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OF
MECHATRONICS AND CLEAN TECHNOLOGIES

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In this Issue

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MODERNIZATION OF THE EXISTING RESEARCH INFRASTRUCTURE

FIRST SOD IN LOZENETS CAMPUS

The first sod of the Lozenets campus took place on March 31, 2022. The ceremony included a presentation of the scientific complex by Corresponding Member Toni Spasov in the meeting hall of the Faculty of Chemistry and Pharmacy and symbolic laying of its foundations with the "first sod" in front of the building for renovation at 28 Zlatovrakh Street. The event was attended by the Deputy Minister of Education and Science Member of BAS Konstantin Hadjiivanov, the Vice Rector of Sofia University Member of BAS Nikolay Vitanov, the Executive Director of the EA "Programme Education" at the Ministry of Education and Science Prof. Georgi Vayssilov, the mayor of the Lozenetz district Konstantin Pavlov, the coordinator of the project "National Center of Mechatronics and Clean Technologies" Prof. Plamen Stefanov, the head of the Lozenets campus Corresponding Memeber Tony Spasov, researchers and guests.

Corresponding Member Tony Spasov greeted the guests of the event and presented the implementation of the "National Center of Mechatronics and Clean Technologies" project. According to the project, three research complexes are being built: Geo Milev campus, which is located at the BAS, Studentski Grad campus - at the Technical University in Sofia, and Lozenets campus.

The program for the creation of the Lozenets campus within the Center of Excellence in Mechatronics and Clean Technologies consists of the reconstruction of the building at 28 Zlatovrakh Street and research in the field of clean technologies. Seven of the 13 laboratories of the complex will be located in the renovated building with an area of 550 sq. m. The remaining laboratories are located in the existing buildings of the Faculty of Physics and the Faculty of Chemistry and Pharmacy. The complex, whose total area is 1 000 sq. m., will have conference rooms and office spaces.

Prof. Spasov briefly presented the activities of the laboratories in the complex he manages, the purchased equipment and its importance for the development of technologies and materials for environmental cleanliness

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control and energy storage. He emphasized that everything was achieved thanks to joint efforts, “This is a big step that cannot be realized without the joint efforts of colleagues from various institutions, experts, Executive Agency and Ministry of Education and Science.” In his words, this means that from the scientist and the manager to the young scientist, everyone has to be in their place.

In front of the building under renovation at 28 Zlatovrakh Street, the official guests met with some of the researchers of the complex. The Deputy Minister of Education and Science Member of BAS Konstantin Hadjiivanov expressed his satisfaction to attend the event. He stated that the MES places great hopes on centers of excellence and competence centers, as they are one of the main tools for the development of science in the future and for making connections between science and business. Member of BAS Hadzhiivanov noted that he is emotionally connected to this center, as he was the chairman of the Center's Management Board and devoted a lot of time to the preparation of the project. So, he is extremely pleased to see how the project's goals are being achieved. In his words, “This project is the largest in Bulgaria and, accordingly, the most difficult to implement.” He also offered greetings on behalf of Minister Denkov, wished success and expressed hope that in the near future there will be a working center.

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Prof. Georgi Vayssilov and the mayor of the Lozenets district, Dr. Konstantin Pavlov, also offered greetings and wishes for success. For the Vice Rector of SU "St. Kliment Ohridski", Member of BAS Nikolay Vitanov, the establishment of the center is an opportunity to deepen the cooperation of the university with the BAS institutes. He pointed out that science in Bulgaria is fragmented. These centers help to consolidate research in important scientific areas. Member of BAS Vitanov compared the centers to locomotives that pull the entire Bulgarian science forward.

Finally, Member of BAS Nikolay Vitanov, Corresponding Member Tony Spasov and Dr. Konstantin Pavlov symbolically made the first sod of the Lozenets campus in Center of Excellence in Mechatronics and Clean Technologies in front of the renovation building.

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OPENING OF STUDENTSKI GRAD CAMPUS

The Studentski Grad campus at the Technical University in Sofia - one of the three research complexes that making up the Center of Excellence in Mechatronics and Clean Technologies was solemnly opened on May 16, 2022. The event began with a Ribbon Cutting ceremony attended by the Minister of Education and Science Member of BAS Nikolay Denkov, the Mayor of the Municipality of Sofia Mrs. Yordanka Fandakova, the Executive Director of the Executive Agency "Programme Education" Prof. Georgi Vayssilov, the Rector of the Technical University - Sofia Prof. Ivan Kralov, the Rector of the Technical University - Gabrovo Prof. Iliya Zhelezarov, the Rector of the University of Chemical Technology and Metallurgy Prof. Sanya Terzieva - Zhelyazkova, the project coordinator Prof. Plamen Stefanov, the chairman of the Management Board of the project Member of BAS Konstantin Hadjiivanov, the head of Studentski Grad campus Prof. Georgi Todorov, the head of Lozenets campus Corresponding Member Tony Spasov, directors of scientific institutes, business representatives, teachers, researchers and students.

The Rector of the Technical University - Sofia Prof. Ivan Kralov, welcomed the guests on behalf of the academic leadership and thanked everyone who participated in the establishment of the campus. He expressed special thanks to the Management Board of OP NOIR, which has supported and motivated them to justify the need and deliver the most modern equipment in full compliance with the regulations of our country, to the management and employees of the Ministry of Education and Science for their great understanding and cooperation, help, empathy and an awakening spirit.

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In his speech, Minister Denkov stated, “Every science at the international and world level is built on three pillars: material base, quality researchers and funding to free the creative spirit of every participant in this process. The material base is available, you have appointed young and promising colleagues. Our common effort must be to provide conditions for the talented and motivated, those who can do science at the highest level, to find their place and realization in Bulgaria.”

The Studentski Grad research complex is a union of technical universities in Bulgaria and the University of Chemical Technology and Metallurgy. It was created in accordance with the requirements of the National Development Program “Bulgaria 2030”. It consists of 11 laboratories, 16 sections of which are located in the reconstructed educational block 8 of the Technical University, Sofia.

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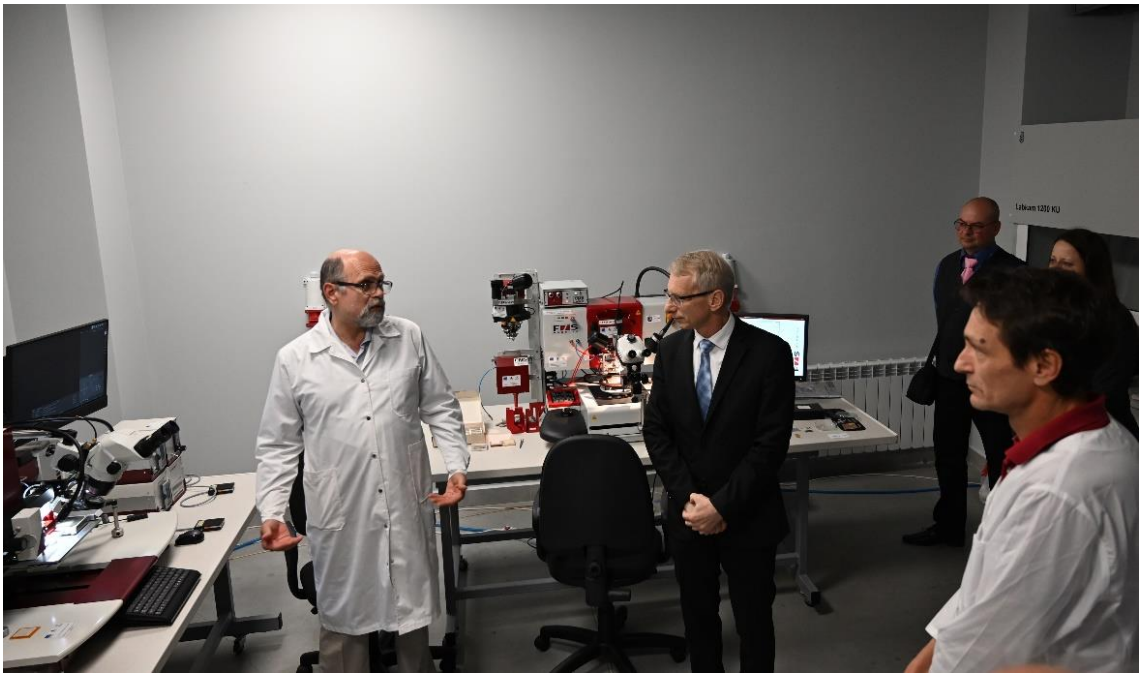
After the Ribbon Cutting ceremony, the guests and residents of the capital had the opportunity to visit the laboratories in the renovated building equipped with the most modern and unique for our country equipment. They are a venue for research in the field of mechatronics, virtual engineering and digital manufacturing, biomechatronics, robotic systems, vibration and acoustic control systems, functional coatings and new materials, transportation engineering, electromobility, etc.



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Some of the engineering solutions were developed by scientific teams of the Technical University - Sofia, such as the system for prototyping complex products or their industrialization. Thus, researchers, PhD students and students can be not only users, but also a step forward in technology.

Much of the equipment is oriented to the specific needs of the business, especially start-ups, and their activity will be supported with the opening of this infrastructure. Three young scientists, excellent students from the Technical University, have already been appointed full-time at the center and 37 researchers work part-time. All this will ensure the sustainability of the Center of Excellence in Mechatronics and Clean Technologies as a developing research organization with active collaboration with partners from both the research sector and business.

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THE PRESIDENT RUMEN RADEV VISIT THE NEWLY OPENED STUDENTSKI GRAD CAMPUS

The Head of State Rumen Radev visited on Jun 17, 2022 the opened a month ago Studentski Grad campus at the Center of Excellence in Mechatronics and Clean Technologies.

The Rector of the Technical University in Sofia Prof. Ivan Kralov, spoke about the implementation of the idea for the Center, emphasizing its importance for creating innovations in the most modern fields of science, their transfer to industry and their role for society. In addition, according to Prof. Kralov, "The new center can create the future technical elite of the country, as in it work both young specialists and established scientists."

In his speech, the President Rumen Radev stated that the future belongs to those nations that choose science and education as a national priority, that the implementation of this project is of great importance for not only Bulgarian education and science, but also for the future of Bulgaria and that similar projects will help of our country to position itself among the leaders in the field of scientific developments. The project is important for our social and economic rapprochement with the developing countries of the European community. „With

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this center, Bulgaria makes a strong request that it wants to return to the map of scientific and technical progress, where we belong," said President Radev.

With his presentation, the head of the Studentski Grad campus, Prof. Georgi Todorov, introduced Mr. Radev to the creation, activity and development plan of the research complex, after which the Head of State visited the laboratories and met with the researchers who work in them.

EUROPEAN COMMISSIONER MARIA GABRIEL VISIT STUDENTSKI GRAD CAMPUS

The Studentski Grad campus of the Technical University was visited on 10 November 2022 by Maria Gabriel, European Commissioner for Innovation, Research, Culture, Education and Youth.

European Commissioner Gabriel was welcomed by the Rector of the Technical University and member of the Management Board of the Center of Excellence in Mechatronics and Clean Technologies Prof. Ivan Kralov.

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He presented the university he leads and the Studentski Grad campus. Prof. Kralov said that in the renovated block 8 of the university there are 16 laboratory sections with modern technologies and equipment at the highest level. The best students of 3 graduations are appointed and they are now doing science, students and PhD students are trained, marketable products are developed and technologies are transferred to industry. The rector added, “In this way, we fulfil our social commitment, working to find solutions to the pressing problems of the economy and society - energy efficiency, environmental protection, health care and training of the country's future technical elite.”

European Commissioner Maria Gabriel thanked for the welcome, the interesting information and stated, “My visit is a sign that we European Commissioners are keenly interested in the development of education, innovation and research. The Technical University in Sofia is a wonderful example of the creation of European university networks and its role in these processes, and its participation in a number of European scientific projects creates additional value for society and raises the authority of your university.”

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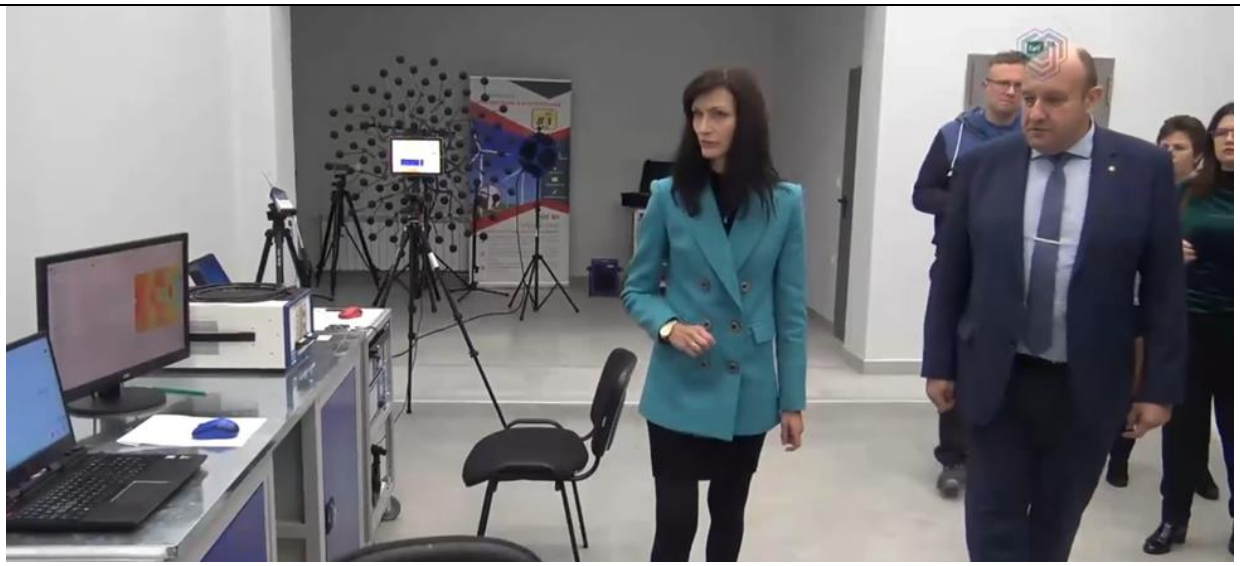

After that, European Commissioner Gabriel visited the laboratories at the Studentski Grad campus led by Prof. Georgi Todorov and was impressed by the modern equipment, the team of young researchers, the results achieved so far and the ambitious plans for work in the future.

SCIENTIFIC IVENTS

WORKSHOP

GEO MILEV CAMPUS – MODERN INFRASTRUCTURE AND RESEARCH OPPORTUNITIES

A seminar for doctoral students and young scientists was held on June 29, 2022 at the Geo Milev campus which is a union of 12 scientific organizations of the BAS and is one of the three research complexes of the Center of Excellence in Mechatronics and Clean Technologies. The forum on the topic "Geo Milev Campus - modern infra-structure and research opportunities" was opened by the project manager Prof. Plamen Stefanov. The program of the seminar included lectures by prominent specialists with experience in the operation of the modern scientific equipment delivered to the campus laboratories, the development and application of analytical techniques and innovative technologies.

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Member of BAS Konstantin Hadjiivanov, who, according to the Stanford ranking, is among the top 2% of scientists in the world in the relevant scientific field, presented the first lecture. His presentation was about the potential of spectroscopic methods as an important prerequisite for the successful development of new functional materials, as they allow establishing the mechanism of the process for which they will be used. He reports some results from applications of *in situ* and *operando* infrared spectroscopy for the fine purification of hydrogen from traces of CO. These results are of particular importance for hydrogen used in fuel cells, where the permissible concentration of CO is no more than 10 ppm.

Prof. Margarita Popova, head of the Chromatography Laboratory, which analyzes organic compounds, presented the lecture on the application of nanoporous materials as catalysts for "green" chemistry, as well as for the development of mesoporous silicates, zeolites and composite materials with suitable particle structure, functionality and morphology in order to obtain new drug delivery systems.

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Prof. Boris Shivachev, head of the Laboratory for X-ray Structural Analysis, which conducts research on substances with different chemical composition and unit cell volume, presented the capabilities of the D8 Venture Single Crystal Diffractometer. It allows a reduction in the size requirements of organic, inorganic, organometallic and biological units. The new apparatus was used to determine the structure in the [100] direction of a new zeolite-like substance MS-21 and the results were published in 2022 in the renowned international journal RSC Advances.

And while the first three lectures were related to clean technologies, the last two – respectively by Assoc. Prof. Rumen Krastev and Boris Yanachkov, were related to equipment and technique related to the development of mechatronics. The presentation given by Assoc. Prof. Rumen Krastev was for determining mechanical characteristics in static and dynamic tests, and Boris Yanachkov's report was devoted to experimental studies and computer simulations on the influence of hydrogen on the properties of metal alloys - an important topic, given the prospects for using hydrogen as a main energy source.

UNIQUE RESEARCH EQUIPMENT

MICRO/NANO DIFFERENTIAL SCANNING CALORIMETER TA INSTRUMENTS – USA NANO DSC

In the Laboratory of Thermochemistry, the behaviour of materials under the temperature changes is studied. By measuring the temperatures and thermal flows correlating with the thermal transitions in the studied materials, the variations that correspond to a change in their structure, composition and phase state are determined.

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The laboratory has a differential scanning calorimeter and apparatus for thermogravimetric analysis, through which data on the behaviour of materials are obtained by determining: specific heat capacity, polymorphism, melting and crystallization, phase transitions/diagrams, degree of crystallinity, glass transition temperatures, oxidative stability, start of decomposition.

Delivered in 2022, the country's unique Micro/Nano Differential Scanning Calorimeter TA Instruments – USA Nano DSC expands the capabilities of the laboratory due to its very high sensitivity of the order of nW. It can be used to examine:

− Occurrence of temperature phase transitions of natural and/or synthetic polymers in aqueous solutions and/or emulsions;
− Identification of high molecular weight compounds, copolymers, mixtures and composites;
− Interaction between a protein and a low or high molecular weight substance.

X-RAY DIFFRACTOMETER

The scientific program implemented within the project includes structural and microstructural characterization of substances and materials with application in energy storage systems, hydrogen production, catalysis, energy efficiency and environmental protection.

The research carried out in the X-ray Analysis Laboratory is aimed at developing new materials with application in the conversion and storage of clean energy and hydrogen storage. Materials with electrocatalytic activity regarding the hydrogen reaction in aqueous electrolysis are also being developed.

The acquired in 2022 X-ray diffractometer allows examination of any kind of samples - from powders to thin films, from amorphous to crystalline substances, including nano- and quasicrystalline materials.

The setup allows operation in both reflection and transmission geometries, as well as sample measurements in capillaries. The availability of various sample holders enables the examination of large samples with dimensions of 9.5 cm x 9.5 cm x 5.1 cm and a weight of up to 2 kg, as well as operation in a temperature range [- 190 °C; + 600 °C].

The database in the accompanying software contains over 300 000 diffraction maps of organic and inorganic compounds, suitable for identification and quantification of unknown samples.

FT-IR SPECTROMETER

The goal of the scientific program of the Laboratory of New Detectors and Creation of Intelligent Process Control Systems is the study of semiconductor nanostructures and bulk materials for optoelectronic and photovoltaic applications. The heads of the laboratory are Prof. Evgenia Valcheva and Assoc. prof. Vesselin Donchev.

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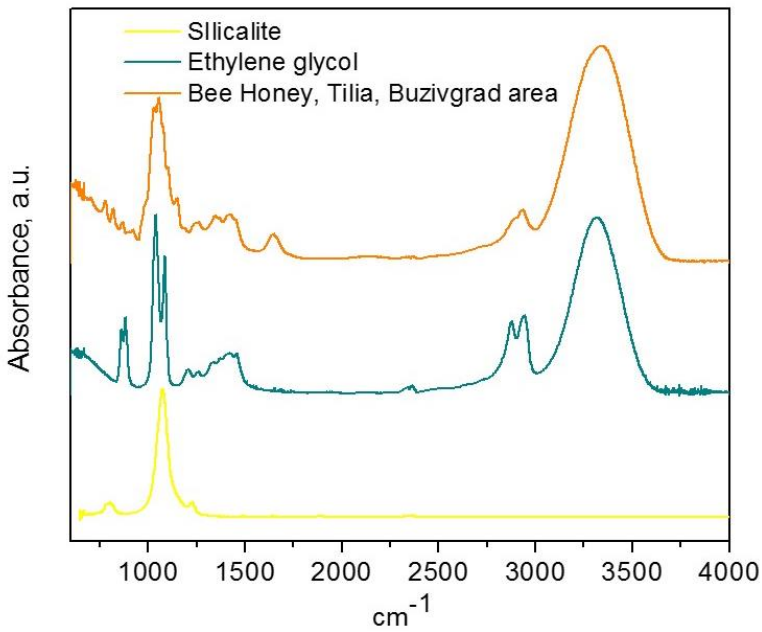
Semiconductor materials and nanostructures for optoelectronic applications such as LED light emitters, infrared detectors, optical memories, photovoltaic elements and structures, highly efficient semiconductor lasers and other components of opto- and nanoelectronics based on quantum effects are studied by spectroscopic methods. The studied objects and systems are components of modern mechatronic devices.



The FT-IR spectrometer, acquired in 2022, for the far IR/THz, mid and near IR regions (Thermo Scientific Nicolet iS50) allows three modes of operation – transmission, diffuse reflection and impaired total internal reflection. It has the following features: Standard resolution – 0.09 cm^{-1}, Signal-to-noise ratio – better than 55000:1; Linearity: 0.07 %T; Wavelength accuracy: > 0.01 cm^{-1}; Scanning speed: 0.158 – 6.28 cm/sec. It allows determination of infrared absorption or emission spectra of solid, liquid or gas samples. Through IR spectra, the properties of materials are studied, the composition of the sample is revealed, they are used to identify unknown materials, control production processes, etc.

The FT-IR spectrometer includes an attachment for recording diffuse-reflection spectra of solid samples, a reaction cell for operation at a high temperature of 910 ^{0}C (with a temperature controller) and pressure from 133 kPa to 0.133 mPa. The accompanying software has a library of over 3000 spectra.

SCANNING ATOMIC FORCE MICROSCOPE

Section L8_S5 “Energy-efficient mechatronic devices, systems and technologies” has delivered a modern configuration of a scanning atomic force microscope (AFM) with the possibility of studying topological electrical and magnetic properties of samples with a spatial accuracy of up to 2 nm. It has been put into operation during the past year. AFM is applicable to the study of metals, dielectrics, ferroelectrics, semiconductors, MEMS, micro and nanoelectronic systems, microelectrochemistry, as well as organic and biological samples and materials.

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The following microscanning techniques may be used: contact force scanning (AFM); close force microscopy (LFM); transient contact scanning; contactless scanning; phase contrast scan; magnetic force microscopy (MFM); electrostatic force microscopy (EFM); conductive scanning (c-AFM); magnetic force microscopy; Kelvin force microscopy (KPFM); piezoresistive force microscopy (PFM); electrochemical AFM (EC-AFM); scanning electrochemical microscopy (SECM); scanning microwave microscopy (SMM); lithographic and spectrographic modes of operation; micro and nanofluidic positioning technology up to 300 nm.

This apparatus allows to perform studies and research in the fields of new electromagnetic nanomaterials; phase-active materials for magnetic and quantum recording of information; multi-structure coatings; micro electrochemistry; bioactive materials; architectures of micro electromechanical and mechatronic actuators, transducers and sensors; micro and nano printing of active structures.

SCIENTIFIC COMPLEX SYSTEM /STANDS, SOFTWARE AND HARDWARE/ FOR STATIC TESTS OF NODES AND AGGREGATES OF RAILWAY OBJECTS

Section L4_S2 “Modelling, analysis and synthesis of mechatronic systems for railway transport” has delivered a “Scientific complex system /stands, software and hardware/ for static tests of nodes and aggregates of railway objects”. It includes the following main subsystems:

Railway brake test stand: allows measurement of all controlled parameters of railway brake systems. The final results are presented in the form of a Protocol with notation of the values, date of measurement and the person who performed the test. The facility is mobile and allows measurements in both laboratory and production/repair rooms.

Complex for static testing of railway objects: includes amplifiers with their own software, force transducers, linear displacement transducers, strain gauge schemes and materials. It serves for precise measurements of forces, displacements, deformations, accelerations, temperature, etc. parameters. For the purposes of scientific research, its application is: carrying out examinations, testing new structures, optimizing the parameters of various types of engineering structures (not only railway vehicles), commissioning new wagons and locomotives, etc.

GAS SENSOR TESTING SYSTEM

The scientific program of the Laboratory for Investigation of Sensor Properties is related to the fabrication of functional materials and nanostructures for electrical and optical detection of chemical agents and their integration into sensor devices for applications in various fields of industry, biology, agriculture, environmental protection, quality of life.

The research carried out in the Laboratory is aimed at developing a wide range of selective sensitive inorganic materials (semiconductor and dielectric metal oxides and chalcogenides, oxo-zeolite composites and dispersions of graphene, mesoporous oxide materials); deposition and functionalization of thin layers of these materials through various technological methods and subsequent characterization from the view point of their application in sensors for detection of various gases.

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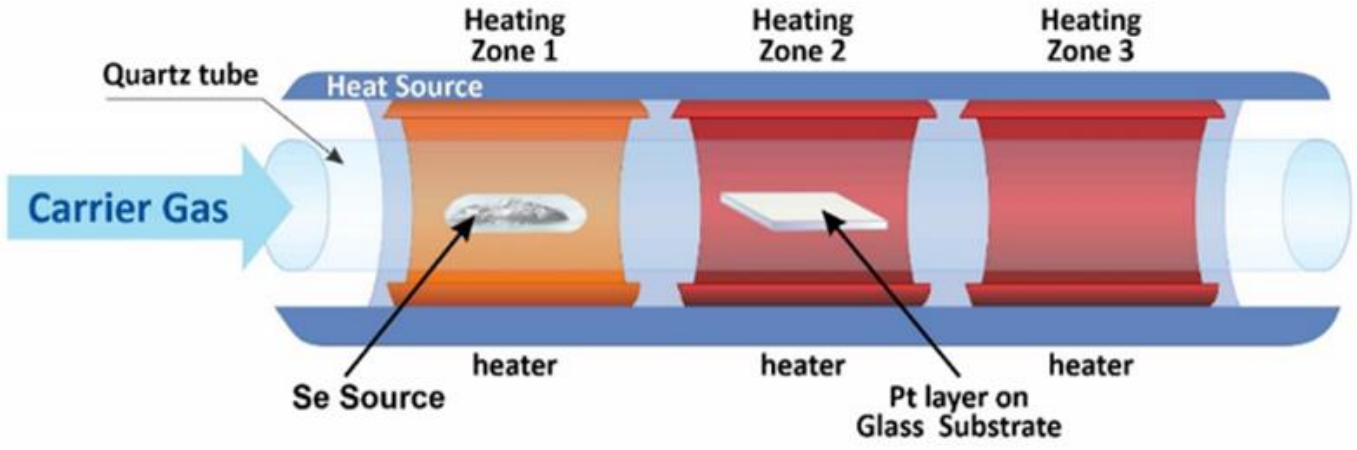
The unique Kenosistec KGAS4S system (which was acquired at the end of 2021) allows testing the sensor response of the investigated materials and structures under various conditions simulating the environment, such as humidity, temperature and concentration of various gases by measuring the change in the resistance of the sample when changing the parameters of environment. The system has six gas lines for feeding different gases in the working chamber at controlled humidity ranging from 10 to 90%. Through precise mass flow controllers, the gas concentration can be changed very accurately in the range from 1 to 5000 ppm. The system is currently equipped with the following test gases: CO_2, NO_2, NH_3. Measurements can be performed at temperatures from room to 400 °C with an accuracy of ±2 °C. The working chamber can be pre-evacuated to a pressure of about 10^{-5} mbar. Electrical measurements are performed with two Keithley 6487/E SMU picoammeters, at constant voltage up to 500 V. The chamber design allows applying of additional optical stimulation of the sensors with visible and UV light. The measurement setup can also test and calibrate unbonded/unpackaged sensor devices.

SCIENTIFIC ACHIEVEMENTS

OBTAINING 2D $PtSe_2$ COATINGS AND THEIR OPTIMIZATION FOR ANTI-BACTERIAL APPLICATIONS

Antibacterial materials and coatings are the subject of increased interest at the moment due to the dramatically increased health threats and the strict hygiene requirements. $PtSe_2$ is widely used in photocatalysis, and therefore its application as an antibacterial coating in the dark and in the light was sought for the first time. The research was carried out at the Laboratory for 2D Materials and Nanolayers by scientists at the Institute of Optical Materials and Technologies, together with scientists from the Demokritos Research Center in Greece. The deposition of Pt was done by magnetron sputtering and then in a chemical vapour deposition system the selenization of the layer was done.



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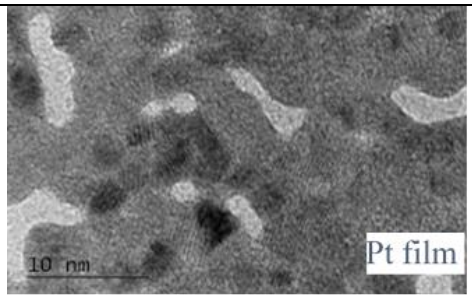
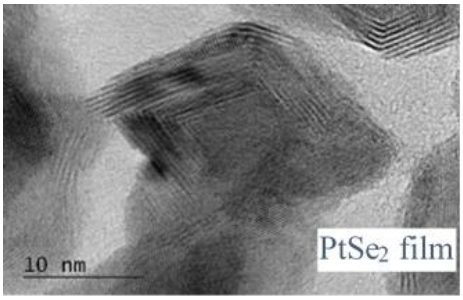
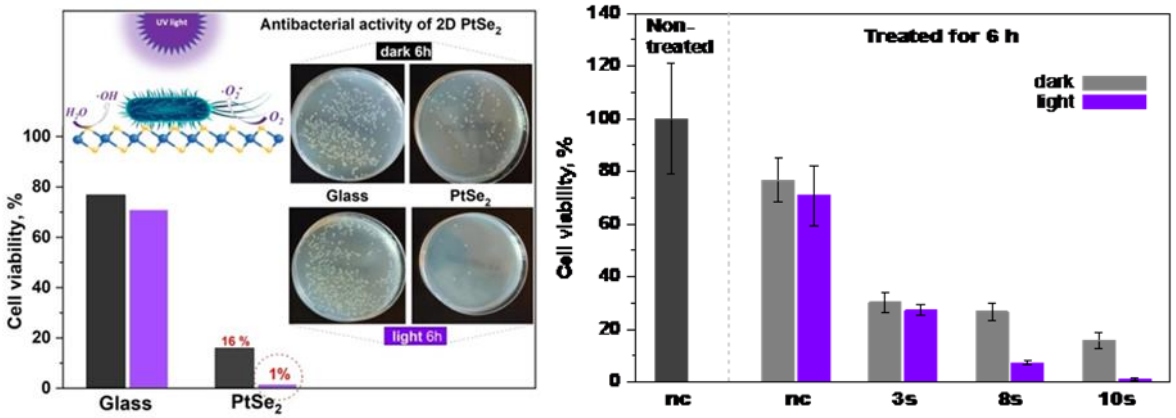




Several coatings with different thicknesses were investigated and characterized by various methods such as X-ray diffraction, X-ray diffraction, Raman spectroscopy and UV spectroscopy. The antibacterial activity of the $PtSe_2$ coatings against Escherichia coli was investigated according to the ISO standard. The tests performed for antibacterial activity, which are shown, are for coatings of different thickness and action in the dark and in the light.

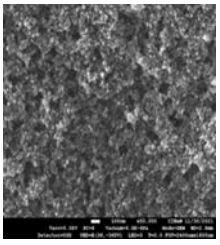


From the figure it can be seen that the thickest coating has the most significant activity, reaching up to 15% bacterial viability in the dark after 6 hours, while in the light this percentage drops to 1.2%.

The results of the research were published in 2022 in Applied Surface Science, which is in the top 10% of the most prestigious journals in the relevant scientific field.

ELECTROCHEMICAL SENSOR FOR DETERMINATION OF GLYCEROL

Interest in the electroanalytical determination of glycerol is growing significantly due to its application in various fields, such as human health control, environmental protection, quantification of free glycerol in biodiesel, and the quality of food and beverages such as wine. Depending on the specific application, the practical range for the detection of glycerol can vary widely. For this reason, electroanalytical studies cover many different concentration ranges of glycerol and this necessitates that sensor materials with specific electroanalytical characteristics be used for various specific application areas.



In the Electrochemical Technologies Laboratory, scientists from the Institute of Physical Chemistry have conducted experiments with Pd nanoparticles spontaneously deposited on mesoporous carbon for the electrochemical detection of glycerol. The spontaneous deposition of Pd was obtained by dipping the pre-reduced carbon electrodes in an aqueous solution of 2 mmol/l $PdSO_4$ and 0.5 M H_2SO_4. The metal deposition process is monitored by the change in the open circuit potential of the working electrode.

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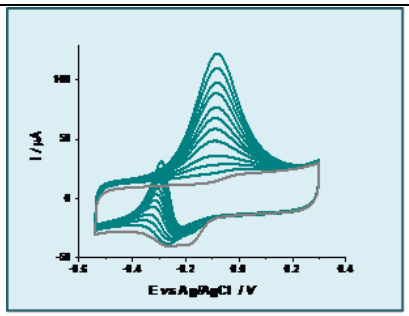
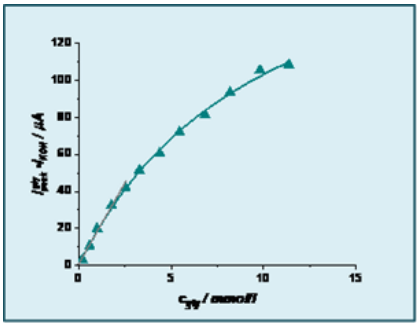
Cyclic voltammetry was used for electroanalytical studies at different concentrations of glycerol. The concentration dependence of the peak glycerol oxidation current is modelled by a Langmuir-type function, which allows the detection of glycerol in the concentration range from 0.2 to 15 mmol/l.





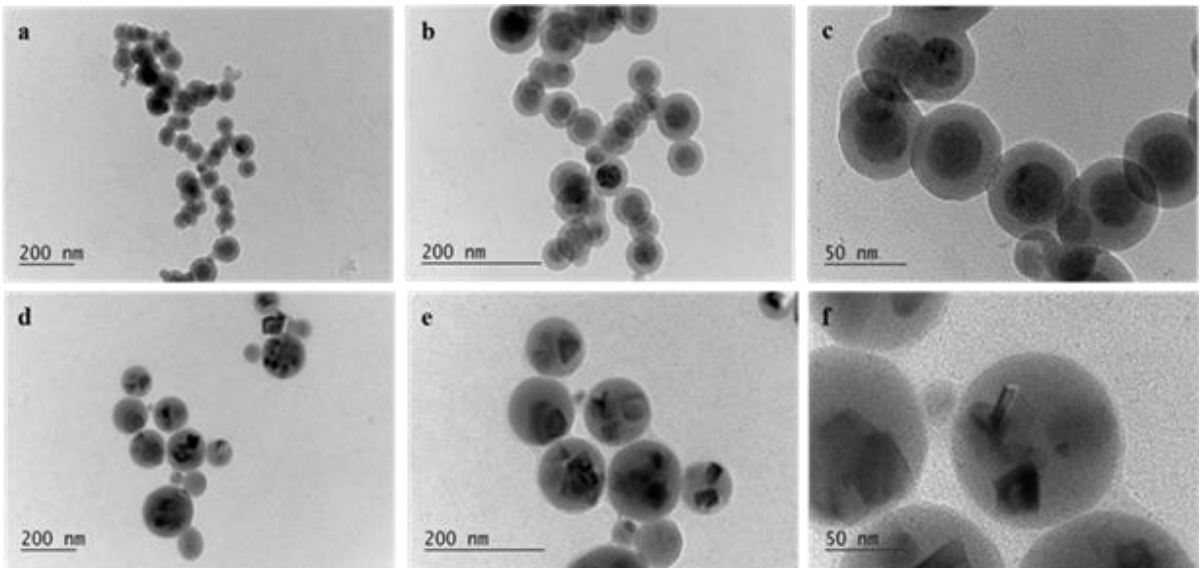
The calibration curves obtained on this basis can be used for electroanalytical determination in the entire studied concentration interval of glycerol. The developed approach by facile preparation of Pd nanocatalysts and the use of disposable carbon electrodes represents a good prospect for practical applications.

The results of the conducted research were published in Electrochimica Acta, which falls into the Q1 quartile of journals in the relevant field.

INVESTIGATION OF THIN FILMS OF PVA – POLYMERS WITH GRAFTED CHAINS OF PMA AS ACTIVE MEDIA FOR OPTICAL GAS SENSORS

Acetone is one of the organic solvents widely used as a reaction and/or separation medium in various technological processes in the chemical and pharmaceutical industries. Since it is considered harmful to human health, the development of reliable sensors for the detection of acetone vapour is of vital importance. Most of the acetone sensors are metal oxide semiconductors, which operate at temperatures above 200 ^{0}C, which requires energy costs and reduces lifetime.

In the Laboratory of Organic Synthesis, layers of different copolymer compositions were synthesized and tested as sensors for acetone sensitivity at room temperature. Transmission scanning microscopy images of the resulting films exhibit 70 nm and 73 nm polymer particle size.



The sensing properties of the films were tested with acetone vapour at different ambient humidity. It can be seen from the figure that the influence of humidity is almost negligible, and the film with larger particle sizes is more sensitive to acetone.

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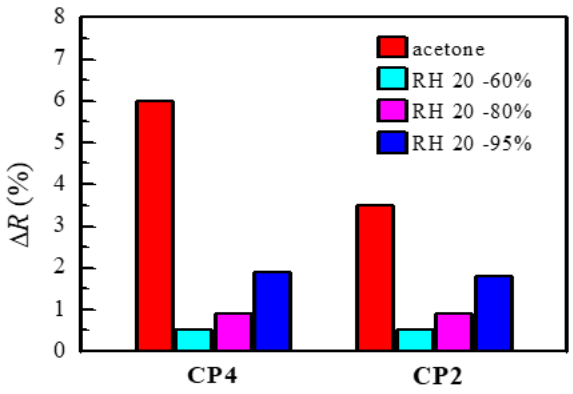
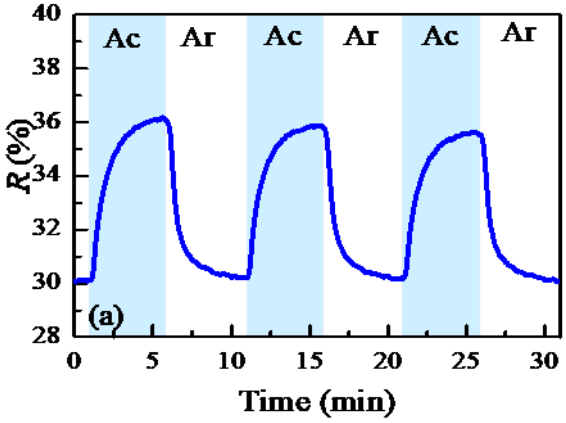


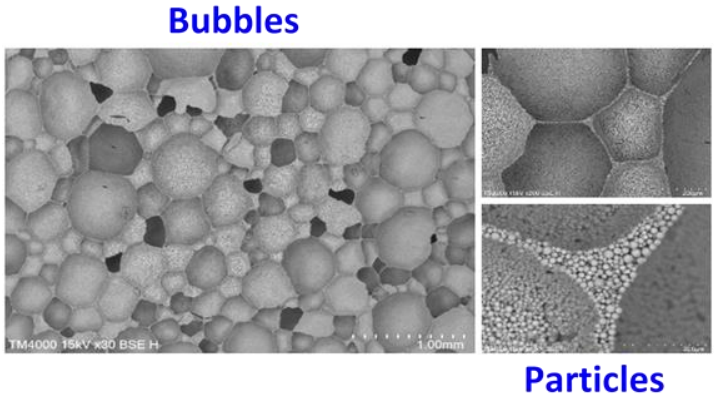


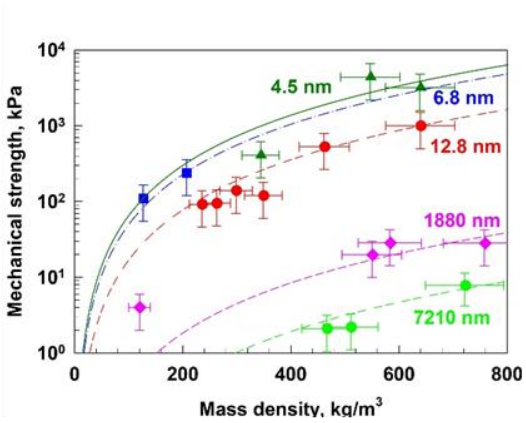
Another important characteristic is the restoration of the sensitivity of the sensor, after several cycles of operation. Stable sensing behaviour and sensor recovery without the need for additional heating is observed. These results indicate a possibility of practical application of the polymer sensor. The results were published in 2022 in the journal Coatings, which is in the Q2 quartile of journals in the relevant scientific field.

MECHANICAL PROPERTIES OF POROUS CERAMIC MATERIALS WITHOUT SINTERING

Porous ceramic materials can be used as fire-resistant highly effective heat and noise insulations, provided they have a sufficiently low density and high mechanical strength. The two characteristics counteract each other, and lower density usually results in significantly more brittle materials and vice versa. In order to improve the mechanical strength of materials, they are usually fired at a temperature of partial melting (sintering), where huge amounts of energy are lost.

In the Laboratory for Characterization of the Properties of Foams, Emulsions and Porous Materials was investigated a pathway for improvement of the mechanical properties of the porous materials without the use of sintering. Porous materials were prepared by foaming micro- and nanoparticles in the presence of surfactants and ambient drying. It was found that the strength of the ceramic materials could be increased several thousand times simply by reducing the size of the particles used. The resulting high-strength materials were comparable in their mechanical properties to materials processed at high temperatures, providing new greener alternatives to existing technologies.





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The mechanical strength results obtained here, were explained theoretically by the van der Waals interactions between the particles in the materials, allowing the results to be easily transferred to other types of particles and materials.

RECRUITMENTS

Consolato Rosmini after graduating with a bachelor's degree in chemistry in 2016 from the University of Messina (Italy), continued his education at the same institution with a two-year master's program specializing in "supramolecular and nanostructure chemistry", obtaining his master's degree in chemistry in 2019 with a thesis focused on graphene platforms useful for drug/gene delivery and molecular diagnostic (nano-teragnostic). The data reported in the thesis, and the two scientific publications produced from it, are the result of the two semesters that Consolato Rosmini carried out at the "Center for Nanobiophotonics" at Babeș-Bolyai University in Cluj-Napoca (Romania).

In October 2019, he continued training with the position of Early Stage Researcher granted by the Marie Skłodowska-Curie Actions - ITN within the project „BIKE - Bimetallic catalyst knowledge-based development for energy applications", within the research group "Organic Reactions on Microporous Materials" at the Institute of Organic Chemistry with Centre of Phytochemistry of the Bulgarian Academy of Sciences (IOCCP - BAS) under the supervision of Prof. DSc. Tanya Tsoncheva. During the three-year period, he developed efficient methods for the synthesis and characterization of mesoporous mixed metal oxide materials and bimetallic nano-alloys, for use in reactions currently being explored as an energy carrier for theproduction of green hydrogen. The hydrogen reactions mainly concern methanol decomposition, aqueous phase reforming of polyols, electrochemical water splitting in alkaline environment.

Again, in the same three-year period, the vast range of data produced at the BAS was coupled with the data he produced during two-month training periods at the best research and development institutes in Spain, Norway, Germany and the Netherlands (such as CSIC, NTNU, KIT and TU/e). The results for a total of 8 months abroad at these institutions have been reported in three publications in high ranked journals.

Currently, he is employed as an Assistant at IOCCP - BAS and continues to work in the field of green hydrogen production and biomass valorization. Recently, Consolato has joint the research team at the Institute of Polymers, BAS, implementing tasks of the work program of the Centre of Excellence in Mechatronics and Clean Technologies. He is involved in research on design of catalytic materials applicable in green processes.

Vasil Georgiev graduated in 2012 from the „Kliment Timiryazev" Agricultural High School in Sandanski. He continued his education at the Faculty of Chemistry and Pharmacy of Sofia University "St. Kliment Ohridski" in the bachelor's program „Engineering chemistry and modern materials". After that, he received a master's degree in the specialty „Disperse systems in chemical technology".

During his studies, he actively engaged in research activities in the Department of Engineering Chemistry and Pharmaceutical Engineering, where he did bachelor's and master's theses under the supervision of Prof. Slavka Cholakova and Dr. Nadia Politova - Brinkova. The research carried out in the department is based on the antifoam activity of mixed silicone antifoams and foams stabilized with different mixtures of surfactants. The foamability of green biodegradable surfactants at high

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temperatures (alkyl-polyglucosides) was also investigated. The research results including Vasil's contribution have been presented at several conferences.

After defending his master's thesis, Vasil Georgiev was enrolled as a full-time doctoral student again under the supervision of Prof. Slavka Cholakova in the Department of Engineering Chemistry and Pharmaceutical Engineering. In 2022 he was recruited on the „National Center of Mechatronics and Clean Technologies" project.

Konstantin Dimitrov graduated in 2016 from the National High School of Mathematics and Science "Academician Lubomir Chakalov" in the city of Sofia. While in the mathematics and informatics class, he took part in four Olympiads on the subjects of mathematics and physics. He continued his education at the Technical University of Sofia, where he studied Mechanical Engineering and received a bachelor's degree in "Computer Design and Technologies in Mechanical Engineering" and a master's degree in "Digital Industrial Technologies". At the end of his studies, he actively engaged in research activities at the Scientific Research Laboratory "CAD/CAM/CAE in Industry".

Konstantin Dimitrov developed bachelor's and master's theses in the Department of Technology of Machine Building and Metal-Cutting Machines under the guidance of Assoc. Prof. Dr. Eng. Konstantin Kamberov where he thoroughly investigates dynamic free fall processes using explicit engineering analysis and validation through high-speed imaging. The results of his research have not yet been published, but already have an impact on the work of the research section, expanding the range of possibilities in terms of validation and testing of prototypes and product certification. While studying for a master's degree, he worked as a trainee in rapid prototyping and validation of complex three-dimensional objects at the Association for Scientific Research and Development on the territory of Sofia Tech Park and Technical University of Sofia.

After the defending his master's thesis, Konstantin Dimitrov began working in the project "National Center of Mechatronics and Clean Technologies" project, where he was engaged in the study of the dynamic processes of free fall, the validation of explicit dynamic analyses and their application in the prototyping, development and certification of new products.

Currently, he is a PhD student at the department „Manufacturing technologies and machine tools" at the Faculty of Industrial Technology, Technical University - Sofia.

COLLABORATION

SCIENCE AND BUSINESS

STUDENTSKI GRAD CAMPUS - COOPERATION PROJECT WITH NATIONAL ELECTRIC COMPANY EAD

The research teams from the Studentski Grad campus at the Center of Excellence in Mechatronics and Clean Technologies are involved in several joint projects, mainly with Bulgarian partners. One of these projects is based on the implementation of a contract with the subject: "Survey and analysis of the possibility of work for HA 3 in PSHPP Chaira" concluded with National Electric Company EAD. The main goal is to assess the condition and possibilities for continued operation of hydraulic turbine No. 3 (HA 3).

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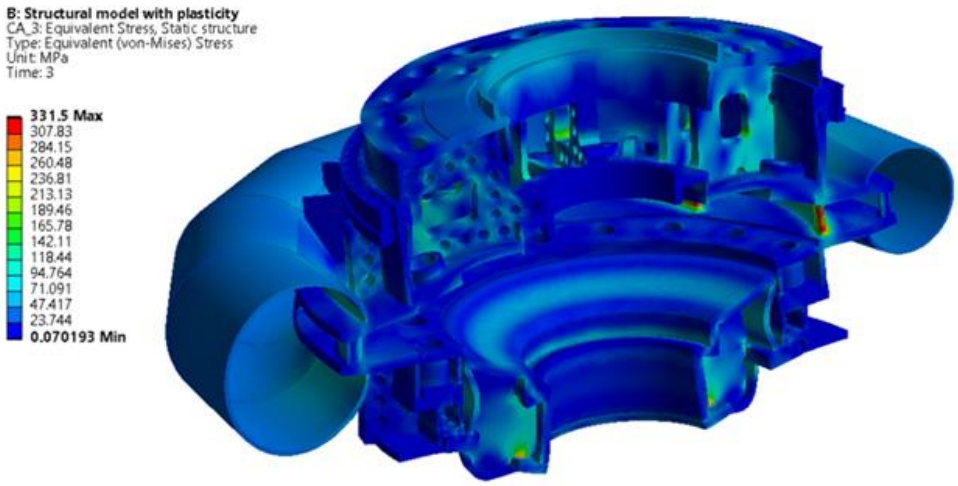
The survey and analysis of the possibility of operation of HA 3 in PSHPS Chaira (Chaira Pumped Storage Hydro Power Plant) includes the following activities: construction of a three-dimensional model of the flow part of the turbine; creating a computational finite element model (FEM); conducting simulations for the transient and operating modes of the turbine; examination of spiral chamber and stator columns; analysis of the possibility of commissioning and reliable operation of HA 3.



The main contractors on the part of the Studentski Grad campus at the "Mechatronics and Clean Technologies" CoE are laboratory L1 "Virtual Engineering and Digital Manufacturing - Industry 4.0" and laboratory L3S2 "Mechatronic Systems for Protection and Accumulation of Energy from Vibration and Noise".

PROJECT TEAM MEMBERS IN THE STANFORD RANKING

In 2022 one more scientist from the project "National Center of Mechatronics and Clean Technologies" was included in the list of top scientists in the world, according to the Stanford University ranking for overall career development. Corresponding Member Tony Spassov joined the researchers: Members of BAS Petar Kralchevsky (1956-2020), Members of BAS Konstantin Hadjiivanov, Members of BAS Nikolay Vitanov, Corresponding Member Stanislav Vassilev, Prof. Vesela Tsakova, Corresponding Member Krasimir Danov, Prof. Georgi Vayssilov, Prof. Dora Karagiozova, Prof. Radostina Stoyanova, Prof. Nikolay K. Vitanov and Prof. Hristina Vassileva.

Corresponding Member Tony Spassov is the head of Lozenets campus. He graduated from the Faculty of Chemistry of Sofia University "St. Kliment Ohridski" in 1984 and in the same year, after a competition, he was appointed assistant professor of inorganic chemistry. In 1988, he defended his thesis on "Kinetics of crystallization of amorphous metal alloys". In 1994, he was elected associate professor, and since 2005 he has been a professor of solid state chemistry in the department of Applied Inorganic Chemistry. In 2004 he defended his thesis for a Doctor of Chemical Sciences and has been a Corresponding Member of the Bulgarian Academy of Sciences since 2012. Since 2011 he has been the head of the Department of Applied Inorganic Chemistry. He was the dean of the Faculty of Chemistry and Pharmacy twice - in the period 2008 - 2015 and from 2019 until now.

The scientific interests of Prof. Tony Spassov are in the field of physicochemical materials science. He is a co-author of more than 170 publications in scientific journals, which have been cited more than 2300 times and his h-index is 26. He has extensive teaching experience. He lectures courses in Materials Science,

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Nanomaterials and Nanotechnologies, Solid State Chemistry, Applied Inorganic Chemistry, Applied Electrochemistry in various bachelor's and master's specialties of the Faculty of Chemistry and Pharmacy. He was the scientific supervisor of numerous successfully defended bachelor's theses, master's theses (45) and doctoral dissertations (15).

In the period 1997-1999, Prof. Spassov was a visiting scientist with a scholarship of the Alexander von Humboldt Foundation at the University of Dortmund, Germany. He also had several long-term specializations and was a visiting professor in a number of research centers and universities: in Germany (1990-1991, 2004), Autonomous University of Barcelona (2001-2002), University of Loveborough, England (1995), Central Michigan University, USA (2005), University of Bochum, Germany (2010), University of Melbourne, Australia (2018).

INFORMATION DAY

IMPLEMENTATION OF THE PROJECT

NATIONAL CENTER OF MECHATRONICS AND CLEAN TECHNOLOGIES

IN 2022 YARE

The Technical University of Sofia (TU - Sofia) hosted on December 15, 2022, the fourth Information Day since the launch of the project. The forum took place at the Conference Hall of Studentski Grad campus. It was opened by the rector of TU - Sofia Prof. Ivan Kralov, who is also a member of the Management Board of the Center of Excellence in Mechatronics and Clean Technologies.

In his speech, Prof. Kralov stated, “This is the largest project in the country with a budget of nearly BGN 70 million, and it is a clear indication of what we can and should give to society.” He emphasized that the project unites a number of universities, institutes from the Bulgarian Academy of Sciences and associated partners and the results of its realization are already visible. “These are modern infrastructure, new machines and technologies, but the most important thing is the participation of young scientists. The top students of our graduations are researchers in this center, which is a guarantee that we work in a correct way, a guarantee for the sustainability of this project,” said Prof. Kralov. He thanked all participants in the project for the work and efforts put in so that the Bulgarian society could be sympathetic to the technologies and modern developments in the field of technics and Bulgaria to establish itself as a technological power in Europe and the world.

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Prof. Neli Koseva - Scientific Secretary - General of the BAS congratulated all participants in the project on the successes achieved, as well as the hosts from the Technical University in Sofia. “A long time ago, we joined together to create this huge consortium, which proved that the research capacity in our country in this extremely important area - mechatronics and clean technologies, is compact, and we all work together and join efforts to meet the challenges,” said Prof. Koseva. At the end of her speech, she stated that there is a year ahead in which last efforts must be made to finish the project with pride, as well as to prepare a worthy project to continue the achievements of the Center of Excellence in Mechatronics and Clean Technologies and ensure its sustainability.

A documentary film about the Studentski Grad campus and presentations by the heads of the other two campuses of the Center of Excellence in Mechatronics and Clean Technologies were included in the program of the Information Day with moderator Prof. Georgi Todorov. The film about the campus led by Prof. Todorov and the presentations by Corresponding Member Toni Spasov, head of the Lozenets campus, and Prof. Plamen Stefanov, head of the Geo Milev campus, presented the results of upgrading the research structure of each scientific complex, increasing research capacity and its successful use.

The Studentski Grad campus documentary, which included footage of both the state of block 8 before the reconstruction and the laboratories in it, equipped with new specialized equipment at the world level in the field of mechatronics, impressed the forum participants with the results achieved.

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Corresponding Member Tony Spasov presented the laboratories at the Lozenets campus, the scientific equipment and the results that were published in a number of prestigious scientific journals with a high impact factor. Four young researchers and 12 postdoctoral fellows who have a permanent commitment to the project for several hours a day work on campus. He also noted that the Sofia University „St. Kliment Ohridski“ participates in the Center of Excellence in Mechatronics and Clean Technologies with two faculties - the Faculty of Chemistry and Pharmacy and the Faculty of Physics. Both faculties have existed for about 50 years and they have been successfully developing structural and microstructural analysis, synthesizing and researching new substances and materials using various technologies. Part of the research at the Lozenets campus is focused on the problems of obtaining hydrogen and its storage, as well as on the efficient use of energy.

The presentation of Prof. Plamen Stefanov was about the tasks that the researchers at the Geo Milev campus are working on, the goal of which is to contribute to a faster transition of our country to a green, energy-efficient and circular economy. The renovation of block 29 will be launched in 2023, in accordance with all requirements for modern research infrastructure, as well as the relocation to it of the laboratories that are planned for the Geo Milev complex. Although the renovation of the building has not been completed, high-tech equipment from world-renowned manufacturers has been delivered for the planned laboratories. Prof. Stefanov presented the work of the currently operating laboratories located in the individual institutes of the BAS.

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The presentations by Prof. Galya Madzharova from the Lozenets campus and Prof. Olya Stoilova from the Geo Milev campus were about significant scientific achievements in the modelling and creation of materials for clean energy, environmental protection, energy storage and others.

The last presentation was by Tsvetelina Vladimirova - an expert in monitoring and control, for the implementation of the financial plan and the main indicators laid down in the project program.

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The presentations generated interest among the Information Day participants and were followed by questions about opportunities for joint research. The Information Day'2022 showed that the enriched scientific apparatus is used to the fullest extent and together with the scientific staff there is an opportunity to develop a richer scientific program. Moreover, 4 years after the start of the project, there is a strengthening of the integration between the partners.

The forum was broadcast on the YouTube channel of the National Center of Mechatronics and Clean Technologies project ((https://www.youtube.com/watch?v=8elNHrXH2BU), and ended with a visit to the laboratories on the Studentski Grad campus.

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