their multilayers** will be prepared using PLD. The preparation of a bolometric model structure on the base of the LSMO films exhibiting transition to the ferromagnetic state at room temperature or above is also one of the goals. In the case of MgB_2 we will focus on the detailed study of the microstructure of the prepared thin films. **Thin films for resistive switching structures** - in the frame of suggested research plan we will develop new type of memory structures based on resistive switching. It appears that mastering of resistive switching structures (memristors) can be used not only in electronic memories, but these structures can imitate human brain operation (pattern recognition, reconfigurable logic circuits, neumorphic computing). **Ferromagnetic thin films** will be prepared to study magnetic effects at nanoscale, spin waves and skyrmions. The theoretical part will deal with magnetic ground state calculations and with dynamic properties of the nanomagnets, including spin waves calculations. Theoretical and experimental approach should lead to new knowledge in the field of magnetism. Based on the knowledge, structures for skyrmion memories as well as microwave devices for quantum informatics will be prepared and tested.

III-V transistors for ultra-fast electronics, high-power switches and III-V nanowires.

The research will be concentrated on progressive III-V transistors for ultra-high frequency circuits of communication and information systems. In the field of MOCVD we will study preparation of unipolar HFET structures with InN channel representing semiconductor material with the highest drift velocity. InN channel will be combined with a semi-insulating InAlN buffer layer which represents another challenging milestone for the growth. To study III-V transistor technology we will apply direct electron lithography for ultra-short gate structures with a variable cross-section, techniques of self-aligned contacts and gate insulation using ALD. **The GaN-based high-power switches** replacement of Si technology in electrical converters will lead to unprecedented energy savings. Nowadays solutions for GaN transistors however do not meet industrial requirements. Thus we will focus on finding ways how to increase the threshold voltage of normally-off planar transistors and how to design vertical transistors for achieving ultra-high break-down voltage. **III-V nanowires** represent a unique system for exploring phenomena at the nanoscale and are also expected to play a critical role in future electronic and optoelectronic devices. The low dimensional nanowire structure is an ideal platform to probe material properties. Extraordinary structural, optical and electrical properties of the NWs predetermined them for exceptional applications, i.e. broadband and omnidirectional antireflection coatings for solar cells, holders of catalyst in chemical reactions, selective sensors for chemicals and pollutants.

Sensors and detectors - MEMS - The goal is to fabricate microsensors that work at extreme conditions (high temperature, chemically aggressive environments). New materials such as III-Nitrides are very attractive for such microsensors, as their excellent piezoelectric properties are preserved in wide temperature range. To realise such microsensors, one has to deal with modelling/simulation of their mechanical/electrical properties, processing technology, evaluation of their functionality, and, finally, validation of the model which includes optimization of the microsensor. **X-ray semiconductor detectors** of ionizing radiation will be based on GaAs and 4H-SiC. Single and 2D pixel detectors for imaging and tomography will be tested in spectrometric and detection experiments, including tests on radiation hardness in harsh environment (e. g. nuclear reactors, high temperature/radiation endurance). X-ray crystal optics will be designed, and together with pixel detectors it will improve methods of X-ray tomography.

Superconductors:

In the next period (years 2016-2020) we will continue in the studies and development of progressive composite superconductors (**MgB_2 and iron pnictides**) and their superconducting, electro-mechanical and thermal properties. Preliminary studies of internal magnesium diffusion (IMD process) of MgB_2 superconductors show a real possibility for an effective improvement of these basic properties. We will follow a possibilities for: improvement of critical current densities in the winding made of MgB2 superconductor in the medium magnetic fields (1-5T), decreasing of MgB_2 composite mass (by Al thermal stabilization), lowering of AC losses (by Rutherford cables) and improvement of strain tolerances (by effective reinforcement). **Electromagnetic properties** of superconducting and ferromagnetic materials will be investigated by theoretical and experimental methods in order to understand better the magnetic flux pinning in superconductors and the electromagnetic behaviour of composites containing both superconducting and ferromagnetic parts. Influence of materials parameters and its microstructure on the process of magnetization will be studied and these features incorporated into theoretical models predicting the performance in wide range of temperatures and magnetic fields. Achieved knowledge will be utilised in the design of innovative devices for the magnetic field shielding and cloaking. Activities addressing the application of superconductors in **electric power devices** like transmission cables, magnets, motors, transformers and fault current limiters will on one side pursue techniques for the most adequate characterization of materials that undergo continuous improvement and on the other side the development of methods that allow the design of devices incorporating all the substantial features of the used materials. Theoretical methods for numerical modelling will be further improved in the computing speed and resolution as well as in better addressing the problems of higher complexity like true 3D modelling instead of using 2D approximations. Experimental techniques will be developed to obtain relevant data and demonstrate the advantages of superconducting devices in the range of temperatures outside the usual fixed-temperature regimes provided by evaporation of cryogenic liquids (4.2 K with helium, 77.3 K with nitrogen). Building of the infrastructure allowing to test small laboratory models operating at temperatures between 20 K and 77 K energized by DC or 50-60 Hz electrical currents as large as 5 000 A is planned.

iv. Proposed strategies and methods to be applied, and time schedule

Four Scientific Departments represent the units with necessary critical mass of researchers allowing to take full responsibility for autonomous formulation of research topics and targets. Common feature and significant strength of the Departments is the ability to cover the whole spectrum of tasks from the material preparation through theoretical and experimental study of the physical phenomena up to the manufacturing of a laboratory prototype of a new device and its experimental testing. We are convinced that such complex approach to research challenges represents a feature that should be further cultivated. It is therefore the prime responsibility of Departments to work on the upgrades of scientific equipment and its effective utilization, to pursue active search of students at all the grades, and organize outreach activities. Financial benefits from external funding are also managed by the Departments, leading to certain differentiation of salaries depending on activity and success rate that may vary in time and among the Departments - such approach will be followed also in the future.

High level of research autonomy requires on the other hand to safeguard certain level of inter-departmental information exchange and discussion. This is secured by several types of seminars accessible to every employee: publication seminars (each paper after being published is briefly explained by the main author), PhD student reviews (at least once a year each PhD student has to present the status of his research), and ad-hoc discussion e.g. about the purchase of important infrastructure. Essential issues regarding the organization and evaluation of scientific work are discussed also in the Scientific Council of the Institute composed of 9 respected scientists from which 3 are from outside. The most important event in this regard are the Department presentations of the activities carried out during the calendar year. This is a whole-day event serving for the information exchange and scientific discussions. Acceptable level of internal competition is assisted by this event, and it is our intention to cultivate it further.

Useful instrument for transparent information about the events, activities, and achieved results, is the web-page of the Institute. Any visitor could easily find the information about experimental facilities, running and finished projects, complete list of publications authored by each employee, announcements of seminars and other events etc. In order to keep pace with the development of social networking the Institute was registered in 2015 at Facebook, Twitter and Researchgate. Vital task in the next period will be to exploit fully the potential of the media.

Important tool for motivating the researchers to concentrate on top quality research is the individual productivity assessment performed yearly. It is based on evaluating several aspects of the researchers activity: number of papers published in high-quality journals, response to the previous work measured by the number of citations, conference presentations (world conferences having higher weight than the regional ones), participation in competitive research projects, involvement in teaching and PhD tuition, participation in outreach actions and other activities serving to improve the conditions for research and overall standing of the Institute. The system is a peer review supported by extensive hard data, and slight improvements towards better valuation of different aspects will be achieved in discussion with the Scientific Board.

In order to promote international collaboration and hosting of foreign scientists the Institute will take more active role in the next period by assisting the Departments in administrative and infrastructural aspects. In particular it will take the responsibility for overcoming administrative barriers in accepting scientists from outside European Community, care for suitable accomodation and provide standard office place for the visiting scientist. It will also encourage scientists to invite applicants for PhD study from outside European Union and establish for this purpose the necessary cooperation with Universities administering our PhD programs.

Cooperation with domestic industry remains an issue where we cannot see an easy solution. Institute's membership in the association of Slovak electro-technical industry “Združenie elektrotechnickeho priemyslu SR“ (ZEP) lead to several presentations and meetings however the extent of real collaborations is still unsatisfactory compared to the cooperation we have with industrial companies abroad. Experience of individual researchers in developing collaboration links indicate that there is a substantial part of high-tech system missing in Slovakia, namely the institutions specialized in technology transfer from academia to industry. Our efforts to act as a substitute have very low efficiency also because of lacking competences in IPR protection, patent law, marketing and other activities as well as venture capital necessary for a successful technology transfer. This should substantially change after the transformation to the public research institution scheduled for 2017 that would allow us to create spin-off companies. The Institute is able to transfer the know-how and share technologies with such spin-off companies. Interesting products of interest for the market read special tips for scanning probe microscopes, detectors for irradiation, THz detectors, MEMS pressure sensors etc.

Project proposals submited to 7RP or H2020	2012	2013	2014	2015
Institute as coordinator	1	0	0	0
Institute as participant	1	0	2	3

4. Other information relevant for the assessment

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RNDr. Vladimír Cambel, DrSc.
director

Bratislava, August 4, 2016