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

Ústav materiálov a mechaniky strojov Slovenskej akadémie vied
Institute of materials and machine mechanics Slovak academy of sciences (IMSAS)
Dúbravská cesta 9/6319
845 13 Bratislava
Slovakia

Previous address (up to 17th January 2016):
Račianska 75
831 02 Bratislava
Slovakia

1.2. URL of the institute web site

http://www.umms.sav.sk

1.3. Executive body of the institute and its composition

Directoriat	Name	Age	Years in the position
Director	Ing. Karol Iždinský, PhD.	57	4
Deputy director	Ing. Mária Lazarová	44	4
Scientific secretary	Ing. Ján Košút, PhD.	58	3

1.4. Head of the Scientific Board

Ing. Juraj Lapin, DrSc.

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	50,0	40,870	48,0	42,030	58,0	38,020	42,0	41,100	**198,0**	**49,5**	**40,505**
Number of PhD students	6,0	4,138	5,0	3,189	7,0	1,659	6,0	3,058	**24,0**	**6,0**	**3,011**
Total number	50,0	45,008	48,0	45,219	58,0	39,679	42,0	44,158	**198,0**	**49,5**	**43,516**

Note 1: All internal PhD students of the institute are also its part-time employees. All PhD students are fully engaged in research projects. $FTE_{PhD\ student} = 1 - FTE_{employee}$.

Note 2: FTE may be grater than number of employees because FTE includes all employees in the year while the number of employees represents number of employees at Dec. 31st, only.

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	50,0	40,870	48,0	42,030	58,0	38,020	42,0	41,100	**49,5**	**40,505**
Division 1 - New materials and technologies and detached workplace INOVAL	17,0	15,200	20,0	18,110	18,0	19,040	17,0	16,250	**18,0**	**17,150**
Division 2 - Microstructure of surfaces and interfaces	15,0	11,580	15,0	10,640	12,0	7,820	13,0	9,000	**13,8**	**9,760**
Division 3 - Properties of materials and structures	14,0	10,690	11,0	11,280	27,0	9,910	11,0	14,850	**15,8**	**11,683**
Public relations department	4,0	3,400	0,0	0,000	0,0	0,000	0,0	0,000	**4,0**	**3,400**
Department of economics and supporting activities	0,0	0,000	2,0	2,000	1,0	1,250	1,0	1,000	**1,3**	**1,417**

Note 1: In 2013, The Public relation department was cancelled. Part of its research employees has been intergrated into Department of economis and supporting activities.

Note 2: FTE may be grater than number of employees because FTE includes all employees in the year while the number of employees represents number of employees at Dec. 31st, only.

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]*	588,533	667,703	595,391	591,203	**610,708**
Other Salary budget *[thousands of EUR]*	509,754	435,859	463,009	513,185	**480,452**

Note: Other Salary budget includes also sources from business activities of the Institute.

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

1. The Institute performs basic and applied research in the field of materials engineering and mechanical engineering:

   Materials engineering is oriented to development of advanced metallic materials, especially composites, metallic foams, nanostructured materials and intermetallic alloys using modern technologies, such as pressure infiltration, plasma spraying, unidirectional solidification of melt, deposit methods joined with pressing, powder metallurgy, nanotechnology, etc. as well as to the research of their physical and mechanical properties on the basis of knowledge of their structures.

   In the field of mechanical engineering, the Institute is oriented mainly to the applied mechanics with emphasis on the research of materials and structures including composites, theory of noise and vibration insulation, acoustic elasticity, destructive and non-destructive testing of materials and structures, in-service life of structures under conditions of fatigue and creep, in conjuction with stress-strain analyses, numerical computations and simulations.

   At the same time, IMSAS´s activities support interdisciplinary projects of SAS, oriented towards material engineering and mechanical engineering.

2. The Institute provides consultation and other expertise services related to the main institute activity.

3. The Institute carries out doctoral study in accordance with applicable laws.

4. The Institute publishes results of its R&D activity using periodical and non-periodical press. Publishing of the periodical and non-periodical press is governed by resolutions of the Presidium of SAS.

5. According to the resolution of the Presidium of the Slovak Academy of Sciences No. 638 from the 1st February 2007 in accordance with Act No. 523/2004 Section 28 paragraph 2 on budget rules of public administration and on change and supplementation of some Acts as amended, the Institute, as a subsidized organisation, beyond the main activity to which it has been established, may carry out business activity which subject is:
   - manufacturing and sale of equipments for testing of new materials,
   - manufacturing and sale of technological equipments for production of new materials,
   - production of specimens and components made from new materials in range of small batch production and their sale.

   The Institute carries out this business activity on the basis of Trade licence issued on 3rd September 2007 by Obvodný úrad v Bratislave, odbor živnostenského podnikania, Staromestská 6, 814 40 Bratislava under No. OŽP-A/2007/37557-2/CR1, No. of trade register 110-171425.

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)

In accordance with the Foundation Charter, IMSAS R&D activities during the assessed period were mainly devoted to:

- ✓ the design and development of advanced metallic materials, in particular metal matrix composites, metallic foams, intermetallics, bulk nanostructured materials and ultrahard coatings,
- ✓ the development of unique technologies for manufacturing of these materials, including vacuum metallurgy, plasma melting, directional solidification, magnetron sputtering, gas pressure infiltration, foaming of aluminium and various advanced powder metallurgy techniques such

as hot and cold isostatic pressing (CIP, HIP), equal channel angular pressing (ECAP) and extrusion or forging of powder mixtures, etc.,

- ✓ the development of advanced techniques for rapid manufacturing of prototypes from the developed materials such as 3D printing, investment casting using printed models, foaming assisted casting, etc.,
- ✓ the advanced characterisation of the developed materials comprising systematic microstructural analysis (incl. X-Ray microtomography, SEM, TEM) and testing of mechanical and physical properties (incl. development of methods for non destructive testing (NDT)),
- ✓ the development of the theoretical base for reliable estimation of fatigue endurance limits of materials and structures working under stochastic loading, for simulation and modelling of their structural and mechanical properties and for evaluation of their behaviour at high temperatures
- ✓ the vibroisolation and attenuation of vibration influence on human body.

The research topics are strongly affected by Institute's research tradition, competence of leading researchers and availability of technological devices and equipment for characterisation and testing. The acquired ability of the IMSAS to convert the research results into practical solutions (components or technological equipment) has attracted the interest of many industrial partners who significantly contributed to initiation of the performed research topics.

As mentioned in the previous assessment, the main research activities of IMSAS **in the field of material research** were planned in following topics:

- ✓ Lightweight metallic materials for structural applications
- ✓ Structural materials for high temperature applications
- ✓ Materials and components for thermal management

In the field of machine mechanics the research was oriented towards identification, simulation and modelling of interactions of structural part with surrounding environment (loading, vibrations, etc.) with main attention paid to:

- ✓ Interactions between road and vehicle
- ✓ Vibration control of structural part with an aim to improve human body protection
- ✓ Operational fatigue endurance of structural part under random loading

Lightweight structural materials

The research objectives were aimed to develop materials enhancing stiffness- and strength-to-weight ratio of the structures. The research activities in this field were mainly devoted to the design, development and optimisation of:

- ✓ complex aluminium alloys with extraordinary mechanical properties prepared via consolidation of rapidly solidified highly alloyed Al powders and melt-spun ribbons (project APVV 0647-10),
- ✓ aluminium matrix composites reinforced with ceramic particles with increased ratio of elastic modulus to density, controlled thermal expansion and improved wear resistance (project VEGA, APVV 0647-10, ERDF project and industrial cooperation),
- ✓ ultra-fine grained Al+Al_2O_3 composites formed during consolidation of ultrafine Al powders with enhanced structural stability and properties at elevated temperatures (project VEGA, APVV 0647-10, bilateral cooperation NSC Taiwan, industrial cooperation),
- ✓ Al+AlN composites containing nanoscale AlN crystallites prepared via partial in situ nitridation of Al powder green compacts in gaseous nitrogen followed with full densification (project VEGA, industrial cooperation),
- ✓ complex lightweight structures based on aluminium foam core with excellent stiffness and strength to weight ratio (project APVV 0647-10, ERDF project and industrial cooperation),
- ✓ magnesium alloys reinforced with continuous carbon fibres for aerospace applications (project ESA).

The most significant results achieved in assessed period:

- A model for suitable composition of complex alloys based on aluminium possessing the elastic modulus up to 100 GPa and a density comparable to conventional Al alloys has been formulated. Optimized AlCrFe based alloy has been investigated in the engine pistons of sports motorcycles, with an almost 30 % reduction in weight.
- The role of oxides on the thermal stability of ultrafine-grained Al–Al_2O_3 composite HITEMAL (high temperature aluminium) prepared by compaction of ultrafine Al powders has been explained. It was shown that the morphological changes in oxide microstructure during first heating after gas atomisation of fine powders have a decisive effect on the subsequent material properties. Based on this knowledge a novel industrially viable manufacturing technique has been developed, resulting in a material with superior mechanical properties, enhanced creep performance and increased thermal stability at elevated temperatures even after prolonged high temperature exposure.
- A novel ultrafine-grained Al matrix composites reinforced with in-situ Al_3Ti filaments were prepared by coextrusion of fine Al and Ti powders. These composites exhibit a combination of increased strength and Young's modulus in addition to excellent creep performance and structural stability.
- The composites based on fine-grained Al powder were developed for the application in containers for storage of used nuclear fuel. The industrially feasible technique assuring the required material properties and component reliability has been proposed and successfully tested (industrial collaboration). The automotive profiles made of various aluminium alloy powders reinforced with SiC particles have been developed for industrial partner. The modulus of elasticity of the composite material produced in industrial conditions exceeded 100 GPa, what resulted in almost 50 % stiffness enhancement as compared to the conventional aluminium profile of the same geometry and weight.
- An original technology for the manufacturing of hybrid plastic mouldings with a core of aluminium foam has been developed and successfully proven in industrial environment. The stiffness and strength of the prototype hybrid casting, consisting of AlSi foam core fully embedded in glass particle reinforced polypropylene, increased almost 10 times if compared to the plain polymer counterpart, while the weight increased only up to 15 %.
- A novel aluminium based master alloy containing 50 vol. % of alumina particles has been developed for manufacturing of cast composite components. The alloy was prepared via gas pressure infiltration of alumina powders, whereas the desired matrix-particle bonding was realised using proper reactive elements (project VEGA).
- Extraordinary mechanical properties of Mg alloys reinforced with continuous carbon fibres were demonstrated. The developed materials regularly possess the bending strength over 900 MPa, Young modulus over 130 GPa while keeping the density of pure Mg. Based on these results a new ESA project aimed in their application in space related structure has been launched (research for ESA).
- A "foaming assisted casting technique" (FACT) for the revolutionary production of large ultralight components (e.g. car body structure) has been developed and patented (PCT, EP). This original method combines traditional gravity casting and foaming into one operation whereas the foam expansion inside the mould cavity creates necessary mould filling pressure and superheated aluminium alloy melt brings required heat to start and carry on the foam expansion inside the mould cavity. The high porosity of final casting in core sections results in excellent stiffness to weight ratio and crashworthiness. The bulk aluminium skin formed by used aluminium alloy melt brings necessary surface quality and strength. The technology was successfully tested on several prototypes of car body structural parts (project APVV, ERDF, industrial cooperation).

Structural materials for high temperature applications

The research objectives were aimed to develop materials enhancing the temperature limits for current structural components. For such components long term high-temperature strength, room-temperature fracture toughness and reliability in operation are crucial issues. The research

activities in this field were mainly devoted to the alloy design, development of processing technology and optimisation of microstructure and mechanical properties of:

- ✓ advanced TiAl-based intermetallics for automotive, power engineering, aircraft and space related applications (projects ESA, APVV, VEGA, industrial cooperation),
- ✓ Ni-based superalloys for turbine blades and power engineering (VEGA, bilateral international project and industrial cooperation),
- ✓ silicide matrix composites reinforced with percolation refractory phase (project Siltrans 7th FP EU),
- ✓ NiAl matrix composites for applications in engine valves (project MATRANS 7th FP EU).

The research on TiAl alloys was based on complex approach including alloy design, ingot metallurgy, fundamental studies of solidification behaviour, solid phase transformations, heat treatments, numerical simulation and characterisation of microstructure and mechanical properties. The effort was focused also on the development of cost-effective casting technology for processing of complex shaped components such as turbocharger wheels containing thin wall blades and thick root. Following important results have been achieved in the assessed period:

- An original numerical Bridgman furnace front tracking model tailored specifically for use with the experiment apparatus, to estimate the transient thermal conditions, growth conditions for columnar to equiaxed transition and other microstructural transitions in TiAl based alloys has been developed. An important link, due to the nature of the power-down technique, between the reversal of radial heat flow in the hot zone of the furnace and unwanted radial columnar growth, was explained using the model.
- An experimental-numerical method where a discrete proportional integral derivative controller manipulates the radial heat flux in a front tracking solidification model so that the output temperature profile matches experimental data has been developed. The method is applicable for other experimentalists and modellers and its usefulness was demonstrated by examples.
- An original knowledge about macrosegregation and microsegregation behaviour of the main alloying elements during columnar to equiaxed transition in ingots from a new peritectic TiAl based alloy prepared at different solidification conditions using: (i) vacuum induction melting and solidification in water cooled crucible, (ii) power down technique in Bridgman type apparatus and (iii) quenching during directional solidification.
- An original “power down technique” for experimental simulation of columnar to equiaxed transition under controlled solidification conditions. First experimental data in the world about columnar to equiaxed transition in several peritectic TiAl based alloys prepared at various constant cooling rates have been produced.
- An original precise casting technology for processing of TiAl turbocharger wheels. The casting technology includes development and optimisation of chemical composition and properties of ceramic crucibles and ceramic moulds for induction melting and casting, respectively. Adaptation of induction furnace for melting of TiAl based alloys including design of resistance furnace for preheating ceramic mould in the vacuum chamber of the furnace.
- New processing route for low cost prototype TiAl turbocharger wheels with a controlled level of contamination acceptable for practical applications. Explanation of the effect of the processing route and experimental parameters on the melt-crucible interactions, chemistry, level of contamination and properties of the castings.
- IMSAS with several member states of ESA also participates on the project with European Space Agency focused on solidification behaviour of TiAl-based alloys in microgravity and hyper gravity conditions using parabolic flight of MAXUS rocket and large centrifuge of ESA.

The internationally recognized reputation of IMSAS in the field of directional solidification and single crystal growth resulted in international bilateral project with TUBITAK MAM (Turkey) focused on fundamental solidification problems and microstructure degradation of single crystalline nickel based superalloy. IMSAS has contributed to the following particular knowledge in this field in assessed period:

- An original knowledge about the effect of solidification parameters on morphology of solid-liquid interface, cellular and dendritic growth during steady state single crystalline growth. The effect of non-steady growth conditions on columnar dendritic growth and columnar to equiaxed transition has been described.
- Elucidation of the effect of multiaxial stress conditions caused by notches on microstructure degradation. The effect of chemical heterogeneity, local stresses and temperature on microstructure degradation within the single crystalline turbine blades of stationary gas turbines has been explained.
- An original model based on numerical calculations of local stresses and microstructural evaluation of degraded microstructure describing the effect of local stresses on orientation of creep rafts.

The activities aimed at the development of material for applications operating in temperature ranges beyond currently used Ni based superalloys have led to the research on novel silicides made in situ during infiltration of refractory metal skeleton (Mo, Nb, W) with liquid silicon. The continuous metallic skeleton provides efficient tool against crack propagation, thus improving fracture toughness of material at both high and low temperatures and silicide matrix increases the creep resistance and helps also against HT oxidation. The knowledge gained by the study of reactive infiltration resulted in the development of new pressure assisted reactive synthesis for the preparation of functionally graded Mo/Mo silicide composites. Newly formed Mo silicides exhibit sufficient plasticity what enables to obtain nearly poreless structures. This was successfully demonstrated on a selected part for space application aimed as a component of thermal protection system for new space shuttle program. The experimental tests confirmed the outstanding oxidation resistance of this structural part. The newly developed gradient Mo/Mo_xSi_y composite has high temperature bending strength of 289 MPa at 1150 ℃ what clearly exceeds that of currently used top PM 1000 material with the strength of 160 MPa (project SILTRANS 7th FP EU).

New family of combustion engine valves based on graded intermetallic Ni-Al alloys reinforced with Al_2O_3 particles was also developed. The technology is derived from reactive pressure infiltration of Ni + Al_2O_3 particles with molten Al. The main advantage of the technology is the preparation of complex parts from materials with very high melting temperatures at the relatively low melting temperature of Al. A series of demonstration valves were prepared. They successfully passed the fatigue tests at 800 ℃ surviving 10^7 loading cycles as well as testing employment in combustion engine. The applied technology has a potential in large scale production (project MATRANS 7th FP EU).

Materials and components for thermal management.

The research objectives were aimed to develop:

- ✓ various copper matrix composites for heat sink applications in automotive components, power electronic, HT reactors, sliding current contacts or special electrodes. The optimisation of composite architecture and tailoring of interfaces was the main objective, with an aim to improve thermal conductivity, control CTE and stabilise the structure under thermocyclic loading. The main target was to increase structural stability of components at constantly changing temperatures and parallel high heat and/or current flux. The composites were prepared by well established gas pressure infiltration (project MATRANS 7th FP EU, APVV, VEGA, industrial cooperation).
- ✓ novel heat storage materials based on aluminium foam infiltrated with proper phase change material (PCM) (project APVV, ERDF).

<u>The most significant results achieved in assessed period:</u>

- Copper matrix composites reinforced with Granoc high modulus short carbon fibre have been developed and tested. Due to the applied gas infiltration technology fibres were oriented predominantly in *x-y* directions. A new CVD process for deposition of carbon nanotubes on the

surface of C fibres in order to increase the thermal conductivity in perpendicular *z* direction has been proposed and realized (VEGA, APVV).

- New type of copper matrix composites reinforced with W wires aimed as cathodes in plasma generating devices have been developed. The geometry and inner architecture of electrode were optimized respecting the discharge – electrode interaction. The composite has been successfully applied in the drilling system based on centric electrodes with rotating discharge. The life cycle for electrodes with Cu/W composite subjected to erosion increased 60 times when compared with traditional copper electrode (ERDF project, industrial cooperation).
- Alternative method for the infiltration of ceramic discs with the diameter of 120 mm with molten copper has been developed. Composite discs aimed as brake discs successfully passed tribological tests. The applied technology can be used for the infiltration of Al_2O_3 preforms with homogeneous as well as graded structure or preforms composed of ceramics segments that very effective hinder the crack propagation in composite. Cu/Al_2O_3 discs with gradient alumina preforms outperformed the currently used grey iron discs. (project MATRANS 7th FP EU).
- New heat storage component based on phase change materials has been proposed and developed for the storage of high temperature solar heat produced by solar concentrators. The component consists of porous solid foam with good thermal conductivity impregnated with PCM having the melting point in the range 300 – 400 ℃. The solar heat storage prototype was successfully applied in the solar power tower by industrial customer (bilateral industrial cooperation).
- Heat exchanger prototype aimed for short time heat storage for train air conditioning based on phase transformations in PCM has been developed and successfully tested. The exchanger based on aluminium foam 150 x 250 x 500 mm (18,5 l) was filled with PCM having melting point of 5 ℃. The heat storage capacity of the com ponent was in the range 12 MJ. Extensive testing confirmed that the composite aluminium foam/PCM can effectively restrain the problem with the insufficient thermal conductivity of PCM and reveals thus very promising potential in all application where excessive heat peaks needs to be avoided (battery housings, power electronics, sensitive machines, breaking systems *etc.*) (APVV project, industrial cooperation).
- The novel heating/cooling panels based on aluminium foam filled with PCM have been developed and systematically tested for the application increasing thermal comfort in small houses. It was confirmed that high thermal conductivity of the aluminium cell walls allows uniform distribution of the heat within the whole panel volume thus improving heat flow into PCM and also heat flow out of it during cooling cycle. The functional foam samples of size 600x600 mm with foamed in steel pipe were prepared and their properties were tested in simulated real conditions in our Smart Grid laboratory. The short term heat storage capacity in the heating/cooling panels may bring revolutionary improvement in the use of easy available renewable heat resources, as it allows time shift between time of their availability and time of their necessity. In our climatic conditions the developed panels allows construction of near zero energy houses at reasonable costs without any compromises with respect to achieved thermal comfort. (APVV project).

In the field of machine mechanics the research was oriented towards identification, simulation and modelling of interactions of structural part with surrounding environment (loading, vibrations, etc.) with main attention paid to:

- ✓ <u>interactions between road and vehicle</u>, in particular to analysis and evaluation of vibration in a road-vehicle-driver interaction system based on real and artificial road profiles; improvement in characterization of the main vehicle excitation source, *i.e.* longitudinal road unevenness, to reflect ride comfort and ride safety in a vehicle; development of new improved vibration isolation system of beam transversal vibrations based on electromagnetic and eddy current principles (projects VEGA),
- ✓ <u>vibration control</u> of structural part with an aim to improve human body protection against whole body vibration, including simulation and modelling, whereas an technically and economically viable vibration control means for vibration mitigation in non-vertical directions has been optimised,

- ✓ estimation and/or calculation of operational fatigue endurance of structural part under random loading, with an aim to develop credible methodology of evaluation of fatigue life, reliability and safety of structure operation for the complicated load conditions and new advanced materials. (projects VEGA, APVV).

The most significant results achieved in assessed period:

related to **vibration analysis in a road-vehicle-driver interaction** system:

- The correlation between twenty-seven road unevenness indicators and vehicle vertical vibration in terms of ride comfort and ride safety for different vehicle speeds was assessed.
- The most appropriate mathematical model of the coherence function between vertical displacements of longitudinal road profile in the left and right tracks was estimated using a 3,500 parallel tracks.
- The optimal analytical approximation of raw road elevation spectrum based on processing real test sections was identified.
- The sensitivity of the twenty-seven road unevenness indicators to the dimensions of various road distresses (height, length, number of obstacles per km) was mutually compared for 3,000 real road profiles.
- The influence of three tyre-road contact models on vehicle vibration response was estimated for 1,600 real road profiles to identify the limits of tyre-road point contact model.
- Fourteen innovative proposals of road unevenness indexes and their correlation with induced vibration response on passenger car and truck model for real profiles were compared.
- The limits of the most widely used indicator of road unevenness, International Roughness Index (IRI), to reflect ride comfort and safety were quantified.
- The conversion relationships between two important unevenness indicators – IRI and straightedge indexes for different boundary conditions were derived.

related to **vibration isolation systems**:

- Theoretical analysis of the influence of electromagnet in combination with a permanent magnet on the system statics and dynamics was thoroughly performed. Analysis showed mitigation of vibration acceleration to two thirds of the value for a mechanical system without the electromagnetic damper.
- A new theory of vibration attenuation based on the eddy current principle was developed; Experimental measurements on real rotary machine at rotational frequency showed mitigation of vibration acceleration to half of the value for a mechanical system without damper. A national patent application (PP50072-2014) on eddy current damping device of beam transversal vibrations was lodged.

related to **operational fatigue**:

- The model of fatigue life calculation in the form of “current fatigue-life distribution function (FLDF)” has been proposed. Current FLDF is computed in real time on the basis of continuos measurement of the loading process and represents the scatter of material’s cyclic properties and course of loading by actual time of operation.
- The methodology of fatigue-life assessment has been extended also to the case of welded joint. The effect of weld grinding has been investigated with the aim to reduce the notch effect of the weld. It has been shown that the effect of weld grinding is of a probabilistic character and the result doesn’t need to be always positive.
- The methodology of continuous assessment of fatigue reliability of the construction has been developed. The method is based on continual computation of the current FLDF and its comparison with the requirements on the structure operation (required service life for allowable probability of premature fatigue fracture occurrence).
- For the purpose of continual monitoring of fatigue damage of the construction the computing program has been developed. The program in real time computes and displays all the

indicators needed for complex assessment of the construction from the point of view of the fatigue-damage (accumulated fatigue damage at current time of operation, immediate probability of survival, immediate residual life for allowable probability of the premature fracture, etc.).

Besides the mainstream research also **additional R&D activities** were performed in the assessed period. These included small scientifically oriented projects funded mostly by SGA SAS, education activities, development of methodology, equipment improvement and expertises for industrial partners. More details concerning these activities are given in next chapters or at the internet web site of IMSAS.

The most important projects include:

- ✓ Deposition of superhard nanostructural composite coatings via reactive magnetron sputtering:

  Si-Cr-N coatings with high content of Si ≥ 25 at.% exhibited an excellent oxidation behaviour resulting from the formation of stable and dense Cr_2O_3 oxide after exposure to temperatures above 1080℃ in air. The formation of crystalline p hases in the coatings from the amorphous structure during annealing reveals a significant effect on increasing coating hardness (up to 34 GPa).

  Thermal stability of Ti–B–N hard coatings was enhanced by alloying with Ta (15–40 at.%). Structural development of the coatings led to the formation of nanocomposite systems consisting of crystalline Ti(Ta)N and disordered a-BTi(Ta)N phases. Ta reveals a positive effect on the elasticity of the Ti–Ta–B–N coating, which may improve toughness and resistance to crack formation.

  It has been confirmed that Ta has also positive effect on the thermal stability of Cr-Al-Y-N coatings. The presence of Ta in the solid solution shifts the start of the decomposition process to higher temperatures (≥1000 ℃ for Ta content of 0.11 at.%).

  TiAlN-based systems highly alloyed (> 25 at. %) with pentavalent VB group elements (Nb, Ta, V) were found to possess improved ductility compared to brittle Ti-Al-N ternaries. The highest hardness ~ 32.5 GPa and the highest Young´s modulus ~ 442 GPa were obtained in Nb-free Ti0.46Al0.54N. Increasing the Nb content resulted in a slight reduction of hardness in the range from ~ 27.9 to ~ 31.1 GPa and in a significant reduction of Young´s modulus from ~ 442 to ~ 358 GPa which leads to toughness enhancement.

  Novel HiPPMS deposition method has been proposed for low friction Cr-C-N and Mo-S coatings on bearing steels. The method allows deposition of hard coatings at very low temperatures up to 180℃, which enables the use of temperature sensitive substrates such as bearing steels.

- ✓ Lead-infiltrated-ceramic electrodes for new type of bipolar batteries

  The long term research in this field for industrial company has been successfully upscaled to the pilot production of standard size electrodes (150 x 200 x 0.7 mm). The relation between infiltration parameters and quality of pore impregnation has been established. New Xray inspection method has been developed for electronic NDT quality control that allows easy and economically feasible inspection of all produced plates.

- ✓ Unique technological facility for the preparation of aluminium and aluminium alloy (Cr, Fe, V, Mo, Li, Si, Ti,Ni, Mn) powders via gas atomizing process has been established. The technology includes the vacuum melting of the alloy, alloy atomizing into fine powders, that subsequently solidify in the cooling tower. The powder is then collected in a cyclone unit and the gas is recycled for repeated atomization cycle. The atomizer makes the preparation of 25 kg powders within one charge possible.

- ✓ Research on biodegradable medical implants

  Composite consisting of biocompatible Ti and biodegradable Mg for dental implants has been was developed. This composite was produced from Ti+Mg powder mixture by hot extrusion. This type of material exhibits lower Young´s modulus, sufficient strength, fatigue performance and bioactive surface helpful for osseointegration. Mg gradually dissolves after implantation

further reducing elasticity modulus and forming additional space for bone implementation (PCT patent application).

Project aimed to develop biodegradable Mg medical implant from pure Mg powder has been launched. The aim is to increase the strength of implants and control dissolution rate via manipulation of surface oxides/nitrides at the original Mg powder particles without use of any alloying elements. First results show remarkable increase of the mechanical properties and decrease in corrosion rate using this approach.

- ✓ Recycling of aluminium chips

  A novel method for recycling of chips from aluminium machining has been developed and successfully implemented at industrial partner. The method comprises environmentally friendly cleaning of chips using distillation techniques followed by hot extrusion without intermediate melting of chips. No chemical additives are used during recycling. The mechanical properties of obtained extruded profiles were in many cases even better than properties of profiles made of primary aluminium, because of the smaller grain sizes in case of chips and the presence of nanometre thick oxides. The reuse of chips via relatively cheap method brings also interesting economic benefit for industrial partner.

- ✓ Proposal for the better use of Slovak resources on magnesite

  A study for Ministry of Education, Science, Research and Sports of Slovak Republic aiming in suggestion of ways for improvement of added value of product made from Slovak magnesite was prepared. Slovakia has large resources of magnesite (worldwide 4th largest), its utilisation is however mostly oriented towards dead burned magnesia for refractory purposes with relatively small added value. In the study performed alternative ways of use has been analysed and assessed from environment and also economic point of view. Production of metallic magnesium via electrolytic decomposition of $MgCl_2$ was suggested as one of the promising ways with future potential in lightweight automotive structures, nevertheless another benefits needs to arise from such production to be worldwide competitive. The utilisation of the potential plant for efficient regulation of Slovak electricity grid and potential use of magnesium as hydrogen storage component were suggested as most efficient future benefits associated with such production. Feasibility calculation has confirmed these assumptions. The results of the study initiated the preparation of Slovak strategic project on this topic.

Highlights of the IMSAS research output in assessed period:

developed knowledge *(see chapter 2.1.2 for references):*

- ✓ explanation of the effect of surface oxides on gas atomised fine Al powder particles on the properties of materials compacted from such powders. The effect of temperature and changes in the oxide structure has been described. The oxides decorate grain boundaries in fine grained structure, thus preventing the grains from growth at elevated temperature. This results also in the extraordinary creep resistance of prepared aluminium based components [3, 13].
- ✓ explanation of the kinetic of nitridation of aluminium powders and determination of the role of alloying elements influencing it significantly [4]
- ✓ explanation of the reaction kinetics and stability of developed products in Mo-Si system during reactive infiltration of Mo with liquid silicon [25]
- ✓ a new theory of vibration attenuation based on the eddy current principle (patent pending PP50072-2014)
- ✓ determination of the correlation between twenty-seven road unevenness indicators and vehicle vertical vibration in terms of ride comfort and ride safety for different vehicle speeds [17, 18, 19]
- ✓ description of macro and microsegregation behaviour of the main alloying elements during columnar to equiaxed transition in ingots made from a new peritectic TiAl based alloy prepared at different solidification conditions using: (i) vacuum induction melting and solidification in water cooled crucible, (ii) power down technique in Bridgman type apparatus and (iii) quenching during directional solidification [28, 30].

new materials:

- ✓ Al-AlN composite with extraordinary structural stability and mechanical properties at elevated temperatures [2, 4]
- ✓ Cu-W composite with proprietary arrangement of W wires for reduced thermal stresses in high heat flux applications (patent pending)
- ✓ Mo/Mo-silicide composite made by reactive infiltration for applications at temperatures over 1200C℃ [25]
- ✓ a new aluminium foam / PCM composite for efficient heat storage application (research for industry)
- ✓ a new hybrid casting comprising porous core made of aluminium foam for lightweight structural applications (patent pending)
- ✓ novel NiAl/alumina composite made by reactive infiltration of Ni/alumina powder mixture with liquid Al [32, 39]
- ✓ novel material for medical implant with partially biodegradable component (patent pending).

new technologies:

- ✓ novel "foaming assisted casting technique" (FACT) for the revolutionary production of large ultralight components (patent pending),
- ✓ novel technology for manufacturing composites aimed for high heat flux (patent pending),
- ✓ novel technology for manufacturing medical implants (patent pending),
- ✓ novel technology for efficient recycling of aluminium chips (research for industry),
- ✓ novel reactive infiltration technology for manufacturing materials with high melting point (aluminides, silicides) [25, 32]
- ✓ cost efficient technology for manufacturing Al/AlN composites (research for industry)
- ✓ novel HiPPMS method for PVD deposition of low friction Cr-C-N and Mo-S coatings on sensitive substrates allowing good adhesion at very low temperatures up to 180℃ (research for industry).
- ✓ industrial extrusion of Al/SiC composites made from powdered precursors (transferred to industrial partner)
- ✓ original precise casting technology for processing of TiAl turbocharger wheels. The casting technology includes development and optimisation of chemical composition and properties of ceramic crucibles and ceramic moulds for induction melting and casting (research for industry).

new products & most important applications:

- ✓ novel composite electrode for bipolar battery (producer Effpower Sweden)
- ✓ infiltrated grafphite sliding contact for locomotives (producer Elektrokarbon Topoľčany)
- ✓ crash box for railway carriages made of aluminium foam (producer IMSAS)
- ✓ heating / cooling panel made of aluminium foam (producer IMSAS)
- ✓ material for containers for used nuclear fuel (supply to Austrian company NMD)
- ✓ novel biomedical tooth implants (IMSAS)
- ✓ heat storage containers (radiators) made of Al-foam infiltrated with PCM (industrial partner - confidential)
- ✓ cast TiAl turbocharger wheels (CCN Castings).

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 = 30% / 70%

international/regional = 60% / 40%

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

1	BALOG, Martin - KRÍŽIK, Peter - NOSKO, Martin - HÁJOVSKÁ, Zuzana - CASTRO RIGLOS, Maria Victoria - RAJNER, Walter - LIU, De-Shin - SIMANČÍK, František. Forged HITEMAL: Al-based MMCs strengthened with nanometric thick Al_2O_3 skeleton. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2014, vol. A 613, p. 82-90. (2.409 - IF2013). (2014 - Current Contents). ISSN 0921-5093.
2	BALOG, Martin - YU, P. - QIAN, M. - BEHULOVA, M. - ŠVEC, Peter - CICKA, R. Nanoscaled Al-AIN composites consolidated by equal channel angular pressing (ECAP) of partially in situ nitrided Al powder. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2013, vol. 562, p. 190-195. (2.108 - IF2012). (2013 - Current Contents, WOS,SCOPUS). ISSN 0921-5093.
3	BALOG, Martin - HU, Tao - KRÍŽIK, Peter - CASTRO RIGLOS, Maria Victoria - SALLER, Brandon D. - YANG, Hanry - SCHOENUNG, Julie M. - LAVERNIA, Enrique J. On the thermal stability of ultrafine-grained Al stabilized by in-situ amorphous Al_2O_3 network. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2015, vol. 648, p. 61-71. ISSN 0921-5093.
4	BALOG, Martin - KRÍŽIK, Peter - YAN, M. - SIMANČÍK, František - SCHAFFER, G.B. - QUIAN, M. SAP-like ultrafine-grained Al composites dispersion strengthened with nanometric AIN. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2013, vol. A 588, p.181-187. (2.108 - IF2012). (2013 - Current Contents, WOS,SCOPUS). ISSN 0921-5093.
5	ČAVOJSKÝ, Miroslav - BALOG, Martin - DVOŘÁK, Jiří - ILLEKOVÁ, Emília - ŠVEC, Peter - KRÍŽIK, Peter - JANIČKOVIČ, Dušan - SIMANČÍK, František. Microstructure and properties of extruded rapidly solidified AlCr4.7Fe1.1Si0.3 (at.%) alloys. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2012, vol.549, p.233-241. (2.003 - IF2011). (2012 - Current Contents, SCOPUS, WOS). ISSN 0921-5093.
6	DUSZA, Ján - MORGIEL, Jerzy - DUSZOVÁ, Annamária - KVETKOVÁ, Lenka - NOSKO, Martin - KUN, Péter - BALÁZSI, Csaba. Microstructure and fracture toughness of Si3N4+graphene platelet composites. In *Journal of the European Ceramic Society*, 2012, vol. 32, p. 3389-3397. (2.353 - IF2011). (2012 - Current Contents, WOS, SCOPUS). ISSN 0955-2219.
7	GRANČIČ, B. - MIKULA, Marian - ROCH, T. - ZEMAN, Petr - SATRAPINSKYY, L. - GREGOR, M. - PLECENIK, T. - DOBROČKA, Edmund - HÁJOVSKÁ, Zuzana - MIČUŠÍK, Matej - ŠATKA, A. - ZAHORAN, M. - PLECENIK, Andrej - KÚŠ, P. Effect of Si addition on mechanical properties and high temperature oxidation resistance of Ti-B-Si hard coatings. In *Surface and coatings technology*, 2014, vol.240, p.48-54. (2.199 - IF2013). (2014 - Current Contents). ISSN 0257-8972.
8	KAVECKÝ, Štefan - VALÚCHOVÁ, Jana - ČAPLOVIČOVÁ, Mária - HEISSLER, Stefan - ŠAJGALÍK, Pavol - JANEK, Marián. Nontronites as catalyst for synthesis of carbon nanotubes by catalytic chemical vapor deposition. In *Applied Clay Science*, 2015, vol. 114, p. 170-178. (2.467 - IF2014). (2015 - Current Contents). ISSN 0169-1317.
9	KHODABAKHSHI, F. - SIMCHI, A. - KOKABI, A.H. - GERLICH, A.P. - NOSKO, Martin. Effects of post-annealing on the microstructure and mechanical properties of friction stir processed Al-Mg-TiO2 nanocomposites. In *Materials and Design*, 2014, vol. 63, p. 30-41. (3.171 - IF2013). (2014 - Current Contents). ISSN 0261-3069.

10	KHODABAKHSHI, F. - SIMCHI, A. - KOKABI, A.H. - ŠVEC, Peter - SIMANČÍK, František - GERLICH, A.P. Effects of nanometric inclusions on the microstructural characteristics and strengthening of a friction-stir processed aluminum-magnesium alloy. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2015, vol. 642, p. 215-229. (2.567 - IF2014). (2015 - Current Contents). ISSN 0921-5093.
11	KHODABAKHSHI, F. - SIMCHI, A. - KOKABI, A.H. - NOSKO, Martin - SIMANČÍK, František - ŠVEC, Peter. Microstructure and texture development during friction stir processing of Al-Mg alloy sheets with TiO2 nanoparticles. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2014, vol.605, no. 5, p.108-118. (2.409 - IF2013). (2014 - Current Contents). ISSN 0921-5093.
12	KOVÁČIK, Jaroslav - EMMER, Š. - BIELEK, J. Thermal conductivity of Cu-graphite composites. In *International Journal of Thermal Sciences*, 2015, vol. 90, p. 298-302. (2.629 - IF2014). (2015 - Current Contents). ISSN 1290-0729.
13	KRÍŽIK, Peter - BALOG, Martin - ILLEKOVÁ, Emília - ŠVEC, Peter - MAŤKO, Igor - ŠTĚPÁNEK, Matěj - NOSKO, Martin - SIMANČÍK, František. The oxidation behavior of gas-atomized Al and Al alloy powder green compacts during heating before hot extrusion and the seggested heating process. In *Journal of Materials Processing Technology*, 2014, vol.214, p.1165-1172. (2.041 - IF2013). (2014 - Current Contents). ISSN 0924-0136.
14	MIKULA, Marian - ROCH, T. - PLAŠIENKA, Dušan - SATRAPINSKYY, L. - ŠVEC, Peter - VLČKOVÁ, D. - DVORANOVÁ, M. - GRANČIČ, B. - GREGOR, M. - PLECENIK, A. - KÚŠ, P. Thermal stability and structural evolution of quaternary Ti-Ta-B-N coatings. In *Surface and coatings technology*, 2014, vol. 259, p. 698 - 706. (2.199 - IF2013). (2014 - Current Contents). ISSN 0257-8972.
15	MIKULA, Marian - GRANČIČ, B. - DRIENOVSKÝ, M. - SATRAPINSKYY, L. - ROCH, T. - HÁJOVSKÁ, Zuzana - GREGOR, M. - PLECENÍK, T. - ČIČKA, R. - PLECENÍK, Andrej - KÚŠ, P. Thermal stability and high-temperature oxidation behavior of Si-Cr-N coatings with high content of silicon. In *Surface and coatings technology*, 2013, vol.232, p.349-356. (1.941 - IF2012). (2013 - Current Contents, SCOPUX). ISSN 0257-8972.
16	MOONEY, Robin P. - MCFADDEN, Shaun - GABALCOVÁ, Zuzana - LAPIN, Juraj. An experimental - numerical method for estimating heat transfer in a Bridgman furnace. In *Applied Thermal Engineering*, 2014, vol.67, pp.61 - 71. (2.624 - IF2013). (2014 - Current Contents). ISSN 1359-4311.
17	MÚČKA, Peter. Correlation among Road Unevenness Indicators and Vehicle Vibration Response. In *Journal of Transportation Engineering ASCE*, 2013, vol.139, p.771-786. (0.863 - IF2012). (2013 - Current Contents, SCOPUS, WOS). ISSN 0733-947X.
18	MÚČKA, Peter. Influence of road profile obstacles on road unevenness indicators. In *Road Materials and Pavement Design*, 2013, vol.14, no.3, pp.689-702. (0.642 - IF2012). (2013 - Current Contents, WOS, SCOPUS). ISSN 1468-0629.
19	MÚČKA, Peter - GRANLUND, J. Is the Road Quality Still Better? In *Journal of Transportation Engineering*, 2012, vol.138, no.12, p.1520-1529. (0.620 - IF2011). (2012 - Current Contents, WOS). ISSN 0733-947X.
20	NAGY, Štefan - NOSKO, Martin - OROVČÍK, Ľubomír - IŽDINSKÝ, Karol - KÚDELA, Stanislav, Jr. - KRÍŽIK, Peter. Pre-review study of the aluminum/alumina master alloy made through pressure infiltration : Short communication. In *Materials and Design*, 2015, vol. 66 Part A, p. 1-6. (3.501 - IF2014). (2015 - Current Contents). ISSN 0261-3069.
21	OROVČÍK, Ľubomír - NOSKO, Martin - ŠVEC, Peter - NAGY, Štefan - ČAVOJSKÝ, Miroslav - SIMANČÍK, František - JERZ, Jaroslav. Effect of the TiH2 pre-treatment on the energy absorption ability of 6061 aluminium alloy foam. In *Materials Letters*, 2015, vol. 148, p. 82-85. (2.489 - IF2014). (2015 - Current Contents). ISSN 0167-577X.
22	ŠEBO, Pavol - ŠVEC, Peter - JANIČKOVIČ, Dušan - ILLEKOVÁ, Emília - ZEMÁNKOVÁ, Milina - PLEVACHUK, Yu - SIDOROV, V. - ŠVEC, Peter Jr. The influence of silver content on structure and properties of Sn-Bi-Ag solder and Cu/solder/Cu joints. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2013, vol. A 571, p. 184-192. (2.108 - IF2012). (2013 - Current Contents, WOS,SCOPUS). ISSN 0921-5093.

23	VIERKE, Jens - SCHUMACHER, Gerhard - BALOG, Martin - NAGY, Juraj - SIMANČÍK, František - WOLLGARTEN, Markus - BANHART, John. Plastic deformation of Al85Ni10La5 by equal channel angular pressing. In *Materials Science and Engineering A - Structural Materials Properties Microstructure and Processing*, 2012, vol.A 558, p.64-69. (2.003 - IF2011). (2012 - Current Contents, SCOPUS, WOS). ISSN 0921-5093.
24	BERONSKÁ, Naďa - IŽDINSKÝ, Karol - ŠTEFÁNIK, Pavol - KÚDELA, Stanislav - DVORÁK, Tomáš - SIMANČÍK, František - HÁJOVSKÁ, Zuzana - RUSNÁK, Andrej. The microstructure and thermal expansion of Mg/C composite prepared by gas pressure infiltration. In *Kovové materiály*, 2015, roč. 53, s. 451-458. (0.406 - IF2014). (2015 - Current Contents, MSCI). ISSN 0023-432X. Dostupné na internete: <http://www.kovmat.sav.sk/>.
25	IŽDINSKÝ, Karol - SENČEKOVÁ, Lucia - SIMANČÍK, František - BERONSKÁ, Naďa - ŠVEC, P. Mo/Mo silicide composites prepared by pressure-assisted reactive infiltration. In *Kovové materiály*, 2015, roč. 53, s. 391-397. ISSN 0023-432X. Dostupné na internete: <http://www.kovmat.sav.sk/>.
26	KAVECKÝ, Štefan - ŠTEFÁNIK, Pavol - IŽDINSKÝ, Karol - NAGY, Štefan - ŠEBO, Pavol - BERONSKÁ, Naďa - OPÁLEK, Andrej. Erosion resistance of copper/alumina composite. In *Kovové materiály*, 2015, roč. 53, s. 463-470. (0.406 - IF2014). (2015 - Current Contents, MSCI). ISSN 0023-432X. Dostupné na internete: <http://www.kovmat.sav.sk/>.
27	KLIMAN, Vladimír - CHMELKO, V. - MARGETIN, M. Analysis of the notch effect of welded joint and of grinding effect. In *Kovové materiály*, 2015, roč. 53, s. 429-441. ISSN 0023-432X. Dostupné na internete: <http://www.kovmat.sav.sk/>.
28	KLIMOVÁ, Alena - LAPIN, Juraj - PELACHOVÁ, Tatiana - NOSKO, Martin. Effect of solidification parameters on microsegregation behaviour of main alloying elements in a peritectic TiAl-based alloy. In *Kovové materiály*, 2013, roč. 51, s. 89-99. (0.687 - IF2012). (2013 - Current Contents, WOS, SCOPUS). ISSN 0023-432X.
29	KÚDELA, Stanislav, Jr. - IŽDINSKÝ, Karol - OSWALD, S. - RANACHOWSKI, P. - RANACHOWSKI, Z. - KÚDELA, Stanislav. Decomposition of silica binder during infiltration of Saffil fiber preform with Mg and Mg-Li melts. In *Kovové materiály*, 2014, roč. 52, č. 4, s. 183 - 188. (0.546 - IF2013). (2014 - Current Contents, WOS, SCOPUS). ISSN 0023-432X.
30	LAPIN, Juraj - KLIMOVÁ, Alena - GABALCOVÁ, Zuzana. Effect of columnar to equiaxed transition on microsegregation behaviour of main alloying elements in peritectic TiAl-based alloy. In *Kovové materiály*, 2013, roč. 51, s.
31	LAPIN, Juraj - PELACHOVÁ, Tatiana - GEBURA, Marek. The effect of creep exposure on microstructure stability and tensile properties of single crystal nickel based superalloy CMSX-4. In *Kovové materiály*, 2012, roč. 50, č.6, s.379-386. (0.451 - IF2011). (2012 - Current Contents, SCOPUS, WOS). ISSN 0023-432X.
32	OPÁLEK, Andrej - ŠTEFÁNIK, Pavol - IŽDINSKÝ, Karol - KÚDELA, Stanislav, Jr. - ZEMÁNKOVÁ, Milina - ŠVEC, Peter Jr. The effect of atmosphere on reactions in Ni-Al green compacts subjected to thermal treatment in argon and air. In *Kovové materiály*, 2014, roč. 52, č. 5, s. 279 - 285. (0.546 - IF2013). (2014 - Current Contents, WOS, SCOPUS). ISSN 0023-432X.
33	SENČEKOVÁ, Lucia - IŽDINSKÝ, Karol - SIMANČÍK, František - MINÁR, Pavol - NOSKO, Martin - ŠVEC, P. The effect of Nb interlayers on compaction of Mo/Mo silicide composites. In *Kovové materiály*, 2012, roč. 50, s.425-432. (0.451 - IF2011). (2012 - Current Contents, SCOPUS, WOS). ISSN 0023-432X.
34	ŠTAMBORSKÁ, Michaela - LAPIN, Juraj - BAJANA, Otto - LOSERTOVÁ, M. Tensile deformation behaviour of ferritic-pearlitic steel studied by digital image correlation method. In *Kovové materiály*, 2015, roč. 53, s. 399-407. ISSN 0023-432X. Dostupné na internete: <http://www.kovmat.sav.sk/>.
35	BALOG, Martin - FLOREK, Roman - NOSKO, Martin - SIMANČÍK, František. Self-propagating synthesis of Ti-Al-C powder mixtures. In *Key Engineering Materials*, 2012, vol.520, p.347-352. (2012 - SCOPUS). ISSN 1013-9826.
36	NOSKO, Martin - SIMANČÍK, František - FLOREK, Roman. The fatigue behaviour of aluminium foam = Vedenje aluminijevih pen pri preizkusu utrujenosti. In *Materiali in tehnologije*, 2013, vol. 47, no.3, p.295. (0.571 - IF2012). ISSN 1580-2949.

37	KORÁB, Juraj - KAVECKÝ, Štefan - ŠTEFÁNIK, Pavol - IŽDINSKÝ, Karol - SIMANČÍK, František - DVORÁK, Tomáš. Microstructure and Thermal Expansion of Hybrid - Copper Alloy Composites Reinforced with Both Tungsten and Carbon Fibres. In *Materials Science Forum*, 2014, vol.782, pp.513-518. (2014 - WOS, SCOPUS). ISSN 0255-5476.
38	KOVÁČIK, Jaroslav - MARSAVINA, L. - ADAMČÍKOVÁ, Andrea - SIMANČÍK, František - FLOREK, Roman - NOSKO, Martin - TOBOLKA, Peter - MINÁR, Pavol - MINÁRIKOVÁ, Natália - JERZ, Jaroslav - LINUL, E. Uniaxial Compression Tests of Metallic Foams: A Recipe. In *Key Engineering Materials*, 2014, vol. 601, p.237-241. (2014 - SCOPUS). ISSN 1013-9826.
39	OPÁLEK, Andrej - IŽDINSKÝ, Karol - NAGY, Štefan - SIMANČÍK, František - ŠTEFÁNIK, Pavol - KÚDELA, Stanislav, Jr.. Microstructure and Properties of Composites Prepared by Reactive Pressure Infiltration of Aluminium into Metal and Ceramic Powder Preforms. In *Materials Science Forum*, 2014, vol.782, pp.523-526. (2014 - WOS, SCOPUS). ISSN 0255-5476.
40	SENČEKOVÁ, Lucia - IŽDINSKÝ, Karol - SIMANČÍK, František - ŠTEFÁNIK, Pavol - ŠVEC, Pavol. The Effect of Ni Interlayers on Compactions of Mo/Mo Silicide Composites. In *Materials Science Forum*, 2014, vol.782, pp. 507-512. (2014 - WOS, SCOPUS). ISSN 0255-5476.
41	ŠTEFÁNIK, Pavol - IŽDINSKÝ, Karol - SIMANČÍK, František - BERONSKÁ, Naďa. Thermal Cycling of Copper Based Composite Reinforced with High Modulus Carbon Fibres. In *Materials Science Forum*, 2014, vol.782, pp.519-522. (2014 - WOS, SCOPUS). ISSN 0255-5476.

2.1.3 List of monographs/books published abroad

2.1.4. List of monographs/books published in Slovakia

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

In 2012, IMSAS participated on analytical study requested by Ministry of Education, Science, Research and Sports of Slovak Republic devoted to the quality of research in the field of light metals and proposal of their further development: „Gaining new knowledge of applied research in the field of engineering and material science for applications in supporting industrial sectors of Slovak Republic“.

In 2014, IMSAS participated on “Feasibility study of technological processing of Slovak magnesite, its extraction and processing waste, as well as magnesium based waste in line with innovative trends in the world, EU and Slovakia” requested by Ministry of Education, Science, Research and Sports of Slovak Republic.

IMSAS was due to its internationally recognized reputation officially asked to take part in the running ESA project to fulfil specific task: Manufacturing of MgLi/C-fibre Metal Matrix composites for the HPMMC project ESA Contract No. 4000108672/13/NL/CBi - Metal Matrix Composites (MMCs) As High Performance Metallic Material HPMMC

Based on the proprietary know how in the field of powder metallurgical preparation of Al composites reinforced with ceramic particles IMSAS has gained a contract for the preparation of containers for used nuclear fuel (all details are condfidential).

As the Institutes’ research activities in assessed period were to a large extent performed within research contracts with industrial partners or in a frame of large research projects of the 7th FP EU (all included large industrial participation), many scientific results could not be published in open literature, because of existing non-disclosure agreements. These results however can be found in plenty of progress reports completed for industrial partners (Havel Metal Foam, Hyundai Motor Europe Technical Center, Elektrokarbon, SAPA, etc.), as well as in technical reports for European Community.

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

IMSAS increased the number of active patents and patent applications from 3 to 10 in spite of relatively large patent costs. We expect that at least two of them *i.e.* "Composite for heat transfer with high-temperature resistance" and "Method of production of component from metal foam, component produced by said method and mould for the realization of said method" have a good potential to bring revenues in the near future as the interest from industry is quite intense.

There have been no licenses sold abroad in current assessed period. However contractual agreements exist with industrial partners, which allow them to use institute's patents under special conditions (*e.g.* long term research projects, lump sum monthly financing the research*, etc.*)

Previously granted active patents:

1	METHOD FOR STRENGTHENING A COMPONENT CONSISTING OF A DEFORMABLE CELLULAR MATERIAL, SAID COMPONENT AND THE USE THEREOF Inventors: Simančík, František – Jerz, Jaroslav Applicant: Institute of Materials and Machine Mechanics SAS (SR). Original application on 4. 4. 2003 - SK20030000425, Publication number: SK4252003 PCT application on 1. 4. 2004 - WO2004EP50419, JP20060505512T, Publication number: WO2004087981, EP1611262, JP2006523536T EP1611262 B1 granted: 16.5.2007 AT362554T T granted: 15.6.2007 DE502004003841D D1 granted: 28.6.2007 ES2285453T T3 granted: 16.11.2007
2	METHOD OF PRODUCING MOLDED BODIES OF A METAL FOAM Inventors: Franz Schorghuber, Frantisek Simancik, Erich Hartl Applicant: Leichtmetallguss-Kokillenbau-Werk Illichmann Gmbh (AT). Original application on 18.4.1997 - US 08/844,227 Publication number: US5865237 A Publication number: 08844227, 844227, US 5865237 A, US 5865237A, US-A-5865237, US5865237 A, US5865237A US5865237 A granted: 2.2.1999, active up to 2014

Patent applications:

1	COMPOSITE FOR HEAT TRANSFER WITH HIGH-TEMPERATURE RESISTANCE Application number: PCT/IB2015/060017 Inventors: Kavecký Štefan, Štefánik Pavol, Iždinský Karol, Simančík František Applicant: Institute of Materials and Machine Mechanics SAS (SR)
2	METHOD OF PRODUCTION OF COMPONENT FROM METAL FOAM, COMPONENT PRODUCED BY SAID METHOD AND MOULD FOR THE REALIZATION OF SAID METHOD Application number: EP15200292.9 Mená autorov: Simančík František, Pavlík Ľubomír, Španielka Ján, Tobolka Peter Applicant: Institute of Materials and Machine Mechanics SAS (SR)
3	METHOD OF PRODUCTION OF COMPONENT FROM METAL FOAM, COMPONENT PRODUCED BY SAID METHOD AND MOULD FOR THE REALIZATION OF SAID METHOD Application number: PCT/IB2015/059639 Inventors: Simančík František, Pavlík Ľubomír, Španielka Ján, Tobolka Peter Applicant: Institute of Materials and Machine Mechanics SAS (SR)
4	BIOAKTIVNI KOMPOZITNI METAL (Bioactive composite metal) Application number: 559-03/2-15-001 (Croatia) Inventors: Balog Martin, Križik Peter, Amir Ćatić, Zdravko Schauperl Applicant: Institute of Materials and Machine Mechanics SAS (SR)

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

Patent applications:

1	SPÔSOB VÝROBY ELEKTRICKEJ ENERGIE, TEPLA A CHLADU POMOCOU ENERGIE SLNEČNEJ, VETERNEJ A ENERGIE ZEMSKEJ KÔRY A JEHO VYUŽITIE PRI STAVBE ENERGETICKY AUTONÓMNYCH STAVIEB (Method of electricity production, heat and cold using the energy of solar and wind and energy from the earth's crust and its utilizing in design of energy autonomous buildings) Application number: PP 5040 - 2013 Inventors: Jerz Jaroslav, Bartko Michal
2	MAGNETIC ABSORBER OF VIBRATION, OPERATING ON BASE OF EDDY-CURRENT, AND ITS POSITION IN OSCILLATING SYSTEM Inventor: Stein Juraj [SK] Applicant: Institute of Materials and Machine Mechanics SAS (SR) IPC: F16F15/03 Publication info: SK500722014 (A3) 2016-07-01 Priority date: 2014-12-02
3	KOMPOZIT NA VEDENIE TEPLA S VYSOKOTEPLOTNOU ODOLNOSŤOU (Composite for heat conduction with high temperature resistance) Application number: PP50091-2015 Inventors: Kavecký Štefan, Štefánik Pavol, Iždinský Karol, Simančík František Applicant: Institute of Materials and Machine Mechanics SAS (SR)
4	SPÔSOB VÝROBY SÚČIASTKY Z KOVOVEJ PENY, SÚČIASTKA VYROBENÁ UVEDENÝM SPÔSOBOM A FORMA NA USKUTOČŇOVANIE SPÔSOBU (Method of production of component from metal foam, component produced by said method and mould for the realization of said method) Application number: PP50082-2015 Inventors: Simančík František, Pavlík Ľubomír, Španielka Ján, Tobolka Peter Applicant: Institute of Materials and Machine Mechanics SAS (SR)

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

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

Scientific publications	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	0,022	0,002	0,0	0,000	0,000	0,0	0,000	0,000	0,0	0,000	0,000	**1,0**	**0,3**	**0,006**	**0,000**
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)*	13,0	0,289	0,022	14,0	0,310	0,021	14,0	0,353	0,024	22,0	0,498	0,037	**63,0**	**15,8**	**0,362**	**0,026**
Scientific papers published in journals registered in Web of Science Core Collection and SCOPUS *(ADMA, ADMB, ADNA, ADNB)*	3,0	0,067	0,005	1,0	0,022	0,001	9,0	0,227	0,015	4,0	0,091	0,007	**17,0**	**4,3**	**0,098**	**0,007**
Scientific papers published in other foreign journals (not listed above) *(ADEA, ADEB)*	2,0	0,044	0,003	2,0	0,044	0,003	1,0	0,025	0,002	3,0	0,068	0,005	**8,0**	**2,0**	**0,046**	**0,003**
Scientific papers published in other domestic journals (not listed above) *(ADFA, ADFB)*	2,0	0,044	0,003	5,0	0,111	0,007	5,0	0,126	0,008	3,0	0,068	0,005	**15,0**	**3,8**	**0,086**	**0,006**
Scientific papers published in foreign peer-reviewed proceedings *(AEC, AECA)*	11,0	0,244	0,019	13,0	0,287	0,019	14,0	0,353	0,024	0,0	0,000	0,000	**38,0**	**9,5**	**0,218**	**0,016**
Scientific papers published in domestic peer-reviewed proceedings *(AED, AEDA)*	0,0	0,000	0,000	1,0	0,022	0,001	0,0	0,000	0,000	0,0	0,000	0,000	**1,0**	**0,3**	**0,006**	**0,000**
Published papers (full text) from foreign and international scientific conferences *(AFA, AFC, AFBA, AFDA)*	2,0	0,044	0,003	2,0	0,044	0,003	7,0	0,176	0,012	9,0	0,204	0,015	**20,0**	**5,0**	**0,115**	**0,008**
Published papers (full text) from domestic scientific conferences *(AFB, AFD, AFBB, AFDB)*	4,0	0,089	0,007	1,0	0,022	0,001	1,0	0,025	0,002	1,0	0,023	0,002	**7,0**	**1,8**	**0,040**	**0,003**

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

The publication activity in the assessed period was strongly affected by EU SF projects which appeared inevitable for improvement of Institute's research infrastructure. These projects finished in 12/2015. Unfortunately preparation and implementation of such projects is coupled with enormous bureaucracy, which exhausted most of the vital resources of active researchers. It is important to know, that our key personnel had to literally supervise the construction of new buildings in Bratislava (Centre of Applied Research and Technology Transfer), Žiar nad Hronom (IMSAS´s branch SAS Innovation center Inoval), and laboratory complex in Trnava (SAS Research centre ALLEGRO) including all furnishing and purchasing of all research infrastructure in the total value exceeding 30 mil €. Moreover, IMSAS had to move in the second half of 2015 with all its personnel and equipments to a new address into current building. This had quite inevitably logical consequences in the reduction of their research and publication activities.
In the previous assessed period 2008-2011 IMSAS published 73 publications (i.e. 73 CC and 0 scientific publications indexed by other databases). In the current assessed period 2012-2015 IMSAS published 80 publications (*i.e.* 63 CC and 17 scientific papers published in journals registered in Web of Science Core Collection and Scopus). There is a clear increasing trend in 2014 and 2015 where the positive effect of new infrastructure appears.
However, due to the predominantly problem solving and not pure fundamental (curiosity driven) research orientation of IMSAS, the main scientific outcomes include besides developed knowledge predominantly new materials, new technologies and new products and important applications, that usually arise from the previously achieved own fundamental research results.
This is further supported by the patent activitites of IMSAS that are important from the overall SAS point of view. In 2015 all institutes of SAS launched 12 Slovak and 6 international patent applications (Výročná správa SAV 2015 – p. 131 http://www.sav.sk/index.php?lang=sk&doc=docs-ann). These included 2 national patent applications from IMSAS (16.7 %) and 4 international patent applications from IMSAS (66.7 %).

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)	234,0	5,199	244,0	5,396	247,0	6,225	267,0	6,047	**992,0**	**248,0**	**5,699**
Citations in SCOPUS (1.2, 2.2) if not listed above	59,0	1,311	91,0	2,012	87,0	2,193	94,0	2,129	**331,0**	**82,8**	**1,902**
Citations in other citation indexes and databases (not listed above) (3.2,4.2,9,10)	0,0	0,000	0,0	0,000	0,0	0,000	3,0	0,068	**3,0**	**0,8**	**0,017**
Other citations (not listed above) (3, 4, 3.1, 4.1)	37,0	0,822	33,0	0,730	32,0	0,806	17,0	0,385	**119,0**	**29,8**	**0,684**
Reviews (5,6)	0,0	0,000	0,0	0,000	1,0	0,025	0,0	0,000	**1,0**	**0,3**	**0,006**

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

No.	Publication	Number of citations
1	MEAD, D.J. - MARKUŠ, Štefan. The forced vibration of a three-layer, damped sandwich beam with arbitrary boundary conditions. In *Journal of Sound and Vibration*, 1969, vol.10, no.2, p.163-175. ISSN 0022-460 X.	101
2	LAPIN, Juraj - ONDRÚŠ, Ľuboš - NAZMY, M. Directional solidification of intermetallic Ti-46Al-2W-0.5Si alloy in alumina moulds. In *Intermetallics*. - Oxford : Elsevier Science, 2002, vol. 10, p.1019-1031. ISSN 0966-9795.	50
3	KOVÁČIK, Jaroslav - EMMER, Štefan - BIELEK, Jozef - KELEŠI, Jozef. Effect of composition on friction coefficient of Cu-graphite composites. In *Wear : An international journal on the science and technology of friction, lubrication and wear*, 2008, vol. 265, no.3-4, p.417-421. ISSN 0043-1648.	49
4	DROZD, Zdeněk - TROJANOVÁ, Zuzanka - KÚDELA, Stanislav. Deformation behaviour of Mg-Li-Al alloys. In *Journal of Alloys and Compounds*, 2004, vol. 378, p. 192-195. ISSN 0925-8388.	37
5	KOZA, Elzbieta - LEONOWICZ, M. - WOJCIECHOWSKI, S. - SIMANČÍK, František. Compressive strength of aluminium foams. In *Materials Letters*, 2004, vol.58, nos.1-2, p.132-135.	32
6	TROJANOVÁ, Zuzanka - DROZD, Zdeněk - KÚDELA, Stanislav - SZÁRAZ, Z. - LUKÁČ, P. Strengthening in Mg-Li matrix composites. In *Composites Science and Technology*, 2007, vol. 67, p.1965-1973. (2.027 - IF2006). (2007 - Current Contents). ISSN 0266-3538.	31
7	LAPIN, Juraj - GABALCOVÁ, Zuzana. Solidification behaviour of TiAl-based alloys studied by directional solidification technique. In *Intermetallics*, 2011, vol.19, pp.797-804. (2.335 - IF2010). (2011 - Current Contents, WOS, SCOPUS). ISSN 0966-9795.	29
8	LAPIN, Juraj - GABALCOVÁ, Zuzana - PELACHOVÁ, Tatiana. Effect of Y2O3 crucible on contamination of directionally solidified intermetallic Ti-46Al-8Nb alloy. In *Intermetallics*, 2011, vol. 19, p.396-403. (2.335 - IF2010). (2011 - Current Contents, WOS, SCOPUS). ISSN 0966-9795.	25
9	ZOLLINGER, J. - LAPIN, Juraj - DALOZ, D. - COMBEAU, H. Influence of oxygen on solidification behaviour of cast TiAl-based alloys. In *Intermetallics*, 2007, vol. 15, no.10, p.1343-1350. ISSN 0966-9795.	25
10	DUSZA, Ján - MORGIEL, Jerzy - DUSZOVÁ, Annamária - KVETKOVÁ, Lenka - NOSKO, Martin - KUN, Péter - BALÁZSI, Csaba. Microstructure and fracture toughness of Si3N4+graphene platelet composites. In *Journal of the European Ceramic Society*, 2012, vol. 32, p. 3389-3397. (2.353 - IF2011). (2012 - Current Contents, WOS, SCOPUS). ISSN 0955-2219.	23

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).

Author	Number of citations
Juraj Lapin	268
Štefan Markuš	191
František Simančík	170
Jaroslav Kováčik	161

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

In the previous assessed period 2008-2011 IMSAS publications had 701 citations in WOS and 163 citations in SCOPUS. In the current assessed period 2012-2015 IMSAS had 992 citations in WOS and 331 in SCOPUS. This corresponds to 41.5 % increase in WOS and 103 % increase in SCOPUS citations. This response confirms that IMSAS papers mostly increase in quality.

It should be noted that to a positive response to Institute's research activities also belong:

- Long term research partnership with industrial partners (Effpower 13 years, Elektrokarbon 34 years, SAPA 16 years)
- Invitations in international (FP7) and national (ERDF) research consortia (see later)
- 20 invited lectures to international conferences/scientific events during reported period
- Award of several prestigious prices as follows:

- ✓ M. Balog received the SAS 2012 award for young researcher for "extraordinary results of scientific work in the field of composite materials Al-AlN and powder metallurgical methods of their preparation"
- ✓ Two main insitute´s research teams headed by J. Lapin and F. Simančík were awarded by SAS as "excellent research teams, exceeding the level of average European research groups working in related topis."
- ✓ The team representing the common Vacuum metallurgy laboratory established between IMSAS and Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava was awarded in the category "Research team of the year" by Minister of Education, Science, Research and Sports of the Slovak Republic in 2012 for effective research and development of advanced metallic materials and composites.
- ✓ F. Simančík was awarded the 2013 „Prize for technology transfer in Slovakia" by Slovak CENTRE OF SCIENTIFIC AND TECHNICAL INFORMATION.
- ✓ M. Balog was awarded a „Fulbright scholarship" for 5 month stay at the University of California, Davis, CA, USA in 2014.
- ✓ IMSAS was awarded as a member of consortia the 2014 „SAS Prize for establishing the infrastructure for science for unique testing laboratory SmartGrid".

IMSAS is a well liked project partner. This can be documented by the fact, that in the latest call for proposals (2016) within the EU SF scheme, IMSAS was addressed and finally applied for 6 new projects with industrial partners.

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.

IMSAS is internationally recognized as partner, who is able to bridge the results of fundamental research with real structural parts and prototypes that can be tested or employed in actual working conditions.

Here is a list of selected research activities based on IMSAS´s results in fundamental research that have been successfully transferred to internationally recognized industrial or research partners in the assessed period.

- Development of Mo/Mo silicide composite for space vehicles (EADS, Germany)
- Development of intermetallic valve based on graded intermetallic Ni-Al alloys reinforced with Al_2O_3 particles with reduced weight for combustion engines (Centro Ricerche Fiat, Italy)

- Development of Cu/Al_2O_3 composite break disc (Centro Ricerche Fiat, Italy)
- Development of MgLi/C-fibre composite (ESA Contract No. 4000108672/13/NL/CBi)
- Development of hybrid casting technology for Al foam (Havel Metal Foam, Germany)
- Development of engine bracket (Hyundai Motor Europe Technical Center, Germany)
- Development of heat storage unit for solar energy collector (Abengoa Solar, Spain)
- Determination of the gravitational dependence of the transition of columnar to equiaxed grains in peritectic TiAl alloys (ESA)
- Development of heat exchanger aimed for short time heat store based on phase transformations in PCM "phase change materials" (i2m GmbH, Austria)
- Development of investment casting of turbine blades from nickel based superalloys (TUBITAK, Turkey)

The reputation of IMSAS has led to the invitation to take part with other 5 SAS institutes in the Centre of Excellence for Advanced Materials Application (CEMEA), focusing on research of advanced materials and nanotechnology, biomedicine, biotechnology and sustainable energy as application areas for advanced materials. The project is based on a long-term strategic cooperation between VTT Technical Research Centre of Finland, University of Helsinki and the Slovak Academy of Sciences. The proposal for Teaming successfully passed phase one in 2015; proposal for Phase 2 has been submitted.

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

- International conference MATRIB 2012 - Materials, tribology, recycling, Vela Luka, Croatia, 20th – 22nd June 2012
- International conference MATRIB 2013 - Materials, tribology, recycling, Vela Luka, Croatia, 27th -29th June .2013
- International conference MATRIB 2014 - Materials, tribology, recycling, Vela Luka, Croatia, 26th - 28th June .2014
- International conference MATRIB 2015 - Materials, tribology, recycling, Vela Luka, Croatia, 25th - 27th June .2015
- 3rd International conference "Mechanical Technologies and Structural Materials" (MTSM) 2013, Split, Croatia, 26th - 27th Sept. 2013
- 4th International conference "Mechanical Technologies and Structural Materials" (MTSM) 2014, Split, Croatia, 25th - 26th Sept. 2014
- 5th International conference "Mechanical Technologies and Structural Materials" (MTSM) 2014, Split, Croatia, 24th - 25th Sept. 2015
- Workshop: "Supporting of Entrepreneurs in Market Entry of Innovative Products" Smolenice, Slovakia, 18th March.2013
- Workshop "Renewable Energy and Energy Efficiency in Industrial Processes" Bratislava, Slovakia, 27th March 2014
- 32nd DANUBIA - ADRIA SYMPOSIUM on Advances in Experimental Mechanics, Starý Smokovec, Slovakia, 22nd - 25th Sept. 2015

2.3.3. List of edited proceedings from international scientific conferences.

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)

The Institute is publisher of scientific journal:

Kovové Materiály-Metallic Materials (ISSN: 0023-432X)

The journal publishes original and experimental works devoted to structure, properties and processing of metallic and selected non-metallic materials;
published bimonthly since 1963; language English;
cited by Materials Science Citation Index (MSCI), Institute for Scientific Information, Philadelphia, USA

Year	2011	2012	2013	2014	2015
IF	0.451	0.687	0.546	0.406	0.365

URL: http://www.kovmat.sav.sk/

2.3.4.2. SCOPUS

2.3.4.3. other databases

2.3.4.4. not included in databases

The Institute is publisher of scientific journal:

Strojnícky časopis - Journal of Mechanical Engineering (ISSN: 0039-2472)
The Journal is dedicated entirely to the full range of science and technology associated with machine dynamics,
published: 1950 – 2013, bimonthly
language: Slovak/Czech and English,
scaned by: Shock and Vibration Digest, Sage Publications, Inc., Thousand Oaks, CA, USA and Applied Mechanics Reviews (Journal of the American Society of Mechanical Engineers), Fairfield, NJ, USA.
URL: http://www.strojcas.sav.sk/

The Institute is co-publisher of scientific journal:

Powder Metallurgy Progress,
Journal of science and technology of particle materials, published by Institute of Materials Research SAS Košice and co published by Institute of materials and machine mechanics SAS and Miba Slovakia, s.r.o., Dolný Kubín.
language: English,
URL: http://www.imr.saske.sk/pmp/index.htm/

- **National position of the institute**

2.3.5. List of selected projects of national importance

The most important projects representing the national position of IMSAS in assessed period are undoubtedly the ERDF projects. They have substantially changed the IMSAS´s potential not only in Slovak but even European research area.

IMSAS coordinated three projects with the total funding for the institute in the assessed period 1 475 458 €. These included:

- Scientific oriented project ***Development of Centre of excellence for research and development of structural composite materials (CEKOMAT)*** - for the research and development of structural composites for engineering, construction and medical applications, comprising 5 SAS institutes and Slovak University of Technology – the main research activities are located in Bratislava and their general objective is to create state-of-the-art research infrastructure and excellent competencies in preparation, characterisation and testing of advanced MMCs, with strong focus on simulation and modelling activities.

- Application oriented project ***Competence center for industrial research and development in the field of light metals and composites INOVAL*** – for applied research on light metals and composites, comprising 12 partners among them University of Zilina, Technical University Kosice and 9 important industrial partners working in aluminium and related sectors (SAPA Profily, Fagor, Thermosolar, Spinea, Matador Automotive, SlCP, Esox, Tuvatech). The centre is located in Žiar nad Hronom in the region with highest importance for research on aluminium in Slovakia (more than 40 potential industrial partners have been identified so far). The Centre should serve as the incubator for efficient transfer of research results into the praxis. Some strategic bilateral partnerships with industry have already been launched. The main objective of INOVAL is to develop the competencies for lightweight construction, modelling and simulation of temperature fields and mechanical stresses, usually arising during manufacturing of Al-based components. The efficient recycling of aluminium scrap is addressed as well.

- Infrastructure oriented project ***Development of technological infrastructure of research center SAS for research of light metals and composites – INOVAL*** – oriented towards equipment of the founded center with proper technologies,analytical and characterization techniques.

These projects were supplemented with 11 other ERDF projects (full list is in 2.4.7) with the total funding of 2 331 605 € for IMSAS in the assessed period. IMSAS belongs to the most successful applicants in this scheme. It helped to update the current infrastructure i.e. technological, analytical and characterization with particular focus on fundamental research in Bratislava and applied research in Žiar nad Hronom. Besides these, IMSAS was authorized to supervise the construction of new building in Bratislava (Centre of Applied Research and Technology Transfer), and laboratory complex in Trnava (SAS Research centre ALLEGRO) including all furnishing and purchasing of all research infrastructure in the total value exceeding 20 mil €. Within Centre of Applied Research and Technology Transfer the new transmission electron microscope with atomic resoultion Titan Themis has been purchased. It belongs to top analytical devices not only in Slovakia.

Beside ERDF projects IMSAS was also participating in many APVV projects (full list is in Chapter 4). The most important among them were:

ULTRALIGHT – aimed in the development of lightweight stiff structures based on novel complex Al alloys, composites and foams

SOPERTI - aimed in the research on solidification and properties of novel peritectic TiAl - based alloys

INSIALCO - aimed at aluminium based composites formed in situ through reactive infiltration

PCMPANEL – aimed at heating/cooling panels based on aluminum foam filled by PCM

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

Institute main field	Project title	Duration in months	Main project objective
Lightweight structural materials	Microstructure - mechanical properties relationship for metallic foams	01/2013 – 12/2014	Research on structure/property relation of metallic foams.
	Application of advanced metallic materials for stiffness enhancement of lightweight structural components (ULTRALIGHT)	05/2011 - 10/2014	Development of lightweight stiff structures based on novel complex Al alloys, composites and foams.
	Aluminium based composites formed in situ through reactive synthesis	10/2013 - 09/2016	Research on aluminium based composites formed in situ through reactive infiltration.
Structural materials for high temperature applications	Solidification and properties of novel peritectic TiAl - based alloys (SOPERTI)	05/2011 - 10/2014	Research on solidification and properties of novel peritectic TiAl - based alloys.
Materials and components for thermal management.	Heating/cooling panel based on aluminum foam filled by PCM	10/2013 – 09/2016	Research on heating/cooling panels based on aluminum foam filled by PCM, proerties, structure optimization.
	Development of a new type of solar thermal collector for medium-temperature applications	07/2015 – 07/2018	Research on new type of solar collector with increased working temperature.
Additional R&D activities	Efficent preparation of powdered magnesium hydrid directly from the magnesium melt	07/2015 – 06/2018	Application of new technology for magnesium hydride preparation.

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

Institute main field	Project title	Duration in months	Main project objective
Lightweight structural materials	In-situ preparation and research of ultra-fine-grained Al-AlN composites	01/2011 – 12/2013	Research on Al+AlN composites containing nanoscale AlN crystallites prepared via partial in situ nitridation.
	Gradient aluminium foams	01/2010 – 12/2012	Research on properties of complex structures based on Al foams.
	Investigation of Ti and Ti alloys compacts prepared by powder metallurgy methods	01/2013 – 12/2015	Research on the sintering of novel Ti based materials.
	On the study of the novel Al based composites prepared in situ via powder metallurgy approach	01/2014 – 12/2016	Research on novel ultrafine-grained Al matrix composites reinforced with in-situ Al3Ti filaments were prepared by coextrusion of fine Al and Ti powders.
	Development of the aluminium matrix composite reinforced by Al_2O_3 particles	01/2013 – 12/2015	Development of proper technique for homogeneous distribution of alumina púarticles in Al melt.
Structural materials for high temperature applications	The effect of multiaxial stress state on microstructure degradation of nickel based single crystal superalloys during creep	01/2010 – 12/2012	Research on degradation of nickel based superalloy subjected ot multiaxial stress.
	Erosion study of copper matrix composites by LIBS method	01/2013 – 12/2015	Research on failure mode of Cu matrix composites subjected to laser beam impact.
	TiAl based intermetallic alloys for applications in the automotive industry and energetics	01/2013 – 12/2015	Research on technology of preparation and high temperature properties of TiAl based alloys.

2.3.8. Projects of SAS Centres of Excellence

Institute main field	Project title	Duration in months	Main project objective
Lightweight structural materials	CE for functionalized multiphase materials	08/2011-12/2014	Research on PM composites based on atomized Al(Mg) particles.

2.3.9. National projects supported by EU Structural Funds

Project title	Project number	Duration in months	Note on projects with special meaning for the Institute
Development of CE for R&D of structural composite materials - 2nd stage (CEKOMAT II)	26240120020	07/2010 - 09/2014	Research and development of structural composites for engineering, construction and medical applications.
Competence center for industrial research and development in the field of light metals and composites (INOVAL)	26220220154	07/2011 - 12/2015	Development of the Innovation center INOVAL in Ladomerská Vieska (Žiar nad Hronom).
Centre for applied research of new materials and technology transfer	26240220088	09/2013 - 12/2015	Building up of new main building of the Institute common with the Centre of applied and improvement of research and research infrastructure.
Development of technological infrastructure of research center SAS for research of light metals and composites - INOVAL	26210120014	01/2013 - 11/2015	Development of infrasctucture of the Innovation center INOVAL in Ladomerská Vieska (Žiar nad Hronom).
Research Center of advanced materials and technologies for current and future applications (PROMATECH)	26220220186	09/2013 - 12/2015	Final stage of the establishement of Innovation centre INOVAL centre in in Ladomerská Vieska (Žiar nad Hronom).

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

- BALOG, M.: HITEMAL. In Mikroskopie 2015: Konferencia CSMS. Lednice na Moravě, Czechia, May 12-13, 2015. http://nucleus.img.cas.cz/mikrospol/SBORNIK-2015.pdf
- IŽDINSKÝ, K: The role of microscopy in development of metal matrix composite materials. In Mikroskopie 2012. - Praha: Československá mikroskopická společnost, 2012, p .21.
- IŽDINSKÝ, K. Metal matrix composite materials - structure and interfaces. In NANOVED 2013 & NANO INFO DAY: 6th International Conference on Nanosciences, Nanotechnologies, Nanomaterials and NANO INFO DAY of the Nanoforce Project. - Brno: TRIBUN EU, 2013. ISBN 978-80-263-0511-8.
- JERZ, J. - OROVČÍK, Ľ. - SIMANČÍK, F. - FLOREK, R. Innovative high-tech products made of aluminium foam. Mechanical Technology and Structural Materials 2013 - 3rd International Conference. Sept. 26, 2013, Split, Croatia.

- JERZ, J. - SIMANČÍK, F. - FLOREK, R. - OROVČÍK, Ľ. Increasing of energy efficiency by high-tech aluminium foam panels for celling cooling and heating. SymPorMat 2013 - Symposium on Porous Materials, Dec 17, 2013, Maribor, Slovenia.
  JERZ, J. - SIMANČÍK, F. - OROVČÍK, Ľ. Advanced solution for energy storage in net zero-energy buildings. Mechanical Technology and Structural Materials 2014 - 4rd International Conference. Sept. 25, 2014, Split, Croatia.
- LAPIN, J. Trends in Materials Development. In Brokerage Event 2013 - Moderní materiály. Nové možnosti pro průmysl a lékařství. Nov. 6, 2013, Ostrava, Czechia.
- LAPIN, J.: Trends and direction in materials development. In: 23rd International Conference on Metallurgy and Materials, METAL 2014. Tanger Ltd, 2014. May 21 – 23, 2014, Brno, Czechia.
- NOSKO, M. – Orovčík, Ľ. – Balog, M. – Krížik, P. – Čegan, T. Characterization of Ultra Fine Grained Microstructures Using EBSD Method. MCM 2015 EGER, 12th Multinational Congress on Microscopy, August 23-28, 2015, Eger, Hungary.
- SIMANČÍK, F.: "Trends in the development of materials for innovative design" Siemens PLM Channel meeting CEE, Viedeň, Jan 22, 2013. Conferene of Siemens organizations from CEE region.
- SIMANČÍK, F. - BALOG, M. - FLOREK, R. Microstructure as major tool for tailoring the material properties. In Metallography 2013: 15th international symposium on metallography. Abstract booklet. Stará Lesná, April 24-26, 2013. - Košice: Technical University, 2013, s. 20. ISBN 978-80-553-1412-9.
- SIMANČÍK, F. - BALOG, M. Nanostructuring - powerful tool for tailoring of Aluminium properties. In NANOVED 2013 & NANO INFO DAY: 6th International Conference on Nanosciences, Nanotechnologies, Nanomaterials and NANO INFO DAY of the Nanoforce Project. - Brno : TRIBUN EU, 2013. ISBN 978-80-263-0511-8.
- SIMANČÍK, F., Balog, M., Krížik, P., Florek, R.: „How far can be properties of aluminium manipulated without alloying elements? 13th International Symposium on Physics of Materials: ISPMA 13. Department of Physics of Materials, Charles University in Prague, Aug. 31 – Sept. 4, 2014, Praha, Czechia.
- SIMANČÍK, F.: „Ultrafinegrained Aluminium with long term structural stability at elevated temperatures“. International conference Nano Ostrava 2015, May 20, 2015, Ostrava, Czechia.
- SIMANČÍK, F.: „Advanced materials and technologies for lightweight car body structures“ Matrib 2015, Vela Luka, Croatia, June 25-27, 2015
- SIMANČÍK, F.: Manufacturing challenges for large structural parts made of aluminium foam. Medzinárodná konferencia METFOAM 2015, Barcelona, Spain, Aug. 31 - Sept. 3, 2015
- SIMANČÍK, F.: Renewable energy for air conditioning of buildings, Abu Dhabí, United Arab Emirates, Nov. 18, 2015

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

Researcher	Conference	Year	Committee
Jaroslav Jerz	MATRIB 2015 - materials, wear, recycling, Vela Luka, Croatia	2015	programme
	MATRIB 2014 - materials, wear, recycling, Vela Luka, Croatia	2014	programme
	MATRIB 2013 - materials, wear, recycling, Vela Luka, Croatia	2013	programme
	MATRIB 2012 - materials, wear, recycling, Vela Luka, Croatia	2012	programme
	MTSM 2015 - 5th International Conference Mechanical Technologies and Structural Materials, Split, Croatia	2015	programme
	MTSM 2014 - 4th International Conference Mechanical Technologies and Structural Materials, Split, Croatia	2014	programme
Jaroslav Kováčik	ARTENS 2013 - 14th Symposium on Experimental Stress Analysis and Materials Testing, Timisoara, Romania	2013	programme
Juraj Lapin	24th International Conference on Metallurgy and Materials (METAL 2015), Brno, Czechia	2015	programme
	23rd International Conference on Metallurgy and Materials (METAL 2014), Brno, Czechia	2014	programme
	22nd International Conference on Metallurgy and Materials (METAL 2013), Brno, Czechia	2013	programme
	21nd International Conference on Metallurgy and Materials (METAL 2012), Brno, Czechia	2012	programme
	13th INTERNATIONAL SYMPOSIUM ON PHYSICS OF MATERIALS, Prague, Czechia	2014	programme
František Simančík	Metfoam 2015, Barcelona, Spain	2015	programme
	Metfoam 2013, Raleigh NC, USA	2013	programme
	MATRIB 2015 - materials, wear, recycling, Vela Luka, Croatia	2015	programme
	MATRIB 2014 - materials, wear, recycling, Vela Luka, Croatia	2014	programme
	MATRIB 2013 - materials, wear, recycling, Vela Luka, Croatia	2013	programme
	MATRIB 2012 - materials, wear, recycling, Vela Luka, Croatia	2012	programme
	MTSM 2015 - 5th International Conference Mechanical Technologies and Structural Materials, Split, Croatia	2015	programme

- **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

- LAPIN, J.: Development of TiAl-based alloys for high temperature structural applications. SAS – IVF – JST Workshop Bratislava – Smolenice Castle, July 9 – 11, 2013.
- SIMANČÍK, F.: Vlastnosti materiálov šité na mieru (Material properties tailored). Veda v Centre, May 31, 2012, CVTI Bratislava.
- SIMANČÍK, F.: High product value instead of low labour costs – the only way to competitiveness and prosperity. SLOVAK CLUSTER MATCHMAKING ROADSHOW Prosperity through Cooperation. March 7, 2012 Bratislava (invitation of Ministry of Economy SR)
- SIMANČÍK, F. - BALOG, M. - FLOREK, R. Microstructure as major tool for tailoring the material properties. In Metallography 2013: 15th international symposium on metallography.

Abstract booklet. Stará Lesná, April 24 – 26, 2013. - Košice: Technical University, 2013, s. 20. ISBN 978-80-553-1412-9.

- SIMANČÍK, F.: Načo sú nám inovácie? (What's the use of innovations?). Conference of industrial bipartite on industry innovation - How to make a business out of science. Bratislava, Hotel Sorea June 18, 2013
- SIMANČÍK, F.: Lightweight construction via tailored microstructure of light metals. SAS – IVF – JST Workshop Bratislava – Smolenice Castle, July 9 – 11, 2013.
- SIMANČÍK, F. et al.: Functional gradient materias based on refractory metal silicides. Colloquium of Metallurgy and Metallurgical Engineering CMME 2014, TÁLE – Nízke Tatry, Slovakia, July 6 – 10, 2014.
- SIMANČÍK, F.: Exothermic reaction - a useful tool for synthesis of advanced materials from reactive powders. DFPM 2014, Stará Lesná, Nov. 26 – 29, 2014
- SIMANČÍK, F.: Horčík – ultraľahký konštrukčný materiál so zatiaľ nevyužitým potenciálom v automobilových konštrukciách (Magnesium - ultra lightweight construction material with the yet untapped potential in automotive engineering). Conference NEWMATEC 2015, Tále, March 10, 2015
- SIMANČÍK, F.: Advanced materials and technologies for lightweight car body structures. Conference NEWMATEC 2015, Tále, March 11, 2015
- SIMANČÍK, F.: Nové konštrukčné materiály pre strojárenstvo (New construction materials for engineering). Slovak - Ukrainian forum 2015 (SUBF 2015), Košice, April 22, 2015
- SIMANČÍK, F.: Advanced materials and technologies for lightweight car body.The third regional automobile meeting PWC Bratislava“, May 19, 2015
- SIMANČÍK, F.: Ľahké materiály pre budúce autá (Lightweight materials for future cars). 2nd Innovation symposium China + 16 central European countries, Bratislava, Sept. 21 – 23, 2015
- SIMANČÍK, F.: Kompetenčné centrum pre ľahké kovy a kompozity (Competence Centre for light metals and composites). Conferene Best of the Best OP R&D 2007-2013, Bratislava, Bôrik, Nov. 23, 2015

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

Researcher	Conference	Year	Committee
Karol Iždinský	XX. medzinárodný akustický seminár, Kočovce	2015	programme
	XVIII. medzinárodný akustický seminár, Kočovce	2013	programme
Jaroslav Jerz	Obnoviteľné zdroje energie a energetická účinnosť priemyselných procesov, Bratislava	2014	programme organising (chairman)
	Seminár akadémie INNOVMAT-u: Podpora podnikateľov pri vstupe inovatívnych výrobkov na trh, Smolenice	2013	programme / organising (chairman)
František Simančík	Budúcnosť rozvoja ľahkých kovov a kompozitov na Slovensku 2015, Ladomerská Vieska	2015	programme / organising (chairman)

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

IMSAS has been involved into wide international cooperation at all levels of R&D activities – fundamental research and education with universities; problem oriented and applied research with

R&D centres and transfer of knowledge with industrial partners. The most important international partners of IMSAS currently include (only real cooperation including information and/or sample material exchange):

- Universities:
- Charles university Prague (CZ),
- Inst. Nat. Polytech. Lorraine, (F),
- Warsaw TU (PL),
- TU Vienna (A, 3 institutes),
- TU + HMI Berlin (D),
- EPFL Lausanne (CH),
- Wroclaw Technical University (PL),
- TU Darmstadt (D),
- Shafir University of Technology, Tehran (IR)
- Research centres:
- IFAM FhG Bremen + Dresden (D),
- EADS Ottobrun (D),
- Centro Ricerche Fiat (I),
- IPP Max Planck Garching (D),
- ARCS Seibersdorf (AT),
- Institute of Physics CAS (CZ),
- Fagor Edertek (SP),
- IMM PAN Krakow (PL),
- IPMS UAS Kiev (UA),
- Hyundai Motor Europe Technical Center (D)
- Industry:
- LMT GmbH Laakirchen (AT),
- Gleich Kaltenkirchen (D),
- SAPA AB, (S),
- NMD GmbH St.Pantaleon (AT),
- SHW GmbH Wasseralfingen (D),
- ATL Ltd. Marlow (UK),
- Kochanek Entw. GmbH Neustadt (D),
- Havel Metal Foam GmbH Brangenburg an der Havel (D)
- i2m GmbH Graz (AT)

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"),

Year	Project title	Typ / Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	Gravity Dependence of CET in Peritectic TiAl Alloys	ESF/AO-2009-1105	07/2010 - 06/2016	80 000 (130 833)	W/Juraj Lapin
	Micro and Nanocrystalline Silicide - Refractory Metals FGM for Materials Innovation in Transport Applications (SILTRANS)	FP7/ NMP3-SL-2009-229127	10/2009 - 09/2013	414 580 (554 210)	C/František Simančík
	Micro and Nanocrystalline Functionally Graded Materials for Transport Applications (MATRANS)	FP7/FP7-228869	02/2010 - 01/2013	172522 (256913)	W/František Simančík
	Establishment of cross-border platform for technology transfer focused on the application of advanced engineering materials in the region of Vienna – Bratislava	INTERREG/ N00081	06/2010 - 03/2013	41 077 (41 077)	I/Jaroslav Jerz
	Energy related multidisciplinary knowledge alliance aiming to introduce an innovative training programme	EU EAC/ EAC-S03-2012-061	12/2012 - 08/2014	23 364 (23 364)	W/František Simančík
2014	Metal Matrix Composites (MMCs) as High Performance Metallic Material	ESA Contract no. 4000108672/13/NL/Cbi	1/2014 - 12/2014	0 (funded through a subcontract)	W/František Simančík

Note: The numbers in parentheses are the Institute funding for the whole project period including contracted funding in the future.

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

Year	Project title	Typ / Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	The study and modeling of mechanical and tribological characteristics of novel ultra-finegrained Al-Al2O3 composites	Agreement SAS-NSC JRP 2011/06	01/2012 - 12/2014	66 704 (66 704)	C/Martin Balog
2013	Investment casting of turbine blades from nickel based superalloys (INCAST)	Agreement SAS-TUBITAK	11/2013 - 10/2016	54 167 (70 834)	C/Juraj Lapin
2014	Magnesium Nanocomposites for Biodegradable Medical Implants	Agreement JRP SAV - TUBITAK	12/2014 - 11/2017	27 083 (52 083)	C/František Simančík

Note: The numbers in parentheses are the Institute funding for the whole project period including contracted funding in the future.

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

Year	Project title	Type / Project number	Duration in months	Role of the Institute / Responsible person
2012	Application of acoustic methods in testing of ultralight alloys and matrix composites (MMC) based on Mg and Al before and after processing using intensive strain methods	Agreement, PAV, Poland	01/2010 - 12/2012	C/Stanislav Kúdela Jr.
	Acoustic emission in compressed Mg and Al alloys and composites before and after pre-deformation by intensive strain methods	Agreement, PAV, Poland	10/2009 - 09/2013	C/Stanislav Kúdela Sr.
2013	Mechanical and Microstructural Characterization of Al-PM Based Composites Prepared Via Hot Working Route	Agreement, Centro Atómico Bariloche, Argentina	01/2013 - 12/2014	C/Martin Balog
	Investigation of novel concrete compositions with application of X-ray microtomography	Agreement, PAV, Poland	01/2013 - 12/2015	C/Stanislav Kúdela Jr.

- **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”.

Year	Project title	Typ / Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	Solidification and properties of novel peritectic TiAl - based alloys (SOPERTI)	APVV-0434-10	05/2011 - 10/2014	153 810 (190 000)	C/Juraj Lapin
	High temperature oxidation resistant nanocomposite coatings with improved lifetime (HACONE)	APVV-0520-10	05/2011 - 12/2013	36 809 (50 000)	I/Marián Mikula
	Application of advanced metallic materials for stiffness enhancement of lightweight structural components (ULTRALIGHT)	APVV-0647-10	05/2011 - 10/2014	123 140 (147 900)	C/František Simančík
2013	Aluminium based composites formed in situ through reactive synthesis	APVV-0556-12	10/2013 - 09/2016	191 000 (250 000)	C/Martin Balog
	Heating/cooling panel based on aluminum foam filled by PCM	APVV-0692-12	10/2013 – 09/2016	164 725 (215 885)	C/Roman Florek
	Microstructure - mechanical properties relationship for metallic foams	APVV/SK-RO-0014-12	01/2013 – 12/2014	3 338 (3 338)	C/Jaroslav Kováčik
2015	Multicomponent nanocomposite coatings prepared by highly ionized deposition technologies	APVV-14-0173	07/2015 – 06/2018	7 000 (44 000)	I/Marián Mikula
	Development of a new type of solar thermal collector for medium-temperature applications	APVV-14-0936	07/2015 – 07/2018	25 230 (150 000)	C/Martin Nosko
	Efficent preparation of powdered magnesium hydrid directly from the magnesium melt	APVV-14-0934	07/2015 – 06/2018	26 164 (149 999)	C/František Simančík

Note: The numbers in parentheses are the Institute funding for the whole project period including contracted funding in the future.

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	8	9	9	7
Funding in the year (EUR)	65 212	64 317	56 180	52 879

[1]

- **Summary of funding from external resources**

2.4.6. List of projects supported by EU Structural Funds

Project title	Project number	Duration in months	Note on projects with special meaning for the Institute
Applied research and development of innovative drilling technology for ultra-deep geothermal wells	26240220042	07/2011 - 03/2013	Application of Cu-W composite for plasma generating electrodes.
Center for knowledge marketing and intellectual property rights of SAS (CEKOODUV)	26240220006	09/2009 - 02/2012	Creation of SAS system for IPR treatment.
Centre for applied research of new materials and technology transfer	26240220088	09/2013 - 12/2015	Building up of new main building of the Institute common with the Centre of applied and improvement of research and research infrastructure.
Centre of excellence for high productive plasma treatment of materials and additive creation of structures	26240120036	02/2014 - 10/2015	Development of advanced plasma generating electrodes.
Competence center for industrial research and development in the field of light metals and composites (INOVAL)	26220220154	07/2011 - 12/2015	Development of the Innovation center INOVAL in Ladomerská Vieska (Žiar nad Hronom).
Competence center for new materials, advanced technologies and energetics	26240220073	08/2011 - 11/2015	Development of infiltration technique for lead infiltrated metal-ceramic battery electrodes.
Development of CE for R&D of structural composite materials - 2nd stage (CEKOMAT II)	26240120020	07/2010 - 09/2014	Research and development of structural composites for engineering, construction and medical applications.
Development of technological infrastructure of research center SAS for research of light metals and composites - INOVAL	26210120014	01/2013 - 11/2015	Development of infrasctucture of the Innovation center INOVAL in Ladomerská Vieska (Žiar nad Hronom).
Efficient controlling of the production and consumption of energy from renewable sources (ENERGOZ)	6240220028	04/2010 - 03/2014	Establishment of the laboratory SmartGrid for testing of renewable energy sources.
Industrial research center of service life of selected components of power equipments (ENEL)	26240220081	05/2012 - 10/2015	Research of NDT techniques for analysis and lifetime prediction of power plant facilities.
Long-term operation of nuclear power plants VVER 440 taking into account the environmental impact	26220220395	01/2011 - 12/2013	Development of appropriate techniques for investigation of service damage of long-term operating units.
Research center ALLEGRO	26220220198	10/2014 - 12/2015	Establishment of SAS testing laboratory in Trnava.
Research Center of advanced materials and technologies for current and future applications (PROMATECH)	26220220186	09/2013 - 12/2015	Final stage of the establishement of Innovation centre INOVAL centre in in Ladomerská Vieska (Žiar nad Hronom).
Research of opportunities for direct extrusion of composites based on light metals within the framework of cooperation between Sapa Profily Inc. and SAS	26220220069	06/2010 - 06/2015	Development of production technologies for powder based Al matrix composites.

[1] Excluding projects for the popularisation of science

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	Competence center for new materials, advanced technologies and energetics	26240220073	08/2011 - 11/2015	246 570 (266 028)	W/Juraj Lapin
	Development of CE for R&D of structural composite materials - 2nd stage (CEKOMAT II)	26240120020	07/2010 - 09/2014	491 737 (1 223 779)	C/Karol Iždinský
	Center for knowledge marketing and intellectual property rights of SAS (CEKOODUV)	26240220006	09/2009 - 02/2012	582 (3 300)	W/František Simančík
	Efficient controlling of the production and consumption of energy from renewable sources (ENERGOZ)	6240220028	04/2010 - 03/2014	105 035 (556 118)	W/Juraj Koráb
	Applied research and development of innovative drilling technology for ultra-deep geothermal wells	26240220042	07/2011 - 03/2013	54 223 (60 498)	W/Štefan Kavecký
	Industrial research center of service life of selected components of power equipments (ENEL)	26240220081	05/2012 - 10/2015	201 781 (331 370)	W/Juraj Lapin
	Long-term operation of nuclear power plants VVER 440 taking into account the environmental impact	26220220395	01/2011 - 12/2013	404 312 (1 510 161)	W/Juraj Lapin
	Competence center for industrial research and development in the field of light metals and composites (INOVAL)	26220220154	07/2011 - 12/2015	638 986 (1 822 165)	C/František Simančík
	Research of opportunities for direct extrusion of composites based on light metals within the framework of cooperation between Sapa Profily Inc. and SAS	26220220069	06/2010 - 06/2015	319 535 (674 891)	W/František Simančík
2013	Centre for applied research of new materials and technology transfer	26240220088	09/2013 - 12/2015	114 116 (114 116)	W/Juraj Lapin
	Development of technological infrastructure of research center SAS for research of light metals and composites - INOVAL	26210120014	01/2013 - 11/2015	344 745 (2 197 387)	C/František Simančík
	Research Center of advanced materials and technologies for current and future applications (PROMATECH)	26220220186	09/2013 - 12/2015	495991	W/František Simančík
2014	Centre of excellence for high productive plasma treatment of materials and additive creation of structures	26240120036	02/2014 - 10/2015	82985	W/Karol Iždinský
	Research center ALLEGRO	26220220198	10/2014 - 12/2015	306475	W/Juraj Lapin

Note: The numbers in parentheses are the Institute funding for the whole project period including contracted funding in the future.

External resources	2012	2013	2014	2015	total	average
External resources (milions of EUR)	1,592	1,772	2,117	2,536	**8,016**	**2,004**
External resources transfered to coooperating research institute (milions of EUR)	0,000	0,000	0,000	0,000	**0,000**	**0,000**

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

External resources significantly support the over 10 year stagnating institutional funding. Currently IMSAS needs to cover more than 50 % of its budget by external resources what brings enormous stress to management and researchers who need to spend a lot of time by proposing projects. As there are simply not sufficiently high public resources, strong cooperation with industry in R&D is inevitable. This has a significant influence on the art of research activities – they need to be more application oriented, with higher portion of technological know-how which forms thus main research output instead of generally required publications. This fact cannot be simply neglected.

2.5. PhD studies and educational activities

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

Programme title	Faculty	Study field	Period of validity
Material engineering	Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava	5.2.26 Materials	2009-2015
Progressive materials and material design	Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava	5.2.26 Materials	2015 -

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	**10**			**11**			**10**			**11**		
PhD students	**number**	**defended thesis**	**students quitted**	**number**	**defended thesis**	**students quitted**	**number**	**defended thesis**	**students quitted**	**number**	**defended thesis**	**students quitted**
Internal	6,0	4,0	1,0	5,0	1,0	0,0	7,0	1,0	0,0	6,0	2,0	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	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Note on the international dimension of the PhD study at IMSAS:
One of the Institute's PhD students – Ing. Kateryna Kamyshnykova is the citizen of Ukraine. She studies in the Institute since Sept. 1st, 2015 under the same conditions as Institute's Slovak students, i.e. she is also part-time employee of the Institute.

2.5.3. Summary table on educational activities

Teaching	2012	2013	2014	2015
Lectures (hours/year)[2]	91	52	0	26
Practicum courses (hours/year)[2]	127	88	36	52
Supervised bachelor theses (in total)	4	2	3	1
Supervised diploma theses (in total)	4	5	6	4
Supervised PhD theses (in total)	14	6	8	8
Members in PhD committees (in total)	3	4	4	2
Members in DrSc. committees (in total)	0	1	1	1
Members in university/faculty councils (in total)	5	4	4	3
Members in habilitation/inauguration committees (in total)	0	0	0	1

2.5.4. List of published university textbooks

2.5.5. Number of published academic course books

2.5.6. List of joint research laboratories/facilities with universities

Joint research laboratory of Institute of materials and machine mechanics SAS and Faculty of materials science and technology of Slovak university of technology in Bratislava

Joint research laboratory/common workplace is focused on research and development of special metal materials prepared by vacuum melting and isostatic pressing.

In 2013, the workplace was awarded the Prize of Minister of Education, Science, Research and Sport of Slovak Republic in the category of Science and technology team of the year.

The joint research laboratory was originally built in the building of the Institute on Račianska street. Due to its great importance for both partners, it has been recently moved to the new Institute's building on Dúbravská cesta 9.

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

In 2015, the Institute has been reaccredited by Ministry of Education, Science, Research and Sport of the Slovak Republic as an external educational institution to participation on a new PhD study

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

programme “Progressive materials and material design” provided by Faculty of Materials Science and Technology, Slovak University of Technology in Bratislava. (Note: According to Slovak legislation, PhD study may provide universities, only. If an external educational institution participates on the PhD study, the whole scientific part of the PhD study is accomplished in the external educational institution.)

The level of PhD study in the Institute can be documented by the fact that based on her skilled work within the project FP7 SILTRANS, our postdoctoral fellow Ing. Lucia Senčeková, PhD. (PhD study at the Institute finished on July 17th, 2012) was invited to a three-year stay at the Max-Planck Institut für Eisenforschung in Düsseldorf, to which she joined in March 2013.

2.6. Social impact

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

Applications that already reached serial production level and were still in production within reporting period:

1. New types of sliding contacts prepared by gas pressure infiltration of graphite with copper (Elektrokarbon, Topoľčany, Slovakia) - development of the technology, including supply of world unique fully automatic equipment for infiltration of long contacts for locomotives. The lifetime of contacts has increased by 40% if compared with traditional solution. Serial production continues from 2011.
2. Crash box for protection of railway carriages – innovative part able to absorb impact energy of 50 t wagon up to 8 km/h without damage of suspension part (first serial worldwide application of Al foam in railway) - own production of IMSAS business unit for Gleich GmbH Kaltenkirchen Germany (annual production ~1000 pcs).
3. The novel heating / cooling panels made from aluminium foam. Pilot applications in 260 m^2 open space office room of SAPA Profiles, 130 m^2 Matador Group – successfully running from 2011. The large scale manufacturing is foreseen in 2017. (business unit of IMSAS – possible TT to potential investor).
4. New ultrafine Al powders based composites for storage of used nuclear fuel (New Material Development, Ltd., St. Pantaleon, Austria). Annual production is about 100 t of composites.
5. Technology for efficient recycling of chips from aluminium machining (SAPA Profily, Žiar nad Hronom). SAPA introduced this technology for recycling of all chips produced in the plant. Almost zero waste is produced now by the factory.

Applications at prototype / testing level:

6. Cast turbocharger wheels from light intermetallic TiAl based alloys (CCN Castings, Považská Bystrica).
7. Composite electrodes for plasma drilling (developed for GA- Drilling, Bratislava). The unique electrodes make the plasma driling possible. The company used them for all developed drilling machines (patent pending).
8. Engine Bracket Application made of hybrid Aluminium Foam core casting (Hyundai Motor Europe Technical Center GmbH, Russelsheim). The novel engine bracket has been successfully tested in real conditions with significant improvement of NHV performance. Developed unique manufacturing technique used for casting of hybrid part is patent pending.
9. PCM Container for storage of solar heat (Abengoa Solar, Seville, Spain). The container was developed for storage of latent heat of high temperature produced by solar power plant in Spain. It is based on conductive foam infiltrated with proper phase change material (PCM).

10. Aluminium foam board for LED screen. The multifunctional lightweight panel has been developed for Leyard Europe, Prešov. In comparison with traditional HPDC board the panel has low weight, lower manufacturing costs and improved thermal management. The technology provides significantly more freedom for shape and size design. (patent pending, LE)

Further successfully tested prototypes include:

- NiAl gradient composite valve for car engine
- motorcycle engine piston for enhanced power and lifetime
- holder of ceramic shielding plate for space vehicle
- partially biodegradable TiMg tooth implant
- novel composite for manufacturing of container for used nuclear fuel
- Al-foam roof cover for cabriolet
- Al-foam /PCM heat storage tank
- lightweight body part for bearing transmission

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

Feasibility study of technological processing of Slovak magnesite, its usable extraction and processing waste, as well as metal magnesium-based waste in line with innovative trends in the world, the EU and Slovakia

The feasibility study prepared for Ministry of Education, Science, Research and Sports of Slovak Republic in 2014. The Institute represented by František Simančík was responsible for a workpackage. Revenue for the institute was 65000 EUR.

Participation in preparation of documents for Research and innovation strategy for smart specialization of the Slovak Republic RIS

Dr. Ing. František Simančík as a member of the working group of Ministry of Education, Science, Research and Sports SR for Industrial Technologies as well as a member of SAS team involved in preparing documents for research and innovation strategy for smart specialization of the Slovak Republic RIS, in 2013.

Assessment of possibility of creation of the National Institute of Technology

In collaboration with CEIT, a. s. and other partners, the Institute participated in the project assessment on the possible creation of the National Institute of Technology Fraunhofer type, which would be oriented to the needs of applied research for Slovak subjects, in 2012-2013.

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

Year	Contract/project	Partner	Revenues for the Institute (EUR)
2012	Development and optimisation of the components made from extruded powder aluminium mixtures	SAPA Profily a.s. Žiar nad Hronom, Slovakia	72 000
	Development of structural profiles from aluminum alloys with extraordinary properties	SAPA Profily a.s. Žiar nad Hronom, Slovakia	36 622
	The heat treatment of ingots and creep tests of up to 600 °C. Development of melting and casting technologies of TiAl alloys	CCN CASTINGS s.r.o., Považská Bystrica, MtF STU Trnava, Slovakia	20 948
2013	Technical Assistance Agreement with Hyundai Motor Europe	Hyundai Motor Europe Technical Center GmbH, Germany	24 600
	Development of heating/cooling panels of aluminum foam	SAPA Profily a.s. Žiar nad Hronom, Slovakia	4 750
	Research and development of use of new materials for selected components of bearing reducers	Spinea s.s. Prešov, Slovakia	39 000
	Characterizing the turbocharger wheel properties made from TiAl base alloys	CCN CASTINGS s.r.o., Považská Bystrica, Slovakia	53 572
	Development of pressing method of molten cast aluminum composites	Tecnalia Research and Innovation, San Sebastian, Spain	4 100
	The infiltration of carbon semiproducts by copper alloy	Transport systems, Saint Petersburg, Russia	2 400
	Preparation of composites for heat storage in solar power plant	Abengoa Solar, Spain	9 800
2014	Analysis of problem of defective castings	FINALCAST s.r.o. Žiar nad Hronom, Slovakia	4 127
	Joint research oriented to materials for energy equipments, components and equipments for nuclear power plants	VUJE a.s. Trnava, Slovakia	108 000
	SEM analyses	RHP-Technology GmbH, Austria	2 850
	Aluminum foam panels	Intech Slovakia, s.r.o., Slovakia	1 500
	Development prototype coolers from aluminum foam	APLIK s.r.o. Bratislava, Slovakia	10 000
2015	R&D study	Industrial EU partner - name confidential	77 626
	Analysis of welded joint samples on electron microscope	STU Bratislava, Slovakia	1 718
	Granulometric analysis of graphite samples	Komozitum, Slovakia	1 000
	Expert analysis of submitted samples - casts	Ability s.r.o. Žiar n. Hronom, Slovakia	1 255
	SEM and EDS analyses	MIBA Sinter Slovakia, Dolný Kubín, Slovakia	2 863
	Production of 2 pieces of batteries prototypes	i2m Unternehmen GmbH, Graz, Austria	6 000
		Total revenues for the Institute	484 731

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

There are no licenses sold abroad. However contractual agreements exist with industrial partners, which allow them to use institute's patents under special conditions (e.g. long term research projects, lump sum monthly financing the research, etc.).

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

Dr. Ing. František Simančík participated as a member of the scientific delegation of state visit of President SR 25 - 30 June 2012 in Japan and the Netherlands 20 – 22 Nov. 2012. He presented the potential of Slovak science in the development of materials and technologies through lectures for identified target groups on these visits.

Dr. Ing. František Simančík and Ing. Juraj Lapin, PhD. as members of the accompanying delegation attended the visit of the President of the Slovak Republic Ivan Gasparovic in Turkey in 2013. The purpose of the visit was discussions on cooperation of Turkey and the Slovak Republic in the field of materials research.

IMSAS has been selected to represent Slovakia at the "Technical audit ESA experts with representatives of businesses and research institutions SR" on May 14, 2014. At the meeting Institute presented its results for application in space research. These results took experts present and contributed to the positive assessment of Slovakia by the audit.

The meeting with delegation of Japanese businessmen in IMSAS at the request of the Slovak Agency for Development of Investments and Trade on 11 June 2015. The aim of the meeting was to introduce Japanese businessmen to the latest trends and results in the preparation and processing of lightweight construction materials in Slovakia.

2.6.6. Summary of relevant activities, max. 300 words

2.7. Popularisation of Science (outreach activities)

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

	Author		Title/Topic	Place and time of publication
1	František Simančík	Press	Slovenská budúcnosť patrí aluminium (Slovak future belongs to aluminum)	Revue priemyslu č. 12, 2015, str. 22-25
2	František Simančík	Press	Zmeňme 20-tisíc firiem (Let's change 20-thousand companies)	Hospodárske noviny 10. 6. 2015, Publicistika , s. 8
3	Karol Iždinský	TV	Europrojekty ÚMMS SAV (Europrojects of IMSAS)	Televízna stanica TA 3; Euroskop, 3.3.2015
4	Jaroslav Jerz	Press	Buď energia! (Be energy!)	Quark, Magazín o vede a technike 12/2015 str. 7 - 11
5	František Simančík	Press	Inovácie rušia závislosť. Nik ich od nás nečaká (Innovations avoid subordination. Nobody waits them from us.)	Hospodárske noviny, 20.05.2015, s. 7
6	František Simančík	Internet	Slováci vyvíjajú originálnou technológiou súčiastky do automobilov (Slovaks develop components for automobiles by original technology)	eTREND/Technológie; http://www.etrend.sk/technologie/slovaci vyvijaju originalnou technologiou suciastky do automobilov.html, 5.11.2015
7	Karol Iždinský	Press	Vedci pôjdu s firmami do spoločných podnikov (Scientists will go in joint ventures with companies)	Pravda, 23.02.2014, http://spravy.pravda.sk/domace/clanok/309502-vedci-pojdu-do-spolocnych-podnikov-s-firmami/
8	František Simančík	Radio	Nočná pyramída (Night pyramid - long evening broad cast of Slovak statutory broadcaster with invited guest)	RTVS, 17.8.2014
9	Juraj Lapin	Press	Nové kapacity pre špičkový výskum (New capacities for advanced research)	Revue priemyslu; 2014, č. 5, s. 24 - 25
10	František Simančík	TV	Series of spots promoting the study of science and technology	STV1, TV Markíza, TA3, 2014
11	Juraj Lapin	Press	Slovenská veda vo vesmíre (Slovak science in space)	Pravda, 11.5.2013, roč. XXIII, č. 108, s. 39

12	František Simančík	Press	A promising road to high temperature world	The Parlament - Politics, policy and people Magazine, Vyd. 364, 4.3.2013, str. 58
13	František Simančík	Press	Innovative products - the only way to a prosperous economy (in Bulgarian)	(BG) Evropa 1/2013, str. 14-15.
14	František Simančík	Radio	Appearances on radio on Slovak inventions and the importance of science to the public	radio Best, 15.11.2013
15	František Simančík	TV	HOSŤ V ŠTÚDIU: F. Šimančík o vedeckých projektoch SAV (Guests in studio: F. Šimančík about scientific projects of SAS) (http://www.ta3.com/clanok/15286/host-v-studiu-f-simancik-o-vedeckych-projektoch-sav.html,)	Televízna stanica TA3, rozhovor, 24.5.2012, 14:20, 6 min.
16	František Simančík	Radio	Interview with Dr. Simančík in broad cast "Technology transfer"	Rádio VIVA, 24.10.2012 o 14:30
17	František Simančík	Radio	Naši a svetoví - František Simančík (Ours and universal - František Simančík)	Rádio Regina (30.4.2012, 15:10, http://www.rozhlas.sk/download/file/8312)
18	Jaroslav Jerz	Radio	Interview with Dr. Jerz on industrial applications of advanced materials developed at IMSAS in industrial practice	Rozhlasová stanica Slovensko - relácia Pozor zákruta 9.11.2012
19	František Simančík	TV	Diskusná relácia "Debata s Dr. Simančíkom" (Discussion broad cast "Debate with Dr. Simančík")	Televízna stanica TA3 7.6.2012
20	František Simančík	Press	Veda ľuďom dáva, nie berie peniaze - rozhovor s Dr. Ing. Františkom Simančíkom (Science gives not takes money form people - interview with Dr. Ing. František Simančík)	TREND - Týždenník o ekonomike a podnikaní, č. 44/2012

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	16	5	7	9	37
Appearances in telecommunication media popularising results of science, in particular those achieved by the Institute	6	2	2	1	11
Public popularisation lectures	3	4	2	2	11

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

The most attractive popularisation events in the assessed period were presentations of institute's R&D activities during Scientific Nights in Bratislava. The main aim of these events was to attract young people for study of material science and mechanical engineering.

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	86,0	84,0	88,0	72,0
Research employees from Tab. Research staff	50,0	48,0	58,0	42,0
FTE from Tab. Research staff	40,870	42,030	38,020	41,100
Average age of research employees with university degree	44,5	44,1	42,5	43,0

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	0	0	0
II.a / Assoc. prof.	0	0	1	0	0	0	0	0	0
Other researchers PhD./CSc.	0	4	1	0	0	1	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	1	0	0
II.a / Assoc. prof.	0	0	3	2	1	2	1	2	0
Other researchers PhD./CSc.	1	4	3	0	0	0	2	0	0
doc. / Assoc. prof.	0	0	0	0	0	0	0	0	0

2.8.2. Postdoctoral and mobility scheme

2.8.2.1. Postdoctoral positions supported by national and international resources

IMSAS management provides the possibility for most of the doctoral students successfully finishing their study at IMSAS to stay as postdocs or employees at IMSAS. To gain a funding for such position research projects (mostly APVV, EU FP or ERDF) were prepared well before the end of doctoral study. Following successful postdocs accepted the offer to stay at IMSAS:

2012: Ing. Jana Harnúšková, PhD., Ing. Peter Krížik, PhD.*, Ing. Lucia Senčeková, PhD.*, Ing. Hana Staneková, PhD.

2013: Ing. Alena Klimová, PhD.*,

2014: Ing. Tomáš Švantner, PhD.*

2015: Ing. Andrej Opálek, PhD.*, Ing. Ľubomír Orovčík, PhD.*

Most of them (marked with *) are still working at IMSAS.

2.8.2.2. Postdoctoral positions supported by external funding

Dr. F. KHODABAKHSHI - Post doctorand at the Shafir University of Technology in Tehran spen 3 months at IMSAS in 2012

2.8.2.3. SAS stipends and SASPRO stipends

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

Ing. Peter Krížik, PhD. received funding from Fund of Stefan Schwarz in 1.1.2013 – 31.12.2013 period. He is still actively working at IMSAS

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

The important infrastructure includes equipmemnt and technologies available at IMSAS´s headquarters in Bratislava; IMSAS´s branch at Inoval in Žiar nad Hronom, and two SAS centres managed by IMSAS *i.e.* Centre of Applied Research and Technology Transfer in Bratislava and Research Centre ALLEGRO in Trnava

Important research infrastructure at IMSAS in Bratislava:

Technological facilities:

- 5 autoclaves for pressure infiltration with graphite and induction heating for samples with the diameter up to 300 mm and length of 550 mm
- furnace for foaming of aluminium panels
- equipment for injection molding of metallic foams
- foam expandometer
- vacuum press for hot diffusion bonding (up to 300 000 kp)
- plasma spraying of metallic and ceramic coatings with two separate powder supply units for preparation of composite coatings with various even gradient volume fractions of constituents on flat and round surfaces
- continuous electroless or galvanic coating of carbon fibres with metals Cu, Ni, etc.
- PVD magnetron
- furnace for unidirectional solidification
- 2 plasma melting furnaces
- vacuum furnaces for thermal treatments
- extrusion and ECAP hydraulic presses (up to 500 000 kp)
- equipment for preparation of rapid solidified ribbons from Al alloys with amorphous structure
- (metallic glasses) via „Melt Spinning“ a „Planar Flow Casting“
- complete set of equipment for machining of prototypes and moulds
- gas atomiser, capacity of 30 kg Al powder per batch
- screew forging press (2.7 MN, 14 kJ)
- laboratory and semi-industrial extrusion press (up to 3.5 MN)
- equal chanel angular pressing (ECAP)
- cold isostatic pressing (CIP), max. pressure 400 MPa
- vacuum hot press with induction heating
- vacuum and overpressure furnaces (up to 1600 ℃)
- particle size distribution (PSD)

Structure characterisation equipment:

- metallographic equipment
- light optical microscopy (Olympus GX 51 equipped with CCD digital camera ARTCAM 300)
- fully automated microhardness tester FM-ARS 9000 (10 – 500 p)
- X-ray tomography with resolution better than 0.5 μm (Phoenix X-ray microtomograph Nanotom 180)

- scanning electron microscope JEOL 7600F FEG with resolution from 1 nm equipped with energy and wave dispersive spectrometers (EDS; WDS) and electron backscatter
- diffraction (EBSD)
- scanning electron microscope JEOL JSM 6610 with energy dispersive X ray spectrometer
- transmission electron microscope JEOL JEM 100 C
- precision ion polishing system (Gatan PIPS II)
- optical emission spectrometer with laser induced emission (LIBS – LEA S500)
- computer controlled dilatometer measurements, DTA, DSC, TG (up to 1600 ℃; Linseis, Netsch),
- SPECTROMAXx - optical emission spectroscope
- SPECTRO XEPOS - Table XRF spectrometer

Materials testing equipment:

- universal computer controlled testing machine for determination of mechanical properties under static loading (tensile, compressive, bending tests) (Zwick; 10 000 kp loading force)
- static creep tests,
- thermomechanical testing
- fatigue tests (hydropulsator MTS, EDYZ)
- abrasive wear testing
- thermal conductivity measurement
- vibration and noise measurement and analysis (Bruel & Kjaer)
- hardness measurements (Vickers, Rockwell, Brinell)

Important infrastructure at IMSAS´s branch Inoval in Žiar nad Hronom:

- HAAS VF1-DHE Vertical machining center
- CUT 20P CNC wire cut electric discharge machine
- FORM 20 CNC EDM die sinking machine
- Indutherm VC1000D vacuum casting machine
- M2 Cusing Concept Laser – metal additive manufacturing machine
- Z Printer 650, Z Corporation – 3D printer
- Flir 7000/7600 thermal imaging camera
- Dust Trak DRX aerosol monitor 8533
- *LECO CS844* C + S elemental analyzer
- GALILEO ONH elemental analyzer for O; N, H
- *Q4 TASMAN* CCD based optical emission spectrometer for the metal analysis
- *SPECTRO XEPOS* - Energy Dispersive X-ray Fluorescence (EDXRF) Spectrometer
- NETCH 449 F1 JUPITER simultaneous thermal analyzer
- NETSCH DIL 402C dilatometer
- LINSEIS LFA 1000/1250 Laser Flash Thermal Constant Analyzer
- Tescan VEGA 3 XMU scanning electron microscope equipped with EDX analyzer
- VHX 2000E Keyence Digital microscope
- Tinius Olsen H200KU 200 kN universal testing machine
- Thermomechanical simulator Gleeble 3500
- High resolution CT scanner CT Nikon XT H 225 ST
- Wenzel LH65 coordinated measuring machine

Important infrastructure available at IMSAS managed Research centre ALLEGRO:

- Universal testing machine Zwick 60 kN equipped for mechanical testing up to 1200 ℃
- High speed tensile testing machine Instron 10 kN
- Creep-fatigue testing machine Zwick 5 kN
- Constant load creep machines Zwick
- Constant stress creep machines Zwick
- Instrumented Zwick impact testing machine
- Gleeble 3800 digital closed loop control thermal and mechanical testing system
- Nanoidentation hardness testing machine
- Confocal scanning microscope LSM
- Vacuum induction melting furnace combined with till casting

- Centrifugal casting machine
- Industrial acoustic emission equipment for monitoring power plans
- LECO ONH836 Oxygen/Nitrogen/Hydrogen Elemental Analyzer

Important infrastructure available at IMSAS managed Centre of Applied Research and Technology Transfer in Bratislava:

- Titan Themis 300 kV transmission electron microscope with atomic resolution

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

IMSAS has got 89 % out of 100 % of points in previous evaluation and was accredited in category A. In its final comment on qualitative evaluation of global indicators the evaluation panel stated: "The achieved results in fundamental and applied research are very good. Recognition by the foreign and national partners is the best proof of the achieved level of the published and patented outcomes as well as knowledge transfer to industrial partners. The experience with the establishing successful links with industrial partners is a way to be followed even by other institutes of SAS."

In its comments, objections to organization´s activities in form of suggestions and specific tasks which must be performed by organization before next regular evaluation the panel outlined:

1) The aluminium niche may decrease in coming years. The Institute has to find similar area of research.
2) The Institute can provide its unique experience with establishing organizational units between Institute and industrial partners.
3) Reach a state where industry will pay royalty.
4) 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.

1) The aluminium niche may decrease in coming years. The Institute has to find similar area of research.

The current portfolio of materials investigated at IMSAS includes besides aluminium also:

- Magnesium and its alloys
- Magnesium composites reinforced with C fibres
- Lead infiltrated ceramics
- Composites with copper matrix reinforced with W, graphite, and ceramic preforms
- Mo/Mo silicide composites
- Ti-Al intermetallic alloys
- Ni based intermetalic alloys
- Hard coatings prepared by physical vapour deposition

However, Al remains the most strategic material for IMSAS predominantly due to local preconditions in Slovakia. Slovakia is an important producer of primary aluminium that is sold abroad with small added value. This is undesired situation that needs to be changed.

If the price for alumnium is 2 €/kg and we change it into an aluminium foam part, this can be sold for 100 € or more (crash boxes for Siemens railway carriages). The involvement of proper know-how increases the added value in quite extreme manner. This is what the local manufacturers of aluminium dream of. There are about 40 companies located close to the SLOVALCO – prime aluminium producer in Žiar nad Hronom however, they have no their own research capacities and cannot substantially increase the added value of their production. Therefore IMSAS has built an SAS innovation centre Inoval in Žiar nad Hronom in order to be able

to transfer the proprietary know-how as well as to be helpful for local companies to solve their manufacturing problems by providing the required infrastructure. The response of local companies is enormous confirming thus the rightness of this approach.

Moreover, quite new opportunities appear with the transfer of aluminium car body assemblies into Slovakia. The importance of Al manufacturing technologies dramatically increased and there is an enormous demand to provide the necessary know how for the suppliers to car industry.

On the whole this is a very good time for aluminium and it will remain a hot topic for some future years. However, we believe, that this will be replaced with magnesium exhibiting even lower density. This will be more and more requested as the allowed car pollutant emissions are tightened. Slovakia has strategic resources of magnesit ore and so it has the potential to become Europe´s important magnesium producer and manufacturer. However this is to be decided by political authorities. When this decision comes, IMSAS will be ready.

2) The Institute can provide its unique experience with establishing organizational units between Institute and industrial partners.

IMSAS has dozens of industrial partners with established cooperation in numerous projects. In some cases this cooperation has grown into common organizational units in line with the recommendations of evaluation panel. IMSAS has currently 5 joint places of work with industrial partners:

Name of the partner: Elektrokarbón a.s. Topoľčany
Name of the work of place: Infiltration autoclave
Field of cooperation: Infiltration of graphite performs with metal alloys.
Founded: 1985

Name of the partner: DECOM a.s. Trnava
Name of the work of place: R&D centre of DECOM and IMSAS - ENERMAT
Field of cooperation: Non-destructive testing and the estimation of service life of selective parts of power equipments.
Founded: 2012

Name of the partner: Thermosolar s.r.o. Žiar nad Hronom
Name of the work of place: Research centre for solar collectors testing
Field of cooperation: Testing of new materials applications in solar collectors.
Founded: 2013

Name of the partner: SAPA Profily a.s. Žiar nad Hronom
Name of the work of place: R&D centre of Sapa Profily a.s. and IMSAS for extrusion of new materials with unique properties
Field of cooperation: Preparation of demonstrators of unique materials extruded from powder blends in conditions approaching the real manufacturing process.
Founded: 2013

Name of the partner: ESOX s.r.o. Uhorská Ves
Name of the work of place: R&D centre for injection of hybrid aluminium/plastic castings
Field of cooperation: Research activities directed towards new innovative products prepared as aluminium/plastic pressed parts using new materials predominantly Al powder based composites or aluminium foam.
Founded: 2014

3) Reach a state where industry will pay royalty

It is generally quite difficult to create a balanced and transparent relation to industry in order to get the fair royalty. First of all the corresponding agreement must be signed before we reveal all the know-how to the partner otherwise we can get into disadvantageous position. At this moment it is quite difficult to estimate the manufacturing costs, how large the production will be

and what will be the market conform prize for the product. Therefore it is difficult to guess what will be the profit for the producer and how much he can pay to the institute. Both sides *i.e.* IMSAS and industrial partners are extremely cautious in this case. IMSAS therefore prefers to sign a research contract with the industrial partner that covers also some profit related to the production.

However, we have patented some key technologies in the assessed period that will give us the opportunity for safe future sale of the technology. For this moment we have worked out a market model based on the quantity of precursor that is used in foam production. This can be purchased from IMSAS or somebody else and in both cases the industrial partner pays some kilogram prize. This can be better controlled and is fair to the partner. If he has a large production, he pays more, if he cannot sell the product and cuts down the production he pays less. Two contracts based on this model were signed in 2015 and one already brings the royalties.

4) 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 effective use of new equipment is the basic precondition for the sustainability of the whole. IMSAS introduced two variants for its partners to provide the access to its unique infrastructure. IMSAS offers to use its infrastructure for partners who are trained and skilled in operation of the instruments. IMSAS is ready to train those interested. This is suitable for partners who prefer to perform their measurements and analysis on their own. In this case only energy costs are reimbursed to them.

If it is too demanding, or they do not want to be trained, IMSAS can offer its own personnel to perform all the requested measurements. In this case some money, covering the costs, is paid in dependence on the extent of exploitation.

If the involvement or the contribution of IMSAS´s personnel is deeper than pure technical work, our people become co-authors of publications. Typical example is the publication:

JANÁK, Marián - FROITZHEIM, Nikolaus - YOSHIDA, Kenta - SASINKOVÁ, Vlasta - NOSKO, Martin - KOBAYASHI, T. - HIRAJIMA, Takao - VRABEC, Mirijam. Diamond in metasedimentary crustal rocks from Pohorje, Eastern Alps: a window to deep continental subduction. In *Journal of Metamorphic Geology*, 2015, vol. 33, p. 495-512. (4.147 - IF2014). (2015 - Current Contents). ISSN 0263-4929.

The SAS awarded its 2016 Prize for international scientific and technical cooperation our colleague M. Nosko, M. Janák from the Earth Science Institute of the SAS and V. Sasinkova from Institute of Chemistry for the first find of diamond and moissanite in the south-eastern Alps. It was found as a bright example of interdisciplinary cooperation.

Several other publications can be found in the IMSAS´s list documenting wide cooperation based on the exploitation of our unique infrastructure.

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

The operation of infrastructure is considerably influenced by EU and Slovak rules. They prohibit any profit (net income) resulting from the exploitation of equipment purchased from the ERDF money. This is of course respected by IMSAS.

Literally, it has to be strictly distinguished between the infrastructure obtained from EU Structural Funds and infrastructure purchased for money from different sources.

In spite of this, IMSAS tries to emply the infrastructure from EU money in various projects intensely. Although financially not very beneficial, we recognize the actual benefits in the obtained know-how or improved skillness of the personnel. This is a sort of investment that has the potential to bring revenues in the future.

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

It is obvious that new materials with improved properties and novel or adapted manufacturing technologies are attractive topics from both national and international point of view. They fully correspond with the priorities of European innovation programme Horizon 2020 and also with national Research and Innovation Smart Specialise Strategy (RIS3), where development of novel materials is the first of 5 research priorities.

European Horizon 2020 programme has not foreseen the development of novel materials as a specific independent topic nevertheless the particular calls frequently address this challenge.
The competency of IMSAS may answer the needs in following priorities of Horizon 2020:

- Excellent science – development of key enabling technologies (development of technologies for manufacturing of smart materials, technologies for flexible manufacturing of large size lightweight structures, manipulations with material structure in nanoscale, etc.),
- Competitive industry – development of techniques for additive manufacturing, cost efficient manufacturing technologies for novel materials such as composites, foams, powder based materials, efficient use of multi material combinations, etc.,
- Societal needs – here IMSAS can contribute in many areas such as materials for green cars (novel batteries, lightweight structural parts, materials for energy storage and recuperation, materials for thermal management, etc.), energy efficient buildings and low carbon economy (energy efficient heating and cooling solutions via aluminium foam panels, heat storage using PCM composites, lightweight energy efficient structures, etc), even in health priority (new medical implants, biodegradable materials).

Slovakia with almost 25% GDP created by industry belongs to strong industrial countries. Most of the industrial output is produced by automotive and electronic sector and associated suppliers. Therefore the development of these two sectors was selected as strategic priority in RIS3.

Large car makers (VW in Bratislava, PSA Pegueot Citroen in Trnava and Kia in Žilina) transferred their most progressive and demanding assemblies into Slovakia. Volkswagen started here unique production of multimaterial car body structures with large portion of lightweight aluminium parts (Audi Q7, Porsche Cayenne and expected Touareg). Jaguar Land Rover is the newest member of the family aiming to produce aluminium body SUV in Nitra. Aluminium body production becomes very interesting topic in Slovakia and this is why development of lightweight metallic materials with particular attention paid to aluminium and magnesium was listed under perspective strategic priorities in RIS3.

Actually there is not as much experience with mass production of aluminium cars worldwide and the presence of these car makers brings the opportunity to rearrange the network of local suppliers from steel to aluminium. IMSAS traditionally belongs to the primary Slovakian developers of novel aluminium based applications and possess all necessary competence. Of course, there is strong interest of IMSAS to develop it further and contribute to the development of Slovakia into an internationally recognized industrial country with strong competency in the products manufactured from aluminium. Therefore the lightweight structural materials remain as the first priority in IMSAS´s strategy.

These however include more than materials for cars. We want to further enhance our knowledge also in the fields of metal matrix composites in order to be prepared for further improvements when current technologies and materials will have to be replaced with more performing ones.

Finally, aluminium will be more and more replaced with magnesium what requires further substantial update of technology and material development. It is quite important to be prepared for this near future and gain the necessary experience.

Materials for energy production, conversion and storage represent one of crucial topics worldwide (and are frequently addressed also in Horizon 2020). These include materials that due to improved properties at elevated temperatures make the energy production more efficient. On the other better

understanding of their degradation process and more precise inspection of energy generating devices and facilities can increase their lifetime making the energy production cheaper and more environmentally friendly.

More and more important role plays energy from renewable sources. These are typically time dependent (wind, solar) and not very suitable for supply on demand. This energy therefore needs to be stored to be available when needed. Here the storage materials offer new opportunities that need to be explored and developed.

It is our common mission to contribute to the development of earth into a better place for life. IMSAS will contribute to this goal by application of its knowledge in medicine and safety of road traffic.

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

The basic philosophy of IMSAS is to perform research and development yielding recognizable and unquestionable benefits to the society. This is in accordance with the Mission of SAS "… the academy fulfils its social mission through the development of progressive technologies, patents, innovations, expertise and the transfer of knowledge to many areas of practical implementation" (http://www.sav.sk/index.php?lang=en&doc=sas-mission). We believe that this is for us a suitable way how to repair and strengthen the position of science in the general public. Coming out from this philosophy, IMSAS will focus its research strategy in following fields:

A) **Lightweight structural materials** aimed mostly for structural application in machine construction with the main interest in automotive industry – addressing pillar 2 in HORIZON 2020. Several ways will be followed:

- Development of HITEMAL (high temperature aluminium) which is an proprietary ultrafine-grained or fine-grained Al–Al_2O_3 composite prepared by compaction of fine gas as-atomized Al powders of commercial purity. Based on the studies revealing the mechanism of interfacial bonding formation other common engineering metal powders will be investigated in order to get composites stabilised by the continuous network of their native oxide with sufficient strength and ductility. These materials will find their use in new generation of engine parts (piston, connecting rods, pins, transmission gears etc.), in piping registers of high temperature solar collectors (APVV project since 07/2015), or in containers for storage of use nuclear fuel (industrial cooperation).
- The nitridation reaction in in-situ Al-AlN composites with enhanced Young´s modulus and high-temperature strength will be studied in order to ensure the controllability and reproducibility of nitridation process of Al powders also in industrial scale (the material is expected for use cases typical for well established Hitemal, nevertheless with enhanced stiffness to weight ratio).
- Proper consolidation technology for the production of nanostructured Al materials will be developed.
- Novel Al matrix composites reinforced with ceramic particles will be developed for containers for storage of radioactive waste (cooperation with large French company since 2015).
- New Al alloys powder with an aim to be used as feedstock for 3D printing (laser sintering) will be prepared by proprietary gas atomization technique recently established at IMSAS.
- Unique casting technology based on patented FACT process (foaming asssited casting) allowing easy casting of large lightweight structural parts, such as car body monocoques, will be further developed to achieve industrial maturity (strategic cooperation with car body suppliers).
- Novel magnesium composites for ultralight structural components will be further optimised (ESA PECS contract since 05/2016).

B) **Materials for energy production, conversion and storage** - addressing pillar 2 and 3 in HORIZON 2020 (secure clean and safe energy, smart, green and integrated transport). Several ways will be followed:

- The research of light weight TiAl-based alloys will be focused on in-situ composites with lamellar matrix consisting of γ(TiAl) and $\alpha_2(Ti_3Al)$ lamellae, where the particles of MAX-phase (Ti_3AlC or Ti_2AlC) will be distributed. Our design of the in-situ composites will be focused on the in-situ composites with Al content between 40 and 47 at.%, Nb content from 3 to 7 at.% and content of C and N will vary to achieve up to 30 vol.% of MAX-phase. The relationships between in-situ alloying of the selected melts by the TiC and TiN particles and morphology (size, shape and distribution), volume fraction and the chemical composition of $Ti_2Al(C,N)$ phases will be studied. The understanding of the basic principles of the structure formation during the gravity and centrifugal casting of simple shape castings and prototype turbocharger wheels will be accomplished.
- Future development of high entropy alloys will be focused on FeCoCrNiX, AlCoCrFeX and CrNbTiZrX systems prepared by melting and casting techniques. The research will be focused on fundamental aspects of formation of anisotropic columnar grain and single crystalline structures prepared by directional solidification, identification of solidification path, columnar to equiaxed transition, phase transformations and microstructure characterisation. Advanced testing techniques of mechanical properties will be supported by numerical macro-, meso- and micro-scale modeling of deformation behavior. Mechanisms controlling room and high temperature deformation will be analyzed.
- Composites for electrodes of power plasma generating devices will be developed. These will be prepared by gas pressure infiltration of W or ceramics (ZrB_2) preforms with Cu. Cu-W composites prepared by proprietary patented technique have proved their appropriateness for this purpose. However larger and larger electrodes being able to transport increasing power outputs are requested by waste incinerator producers or for machining purposes.
- Proprietary heating/cooling panels impregnated with phase change materials have grown up and are now able to provide complex solution for green houses. Their application in construction industry allows the heat accumulation exhibiting cooling effect as well as heat radiation with heating effect. The proposed concept will be tested using our well equipped “SmartGrid” – testing laboratory for production, storage and consumption of energy gained from renewable sources.
- Magnesium is an attractive material for hydrogen storage; the effect of composition of the Mg melt, cooling rate, gas pressure and size of Mg particles on the amount of hydrogen absorbed in the solid powder will be studied. In addition, the ability of such powder to absorb and desorb hydrogen repeatedly without excessive creation of passive layer on the particle surfaces will be determined. The ways of further use of powder after exhausting its ability to effectively bind hydrogen will be examined. The successful results could revolutionary help in the storage of energy from clean and renewable sources, thus contributing to the formation of sustainably clean environment.(APVV project since 07/2015).
- Increasing research activities are devoted to the development of PCM/Al foam composites for improved heat management (battery packages, power electronics breaking systems, machine housings, building interiors) or as heat storage tanks (new Horizon 2020 project Everlast, industrial cooperation).

C) **Human welfare** - adressing pillar 3 in HORIZON 2020 (health and wellbeing). Several ways will be followed:

- Novel approach for the application of magnesium in biodegradable medical implants with satisfactory mechanical properties (close to the properties of natural bone), biocompatibility and controllable degradation rate will be examined. The approach is based on the use of ultrafine Mg or Mg-alloy powders for manufacturing of degradable implants, whereas mechanical properties of the compacted powder will be tailored via (i) grain size of powder particles, (ii) alloying with suitable biocompatible element (Zn, Ca, Mn) and (iii) via amount of surface oxides or nitrides formed on the surface of powder particles before compaction. These native oxides or nitrides will also serve as diffusion barriers for the control of the degradation rate (JRP SAV – TUBITAK project since 12/2014).

- The patented Ti-Mg composites for dental implants prepared by powder metallurgical routes will be tested and optimized in terms of mechanical properties and biocompatibility. As-prepared composites will be subjected to in-vivo tests in order to examine the ability of MgO layer to control the rate of Mg dissolution in animal body.
- In the field of machine mechanics the research will cover the analysis of *vibration in a road-vehicle-driver system*. The research effort will be focused on providing unique in-situ measurements of road roughness and whole-body vibration for various types of vehicles, vehicle velocities, and road categories; the correlation among current indicators of longitudinal road unevenness and measured whole body vibration based on ISO 2631-1 in a vehicle will be determined. Relationship among the parameters of road elevation spectrum (unevenness index and waviness) and whole body vibration based on measured profiles will be derived.

D) **Additional R&D activities** adressing pillar 2 in HORIZON 2020

- Advanced hard ceramic protective coatings possessing high hardness in combination with enhanced toughness will be developed. It means reducing the elastic modulus while maintaining high values of hardness. Suitable way seems to be alloying of well-known brittle ternary transition metal nitrides with nitrides of pentavalent VB group elements. Expected results should be better resistance against thermal shock during machining of hardly machinable materials, longer lifetime of cutting tools, etc.
- Amorphous hard coatings for protective applications at higher temperatures up to 2000℃ in aggressive oxidic atmosphere will be prepared. Material design of amorphous nitride/oxide-based composite coatings with absence of grains preventing to direct contact of external atmosphere with substrate through boundaries surrounding grains, for example protective coatings for ɣ-TiAl blades in turbines, aircraft and space applications, etc.
- New technological approaches for high-rate reactive deposition of oxide coatings with deposition rate exceeding 10 000 nm/min will be investigated. Development of dual-magnetron systems in combination with AC/DC pulsed power supplies.
- Highly ionized deposition technologies to obtain a large quantity of ionized sputtered particles for better structure control of growing films with desired properties will be developed. The formation of high-temperature phases in coatings produced at temperatures less than 500℃, the nanocrystallization of amorphous materials at temperatures of about or less than 100℃ for flexible electronics, etc. will be examined.

The assessed period was the period of unprecedented extensive growth of IMSAS. This process was closely related to the Programming Period of EU 2007 – 2013 extended to 2015 for Slovakia and was powered by its European Regional Development Fund (ERDF). Calls in this fund were oriented predominantly towards the improvement of infrastructure.

IMSAS recognized this as a quite exceptional opportunity that will not be repeated anymore. Therefore large portions of effort and intellectual capacities were invested in preparation of call proposals in order to acquire modern technology and characterisation equipment in order to strengthen the institute´s position at home and in the international research area. IMSAS was finally successful in 15 projects and in 6 of them in the role of coordinator. For these efforts IMSAS has gained 15.6 mil € including 12.4 mil € for investment. As a consequence IMSAS substantially improved the infrastructure of its headquarter in Bratislava and established its branch Inoval in Žiar nad Hronom. The division of roles assumes that the basic research will be in the future predominantly focused to Bratislava and most of the application and innovation work will be performed in Inoval.

This strategy appeared very prescient as in the new Programming Period 2014-2020 Bratislava is due to its degree of development no more eligible for applying in Structural Funds scheme in that extent as in the previous period and most of the money is devoted for other Slovak regions including Žiar nad Hronom. This makes us possible to prolong the successful participation in Structural Funds Calls until 2020.

Besides these, IMSAS was authorised by Presidency of SAS to supervise and manage the establishment of two SAS research centres *i.e.* Centre of Applied Research and Technology Transfer in Bratislava and Research Centre ALLEGRO in Trnava. Both were built up and equipped with infrastructure for millions of €.

However, the philosophy for upcoming period will be different. Now we believe that the basic infrastructure necessary for our activities is already in house and we have to concentrate on the sustainability of the whole. This means in particular, that we have to acquire sufficient resources for qualified scientific personnel able to work with this unique equipment.

Our institutional budget from state is approximately the same for more than 10 years and it covers only part of the salaries that we have to pay. Therefore hiring new personnel requires additional external money from projects or cooperations. These circumstances imply our strategy in the upcoming years. The plan is to employ about 20 new researchers and let them work for EU SF project money. At the end of Programming Period 2014-2020 they should be already skilled enough to be able to earn the requested money without the need of Structural Funds.

At the end of 2020 we would like to see IMSAS due to the quality of its personnel and infrastructure in a more sovereign position making us less dependent on institutional money than we are today.

Project proposals submited to 7RP or H2020	2012	2013	2014	2015
Institute as coordinator	0	0	0	0
Institute as participant	4	0	4	0

4. Other information relevant for the assessment

This document covers the activities of 43.516 FTE of IMSAS per year within 2012-2015. Of course there is limited quantity of energy, talent and creativity in a given period of time and their division into particular tasks influence the final result. However the life is running in certain circumstances that play an important role decreasing the number of degrees of freedom for making proper decisions and should be understood as well.

IMSAS is like other SAS institutes in underfinanced condition where only a part of salaries is obtained from the state. The prevailing number of our co-workers are machine engineers that belong to the most wanted people for automotive sector. This is able to pay twice as much as IMSAS and overtakes the majority of graduate students. It we do not want to lose them, we need to guarantee some acceptable salary. For these purpose we need to get external funding either by research projects or by cooperation with industry.

The orientation of IMSAS is therefore to a large extent enforced with external conditions. The growing gap between salaries paid by industry and academy is so large, that students are not interested to proceed to PhD. studies after finishing the master degree. They have no perspective, that the higher education will bring them some benefit in the future. This is very disappointing for all of us. We hope to attract the young people with latest infrastructure and really good working conditions, but unless the state changes its attitude towards education, nothing will change. We are doing our best to activate all external sources of financing but this process has also its limits.

We have to decide every year what portion of our capacities we will invest into pure fundamental science and how much in the cooperation with industry. This is even more pronounced in current condition. The sustainability of new infrastructure and new buildings will require additional financing in the range of 100 000 to 200 000 € yearly. We have to earn this money by our own while the SAS as announced is not able to increase our budget at all. There is no other choice and our policy needs to respect this fact strictly. Moreover, it is fully in accordance with the governmental policy

assuming that the science should be finally financed up to 33 % from governmental and 66 % from private sector.

Bratislava, Aug. 5th, 2016

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