



Research Innovations Technologies 2021

Warsaw University
of Technology



INTRODUCTION

The "Research Innovations Technologies 2021" catalogue is the next edition of the publication presenting the technological offerings of the Warsaw University of Technology (WUT). It is aimed at the business community and entrepreneurs looking to improve their competitive potential on the market by using innovative solutions developed by scientists.



The Warsaw University of Technology is home to a large number of robust and young, but also highly experienced research teams. The diversity of the technologies showcased in this Catalogue provide ample proof of the Warsaw University of Technology's huge potential to cooperate with business.

Each item, in addition to a description of the technology itself, also contains information on the current technology readiness level (TRL), which makes it possible to determine the stage of its development and the expenditures still needed to see it through to implementation. In addition, the provided description of market maturity facilitates estimating the innovation and implementation potential of the presented technologies.

Feel invited to approach the Warsaw University of Technology to take advantage of our technological offerings.

PROFESSOR ADAM WOŹNIAK, PHD, DSC
VICE-RECTOR FOR DEVELOPMENT

HOW TO READ THE LABELS



TECHNOLOGICAL LEVEL

the level of advancement of a technology is defined using the technological readiness level (TRL):

- 1 starting scientific research
- 2 finding potential applications
- 3 proof-of-concept study
- 4 laboratory verification
- 5 tests in simulated real-world conditions
- 6 prototype tests in close real-world conditions
- 7 prototype tests in operating conditions
- 8 demonstration of the final form of the technology
- 9 technology ready for implementation



COMPETITION

the number of entities on the market providing similar solutions as WUT



MAIN USERS

type of entities being the potential target group of the solution provided by the team



MARKET MATURITY

the level of market maturity

DISCOVER WUT'S SOLUTIONS

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MECHANICAL OSCILLATOR FLOW METER

This solution is a product innovation.

Applications

Mechanical oscillator flow meters are designed for the measurement of liquids and gases. They have been widely tested under industrial conditions, for such liquids as cold and hot water, paraffin, aviation fuel, sewage (pre-treated), liquid sulphur and other liquids present in the technological processes of the chemical and food industries. They are also widely used in the measurement of gases and gas mixtures, such as air, oxygen, nitrogen, acetylene, hydrogen. In special versions, they are used for a non-standard liquids, such as liquid nitrogen, oxygen, liquefied natural gas, biogas.

How it works?

The mechanical oscillator flow meter consists of a flow meter, the size and measuring range of which depends on the diameter of the pipeline and the universal signal booster. The liquid flowing through the flow meter is split by the flow splitter into two flows, which act on the oscillator, which features self-aligning bearings. The oscillator has a magnet attached to it, which, as it vibrates with the oscillator, induces an alternating electromotive force in the inductor located on the outside of

Technology creators:

- » prof. Mateusz Turkowski, PhD, DSc (Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, WUT)
- » Maciej Szudarek, PhD (Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, WUT)
- » Grzegorz Rosłonek, PhD (PGNiG S.A.)
- » Adam Bogucki, PhD (PGNiG S.A.)
- » consortium: PW, PGNiG S.A., Centralne Laboratorium Pomiarowo-Badawcze (Central Laboratory for Measurement and Research)

the body. Volume flow rate is determined on the basis of the frequency of the impulse signal coming from the flow meter.

Basic metrological parameters

Thanks to the special structure of the bearings, which largely allows self-cleaning, the flow meter sensor is resistant to mechanical pollution. Uncertainties of measurement depend on the diameters of the sensor and the measured liquid, as well as the desired ranges.

0.5-1.5% for liquids and 1.5 to 2-times higher for gases. With the non-linearity correction function, it is possible to reduce uncertainties to 0.3%.



TECHNOLOGICAL LEVEL

stage 5: TRL 7-9



COMPETITION

strong competition (a large number of entities)



MAIN USERS

large enterprises international corporations



MARKET MATURITY

the market is at a mature stage of development

Features which make this solution stand out from competing solutions

- universality – the flow meter has been tested in both high and low temperature conditions,
- durability – the proposed solution features a knife bearing, which provides higher durability than the sensitive bearings of turbine flow meters,
- price – structural simplicity could translate into affordable price when compared to the competition.

ANGULAR MICRO-DISPLACEMENT SENSOR

How it works?

Two-beam interferometers, in which the incoming beam is first split into two beams running along the two arms of the device, are widely known. The laser beam in each interferometer arm is usually directed through several reflecting surfaces to the other (outgoing) beam splitter. This beam splitter then combines both beams to cause their interference. If the beam entering the interferometer (i.e. the beam falling on the incoming beam splitter) is deflected by a small angle in the interferometer plane, and there is the same number of reflections in both interferometer arms (in general, if there is an even or odd number of reflections in both arms), then the two interfering outgoing beams become deflected by the same angle and in the same direction, without impacting the interference effect in the form of the analysed interference pattern, which is advantageous in interferometric systems that count the moving fringes.

Features which make this solution stand out from competing solutions

The creators of the discussed sensor have proven (the description can be found in scientific publications) that if the number of beam reflections in both arms of the interferometer differs by an odd number, then the incoming beam deflection will cause the deflection of

Technology creator:

- » prof. Marek Dobosz, PhD, DSc
Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, WUT)

interfering beams by the same angle value, but in opposite directions. This way, the interference angle changes, causing a change in the period of the observed interference fringes. The creators of the sensor have developed a photodetection system and algorithms for the analysis of signals from individual photodetectors, to determine the change of period of the fringes and to convert it into a change in the interference angle, and eventually into a change in the angular position of the incoming interferometer beam.

The creators suggested a remarkably simple technical implementation of the said method in the form of an integrated optical system consisting of a single beam splitter cube with two prisms fixed to it with an adhesive, a rectangular one and a corner cube one. Thanks to this structure, an exceptional sensitivity to the angle deflections of the laser beam has been achieved with minimal size of the measuring system. The developed angular micro-displacement sensor is a globally unique device in terms of its manner of operation and metrology and utility parameters in a selected plane.

Application

Sensor models were created for measurement in a single plane and three-dimensional measurement versions, and versions for use in a stabilisation system for beam axis direction were evaluated.

Basic features and metrological parameters

- The sensor features both firmware and software.
- Its advantage is small size, 50x35x30 mm (with electronics).
- The sensor is characterised by an extremely high resolution of up to 25 nrad. The accuracy is $\pm 0.5 \mu\text{rad} \pm 0.005\alpha$ (α – the measured angle). The measuring range is ca. 360 μrad .



TECHNOLOGICAL LEVEL

stage 4: TRL 4-6



COMPETITION

no competition



MAIN USERS

small and medium-sized enterprises



MARKET MATURITY

the market is being created

LASER DIODE INTERFEROMETRIC MEASUREMENT SYSTEM

Interferometer system units constitute one of several optical configurations that allow the measurement of linear and angular displacements. While these configurations are widely known and used in coordinate metrology, thanks to the use of a small-diameter beam (4 mm), the size of the components of the measurement system are about twice smaller than in commercially available devices. The developed measurement system allows the verification of positioning and rotational errors of coordinate machines, CNC machines and all devices performing precise movements. The system contains: a laser head with an interference-stabilised laser diode, optical measurement units, fringe counting and interpolation circuit card, environmental compensator, software, mechanical mounting and adjusting units.

How it works?

A beam emitted by the laser head is introduced into the measurement interferometer unit, in which one of the elements is a measuring reflector. After reception in the head by the photodetection system, the interference signal is converted into appropriate electrical signal, which is then passed to the meter and interpolator system, which in turn converts it into information about reflector displacement. This information is provided to the user on a personal computer.

Technology creator:

- » prof. Marek Dobosz, PhD, DSc
(Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, WUT)

Features which make this solution stand out from competing solutions

The developed laser head feeding the measurement interferometer is a completely original device containing a number of patented solutions, which uses an affordable laser diode as a light source. To stabilise the laser frequency (which is necessary for measurement purposes), the creators developed a new method involving the use of light interference generated as a result of reflections of the beam going through an optical wedge made of a specially selected material. The laser head also includes an innovative system developed by the creators for receiving interference fringes with a finite period using a small-sized integrated photodetector. It consists of 13 photo sensors appropriately distributed with the use of new signal processing algorithms, which ensures that the measurement error is minimised.

Basic metrological parameters

- The measuring ranges of linear and angular displacements are 3.5m and $\pm 5^\circ$, respectively.
- The maximum resolutions of linear and angular displacements are 0.3nm and 0.5", respectively.
- Relative vacuum wavelength instability over 8h: ca. $5 \cdot 10^{-8}$ (average relative displacement).
- Relative measurement uncertainty for linear displacements: 10-6.



TECHNOLOGICAL LEVEL

stage 3: TRL 1-3
stage 4: TRL 4-6



COMPETITION

little competition



MARKET MATURITY

the market is being created

SYSTEM OF OPTIMIZATION AND DESIGN IN AEROSPACE — SODA

In terms of individual analyses, there are numerous computational tools for designing aerial vehicles, but they are not connected into a coherent design and optimisation system.

Competition

There are only a few research projects (members of the Team participated in one of them) in the field of integrated design and optimisation intended for specialised support for aerial vehicles and one commercial solution dedicated for aerospace applications. Numerical tools of this type are also used by the major aerospace companies, such as Airbus, Boeing, Lockheed-Martin, Northrop Grumman, which do not share their software. Only the US company DARcorporation provides its clients with such solutions.

Demand

The rapid development of the unmanned aerial vehicles sector holds promise for potential market interest in this type of product.

Technology creators:

- » prof. Tomasz Goetzendorf-Grabowski, PhD, DSc
(Institute of Aeronautics and Applied Mechanics, Faculty of Power and Aeronautical Engineering WUT)
- » Jacek Mieloszyk, PhD
(Institute of Aeronautics and Applied Mechanics, Faculty of Power and Aeronautical Engineering WUT)

What is the innovation?

The presented solution involves the creation of an integrated system for the design and optimisation of aerial vehicles.

The team has long been working on numerical tools for designing and optimising aerial vehicles, which are successfully used in its own projects. Currently, individual elements of the system, as well as example integrations, are available. However, expenditures for tighter system integration, creating a user-friendly interface and detailed user documentation are still needed.

Features which make this solution stand out from competing solutions

In a lot of cases, the analyses used for design and optimisation in the WUT team are more advanced than the competing solutions.



TECHNOLOGICAL LEVEL

stage 5: TRL 7-9



COMPETITION

little competition



MAIN USERS

natural persons
microenterprises
small, medium-sized and large enterprises
international corporations



MARKET MATURITY

the market is developing

DIGITAL RAILWAY. DIGITAL TWIN OF AN ETCS APPLICATION

“Digital railway” is a framework project – an initiative responding to the digitalisation processes in rail traffic control, which can be observed at the European level (e.g. the Digital Rail for Germany programme). The main driver of these processes is the implementation across Europe of the automatic train control system ERTMS/ETCS as a significant element of the interoperability of the European railway system.

What is it about?

A Digital Twin is a representation of a real-world system in virtual form, which involves data structures and algorithms.

It consists of three fundamental elements:

- the space of the real-world system,
- the space of digital representation,
- a link ensuring data flow between both spaces.

The real-world system is equipped with sensors, recorders, which collect information on its status and the events occurring within it. Via a data link, the collected information reaches the digital twin, where it is gathered. It describes both the current state and the history of operation of the real-world system. The algorithms implemented by the digital twin environment process the accumulated data using simulation and data analysis techniques. The foreground knowledge obtained on the real-world system then comes back to its space, where

Technology creator:

- » Andrzej Kochan, PhD
(Centre for Transport Certification, Division of Traffic Control and Transport Infrastructure, Faculty of Transport, WUT)

it is used for optimising selected aspects of its structure and operation.

How it works?

The Digital Twin of the ETCS application (CBAE) creates a digital representation of the real-world system installed on the railway line. It constitutes the main component of CBAE infrastructure, which is accompanied by CBAE monitor components and the Virtual Laboratory. The monitor allows ongoing analysis of the represented system, while the Virtual Laboratory is a space for conducting research on the real-world system. At the Virtual Laboratory, thanks to the use of an innovative design method, virtual prototyping, the user can quickly and interactively create various ETCS application configurations, which are verified in terms of design principles in real time. The constructed models can be further tested by simulating operating scenarios, which is the second major service provided by the Virtual Laboratory. Operating scenarios are well established in the railway industry as a method of verifying the correctness of cooperation between the ETCS system elements and its environment. This functionality makes it possible to verify and validate the real-world system, which is impossible using dynamic tests and real-world trains. All configuration and operational data appearing in the CBAE infrastructure are recorded in the archive, which is a source of information for analyses that provide new knowledge about the real-world system.



Application

In recent years there has been a noticeable increase in interest in the digital twin concept. Gartner, a leading research and consulting company, has referred to the digital twin as one of the ten most important strategic technological trends in 2019. At the same time, Grand View Research forecasts that the DT market will reach the value of USD 27.06 billion by 2025, which is roughly a tenfold increase over 2017's USD 2.26 billion.

The solution is intended for the transport industry and is in the early implementation stage.

Features which make this solution stand out from competing solutions

The concept presented by our team combines knowledge of information technologies with the knowledge of a transport engineer, including a designer, producer and user, as well as expert in the formal and legal domain.



TECHNOLOGICAL LEVEL

stage 2: finding potential applications



COMPETITION

little competition



MAIN USERS

large companies
international corporations



MARKET MATURITY

the market is at a mature stage of development

FAST AND ACCURATE DETECTION OF HIDDEN INFORMATION SOURCES IN A COMPLEX NETWORK

We have developed a very fast and accurate algorithm for detecting primary sources of information propagation in complex networks.

What is it about?

The method is based on the gradient analysis of network location positions, which may be sources of the signal. The algorithm operates on the basis of the maximum likelihood method and can indicate the most likely source of information having very limited input data about the presence of this information in the network. This means that to find the origin of information, it is not necessary to track its entire route, which is often impossible. To run the algorithm requires only a few to a dozen or so observations (node-time pairs) and knowledge of the connections within the network.

Technology creators:

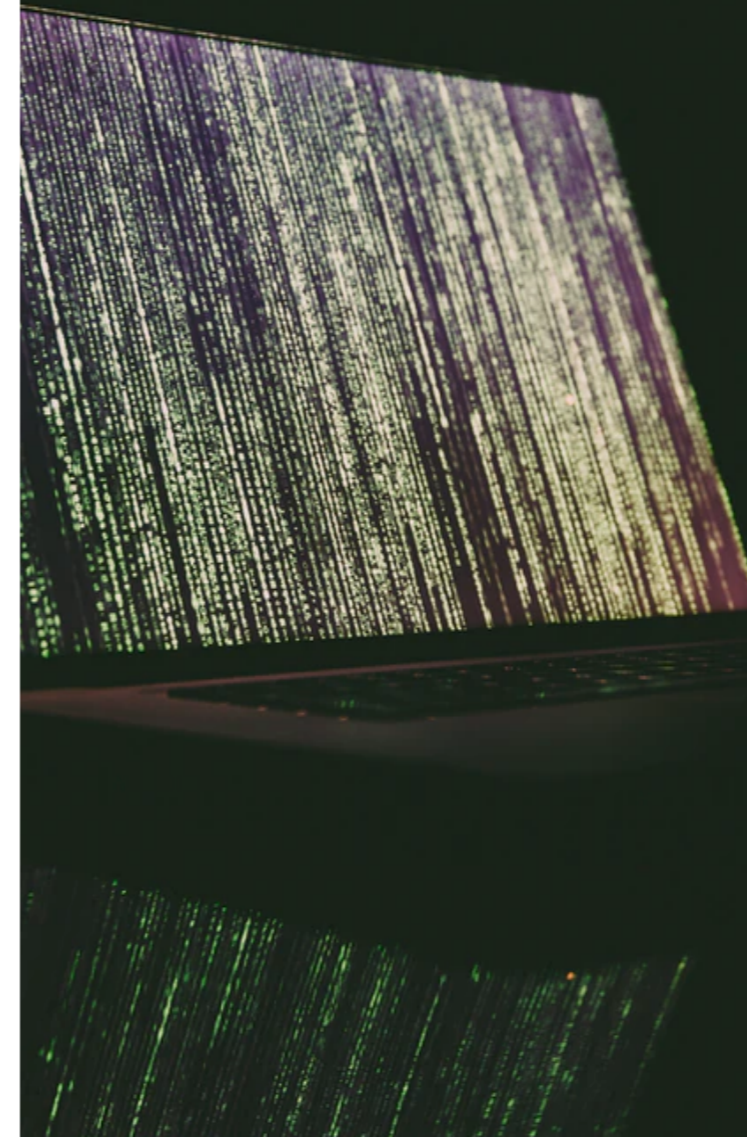
- » prof. Janusz Hołyst, PhD, DSc
(Center of Physics in Economics and Social Sciences, Faculty of Physics, WUT)
- » Robert Paluch, PhD
(Center of Physics in Economics and Social Sciences, Faculty of Physics, WUT)
- » Krzysztof Suchecki, PhD
(Center of Physics in Economics and Social Sciences, Faculty of Physics, WUT)

Features which make this solution stand out from competing solutions

The advantage of this method is its low computational complexity and the resulting speed, which makes it possible to find sources even in networks composed of millions of nodes.

Application

An example application can be locating the centre of an epidemic (with localities as nodes) or an undisclosed source of fake news (with social media users accounts as nodes).



TECHNOLOGICAL LEVEL

stage 1: idea/concept



COMPETITION

little competition



MAIN USERS

small and medium-sized enterprises



MARKET MATURITY

the market is developing

GTS-LOG: MODULE FOR EFFICIENT TIME SERIES CREATION FROM TEXT LOGS USING GPU

In many computer systems, elements of distributed infrastructure report their state to the central monitoring location in the form of text log entries. Such logs may contain billions of entries, which must be processed into numerical information and recorded in a time series database in real time. This is usually handled by distributed processing systems based on the map-reduce method, which provide good scalability to multiple machines, making it possible to reach the required performance.

What is it about?

The use of our module for efficient time series creation from text logs using GPU (GTS-LOG) allows eliminating complex and expensive architecture to obtain the required performance on a single machine equipped with a processing unit. This solution leads to obvious savings on energy consumption, space and personnel costs. Our solution has been tested on a real-world case in an industrial-like environment, where it has proven its extremely high performance which greatly exceeds that of other solutions of its type. In particular, the system can adapt textual data and IP addresses and pair numbers with a performance of up to tens of millions

Technology creators:

- » Krzysztof Kaczmarek, PhD (Department of Information Processing Systems, Faculty of Mathematics and Information Science, WUT)
- » Stanisław Piotrowski, MSc (WUT)
- » Artur Niewiadomski, BEng (WUT)

of matches per second. Processing entire lines of text logs can be performed at 10 million lines per second on a single GPU. The system's architecture is designed in such a way that its performance may increase with multiple GPUs installed on a single machine.

Application

The GTS-LOG module can be used in every place where the processed data is collected in the form of text logs, whereas the format of these logs is of minor importance. The greatest advantage of the system is its speed, which means that it will be especially helpful for applications where real-time data processing is required, in monitoring systems, IoT, telecommunications, content distribution, etc.

Features which make this solution stand out from competing solutions

GTS-LOG has a broad range of configuration options for various file fields in the Apache Log format and an extremely high textual data processing speed.



TECHNOLOGICAL LEVEL

stage 4: TRL 4-6



COMPETITION

little competition



MAIN USERS

large companies



MARKET MATURITY

the market is at a mature stage of development

IMPROVING PRODUCTION PROCESS EFFICIENCY USING MATHEMATICAL MODELLING

The presented solution concerns the mathematical modelling of production processes and constitutes an innovative approach to improving the efficiency of production processes using computer programs.

What is it about?

As part of its operations, the Team focuses on:

- developing mathematical models of processes, including simulation models using the available information technology tools,
- developing dedicated algorithms for optimising processes using selected information technologies for their implementation,
- conducting computation or simulation experiments on the developed models and algorithms, as elements assisting in making business decisions,
- implementing the obtained results in enterprises and organisations,

Technology creators:

- » Cezary Szwed, PhD
(Department of Production, Processes and Project Management, Faculty of Management, WUT)
- » Justyna Smagowicz, PhD
(Department of Production, Processes and Project Management, Faculty of Management, WUT)

In addition, the Team carries out work which involves the following:

- constructing models of business processes using the simulation approach for managing these processes,
- constructing models of critical processes in enterprises and organisations to prepare contingency plans.

Features which make this solution stand out from competing solutions

The innovative nature of the operations results from the application of frontier information technologies for the complete digitalisation of the studied processes, including production processes. The tools used assist in the construction of adequate simulation models and optimisation algorithms for solving production problems.

Application

The proposed approach may be used in the management of production, logistics and services, enhancing business processes and maintaining their continuity. It can be used in both discrete and continuous processes, e.g. in the energy sector.



TECHNOLOGICAL LEVEL

stage 1: idea/concept



COMPETITION

little competition



MAIN USERS

small and medium-sized enterprises



MARKET MATURITY

the market is developing

SUSTAINABLE INDUSTRY 4.0 — ADVISORY MODEL

The research involves developing a model which describes the relationships between Industry 4.0 and sustainable development.

What is it about?

This model can be used as a basis for providing advisory services involving organisational diagnosis and identification of specific areas of improvement connected with sustainable development and the tools and technologies of Industry 4.0 which may contribute to this improvement, along with a detailed evaluation of the suggested changes in the financial, environmental and social contexts.

In addition, the conducted analysis will make it possible to identify the best practices and, if needed, provide a programme for implementing the selected elements of the model.

Technology creators:

- » SUSTAIN 4.0 Research Group
(Institute of Production Systems Organization,
Faculty of Mechanical and Industrial
Engineering, WUT)

Application

It is expected that the parties interested in using the model will include both industrial enterprises and service providers, as well as public administration bodies responsible for promoting and developing the Industry 4.0 concept and sustainable development in Poland.

Features which make this solution stand out from competing solutions:

- speed of service,
- flexibility of operation,
- highest quality of services,
- availability of the team.



TECHNOLOGICAL LEVEL

stage 1: Idea/concept



COMPETITION

little competition



MAIN USERS

small and medium-sized enterprises
large enterprises
international corporations



MARKET MATURITY

the market is developing

GAN-ON-SI HEMT POWER AMPLIFIERS FOR AVIONICS SYSTEMS

A trend to move away from gallium arsenide to wide-bandgap semiconductors has long been observed in the production of transistors and integrated circuits for radar systems. Currently, it is known that the GaN HEMT technology will form the basis for manufacturing active microwave devices for radiolocation. For various reasons, the predominant substrate for GaN epitaxy in GaN-based high-power microwave devices is SiC. However, devices of this type are very expensive

What is the innovation?

An alternative solution involves GaN HEMT transistors on silicon wafers, which can be purchased for half the price. Currently, the GaN on Si technology is rarely used in GaN HEMT production for RF and microwave applications.

Our solution also covers the construction of power blocks, which provides polarisation signals for GaN/Si microwave transistors and controls amplifier operation. The units contain high-performance AC/DC and DC/DC converters based on GaN/Si HEMT transistors, which allow power supply from AC 110-230V and DC 24-30V.

Technology creators:

- » Wojciech Wojtasiak, Phd, Dsc, Associate Professor (Institute of Radioelectronics and Multimedia Technology, Faculty of Electronics and Information Technology, WUT)
- » Daniel Gryglewski, Phd (Institute of Radioelectronics and Multimedia Technology, Faculty of Electronics and Information Technology, WUT)

Application

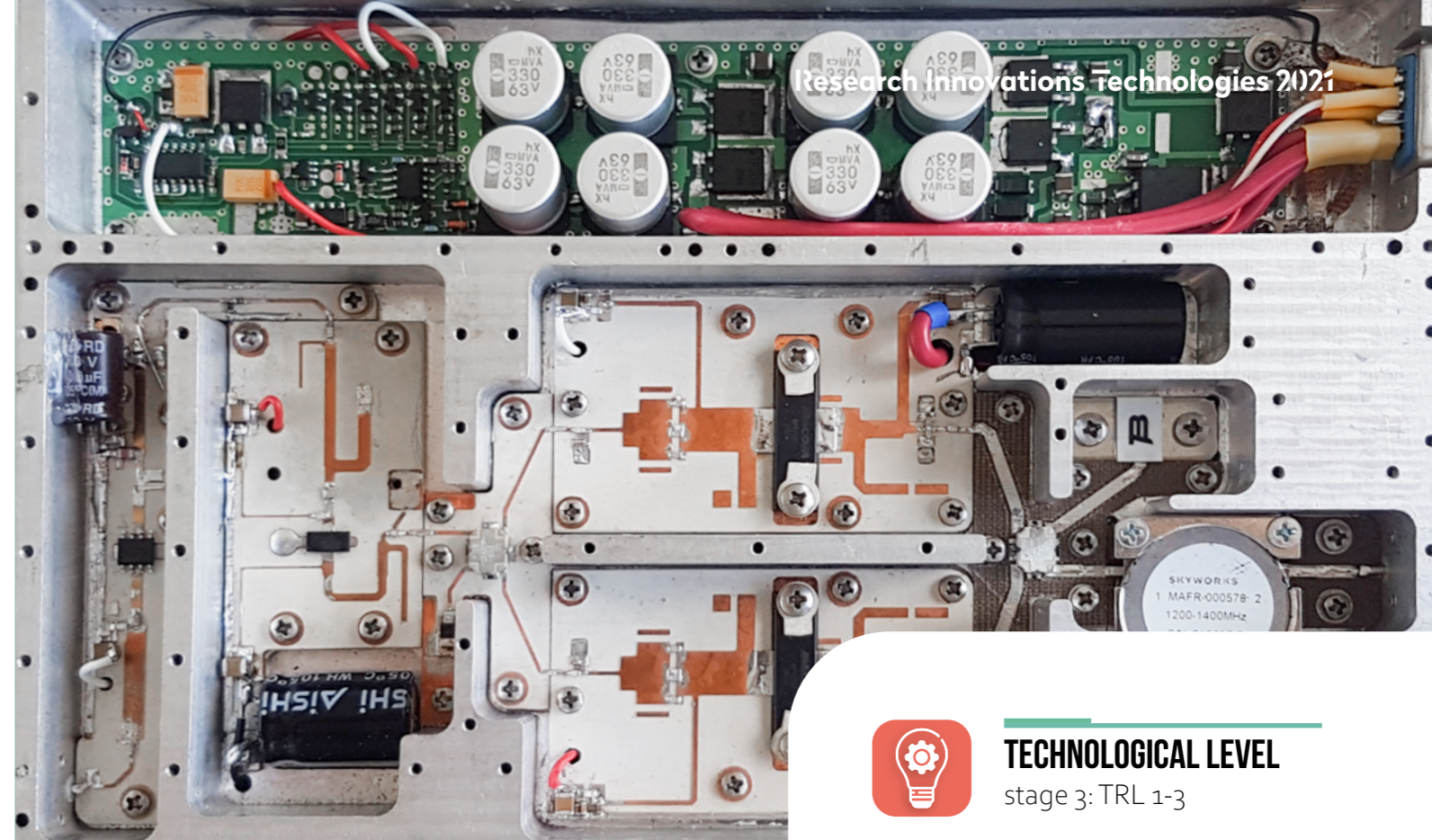
The primary idea is to use a more affordable GaN/Si technology in less demanding systems (with lower power density requirements). Such systems include secondary surveillance radars, including IFF and DME subsystems. The idea is justified by low operating frequencies up to 3.5 GHz and pulse operation with a small duty cycle.

Features which make this solution stand out from competing solutions

The main innovation of the amplifier involves the use of more affordable GaN transistors on an Si substrate in the structure of power amplifiers (to be used in less demanding systems).

However, the application of this solution requires consideration during the circuit design dynamic temperature distributions of active elements.

The channel temperature value under normal operating conditions of the transistor significantly affects its performance.



Firstly, the transistor life span is reduced when operating at channel temperatures close to the maximum allowable value.

Secondly, the parameters of the transistor (both DC and RF) indicate a significant dependence on the temperature of its active region.

The results indicate that the use of this GaN "on" Si transistor for the production of microwave power amplifiers is economically viable.



TECHNOLOGICAL LEVEL

stage 3: TRL 1-3



COMPETITION

no competition



MAIN USERS

small and medium-sized enterprises
large enterprises



MARKET MATURITY

the market is at a mature stage of development

ELECTRIC DRIVE SYSTEM WITH A SWITCHED RELUCTANCE MACHINE

The work conducted by a team from the Faculty of Electrical Engineering of the Warsaw University of Technology as part of the TECHMATSTRATEG project entitled "Technologies of semiconductor materials for high-power and high-frequency electronics" allowed the development of an electric drive system with a switched reluctance machine (SRM) based on transistors made of gallium nitride (GaN). The team developed a complete power electronic converter along with a dedicated control system.

How it works?

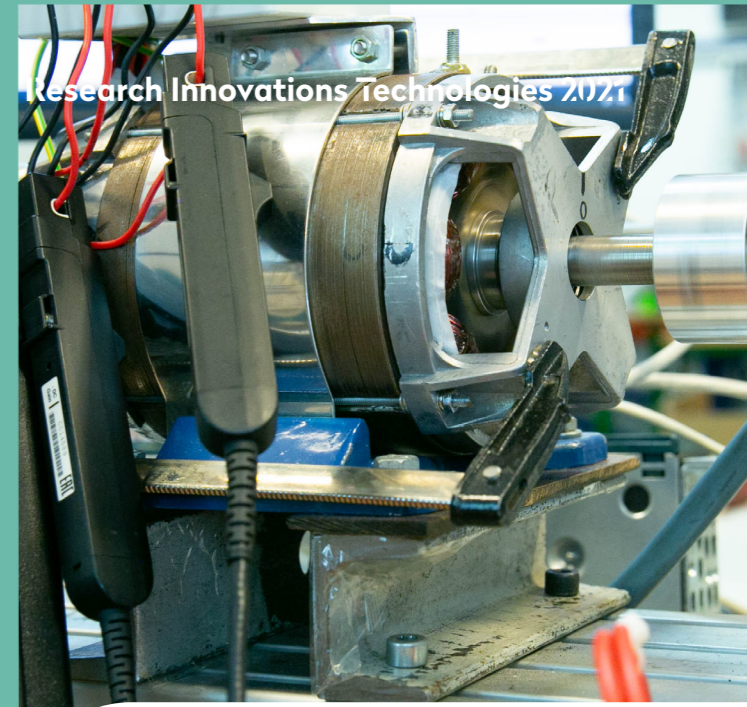
This solution involves providing a special reference signal to the phase current control system of the machine. The signal is selected in such a way as to compensate torque ripples in the system. The reference signal shape is calculated in real time using a multi-resonant current controller in the angular velocity control loop. The innovation involves a different approach to sampling parts of the machine angular velocity controller connected with the multi-oscillation controller. In the developed approach, sampling of the

Technology creators:

- » Krzysztof Jackiewicz, MSc
(Institute of Control and Industrial Electronics, Faculty of Electrical Engineering, WUT)
- » Bartłomiej Ufnalski, PhD, DSc
(Institute of Control and Industrial Electronics, Faculty of Electrical Engineering, WUT)

multi-oscillation controller has been synchronised with the angular position of the machine shaft. This solution allows an effective reduction of torque ripples and angular velocity of a drive system in both steady and dynamic states. An additional advantage is that the operating effectiveness is independent of operating conditions, which allows the use of this solution in variable-frequency drives.

The SRM is made of electrical steel and copper winding located solely on a stator, which makes it inexpensive to produce, simple and, as a result, extremely durable and resistant to damage. The SRM does not contain a mechanical commutator or moving parts other than bearings. No rare-earth elements are required to produce the SRM, which makes it more attractive in the context of the rare-earth-free concept. The structure of the SRM and the converter makes it possible to continue operation even if the winding is partly damaged. The SRM is characterised by a high torque overload factor.



Broad application

Drives based on the SRM can be used in electric vehicles, belt conveyors, pump and fan drives, as well as in places with special requirements, such as explosion hazard areas, completely submerged areas or elevated temperature areas.

Features which make this solution stand out from competing solutions

A traditionally controlled SRM is characterised by a significant torque ripple level, which results in excessive noise and vibration, reducing the life span of the whole device. Research work made it possible to develop a control system that dramatically reduces torque ripple. It is particularly noteworthy that the developed solution involves the appropriate control of the machine's phase currents, and does not require any physical intervention in the drive system.

Opportunities

The SRM is characterised by:

- simple, durable and affordable structure,
- capability to operate under special conditions (no permanent magnet or sparking components),
- high torque overload factor.

An innovative control algorithm allows a significant reduction of the disadvantageous properties of the SRM involving torque ripples. The developed control system is an invention and is currently patent pending (application No. P.432816).



TECHNOLOGICAL LEVEL

stage 5: TRL 7-9



COMPETITION

not defined



MAIN USERS

small and medium-sized enterprises
large enterprises
international corporations



MARKET MATURITY

the market is at a mature stage of development

MECHANICAL TESTING USING MINIATURE SPECIMENS

What is it about?

The concept is a process innovation involving conducting a research procedure to determine the mechanical properties of structural materials present in a limited volume which precludes the preparation of specimens with standard-compliant sizes.

Another application area of miniature specimens is in situations where tests must be non-destructive to (or have a minimal destructive effect on) the analysed device or structure. In such cases, a small amount of the material can be collected and is sufficient to carry out mechanical tests using miniature specimens and determine the mechanical properties of the material of the device or structure in a non-destructive manner (having a minimal destructive effect).

Technology creators:

- » prof. Zbigniew Pakieła, PhD, DSc
- » Rafał Molak, PhD
- » Tomasz Brynk, PhD
- » Barbara Romelczyk-Baishya, MSc
- » Kamil Majchrowicz, MSc
- » Monika Wieczorek, MSc

(Division of Materials Design, Faculty of Materials Science and Engineering, WUT)

Application

This method allows determining the mechanical properties of materials that may be collected in a very limited amount from an operating installation or materials which are available for testing only in low volumes. Potential users include the chemical and petrochemical, power, aerospace, automotive and nuclear industries and science laboratories developing new materials.

Features which make this solution stand out from competing solutions

This solution facilitates determining the mechanical properties of materials available in limited quantities. The typical procedures used in practice and provided by laboratories are based on the requirements set out in standards, which require a relatively high specimen volume.



TECHNOLOGICAL LEVEL

stage 4: TRL 4-6



COMPETITION

little competition



MAIN USERS

small and medium-sized enterprises
large enterprises
international corporations



MARKET MATURITY

the market is developing

ULTRASONIC ATOMIZER

RESEARCH PLATFORM — REPOWDER

The rePowder technology was created for the purpose of research in the course of preparing a doctoral dissertation on the 3D printing of metallic glasses. It facilitates accelerating research on new materials for 3D printing.

How it works?

The device produced by the Amazemet company can atomize any material in any form, even in very low quantities of several grams. In addition, this technology is designed with more than atomization in mind. The rePowder platform can also be used for alloying, homogenisation and moulding of metallic materials regardless of composition. Thanks to the modular build and a number of developed feeders, the feedstock can be in any form – from wire or rod to powder, and failed prints or production waste, which can be recycled this way. In combination with other metal 3D printing devices, the device allows achieving closed-loop production.

Technology creators:

- » Łukasz Żrodowski
(Division of Structural and Functional Materials, Faculty of Materials Science and Engineering, WUT)



Application

This technology is the ideal solution for research units dealing with the development of new metallic materials. The produced powder is of high quality due to its extremely high sphericity, which enhance materials flowability, a very low level of foreign pollutants, including oxidation, and narrow particle size distribution.

Features which make this solution stand out from competing solutions

In contrast to widely known gas atomization, rePowder does not use high-pressure gas for atomization, but ultrasound. The melted material is fed to the element vibrating with ultrasonic frequencies and sprayed on its surface and is then set in the protective atmosphere of the working chamber, forming perfectly spherical powder particles. Melting may be performed directly using a plasma torch, allowing the processing of high-alloy materials or using induction to prevent the loss of elements with a low vapour pressure.



TECHNOLOGICAL LEVEL

stage 5: TRL 7-9



COMPETITION

little competition
(no more than several entities)



MAIN USERS

small and medium-sized enterprises
large enterprises
international corporations
Universities and Research Institution



MARKET MATURITY

the market is developing

AUTOMATED SUPPORT DISSOLUTION AND SURFACE FINISHING STATION – SAFEETCH

An important element of the metal additive manufacturing process is the necessary postprocessing of the print. The removal of scaffold structures and smoothing surface using traditional methods is highly time-consuming and may be responsible for as much as 70% of the overall product cost.

What is it about?

safeEtch is a patented ultrasonic-chemical technology introducing a support dissolution method into the world of metal printing. safeEtch facilitates the removal of all supports without any mechanical processing, while smoothing out surfaces even in the most inaccessible corners. Using a technology that dissolves supports makes it possible to apply a completely new approach to designing elements, with the complete use of the chamber volume, by stacking elements on top of each other.

The principle of operation is based on the chemical dissolution of a thin layer of material using a specially-de-

Technology creators:

- » Łukasz Żrodowski (Division of Structural and Functional Materials, Faculty of Materials Science and Engineering, WUT)



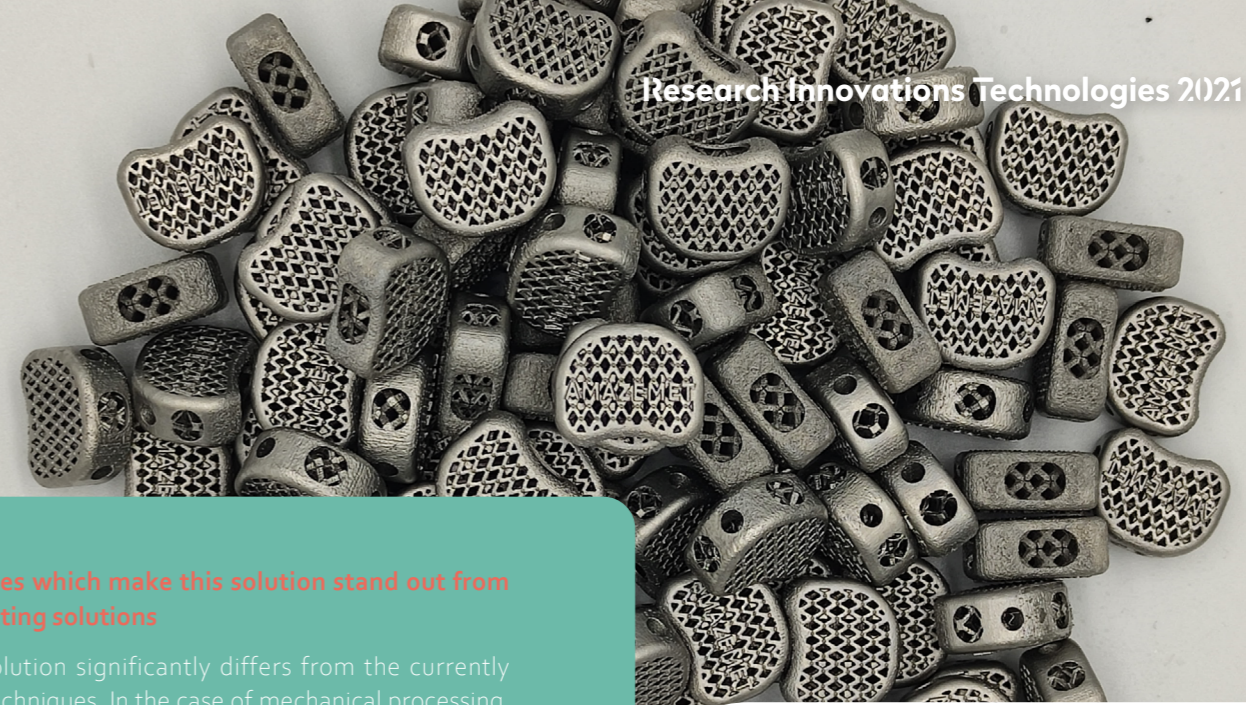
- » associated technologies: :
MaterialsCare Sp. z o.o.
- postprocessing of metallic scaffold structures produced using the SLM (selective laser melting) technology

signed mixture of acids and an additional mixing effect caused by ultrasound. This effect makes it possible to appropriately stimulate the reaction and take advantage of beneficial cavitation phenomena, and facilitates the flow of the solution into every crevice of the detail. As a result, the print is free of supports, features smooth surfaces thanks to the removal of non-dissolved powder particles, and retains sharp edges.

Application

The features of the process make it a particularly good fit for the industrial production of titanium elements and implants manufactured using additive technologies and for automating postprocessing in metal 3D printing.

This technology is used by the MaterialsCare company to remove non-dissolved powder particles in additively manufactured titanium implants used in veterinary medicine.



Features which make this solution stand out from competing solutions

This solution significantly differs from the currently used techniques. In the case of mechanical processing, the process of finishing elements is long and expensive, particularly for components with complicated geometry.

With regard to electropolishing, each element must be connected to a power source, which also reduces production capacity and makes it impossible to process several elements in one go.

In contrast to electropolishing, the safeEtch technology for dissolving support structures and surface finishing allows retaining the sharp edges of the processed elements and ensures a high level of accuracy in relation to the CAD model after the cleaning process.



TECHNOLOGICAL LEVEL

stage 5: TRL 7-9



COMPETITION

little competition
(no more than several entities)



MAIN USERS

small and medium-sized enterprises
large enterprises
international corporations



MARKET MATURITY

the market is developing

BIOCIDAL NANOCOMPOSITE PARTICLES WITH A BROAD SPECTRUM OF ACTION

What is the innovation?

Nanocomposite particles are nanomaterials characterised by unique bioactive and biocidal properties. This solution is provided in the form of a dry nanopowder or as nanocolloidal systems in various solvents. The nanocomposite particles were developed at the Faculty of Materials Science and Engineering of the Warsaw University of Technology and deployed to production by the spin-off company ADJ Nanotechnology Sp. z o.o., which specialises in developing, large-scale production and distribution of bioactive nanocomposite powders for use as raw materials in the production of self-sterilising materials. It is a product innovation.

Main features

The developed biocidal nanocomposite particles are fully effective and, which is particularly important, not only as a raw material, but thanks to exceptional dispersity, also after modifying other materials and coatings. This facilitates the use of protected products in places particularly exposed to the spread of disease-causing microbes. Numerous tests and analyses have also proven that, in contrast to free nanoparticles, nanocom-

Technology creators:

- » Agnieszka Jastrzębska, PhD, DSc, University Professor (Division of Ceramic Materials and Polymers, Faculty of Materials Science and Engineering, WUT)
- » prof. Andrzej Olszyna, PhD, DSc (Division of Ceramic Materials and Polymers, Faculty of Materials Science and Engineering, WUT)



posite systems are safe for the environment, while retaining excellent self-sterilising properties. This means that the functional properties of new nanoproducts also include improved end user safety.

Features which make this solution stand out from competing solutions

The nanomaterial manufacturing process at ADJ Nanotechnology is highly innovative. This is due to: simple concept, flexible production and a virtually unlimited combination of possible chemical compositions of the manufactured nanoproducts. The technology used in in-house manufacturing provides high flexibility in selecting raw materials for synthesis and the process itself can be called one-pot bottom-up. This facilitates obtaining nanopowders with unique chemical compositions and properties.



Other loose materials can also be introduced into the reaction mixture, which are then covered with nanoparticles with a composition matching the substrates contained in the mixture. This results in the formation of a hybrid nanostructure with a chemical composition and parameters that can be easily adjusted to the specific requirements of end users. The obtained nanoproducts can be called "tailor-made" and having unique functional features. The only limitations are the imagination of nanostructure creators, the need to ensure specific functionalities, and, obviously, costs.



TECHNOLOGICAL LEVEL
implementation



COMPETITION
little competition (no more than several entities)



MAIN USERS
natural persons
microenterprises
small and medium-sized enterprises
international corporations

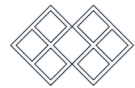


MARKET MATURITY
the market is developing



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Institute of Applied Research
Warsaw University of Technology
www.ibs.pw.edu.pl/eng
e-mail: biuro.ibs@pw.edu.pl
tel. +48 (22) 234 70 52

Centre for Innovation and Technology Transfer Management of Warsaw University of Technology
Dział Brokerów Innowacji
Dział Badań i Analiz
www.cziitt.pw.edu.pl
e-mail: komercjalizacja@pw.edu.pl
tel. + 48 (22) 234 14 70