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CREATING TOGETHER

OPERATIONAL PROGRAMME SCIENCE AND EDUCATION FOR SMART GROWTH

INFORMATION BULLETIN

NATIONAL CENTER

OF

MECHATRONICS AND CLEAN TECHNOLOGIES

2021

In this Issue

Project BG05M2OP001-1.001-0008 funded by the Operational Programme Science and Education for Smart Growth, co-financed by the European Union through the European Regional Development Fund.

SCIENTIFIC IVENTS

WORKSHOP AT THE STUDENTSKI GRAD CAMPUS

On July 15, 2021, workshop was held at the Technical University, Sofia. The participants - students, PhD students and young scientists were introduced to the possibilities of the research infrastructure that is being built in the Studentski Grad campus - one of the three complexes of the Center of Excellence of Mechatronics and Clean Technology. Guests at the event were the project coordinator Prof. Plamen Stefanov and members of the Management Board Prof. Ivan Kralov, Rector of TU, Sofia and Dr. Ventsislav Slavkov, Manager of Spesima OOD and member of the Board of Trustees of TU.

The workshop was opened by the head of the Studentski Grad campus Prof. Georgi Todorov. He highlighted that this is the largest of the five centers of excellence being established in Bulgaria. This is the largest project in terms of resources and number of participants under the procedure BG05M2OP001-1.001 “Creation and development of centers of excellence”. It involves 17 scientific institutions and unites 3 campuses: Studentski Grad - specializing in mechatronics, Lozenets - focused mainly on clean technology and Geo Milev- covering the fields of mechatronics and clean technologies.

Prof. Ivan Kralov said in his welcoming speech that the goal of the largest center of excellence in the country is to create a scientific infrastructure for performance high-level research, thus providing a basis for successful applications under national and European programs and conditions for development and technology transfer of innovative solutions from science to business, industry and regions. According to

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Prof. Kralov, the successful implementation of the project is possible due to the good synergy of all participants in it. He also thanked the business, which fully supports the idea of the center construction, and expressed satisfaction with the progress has been achieved so far, but most of all, with the successful attraction of young people.

The project coordinator Prof. Plamen Stefanov noted in his speech, that the Technical University of Sofia is one of the most successful participants in the project. The building of the campus infrastructure is almost finalized, much of the equipment has been delivered, and research staff has already been appointed.

The participants in the seminar were greeted by Dr. Ventsislav Slavkov on behalf of the business. He expressed the opinion that for the implementation of the project it is necessary to build a bridge between those who started the project and those who will continue to work on it, between science and business, to seek the direct realization of the investment. Dr. Slavkov is convinced that with joint efforts and synergies a sustainable research center can be built, which is a model for successful implementation of science in practice.

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After the opening speaches, Prof. Georgi Todorov presented the structure and management of the project and the Studentski Grad campus. 16 of the sections of the 11 laboratories on the campus are located in the reconstructed body of block 8 of the Technical University-Sofia. Three young specialists - excellent students of TU-Sofia have been employed on the full-time, and 37 researchers with an average age of about 40 years have been employed on part-time. Prof. Todorov is convinced that this project due to the modern infrastructure will give impetus to Bulgarian science for basic and applied research, will benefit student learning and will enable businesses to receive and implement new technologies and products.

Sixteen reports were included in the morning session of the seminar. The speakers were the heads of the sections located in block 8, who are leading scientists in the field of mechatronics.

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During the afternoon session on the YouTube channel of TU,=Sofia a program was broadcast (https://www.youtube.com/watch?v=1QcCiV75Svg), presenting 5 of these sections: “Micro/nanoassembling and micropackaging” by Prof. Prof. Dr. Valentin Videkov, ”Synthesis of new materials and structures for micro- and nano-electronics” by Assoc. Prof. Dr. Georgi Angelov, “3D / CAD / CAM technologies for implantology” by Assist. Prof. Dr. Yavor Sofronov, „Laser Technologies“ by Assoc. Prof. Dr. Detelin Markov and ”Mechatronic systems for protection and energy accumulation from vibrations and noise” by Assoc. Prof. Dr. Krassimir Nedelchev.

INTERNATIONAL SYMPOSIUM

MEDICAL & TECHNICAL ASPECTS IN IMPLANT RESEARCH & DEVELOPMENT

The Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Centre “Acad. A. Balevski” (IMSETHC-BAS) at the Bulgarian Academy of Sciences organized an International Symposium on Medical & Technical Aspects in Implant Research & Development from 22 to 23 September 2021. The scientific forum took place at the Admiral Hotel in the Golden Sands resort near Varna and was opened by the director of the institute, Prof. Ludmil Drenchev.

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The symposium program included lectures on the problems of using trauma and orthopedic implants and the methods for their development and improvement. The lecturers were both physicians and experts in mechanics, as the mechanical aspects of bone structure and function are the subject of biomechanics, which is closely related to the engineering sciences. Among the lecturers were prof. Martin Stoddart and Boyko Gueorguiev from the AO Research Institute (AORI) in Davos, Switzerland, prof. Marc Balligand from the University of Liège, Belgium, prof. Dian Enchev from UMHATEM Pirogov and surgeons Stoyan Ivanov and Preslav Penev from the Medical University, Varna and scientists from IMSETHC

Jan Barcik from AORI presented his doctoral

thesis "Modulation of fracture mechanical conditions and feedback approach to determine the optimal healing environment" during the symposium. The PhD thesis was developed at IMSTCA under the leadership of Prof. L. Drenchev. Ivan Zdeic, PhD student also from AORI, continues to work on his dissertation "Residual Stress Analysis in Plates Used for Orthopaedic Trauma Surgery" under the supervision of Prof. Drenchev.

UNIQUE RESEARCH EQUIPMENT

SYSTEM FOR OPERANDO/IN SITU SPECTROSCOPY

The Operando system consists of four main parts: an infrared (IR) spectrometer, an infrared reactor cell, a gas flow set-up and exhaust gas analyzers. The cell is connected to the gas flow set-up, which includes mass flow controllers for the introduction of gases into the lines. The system allows the study of exhaust gases (reaction agents and products) by mass spectrometer and gas chromatograph.

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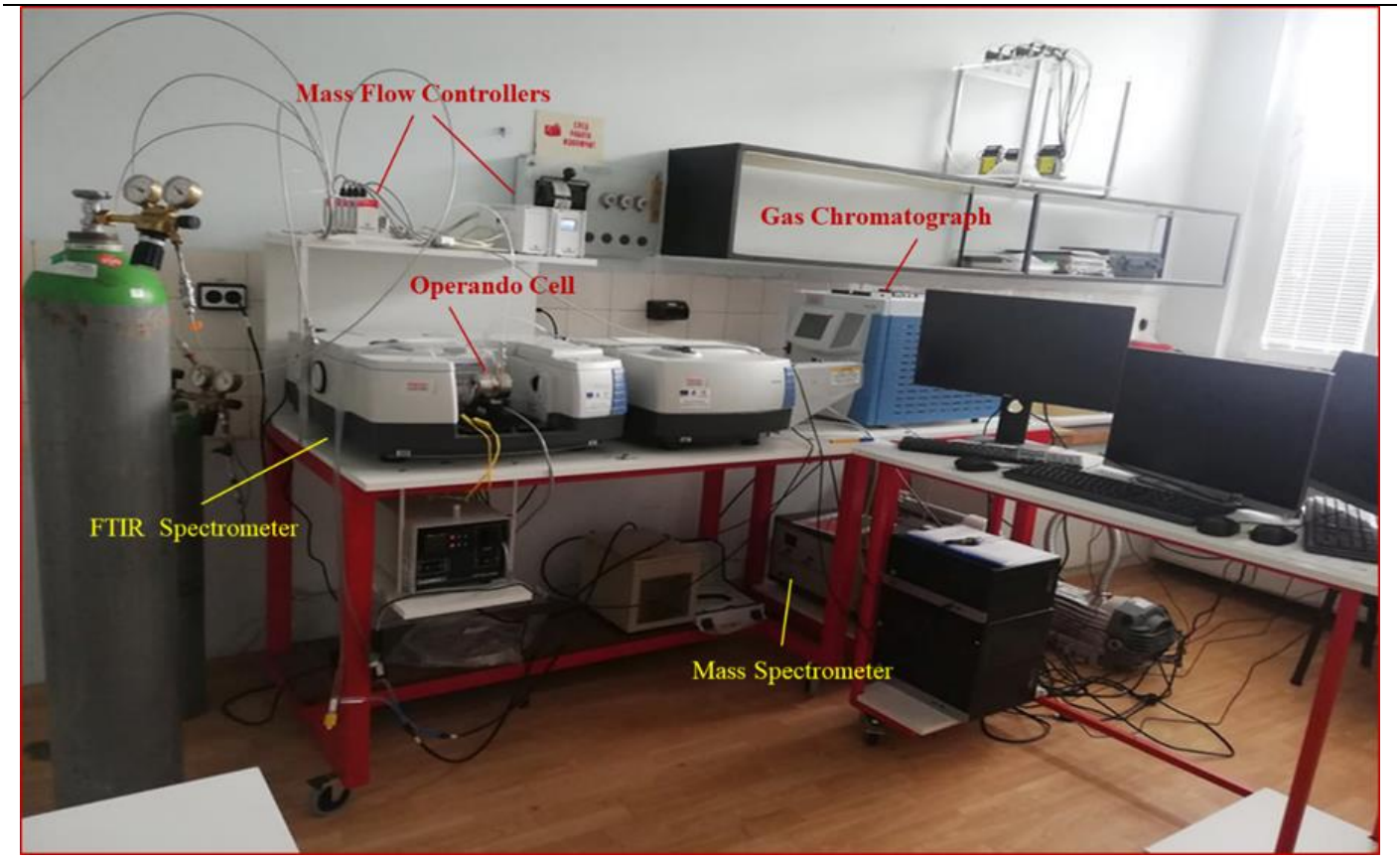

Operando spectroscopy is a methodology that allows the study of the material under its working conditions, e.g. spectroscopic characterization of the catalyst during the reaction, simultaneously measuring its catalytic activity and selectivity. This method is a powerful tool for detailed study of the mechanism of adsorbent and catalysts functioning. The results of operando measurements, along with those of in-situ spectroscopy, can be used as a foundation in the design of efficient materials for clean technologies (gas separation, purification, storage, sensing, catalysis, etc.).

The Laboratory on operando methods of study, which uses the created configuration of the IR spectrometer Thermo Scientific Nicolet iS50R, IR reaction cells from Harrick Scientific, gas chromatograph Thermo Scientific Trace 1300 Series, mass spectrometer Hiden Analytical HPR-20 R&D and Gas flow set-up Bronkhorst EL-FLOW Prestige, is unique for the country. The results obtained by the research staff have already been published in the Molecules journal with Q1 rank.

ROBOTIC SYSTEM FOR RESEARCH AND DEMONSTRATION OF PROCESS OPTIMIZATION

The robotic system RAIS T250MY with a welding robot delivered to the laboratory "Virtual Engineering and Digital Manufacturing - Industry 4.0" at the Studentski Grad campus is made by a Bulgarian company - a leading manufacturer of industrial processing equipment - RAIS Ltd. It is based on a patented technology developed by the Laboratory team within the project. The existence of this

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system is a good basis for the participation of scientists from TU-Sofia in the processes of digital transformation of the industry.

The robotic system combines additive and subtractive technologies, providing process optimization capabilities for multi-purpose tasks. The production of parts via a chip removal process is an economical and widespread technology. It also offers a wide selection of machinable processable materials, tools and processing modes. The combinations of all these possibilities create a huge field for optimization according to various criteria, such as processing time, tool life, etc.

On the other hand, in the production of a parts with complex or medium-complex geometry, the application of additive technologies is gaining popularity. The reverse to chip removal process is used, i.e. material is added only where necessary. There is a significant advantage in terms of speed and cost of the process, especially in complex details. The possibility of production by adding material is a highly innovative alternative to conventional processes and gives freedom in terms of design and production constraints, but despite its development, the accuracy of additive methods is not as good as in chip removal.

PLASMA CONVERSION OF CO_2

The rise of the CO_2 concentration in the atmosphere generated by conventional methods of electricity generation requires their replacement by the use of renewable energy sources. Because renewable energy production depends on time and season and does not meet the current needs of consumers, this requires its storage, which leads to a number of problems. Over the last decade, various methods have been developed to

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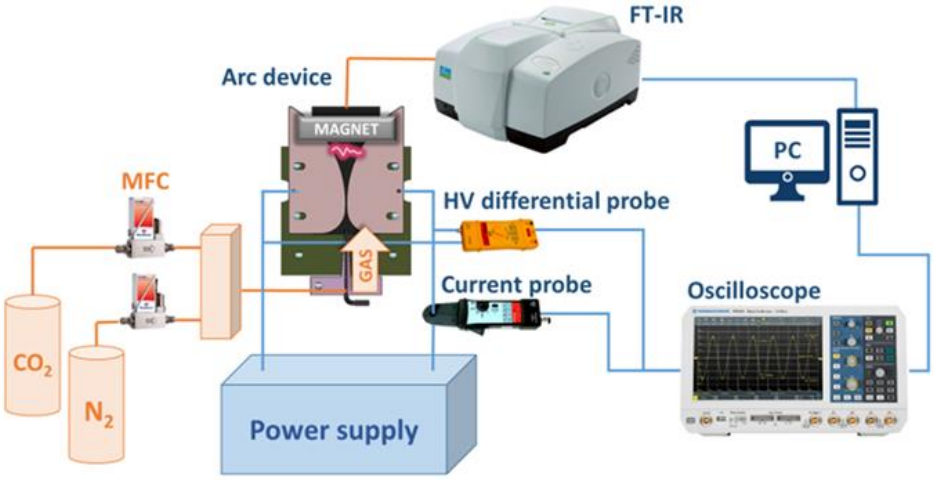
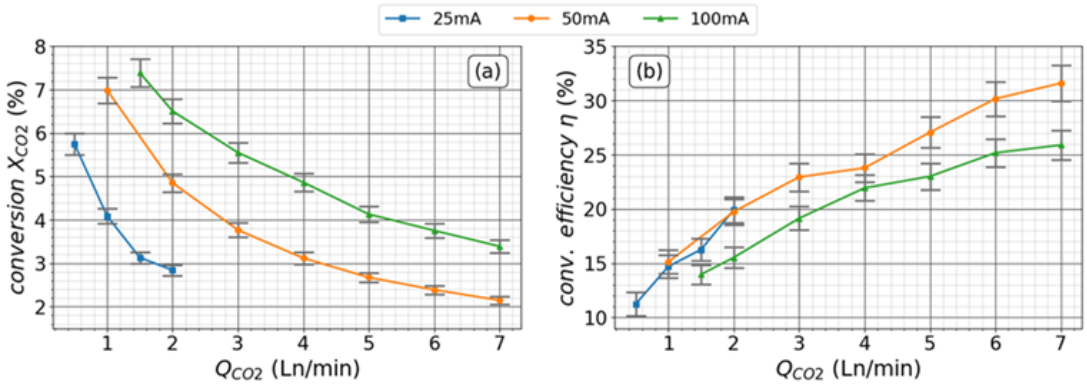
transform the harmful effects of electricity production from known fossil sources into useful chemical compounds. The conversion of CO_2 to CO by plasma treatment is one such method. The main challenges for the research team developing this technology are how to achieve significant conversion of CO_2 with high energy efficiency and how to prove its feasibility on an industrial scale.



The Laboratory of Plasma Technologies on the Lozenets Campus has established a system for studying the dissociation of CO_2 in a stabilized DC arc discharge at atmospheric pressure. The experimental setup includes the gas supply system, the power supply, the discharge and diagnostic systems - electric current and voltage probes and a Fourier spectrometer to measure the degree of dissociation.



The obtained results for the degree of dissociation and the energy efficiency of CO_2 conversion show a strong dependence on the electrical current and power - the higher current leads to an increase in the degree of dissociation and a slight change in efficiency. This shows that in the configuration used it is necessary to work with higher currents. In addition, it was found that the plasma conversion of CO_2 in this discharge with a magnetically stabilized arc has a high efficiency of over 30%, but the degree of dissociation remains relatively low - up to 10%

The studied experimental setup was also analyzed theoretically with the help of numerical models in order to elucidate the mechanisms determining the behavior of the discharge. The results of this research were published in the journal "Plasma Sources Science and Technology" with Q1 quartile. The team will continue to work on additional optimizations in order to increase the degree of dissociation in a stabilized DC arc discharge.

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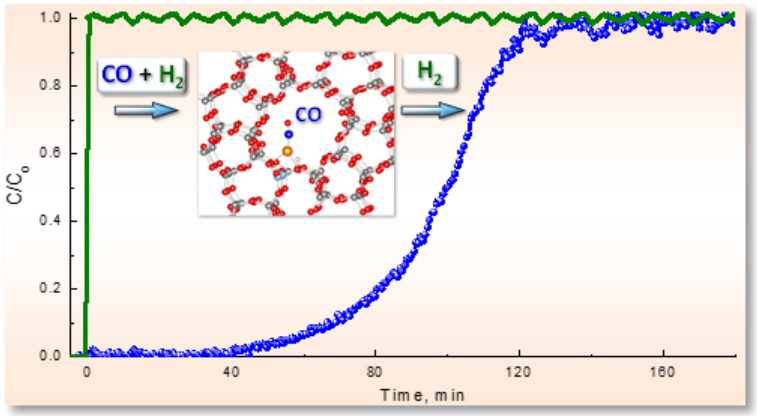
SCIENTIFIC ACHIEVEMENTS

The CoE in Mechatronics and Clean Technologies, which unites highly qualified scientists working on a unified research program with complementary topics, is a modern research infrastructure with unique equipment. Three years after the project starting it provides opportunities for development and high-quality research in accordance with the best world standards and practices. The results of these activities are published in renowned international journals, and those with potential for implementation are subject to intellectual property protection.

PURIFICATION OF HYDROGEN FROM CARBON OXIDE WITH CU/ZSM-5 ADSORBENTS

Hydrogen is the most "environmentally friendly" fuel, as its combustion produces only water that does not pollute the environment. Therefore, hydrogen is considered the main fuel of the future. Significant difficulties in some practical applications of hydrogen are related to its purification and storage.

A new effective adsorbent for fine purification of hydrogen from carbon monoxide has been developed at the Laboratory of Operando Research Methods. This is particularly important for hydrogen fuel cells, as it is necessary that the CO content in hydrogen does not exceed 10 ppm. The adsorbent is a copper-modified synthetic zeolite ZSM-5 by ion exchange. The zeolite matrix was found to stabilize copper in the form of isolated monovalent cations, which play the role of selective adsorption centers for carbon monoxide in the presence of hydrogen, oxygen and water vapor. The method of ion exchange makes it possible to control the amount and energy of the adsorption centres. In this respect, the solid-state exchange is superior to the conventional one (from aqueous solution) as it allows for a ca. twice as high concentration of the centres, at the same time being easier to regenerate.



The figure shows the change in gas concentration after passing a gas flow containing hydrogen and carbon monoxide through the Cu/ZSM-5 adsorbent. The hydrogen passes unimpeded while the CO is retained by the adsorbent for about 40 minutes until it is saturated.

The results of the study were published in the journal Molecules with Q1 rank.

APPROACH FOR PARAMETRIC OPTIMIZATION OF CONSTRUCTIVE PARAMETERS OF A THERMORESISTIC SENSOR THROUGH VIRTUAL PROTOTYPING

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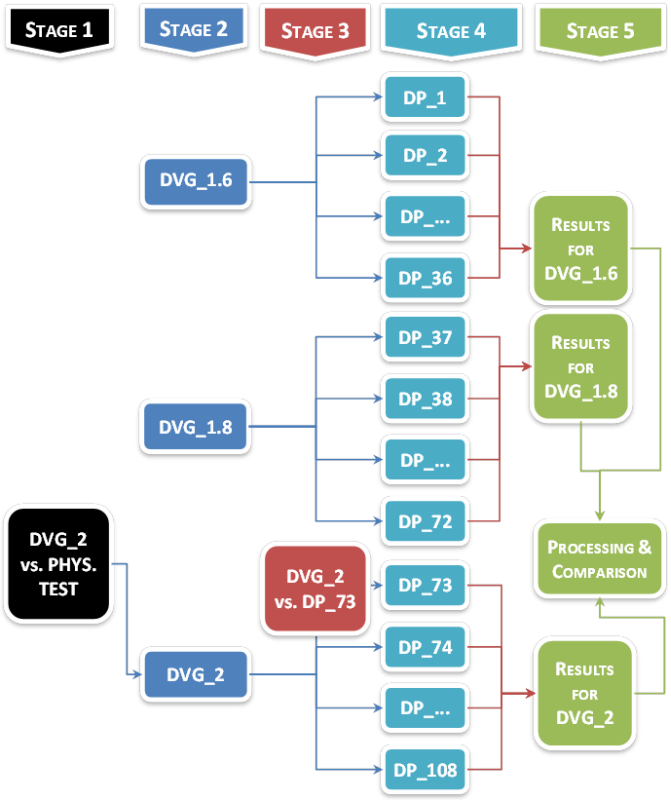
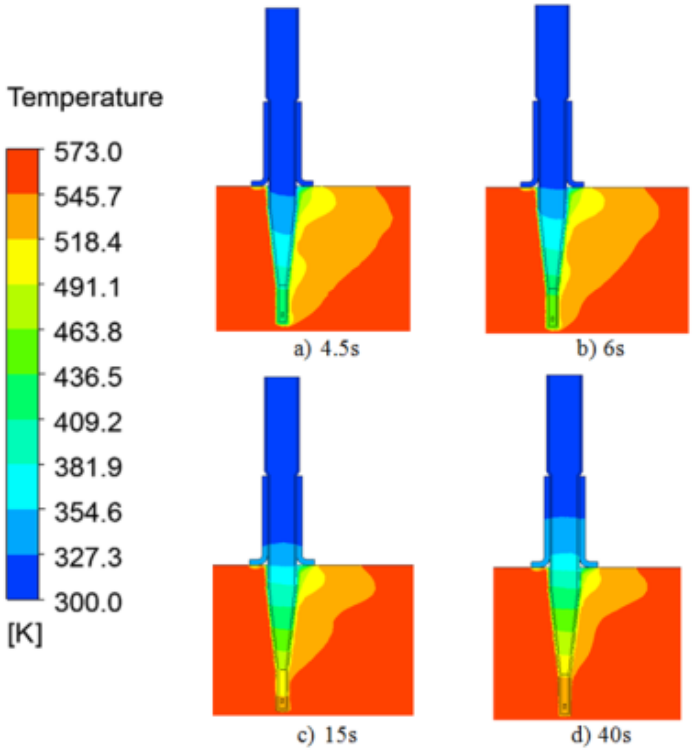
The study presents a successful approach used in the development of a new design of a thermoresistive sensor. The many interrelated parameters and the nonlinear behaviour of the studied object, combined with the need to process a large amount of data, necessitates the search for a new approach that will give fast and reliable results. The developed approach combines detailed multiphysical (thermo-fluid and structural) virtual prototypes, which are validated by physical experiments, using simplified thermostructural models. Its significant advantage is the ability to cover a large number of studied parameters of a product subjected to complex multiphysical impact, which reduces the complexity of engineering analyzes, while maintaining the accuracy of the results within the requirements.





The developed approach is demonstrated through a specific object - an industrial product. The total number of possible combinations of different values studied for the parameters of the studied sensor is 108. Initially, three virtual prototypes were studied by multiphysical analysis, the results of which were used as input parameters for subsequent 108 analyzes of geometry variants of the studied object. For this purpose, the possibilities for parametric modeling and research of the tools delivered under the project - ANSYS Academic Multiphysics Campus Solution - high-end software for virtual prototyping through multiphysical engineering analysis were used.

The developed approach has the potential for use in the development of temperature sensor designs in the company Sensata Bulgaria and has a direct impact on improving the environmental friendliness of the modern automotive industry. Detailed information about the study is published in the indexed in Q1 edition Case Studies in Thermal Engineering.

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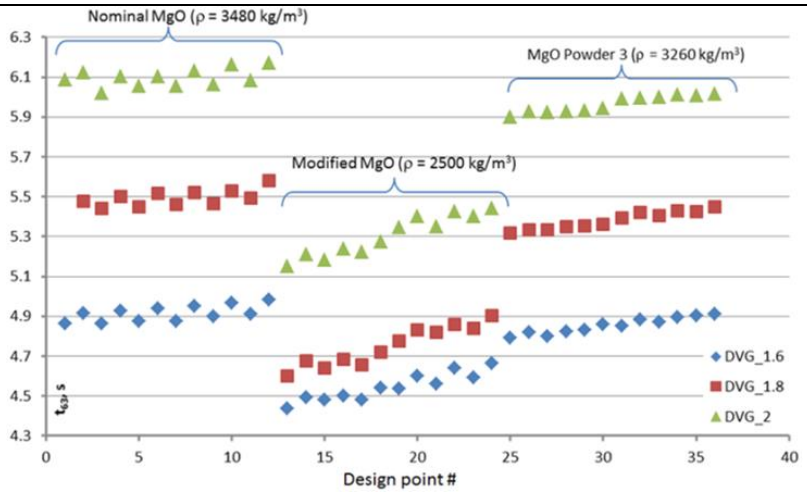

POLYFURANE FOAM MATERIAL AND METHOD FOR ITS PREPARATION

PATENT BG67251 B1 Int. Cl. C 08 J 9/00

An original approach to the synthesis of carbon-containing material from cheap, renewable and affordable precursors has been proposed. The invention relates to the development of a new polyfuran foam material with adsorption properties and a method for its preparation from glucose-fructose syrup. The glucose-fructose syrup used for raw material contains 55-80 wt. % glucose and 20-45 wt. % fructose. It is also known as corn syrup, high-fructose corn syrup or iso-sugar. It is obtained in large quantities from corn starch through the process of glucose isomerase and is widely used in the food industry as a sweetener.

A hydrothermal method is known which allows the production of a nanocomposite from cadmium sulphide nanoparticles coated with a thin layer of polyfuran. The process is carried out at 180 °C for 10 hours in an autoclave with the participation of glucose and not with the use of glucose-fructose syrup as raw material. In addition, the production of foamed material and its use as an adsorbent have not been reported.

The research team headed by Prof. George Tzvetkov and Corresponding Member prof. Tony Spasov has invented an effective method of heat treatment of glucose-fructose syrup with sulfuric acid, which produces a new substance - polyfuran foam material. The resulting carbonaceous material has adsorption properties that can be used to remove contaminants from a liquid phase (e.g. water) at room temperature.

RECRUITMENTS

Evelina Vasileva participates in the project "National Center of Mechatronics and Clean Technologies" as a young researcher, previously trained at the Lozenets campus. She graduated with honors from the Faculty of Chemistry and Pharmacy of Sofia University „St. Kliment Ohridski" and holds a bachelor's degree in Ecochemistry and a master's degree in Functional Materials. Ms. Vasileva obtained these degrees after the defense of diploma theses prepared in the Department of Applied Inorganic Chemistry. She is a co-author of a publication based on the research, which is referred to in the researcher's master's thesis.

The activity of the research team at the Department of Applied Inorganic Chemistry, of which Evelina Vasileva is a member, includes analysis of the structure, phase

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composition and physicochemical properties of functional materials, work with equipment used for the characterization of materials, as well as development of new materials with potential application in lithium-ion batteries, catalysis, storage of clean energy and others.

The current developments, which Ms. Vasileva's is working on, are aimed at obtaining metal alloys as precursors for the formation of porous structures, which find applications in a number of areas. The obtained porous structures are characterized in detail and studied for their potential application as electrodes in different types of lithium batteries - Li-S, Li-ion. The accumulated preliminary experience and knowledge in the field of materials science give her a great advantage in the implementation of her research tasks on the project.

Todor Todorov graduated from 2-nd High School "Acad. Emiliyan Stanev", Sofia in 2013. He continued his education at the Faculty of Industrial Technology, Technical University-Sofia and received a master's degree in Computer-Aided Design and Technology in Machine-building. During his studies he was actively engaged in research at the Scientific Research Laboratory "CAD/CAM/CAE in Industry".

Todor Todorov prepared bachelor's and master's theses in the Department of Technology of Machine Building and Metal-Cutting Machines under the guidance of Prof. DSc. Eng. Georgi Todorov. He has been working on the modelling and research of cooling systems of injection molding in order to reduce the defect of the final product. The results of his research have been presented at international and national conferences. They have been published in several refereed journals, one of which is Creative Business for Smart and Sustainable Growth, CreBUS 2019. In the first year of his master's degree he began working as an intern at Scientific Research Laboratory "CAD / CAM / CAE in Industry", where he participated in the implementation of industrial and national projects and improves his qualification.

After defending his master's thesis, Todor Todorov has joint in the team of the project "National Center of Mechatronics and Clean Technologies", where, again under the supervision of Prof. DSc. Eng. Georgi Todorov, he is doing research on process optimization and creating a methodology and approach for fast determination of parameters during injection molding.

ASSOCIATED PARTNERS

CLUSTER *MECHATRONICS AND AUTOMATION*

The Cluster of Mechatronics and Automation (CMA) was founded in 2006 and it is one of the first established clusters in Bulgaria, working in the field of mechatronics and automation. Its members are high-tech companies working in the field of mechanical engineering, hardware and software. They create equipment and products protected by patents and trademarks, which are exported to highly developed countries around the world. CMA has significant human potential - over 1,500 highly qualified specialists in the field of mechatronics and automation, about 150 of them working in scientific organizations, about 800 - in companies and 60 in NGOs.

The Cluster of Mechatronics and Automation creates conditions for mutually beneficial relations between its members, built on the basis of mutual trust and taking advantage of shared resource. This approach provides excellent opportunities to increase competitiveness in the fields of mechanics, electronics and informatics.

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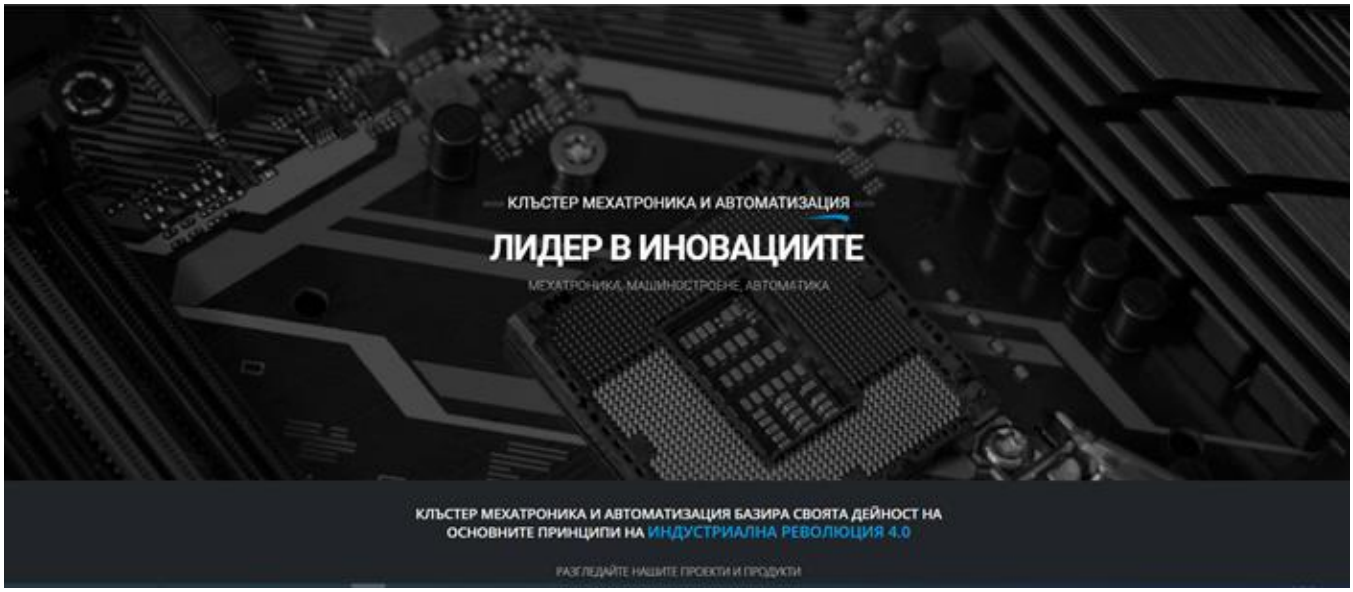
CMA individually and in partnership with other related organizations or consortia of its members has completed over 50 projects in the field of robotics, LED technology, energy efficiency, construction of VPN-communications, automation of continuous production in the energy, chemical and cement industries.



The Cluster of Mechatronics and Automation is a bridge between applied research and industrial applications, combining the advantages of avantgarde thinking with rational management. CMA is initiator for the establishment of Association of Business Clusters in Bulgaria - ABC, whose successor is Bulgarian Employers' Association Innovative Technologies – BRAIT. One of cluster tasks is to support the development of high-tech, export-oriented products, technologies and services that have high added value. As an associate partner of the Center of Excellence in Mechatronics and Clean Technologies, the CMA is engaged in disseminating information among its members and businesses in Bulgaria about the research and development capabilities of the laboratories in this center. Six Regional Training Centers of CMA throughout the country are used for this purpose and the universities and institutes of BAS are included in many of the cluster projects. The beneficiaries of the project “National Center of Mechatronics and Clean Technologies” - Technical University - Sofia, Technical University - Gabrovo and the Institute of Mechanics are among them.

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The Cluster of Mechatronics and Automation supports the project management to disseminate the research infrastructure capabilities of the "National Center of Mechatronics and Clean Technologies". Eng. Ventsislav Slavkov, a member of the CMA Management Board, is an associate member of the Project Management Board. A meeting with the members of CMA was held in 2018. At the meeting they were acquainted with the strategic goal, objectives, research capacity to offer innovative solutions to address industry development, conducting advanced research with applications in clean technologies and expected impact of the project implementation.

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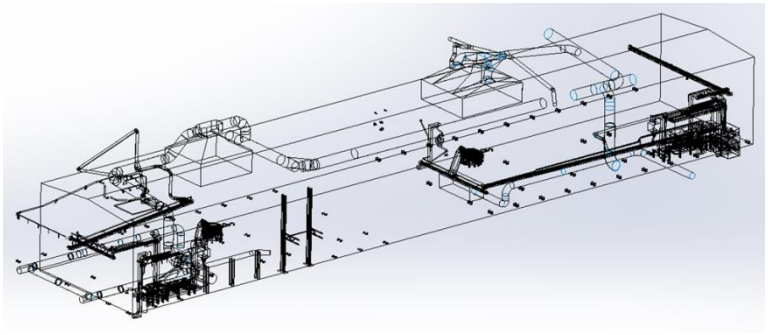
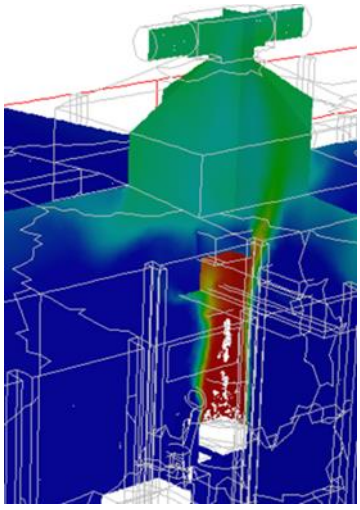
COLLABORATION

SCIENCE AND BUSINESS

STUDENTSKI GRAD CAMPUS COOPERATION PROJECT WITH STOMANA ENGINEERING LTD



In 2021 started a collaboration project "Analysis and optimization of the parameters of an industrial ventilation and filtration system through virtual prototyping" with Stomana Engineering JSC, Pernik. In the project, the developed methodology for virtual prototyping and the delivered equipment in Laboratory "Virtual Engineering and Digital Manufacturing-Industry 4.0" at the Studentski Grad campus have been used. Within the framework of this cooperation, an analysis was performed to determine the levels of pollution with fine dust particles in the foundry of a steel plant in Pernik, applaying its virtual prototype. The validated model of the industrial unit is the basis for evaluating various options for improving the system for industrial ventilation and filtration, looking for the maximum ratio of efficiency and the necessary additional financial investment to achieve better air quality.



The approach is an excellent demonstration of the efficiency of implementing the results of the work on the project "National Center of Mechatronics and Clean Technologies" in real industrial conditions, and especially in the field of clean technologies. A direct result of the joint project with Stomana Engineering S.A., Pernik is the evaluation of four possible solutions based on comparison of their efficiency of dust collection, as well as on the necessary investments for their implementation. The used methodology and equipment, as well as the accumulated expertise are applicable in further developments related to the other industrial capacities of the concern.

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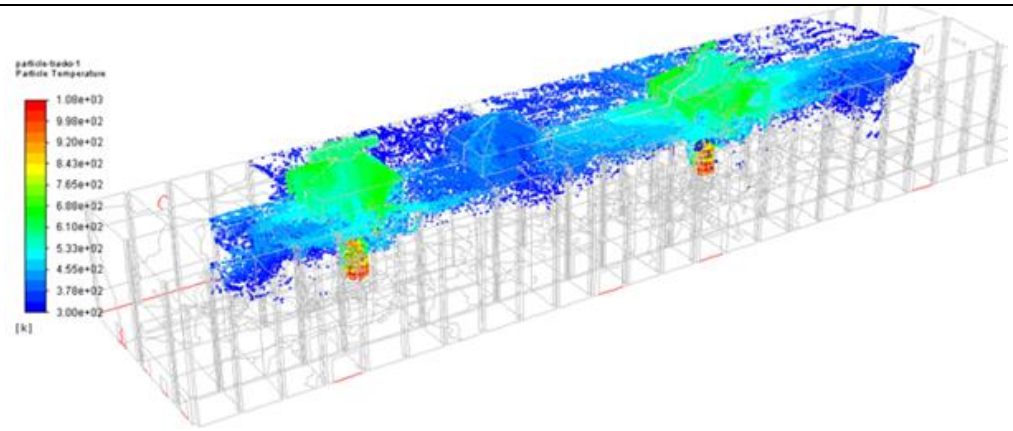


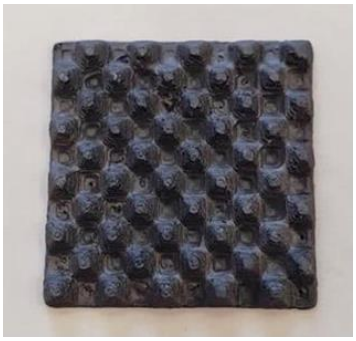
THE PROJECT AND THE CENTERS OF COMPETENCE FOR FINDING ORIGINAL SOLUTIONS IN OVERLAPPING ECONOMIC SEGMENTS

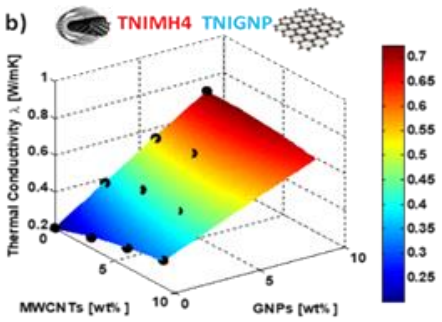
THE PROJECT AND THE CENTER OF COMPETENCE - MIRACLE ABOUT THE ROLE OF IMECH - BAS IN THE DEVELOPMENT OF MECHATRONICS IN BULGARIA

The Institute of Mechanics at the Bulgarian Academy of Sciences is a partner in the project "National Center of Mechtronics and Clean Technologies" (CoE M&CT) and coordinator of the Center of Competence "Mechatronics, Innovations, Robotics, Clean technologies" (CoC - MIRACle). The research plan and objectives that are the core of these centers, as well as the purchased new devices and systems, stimulate scientists from the Institute to coordinate their activities for acquiring new knowledge, to do application-driven research on **creation of modern technologies and components for mechatronic systems, technology development and new materials for engineering and reengineering**.

The research activities include developing technologies for micro- and nanoelectronics, as well as modeling and forecasting of processes and properties of materials for clean technologies, synthesis of new composites, etc. Modern technologies for testing materials and mechatronic components for studying the processes of their deformation and destruction are also developed and used.

Three laboratories have been established and fully equipped under the project "National Center for Mechtronics and Clean Technologies" at the Institute of Mechanics.





Hybrid nanocomposites of poly(lactic) acid, reinforced with carbon nanotubes and graphene nanoplates, are being developed at the Thermal Conductivity Testing Laboratory using the Light Flash (LFA) technique to determine a set of thermophysical characteristics. A fourfold increase in the thermal conductivity of the nanocomposites was achieved with 9 wt.% graphene nanoplates (GNP) compared to that of unfilled

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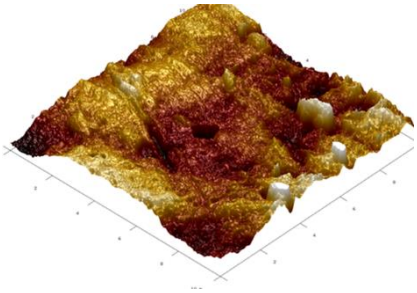
polymer. The results were published in 2020 in the journal Polymers. The resulting GNP / PLA nano-composite can be used as a substitute for elements improving heat transfer in high-power microelectronics, aerospace and the space industry.

Scientists from the Laboratory for Thermal Conductivity Testing are successfully working on 5 European projects funded by the Eighth Framework Program Horizon 2020.

A nanoindenter with a dynamic contact module at the Laboratory for Study of Nanostructures is used to characterize thin layers, MEM, bulk materials, composites, polymers and biomaterials. The mechanical properties, chemical composition, structure and morphology of the latest generation of multi-force bioactive orthodontic arches with application in dentistry have been studied with the help of this equipment.

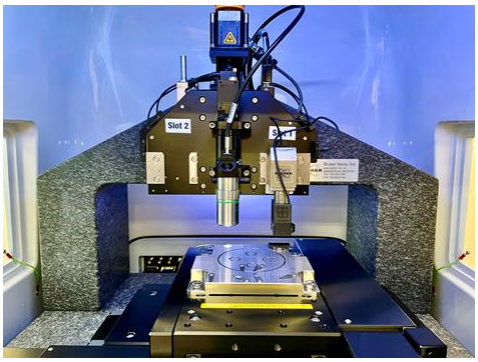


The Laboratory for Mechanical Testing and Express Diagnostics was established jointly with the Institute of Metal Science, Equipment and Technologies with the Center for Hydro- and Aerodynamics "Academician Angel Balevski".

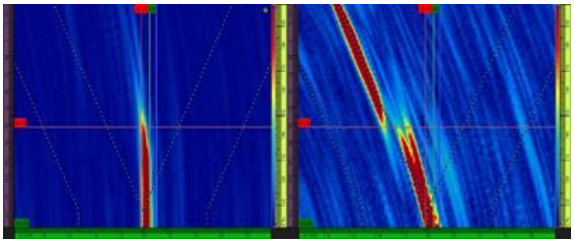
This laboratory possesses a Hopkinson bar system, which is used to obtain the diagram of elastic and plastic deformation under pressure obtained as a result of impact on the specimen with selected parameters. Modulus of elasticity and tensile strength are determined from the diagram. The maximum stress and maximum deformation depend on the selected impact conditions (mass and speed of the striker).

The ZWICK / ROELL, HA-250 servo-hydraulic test machine allows determination the mechanical properties of materials under different conditions. Specimens shall be tested for tensile, compressive, bending, fatigue and crack resistance under static or dynamic loads with different sequences in time and frequency, as well as at different temperatures, which is possible due to the presence of high temperature furnace (up to 1000^{o}C) and temperature chamber 80^{o}C to 250^{o}C).

The research team of the Laboratory for Mechanical Test and Express Diagnostics currently works on a project funded by the National Science Fund, and the investigations are carried out with the delivered equipment. Interest in access to the laboratory equipment has also been expressed by companies.



Seven laboratories located at the Institute of Mechanics will be renovated and equipped within the activities of the project Center of Competence - MIRACle. The Hysitron TI980 triboindenter system operates in the Laboratory for Micro and Nanomechanics of Mechatronic Systems. This is the unique equipment for the country, which allows a wide range of research in nanomechanics of surfaces, elements and systems with applications in mechatronics.



Olympus Omniscan X3 Ultrasonic Defectoscope is part of the new equipment in the Laboratory Monitoring, Non-Destructive Testing, Testing and Characterization of Mechatronic Systems. It is used to indicate imperfections (defects) located in a welded joint.

The equipment in the established laboratories of the CoC - MIRACle and in the 3 laboratories of the CoE M&T is supplemented and the scope of research is expanded. The activity in the laboratories of the CoC MIRACle is definitely more focused on innovation and accelerated application of the obtained results. It is related to problems of the companies from the Cluster of Mechatronics and Automation, which is a partner of both centers, as well as of other business organizations. These activities are carried out in compliance with the principle of not giving preference to associated partners or other organizations.

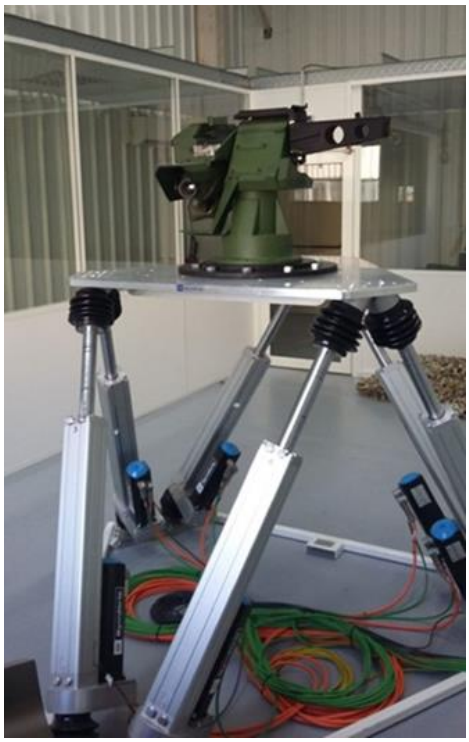
The Institute of Mechanics has good communication with all partners from CoE M&CT and CoC MIRACle and is in contact with TU - Gabrovo, which is the coordinator of CoC in Mechatronics and Clean Technologies in the North Central region of Bulgaria. This is a prerequisite for flexible complementarity of activities and expansion of the opportunities and expertise of these centers for participation in projects and for solving a wide range of tasks set by Bulgarian and foreign companies. The modern scientific infrastructure is being created at the Institute of Mechanics offers an attractive and competitive environment for young scientists to work and develop their skills in the field of mechatronics.

CoE AND CoC IMEESS FOR IMPROVING THE ACCURACY OF MEASURING INSTRUMENTS

The Accurate Measurements of Dynamic Quantities in Mechatronics Laboratory and Smart, Mechatronic Systems for Measurement of Static and Dynamic Quantities Laboratory were

built at the Technical University of Gabrovo as a result of the implementation, respectively of the project Center of Excellence "National Center of Mechatronics and Clean Technologies" and Center of Competence "Smart, Mechatronic, Echo- and Energy Saving Systems and Technologies". The equipment dilivered in these laboratories is unique and at the same time allows to achieve synergy in the field of mechatronics in both research and practical developments for business.

Smart, Mechatronic Systems for Measurement of Static and Dynamic Quantities Laboratory serves to maintain immediate and precise control of geometric dimensions, deviations from the correct geometrical shape and relative position of surfaces and axes, as well as all other requirements set in the technical drawings of engineering products. The laboratory is in the process of accreditation to perform various types of measurements, verification and calibration of measuring instruments.



Accurate Measurements of Dynamic Quantities in Mechatronics Laboratory is the only one of its kind in the country which has at its disposal mechatronic system that has reference properties and six degrees of freedom for studying dynamic characteristics which can experimentally determine and study dynamic characteristics of machines and equipment exposed to alternating mechanical impacts (shocks, vibrations, etc.) The simulation stand in the laboratory is also used for performing analysis, verification and calibration of dynamic accuracy of means and systems measuring parameters of moving objects (land vehicles, ships, aircraft).

Various external impacts occur in real working conditions. All of them significantly reduce the measurement accuracy and make it impossible to achieve the ultimate goal which is related to the results of machining, control or positioning in the coordinate system. In this regard Accurate Measurements of Dynamic Quantities in Mechatronics Laboratory has equipment that can reproduce external impacts recorded in real working environment with high precision. This makes it possible to study the accuracy characteristics of the precision measuring equipment in Smart, Mechatronic Systems for Measurement of Static and Dynamic Quantities Laboratory in near actual conditions.

The combination of the capabilities of the equipment in the two laboratories can lead to effective solutions to important tasks related to improving the accuracy of technological equipment and measuring instruments in real working conditions. The equipment available allows development of models and algorithms for active compensation of external and internal errors where the obtained optimal estimate meets the criterion for minimum variances of model and measurement errors.

PROJECT TEAM MEMBERS IN THE STANFORD RANKING IN THE STANFORD RANKING

THE NUMBER OF PROJECT SCIENTISTS AMONG THE FIRST BEST SCIENTISTS IN THE WORLD IS GROWING

In 2021 three more scientists from the project "National Center of Mechatronics and Clean Technologies" were included in the list of the top scientists in the world, according to a ranking by Stanford University. Thus, in this prestigious ranking, the total number of scientists from the project is eleven. These are

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Members of BAS Petar Kralchevski (1956-2020), Konstantin Hadjiivanov and Nikolai Vitanov, Corresponding Members Stanislav Vassilev, Vessela Tsakova and Krassimir Danov, Professors Georgi Vayssilov, Dora Karagiozova, Radostina Stoyanova, Nikolay K. Vitanov and Hristina Vassileva.

The ranking of the American University is compiled on the basis of a complex analysis which includes information on the number of citations, H-index, corrected in co-authorship Hm-index, citations of articles within different positions of authorship and others. The ranking groups all researchers in 22 scientific fields and 176 sub-fields.

The Chairman of the Project Management Board Acad. K. Hadjiivanov and the heads of laboratories acad. P. Kralchevski, Corresponding Member V. Tsakov and prof. D. Karagiozov were presented in the Information Bulletin'2020. Now the Corresponding Members S. Vassilev and K. Danov, and the Professors R. Stoyanova, N.K. Vitanov and H. Vassileva are introduced to the readers. The rubric in the Annual Information Bulletin will be retained until the end of the project.

Prof. Stanislav Vassilev is a leading scientist at the project "National Centre for Mechatronics and Clean Technology". Prof. Vassilev is employed at the Institute of Mineralogy and Crystallography "Acad. Ivan Kostov" – BAS. He is Doctor in Geological Sciences since 2006, Professor since 2007, and Corresponding Member of BAS since 2021.

The research of Prof. Vassilev is in the fields of mineralogy and geochemistry of solid fuels (biomass, coal, coke, refuse derived fuels) and environmentally safe utilization of their products generated by combustion, gasification and pyrolysis. He has 111 scientific publications with more than 8800 citations in the international literature and Hirsch index - 37. Thirty-three of his publications are among the most cited 10 % in the specific scientific fields.

Prof. Vassilev was a member of the Committee for Coal and Steel (COSCO) at European Commission (2007–2008); Detached National Expert at European Commission, Institute for Energy and Transport, Petten, The Netherlands (2007–2013); High-end Foreign Expert at National Foreign Expert Bureau at Council of Ministers of China (2016–2018). He is Global Expert (SHANXI 100 Talents) at Institute of Coal Chemistry, Chinese Academy of Sciences. Prof. Vassilev is a member of the editorial boards of *Fuel* and *Coal Conversion*; and he was an editor of *Coal Combustion and Gasification Products* and *Waste and Biomass Valorization* – four prestigious international scientific journals in his field.

Prof. Krassimir Danov is a leading researcher at the National Centre for Mechatronics and Clean Technology. He is Doctor in Mathematical Sciences since 2001, Professor since 2005, and Corresponding Member of BAS since 2012. Presently, he is a head of the Laboratory of complex fluids in the Department of Chemical and Pharmaceutical Engineering at the Faculty of Chemistry and Pharmacy, Sofia University "St. Kl. Ohridski".

Prof. Danov works in the fields of mathematical modelling of physicochemical processes (adsorption, micelles, thin liquid films and interactions between colloidal particles) and thermodynamics of complex fluid. He has 204 scientific publications with more than 5300 citations in the international literature and Hirsch index - 40. He is one of the most cited Bulgarian scientists.

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Prof. Danov was a guest professor in Erlangen-Nurnberg University, Germany, Institute "Paul Pascal", France, and National Institute of Physiology, Okazaki, Japan. He was awarded the Bessel Prize of the Humbolt Foundation in 2002 and the Pythagoras Prize in 2019 for significant achievements in science. He was an editor of the respected international journals *Fluid Dynamics* and *Materials Processing*.

Prof. Radostina Stoynova is the head of the Laboratory "Intermetallics and Intercalation Materials" at the Geo Milev Campus. She has been a Doctor of Chemistry (since 1992), a Professor on Solid State Chemistry (since 2012) and the Director (since 2020) of the Institute of General and Inorganic Chemistry at the Bulgarian Academy of Sciences, which is the Coordinator of the project.

Prof. Stoyanova's research interests and expertise are in the field of solid state chemistry. Her investigations are focused on the methodologiacal development of spectroscopic methods such as electron paramagnetic resonance for analysis of solid state materials; examination of the local structure of intercalation compounds and its influence on their electrochemical properties; identification of original classes of electrode materials for lithium and sodium ion batteries and introducing new concepts in the chemistry of energy storage materials. She is an author and co-author of 184 scientific papers in ISI-indexed journals with over 3700 independent citations and H-index of 33.

In recognition of her scientific achievements, Prof. Stoyanova was awarded the prestigious national prize Pythagoras for Outstanding Achievements in the Field of Natural Sciences (2018). She is an Associate Editors of the renowned international journal Chemical Engineering Journal (IF=13.273) and a member of the jury for the doctoral scholarship of the Carol Knowledge Foundation.

Prof. Nikolay K. Vitanov is the head of the Laboratory for the Study of nanostructures in the Geo Milev campus. He has been a Doctor of Physics since 1994, Dr. rer. nat. of the University of Bayreuth, Bavaria, Germany and D. Sc. of Mathematics in 2007, Professor at the Institute of Physics. Mechanics of BAS since 2010, and head of the Department of Fluid Mechanics, where under his leadership research is conducted on complex fluid systems and on other nonlinear systems. He has been leading coronavirus analysis and forecasting teams in support of the Council of Ministers and the Ministry of Health of the Republic of Bulgaria since the beginning of the pandemic.

Prof. Nikolay K. Vitanov is a co-author of over 200 publications in international scientific impact factor journals with over 3,500 citations and an h-index of 33. His scientific contributions include a modified method of the simplest equation for obtaining exact solutions of nonlinear partial differentials equations; mathematical model of ideological struggle; method for prediction of strong gusts of wind; analytical results for the upper bounds of heat transfer in fluid layers under different conditions; numerous models of substance motion in channels of networks with application to the theory of human migration and the theory of growing networks, etc.

Prof. Nikolay K. Vitanov is the winner of the First Prize of the Union of Scientists in Bulgaria for the best scientific achievements in 2007 and 2017. He is Deputy Chairman of the Commission for Monitoring and

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Evaluation of Research Activities of Universities and Research Organizations in the Republic of Bulgaria since 2016.

Prof. Christina Vassileva is employed at the Institute of Mineralogy and Crystallography, BAS. As a researcher at the "National Center of Mechatronics and Clean Technologies", she is involved in the development of a task related to multicomponent utilization of waste products from energy production. She has a PhD degree since 2003, and she is a Professor since 2015.

The scientific achievements of Prof. Vassileva are in the field of mineralogy, geochemistry and sustainable utilization of solid fuels (coal, biomass) and waste products from their thermochemical conversion (fly ashes, bottom ashes, slags). Prof. Vassileva is an author of 68 scientific publications with more than 7400 citations noted in the international literature up to now, and her H-index is 28. Twenty-four of these articles are included in the Scopus Top 10% of the most cited publications in the specific scientific field.

She is currently the head of the Permanent Scientific-expert Commission of Earth Sciences at the Bulgarian National Science Fund.

INFORMATION DAY

PROGRESS IN THE IMPLEMENTATION OF THE PROJECT

NATIONAL CENTER OF MECHATRONICS AND CLEAN TECHNOLOGIES

The Bulgarian Academy of Sciences hosted on December 17, 2021 the third information day since the start of the project. Guests of the forum were the President of BAS Acad. Julian Revalski, the Deputy Ministers of Education and Science Acad. Konstantin Hadjiivanov and Ms. Vanya Stoyneva, representatives of the Board of Trustees of BAS, the Mayor of Municipality Slatina Mr. Georgi Iliev, representatives of the project partners, etc.

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The moderator of Information Day'2021 was Prof. Neli Koseva, member of the Management Board of the project and Scientific Secretary-General of BAS. She noted that for the project participants this is a day of critical analysis of the past year. An important day in which they fulfill their commitment to inform the public how effectively, appropriately and transparently public funds have been used, as well as to explain the usefulness of the obtained results for the development of the country.

The President of BAS, Acad. Julian Revalski, opened the Information day and expressed his satisfaction with the unification of the best scientists in Bulgaria in the field of mechatronics and clean technologies. This is the largest project in terms of scale and funding, which is an example of the most successful cooperation between the institutes of BAS and universities in Bulgaria, a bridge between education and research. Acad. Revalski noted the fact that in recent years there has been a significant improvement in research infrastructure, but another significant step remains to be taken. This important step is to keep the research staff of the project and to attract young people to research, because it is the guarantee for its sustainable development. The President of BAS appealed to the representatives of the Ministry of Education and Science to use their powers to create conditions for retaining and attracting talented researchers. He sees encouraging signs in this direction from the new government, which has recognized innovation and research in its policies and priorities.

Scientists from the Lozenets campus, led by Corresponding Member, Tony Spasov, were the first to present their results. Lozenets campus is specialized in the development and research of new materials with

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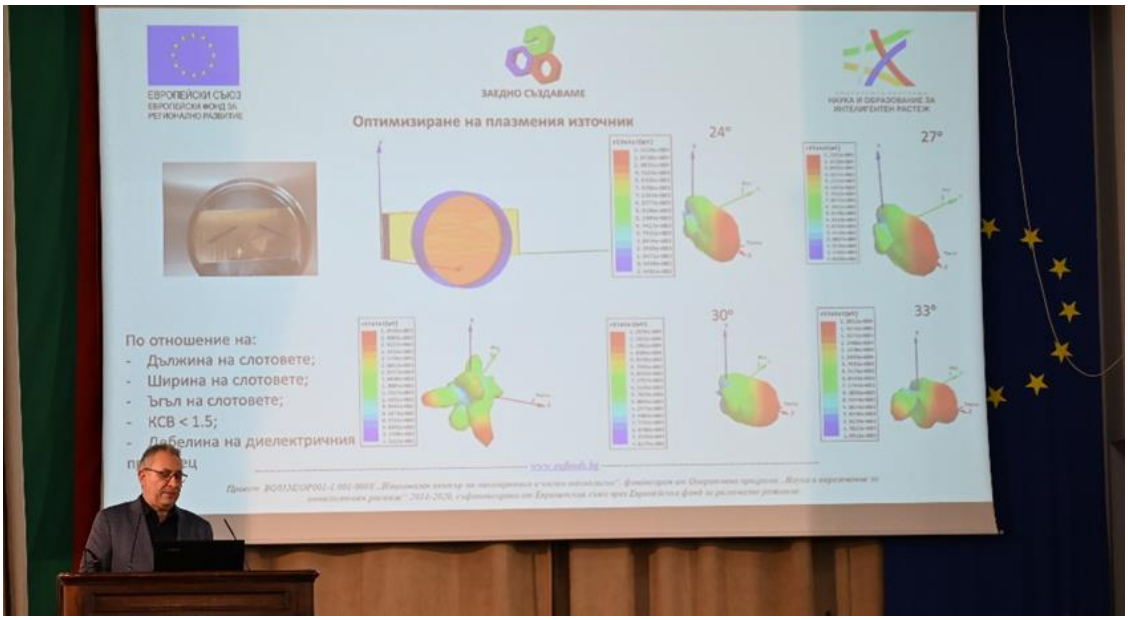
application in key technologies such as energy storage and conversion, catalysis and ecology. Corr. Member Spasov spoke briefly about the activities carried out on the establishment of the research infrastructure on campus and in the laboratory led by him for the creation of nanomaterials for hydrogen storage.



The presentations of Assoc. Professors Zhivko Kissovski and Stanimir Kolev were respectively for the realization of technology for graphene and carbon nanostructures for supercapacitors and batteries and to increase the efficiency of plasma conversion of carbon dioxide to carbon monoxide and molecular oxygen, which is related to transport and environmental protection. A patent granted in 2021 for Polyfuran Foam Material and Method for its Production with authors Georgi Tsvetanov Tsvetkov, Toni Georgiev Spasov, Marianka Nikolova Gadjeva was presented.

The presentation of Assoc. Prof. Kostadin Kamberov was about the activities of scientists on the Studentski Grad campus, which are focused in the field of mechatronics. Sixteen sections of the project laboratories will be located as of this year, in the reconstructed building at the Technical University, Sofia, which today is a modern equipped research infrastructure. The practical orientation of the performed research is the basis of the cooperation of the Studentski grad campus with the UMHATEM Pirogov, for which individual implants have been prepared and for the first steps of implementation of new products in Kolowag AD, Septemvri, Transvagon AD, Burgas and Stomana Engineering S.A., Pernik. Scientists from the campus are

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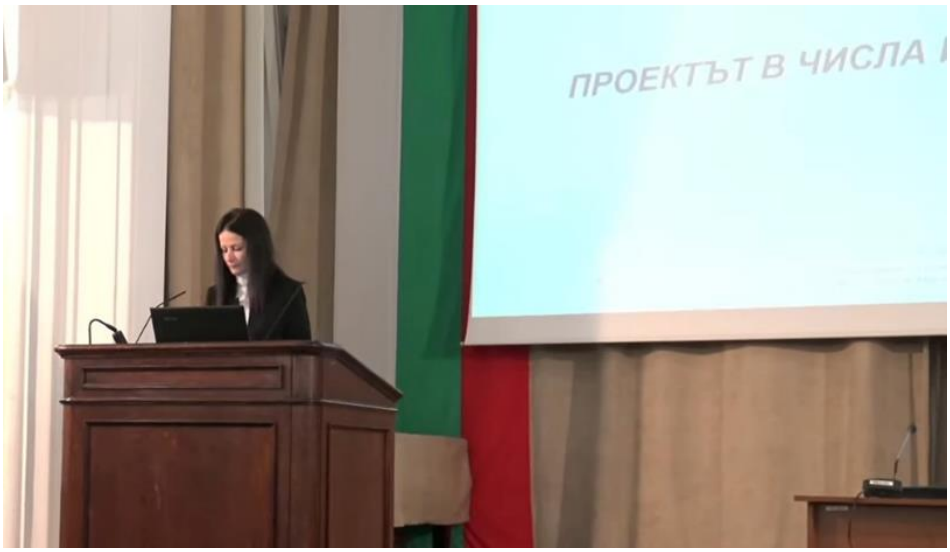
actively involved in the Bulgarian Innovation and Technology Hub DigiTecH 4.0 and together with TU, Gabrovo and UCTM are working on a project for modernization of higher education.

The head of the Geo Milev campus, Prof. Plamen Stefanov, who is also the coordinator of the entire project, presented the progress in the activities for the implementation of the third research complex of the Center of Excellence in Mechatronics and Clean Technologies. Research in the field of mechatronics and clean technologies is carried out at the Geo Milev campus. Many of the investigations are related to the transition to a low-carbon and circular economy and the successful application of the Green Deal.

Prof. Margarita Popova's presentation included results on development of rechargeable batteries, supercapacitors, electrochemical sensors, materials and technologies for purification of air, water and air, for the creation of useful products and valuable chemicals from waste materials. Assist. Prof. Tatiana Simeonova showed the results of experiments to increase the thermal conductivity of composites with potential for use in high power microelectronics, aerospace and space industry and the study of the properties of the latest generation of multi-power bioactive orthodontic arches. Scientists from the Geo Milev campus end 2021 with a total of 56 publications in indexed publications, of which 2 publications are in the top 10% and 16 – in journals in the first quartile according the internation databasis Web of Science.



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The last presentation in Information Day 2021 was delivered by the expert monitoring and control Tsvetelina Vladimirova for the implementation of the financial plan and the main indicators set in the program for project realization. Some of the indicators are expected to be met in the next year. The forum was closed by Prof. Koseva, who outlined the main tasks for 2022.

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