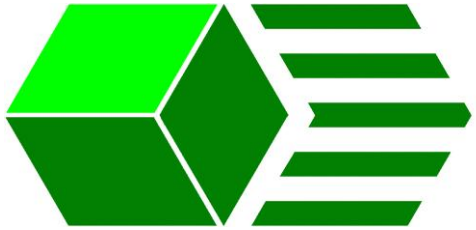


institute of materials and machine mechanics

slovak academy of sciences

IMSAS

Average full time equivalent work capacity of employees with university degree (2012 – 2015)
43,5

Principal types of research output

basic research 30 % - applied research 70 %

Scientific quality and productivity

IMSAS R&D activities during the assessed period were mainly devoted to:

1) ***the design and development of advanced metallic materials***, in particular metal matrix composites, metallic foams, intermetallics, bulk nanostructured materials and ultrahard coatings.

2*)* ***the development of unique technologies*** for manufacturing of these materials

3) ***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.

4) ***advanced characterisation*** of 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)

5*)* ***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

6) ***the vibroisolation and attenuation of vibration influence on human body***

Highlights of the IMSAS research output in assessed period:

developed knowledge

new materials

new products & most important applications

new technologies

Highlights of the IMSAS research output in assessed period

developed knowledge

1) ***explanation of the effect of surface oxides on gas atomised fine Al powder particles on the properties of materials compacted from such powders***

2) ***explanation of the kinetics of nitridation of aluminium powders*** and determination of the role of alloying elements

3) ***explanation of the reaction kinetics and stability of developed products in Mo-Si system during reactive infiltration of Mo with liquid silicon***

4) ***a new theory of vibration attenuation based on the eddy current principle*** (patent pending PP50072-2014)

5) ***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

6***) 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

Highlights of the IMSAS research output in assessed period

new materials:

1) ***Al-AlN composite with extraordinary structural stability*** and mechanical properties at elevated temperatures

2) ***Cu-W composite with proprietary arrangement of W wires*** for reduced thermal stresses in high heat flux applications (patent pending)

3) ***Mo/Mo-silicide composite made by reactive infiltration for applications at temperatures over 1200 °C***

4) ***a new aluminium foam / PCM composite for efficient heat storage application*** (research for industry)

5) ***a new hybrid casting comprising porous core made of aluminium foam*** for lightweight structural applications (patent pending)

6) ***novel NiAl/alumina composite made by reactive infiltration of Ni/alumina powder mixture with liquid Al***

7) ***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°C

8) ***industrial extrusion of Al/SiC composites*** made from powdered precursors (transferred to industrial partner)

9) ***original precise casting technology for processing of TiAl turbocharger wheels***

Highlights of the IMSAS research output in assessed period

new products & most important applications:

1) ***novel composite electrode for bipolar battery*** (producer Effpower Sweden)

2) ***infiltrated grafphite sliding contact for locomotives*** (producer Elektrokarbon Topoľčany)

3) ***crash box for railway carriages made of aluminium foam*** (producer IMSAS)

4) ***heating / cooling panel made of aluminium foam*** (producer IMSAS)

5) ***a new hybrid casting comprising porous core made of aluminium foam*** for lightweight structural applications (patent pending)

6) ***material for containers for used nuclear fuel*** (supply to Austrian company NMD)

7) ***novel biomedical tooth implants*** (IMSAS)

8 ***heat storage containers (radiators) made of Al-foam infiltrated with PCM*** (industrial partner - confidential)

9) ***cast TiAl turbocharger wheels*** (CCN casting)

Highlights of the IMSAS research output in assessed period

new technologies:

1) ***novel "foaming assisted casting technique***" (FACT) for the revolutionary production of large ultralight components (patent pending)

2) ***novel technology for manufacturing composites aimed for high heat flux*** (patent pending)

3) ***novel technology for manufacturing of medical implants*** (patent pending)

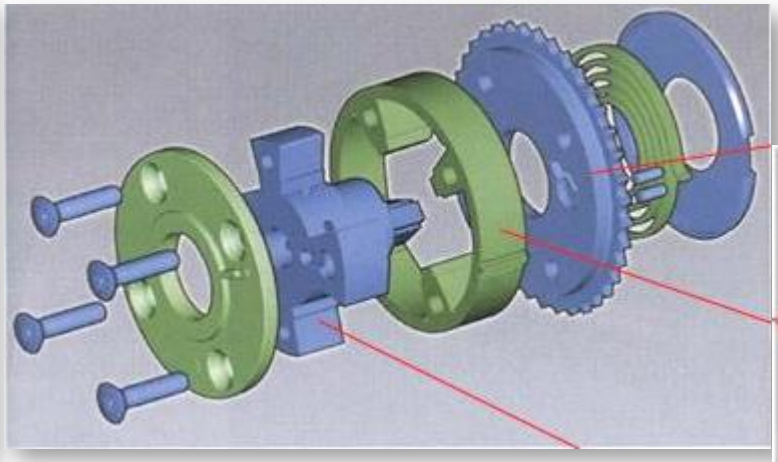
4) ***novel technology for efficient recycling of aluminium ch***ips (research for industry)

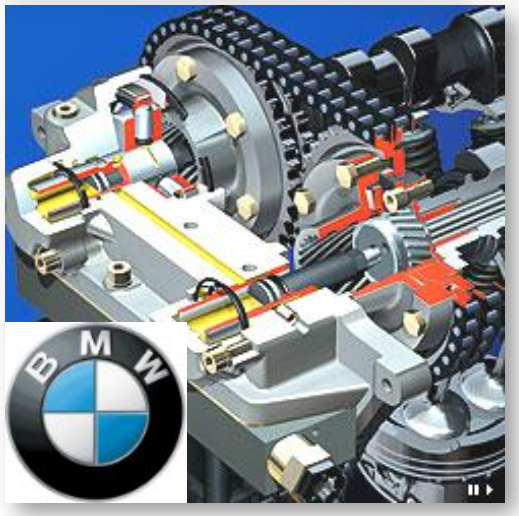
5) ***novel reactive infiltration technology*** for manufacturing materials with high melting point (aluminides, silicides)

6) ***cost efficient technology for manufacturing Al/AlN composites*** (research for industry)

7) ***novel material for medical implant with partially biodegradable component*** (patent pending)

Powder techniques – aluminium composites





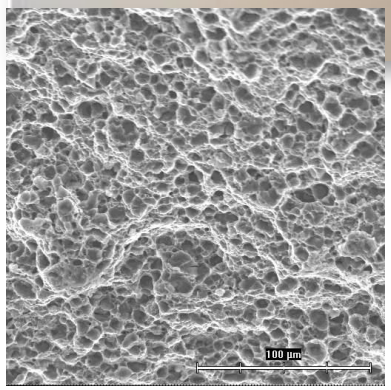
Joint development of:

Slovak Academy of sciences,

SAPA Profily, Žiar nad Hronom (SK)

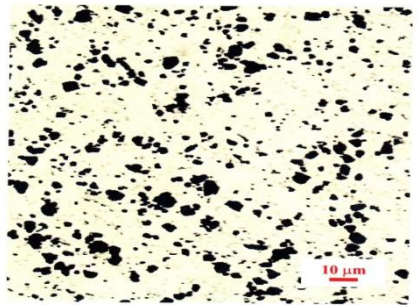
Alulight GmbH, Ranshofen (A)

SHW GmbH, Wasseralfingen (D)

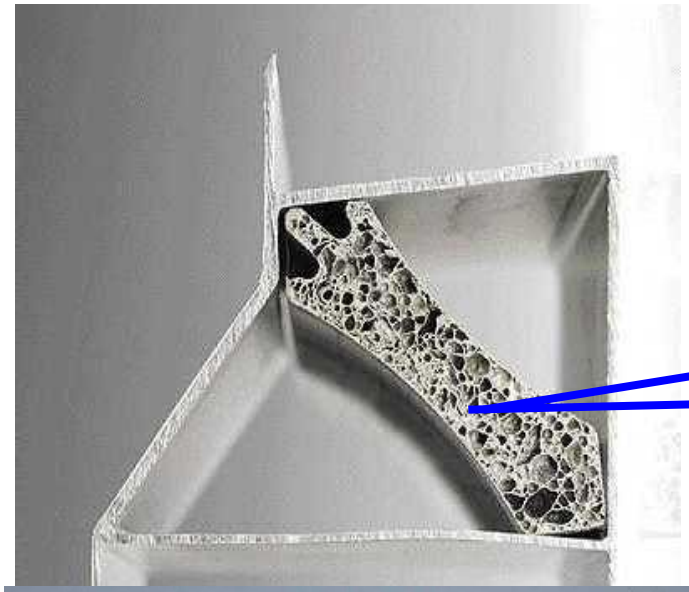


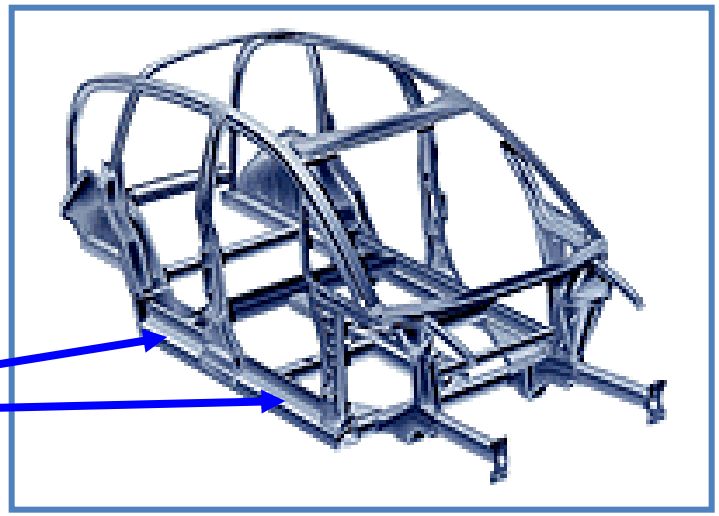
Camshaft phaser stator ring

- **engine BMW, 900.000 pcs/year**



Success cases



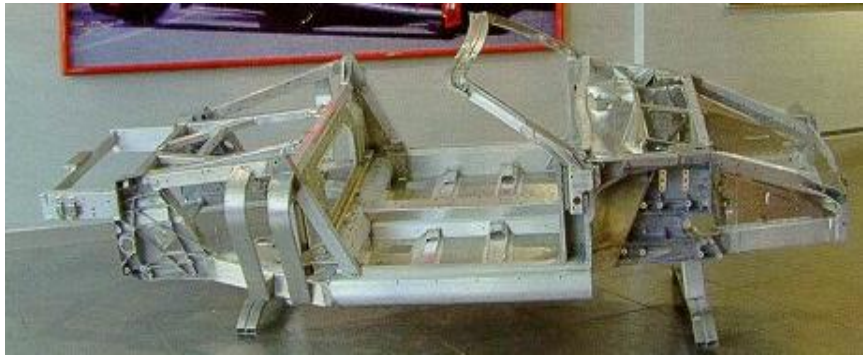


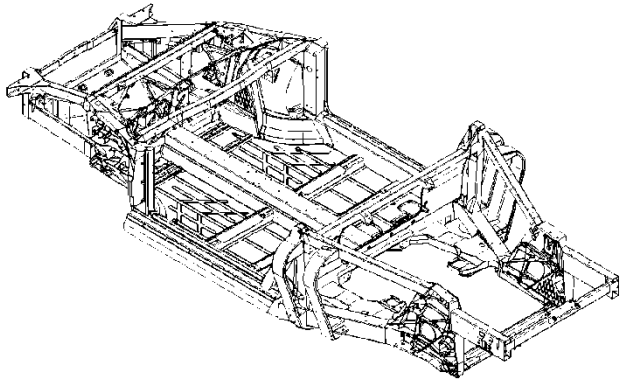
Stiffener of side rail Audi A2:

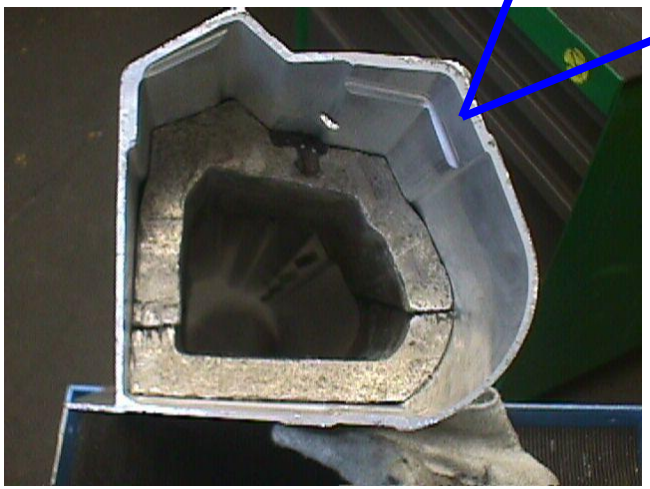
- ✓ **developed by Slovak Academy of Sciences**
- ✓ **start of serial production at Neuman Alufoam GmbH, Marktl (A)**

firts attempt for serial application of Al foam in automotive

Success cases







Stiffener of side rail Ferrari Modena 360:

- ✓ **6.000 pcs/year**
- ✓ **developed by Slovak Academy of Sciences**
- ✓ **Produced by Alulight GmbH, Ranshofen (A)**

worldwide first serial application of Al foam in automotive

Success cases – aluminium foam

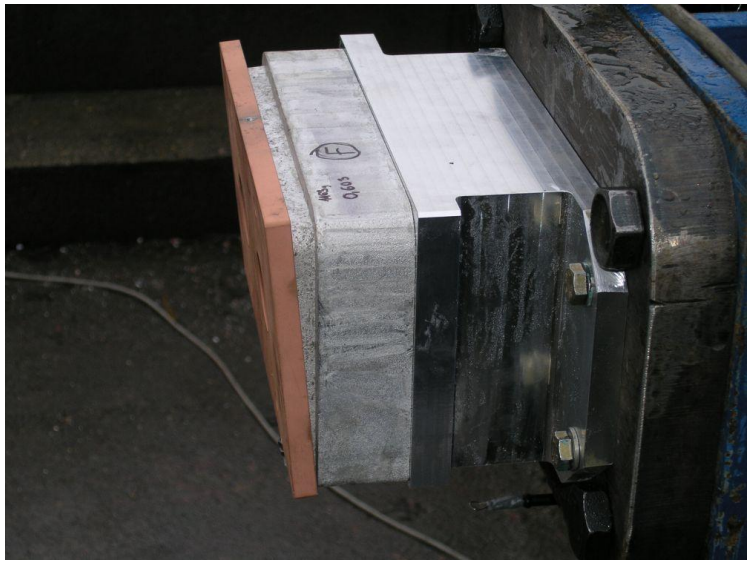
Crash box Audi Q7:

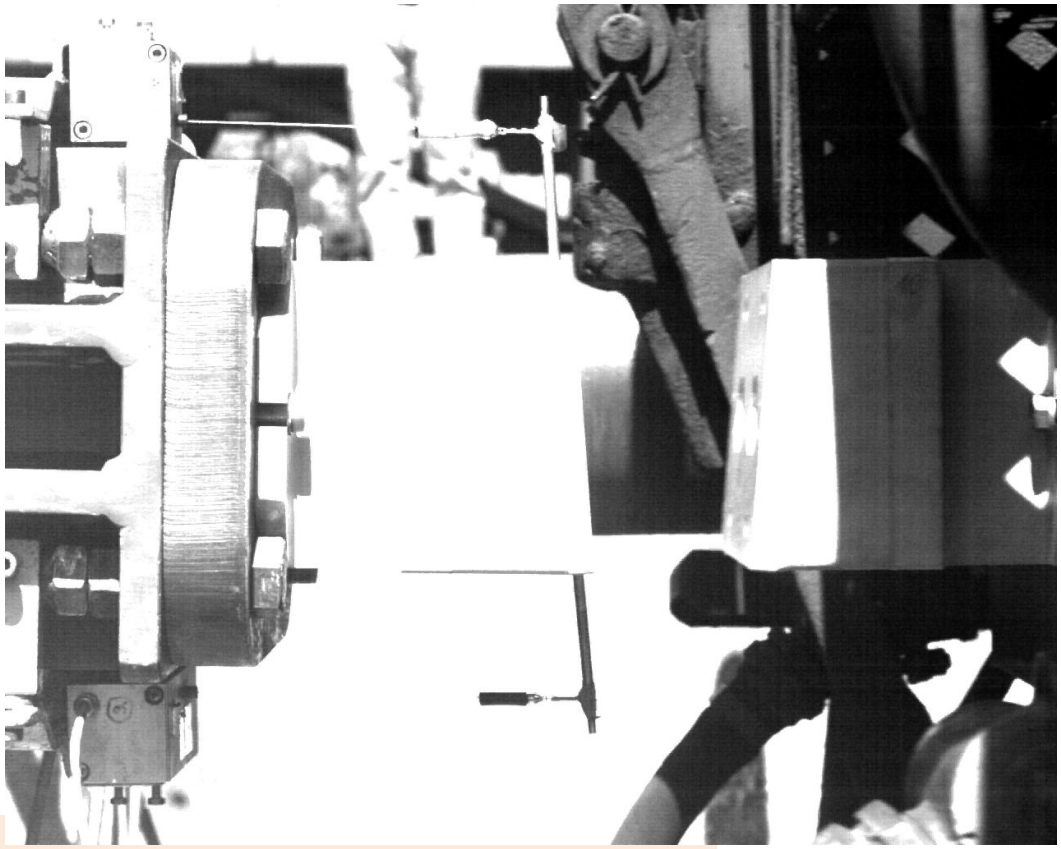
- ✓ **120.000 pcs/year**
- ✓ **developed by Slovak Academy of Sciences**
- ✓ **produced by Alulight GmbH, Ranshofen (A)**

worldwide largest serial application of Al foam in automotive

Success cases

Crash box for railway carriage

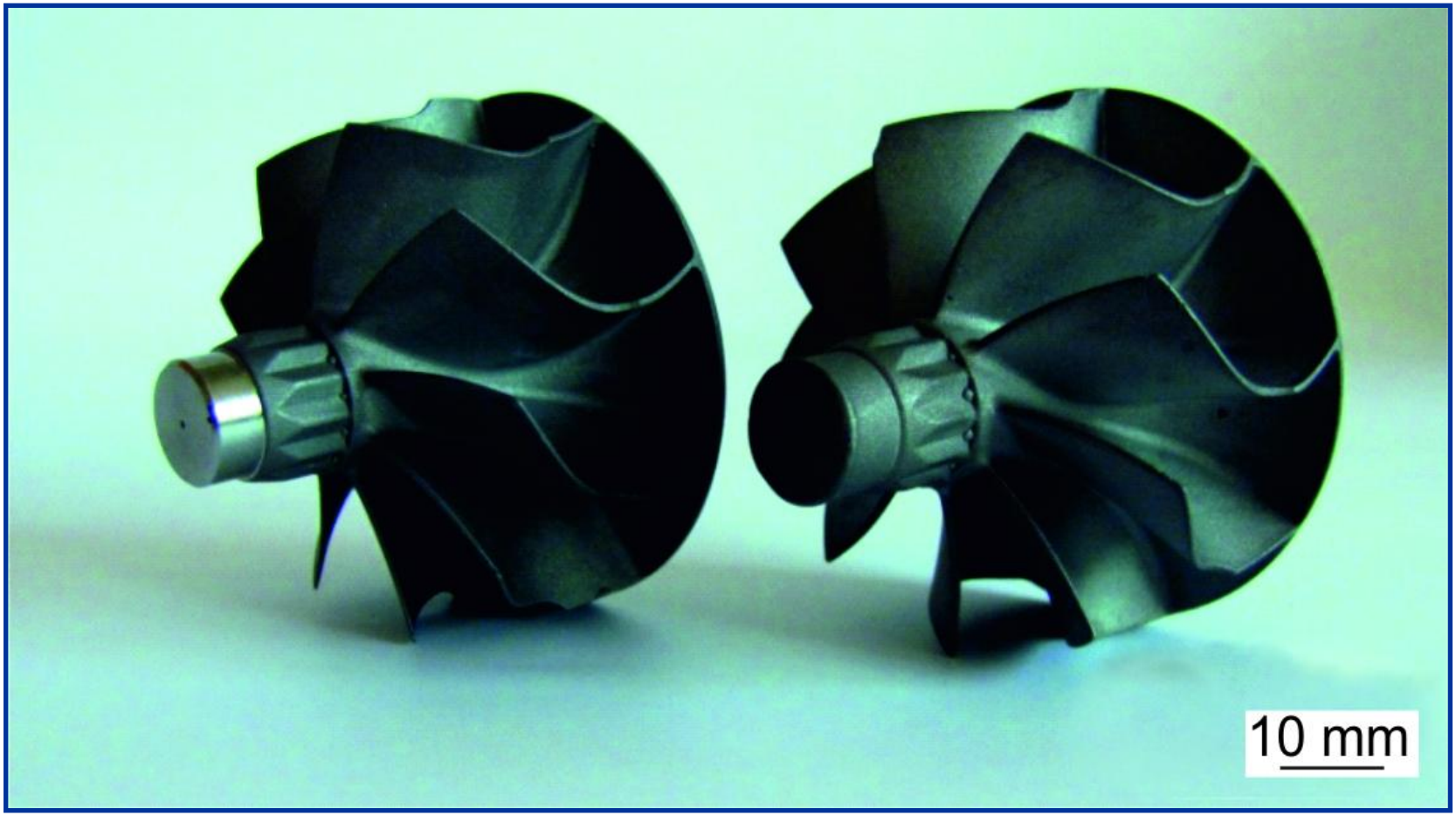




- ✓ 1000 pcs/year
- ✓ developed and produced by Slovak Academy of Sciences
- ✓ Assembled by Gleich GmbH (D)

Results and Discussion

Cast turbocharger wheels



Cast turbocharger wheels with removed feeding heads.

Societal, cultural, and/or economic impact

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 an eligible way how to repair and strengthen the position of science in the general public.

IMSAS tries to fulfill this mission twofold:

-through innovations overbridging the oriented fundamental and applied research

-through inspiration of local industry

IMSAS headquarters Bratislava

IMSAS headquarters Bratislava

FEI Themis ETEM - FEG Scanning Transmission Electron Microscope

Basic technical parameters

resolution – STEM approx. 0.8A

accelerating voltage (X-FEG) – (80, 200, 300) KV

EDX: Output count rate up to 200 Kcps
120 mm^2 combined detector area
Detection of all elements down to boron

Holders: single tilt holder
Double tilt holder
Cryo holder

Detectors: TEM- camera XXX
STEM- HAADF, BF, DF2, DF4
EDX – Super X
EELS – Enfinium spektrometer


Research centre ALLEGRO Trnava
Olomouc
E462
Zakopane
Krynica
Prešov
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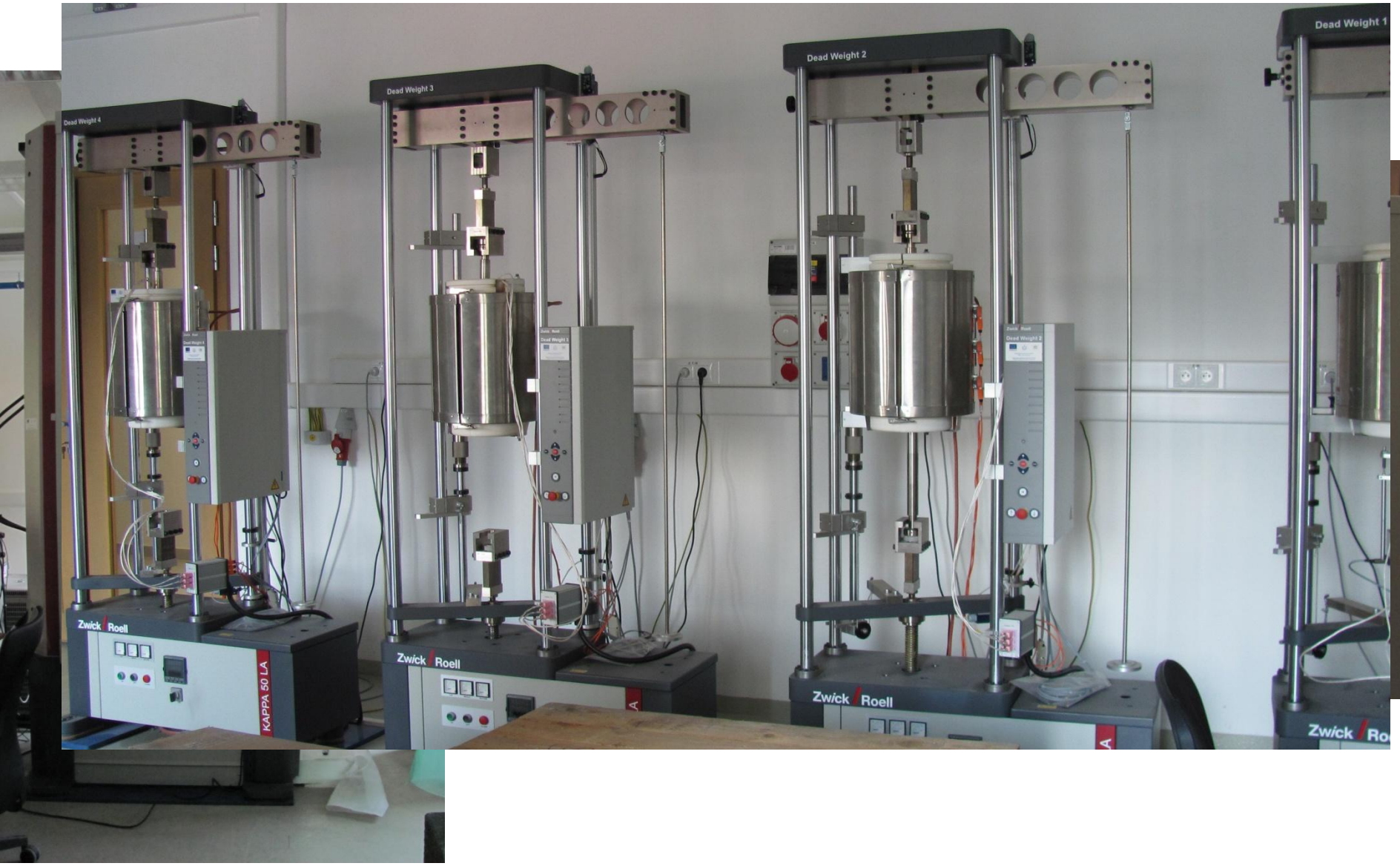
Národný park Nízke Tatry
Slovakia
Košice
E65
E75
E58
Trnava
Nitra
Bratislava
Miskolc
Eger
E79
Nyíregyháza
Vác
E77
E71
E60
IMSAS headquarters Bratislava

IMSAS managed Research centre ALLEGRO in Trnava



Important infrastructure available at IMSAS managed Research centre ALLEGRO:

Universal testing machine Zwick 60 kN equipped for mechanical testing up to 1200 °C
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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IMSAS branch Inoval Žiar nad Hronom
IMSAS headquarters Bratislava

IMSAS´s branch Inoval in Žiar nad Hronom

IMSAS´s branch Inoval in Žiar nad Hronom

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


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IMSAS branch Jelšava ??????
IMSAS headquarters Bratislava

Future prospects (development potential)

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.)

Industrial leadership – 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 – 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)

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

1) ***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.

2) ***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

3) ***proper consolidation technology for the production of nanostructured Al materials*** will be developed

4) ***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)

5) ***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

6) ***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)

7) ***novel magnesium composites for ultralight structural components*** will be further optimised

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).

1) ***the research of light weight TiAl-based alloys***

2) ***future development of high entropy alloys*** will be focused on FeCoCrNiX, AlCoCrFeX and CrNbTiZrX systems prepared by melting and casting techniques

3) ***composites for electrodes of power plasma generating devices*** will be developed

4) ***proprietary heating/cooling panels impregnated with phase change materials*** will be integrated into complex solutions for green houses

5) ***magnesium as a material for hydrogen storage*** will be studied

6) ***PCM/Al foam composites for improved heat management*** (battery packages, power electronics breaking systems, machine housings, building interiors) or as heat storage tanks will be further developed

Human welfare - adressing pillar 3 in HORIZON 2020 (health and wellbeing)

1) ***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

2) ***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

3) in the field of machine mechanics the research will cover ***the analysis of vibration in a road-vehicle-driver system***.

Additional R&D activities adressing pillar 2 in HORIZON 2020

1***) advanced hard ceramic protective coatings*** possessing high hardness in combination with enhanced toughness will be developed

2) ***amorphous hard coatings for protective applications at higher temperatures up to 2000°C in aggressive oxidic atmosphere*** will be prepared

3) ***new technological approaches for high-rate reactive deposition of oxide coatings with deposition rate exceeding 10 000 nm/min*** will be investigated.

4) ***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 assessed period was the time of unprecedented growth for IMSAS

The obtained infrastructure covers the investigation of the full range of objects from atoms to real structural parts

IMSAS has a good chance to realize the proposed vision in the next time