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OPERATIONAL PROGRAMME SCIENCE AND EDUCATION FOR SMART GROWTH

INFORMATION BULLETIN

NATIONAL CENTER

of

MECHATRONICS AND CLEAN TECHNOLOGIES

2018-2019

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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.

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PRESS CONFERENCE AND KICKOFF MEETING

PROJECT *NATIONAL CENTER FOR MECHATRONICS AND CLEAN TECHNOLOGY*

The presentation of the project BG05M2OP001-1.001-0008 ***National Center of Mechatronics and Clean Technology*** took place at „Prof. Marin Drinov" hall of the Bulgarian Academy of Sciences on May 30, 2018. The forum was attended by the members of the research teams and the Project Management Board. Guests of the event were Prof. Anastas Gerdzhikov, Rector of the Sofia University „St. Kliment Ohridski", Prof. Georgi Mihov, Rector of the Technical University, Sofia and Prof. Mitko Georgiev, Rector of the University of Chemical Technology and Metallurgy.

The forum was opened by the Project Coordinator Prof. Plamen Stefanov, Director of the leading organization - Institute of General and Inorganic Chemistry at the Bulgarian Academy of Sciences (IGIC – BAS). The presentation of Corr. Member Konstantin Hadjiivanov, Chairman of the Project Management Board was titled "The center of excellence in the area of mechatronics and clean technologies - a serious chance for the rise of science-based innovation in Bulgaria". It included important information about the Centre as goals, objectives, cooperation with other Centers of Excellence and Competence, expected economic and social impact, etc. Prof. Radostina Stoyanova from IGIC - BAS and Prof. Georgi Todorov from the Technical University in Sofia introduced the scientific topics that are to be developed and the structure of the created for this purpose four Work Packages to the participants.

A press conference was held before the presentation. Corr. Member Hadjiivanov, Prof. Stefanov and Prof. Todorov answered the questions of journalists. They were focused on the first steps and results within three months of the project starting, the use of the Center's research infrastructure by all 17 partners and achieving the sustainability of the National Center of Mechatronics and Clean Technologies after the cessation of the project financing.

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MEETING OF BUSINESS WITH SCIENCE

PRESENTATION OF THE CENTER OF EXCELLENCE IN MECHATRONICS AND CLEAN TECHNOLOGIES

A Meeting of Business with Science, presenting the project National Center for Mechatronics and Clean Technologies was organized on December 17, 2018. The forum was hosted by the associated project partner – Cluster "Mechatronics and Automation".

Participants in the meeting were 14 business organizations, Ms. Daniela Chonkova of the Foundation "Applied Research and Communications", Prof. Valyo Nikolov and Prof. Andon Topalov from the Center of Competence *Intelligent Mechatronic, Eco and Energy Saving Systems and Technol*ogies and others.

Corresponding Member Konstantin Hadjiivanov, Chairman of the Project Management Board and his members Prof. Georgi Todorov and Prof. Tony Spasov informed the participants about the project objectives, the available research resources and the scientific potential of the consortium, consisting of 17 scientific organizations. They made presentations on the capacity of the research structure, which will consist of three complexes („Geo Milev", „Lozenets", and „Studentski grad"), equipped with unique for the country equipment. The infrastructure is designed and functioning on the principle of complementarity and synergism. The research topics of the planned activities, are divided into four Work Packages. The newly created or renovated units (laboratories and sections) will offer innovative technological solutions to support the industry and training highly qualified specialists.

After the presentations, the discussion, led by Dr. Eng. Ventzislav Slavkov, was focused on the sustainability of the National Center of Mechatronics and Clean Technologies and the benefits of building such research consortia. The scientists agreed that infrastructural projects provide the basis for higher-level research and career development, and in combination with the efforts to raise the remunerations, it is an investment in motivating young people to stay in Bulgaria. In addition, conditions for the development of science for the benefit of

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business are created by the prototypes provided and new technologies validated.

A number of issues related to the European Union's personnel training and defence policy were also discussed, as well as preparing of a cooperation agreement between the Center of Excellence *Mechatronics and Clean Technologies* and the Center of Competence *Intelligent Mechatronic, Eco and Energy-Saving Systems and Technologies*.

INTERNATIONAL SYMPOSIUM OF NANOMATERIALS AND NANOTECHNOLOGIES (SNN'2019)

The International Conference of Quantum, Nonlinear and Nanophotonics (ICQNN'2019) and the satellite Symposium of Nanomaterials and Nanotechnologies (SNN'2019) were held from 2 to 5 September, 2019 in Sofia, Bulgaria. The host organization was Sofia University "St. Kliment Ohridski".

The conference and symposium scope covered the investigation of basic phenomena of the light interaction with different natural materials and artificial structures, as well as the technological applications of such phenomena, novel devices, instruments, and methods. The topics included quantum and nonlinear optics, nano-optics, and meta-optics.

The conference and the symposium served as a meeting place for 62 researchers from 15 countries (Australia, Canada, China, France, Germany, Israel, Italy, Kazakhstan, Macedonia, Serbia, Spain, Switzerland, the Netherlands, United States, and Bulgaria).

The reviewed papers presented at the International Conference of Quantum, Nonlinear and Nanophotonics and the Symposium of Nanomaterials and Nanotechnologies were published in Proceedings of SPIE - a journal with SC Imago Journal Rank Indicator (SJR).

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MODERNIZATION OF THE EXISTING RESEARCH INFRASTRUCTURE

CLEAN ROOM CLASS 100 000

In 2019, the partner organization Central Laboratory of Applied Physics (CLAP), Plovdiv carried out renovation and construction activities for renovation and expansion of the clean room with a total area of 410 m^2.

Renovation of the existing clean room, which is differentiated as technological infrastructure:

5 new air-conditioning sections ware installed; the flooring was completely replaced; new LED lighting was installed; the southern technical corridor was renovated; 2 new sanitary complexes were built.

Photos of a technological room in the existing clean room, before (left) and after (right) the renovation.

Building of a new clean room, which is differentiated as research infrastructural unit:
5 separate air-conditioned rooms were constructed. The temperature, humidity, air flows and dust indicators meet class 100 000 (filtering is carried out by special HEPA filters); a new air-conditioner with a special chiller was installed; antistatic floor was made; specialized LED lighting was mounted; new elements such as electrical supply, fluid and gas communications necessary for the functioning of the research equipment, which will be placed in the new clean room, were installed.

Photos of the air-conditioner with a special chiller (left), the inner corridor (center) and a room with research equipment (right) in the new clean room.

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RESEARCH EQUIPMENT

The project activities include the purchase of unique for the country equipment, necessary for Centre construction. The planned equipment has been chosen on the basis of complementarity and synergy necessary for the complete implementation of the scientific program of the project. This complex equipment will contribute to a significant increase of the level of fundamental scientific research in the area of mechatronics and clean technologies and will be further used for solving tasks of industrial importance.

COMPLEX „LOSENETS“

CRYOGENIC TRANSMISSION ELECTRON MICROSCOPY HOLDER CRYO-TEM EQUIPPED WITH A CRYO-TRANSFER STATION

The equipment so far delivered for the needs of the Laboratory for characterization of properties of foams, emulsions and porous materials is a cryogenic transmission electron microscopy holder and is intended to be used for the observation of nanometer objects that have been pre-frozen. The method is particularly suitable for studying the size and shape of micelles, vesicles, and nanometer emulsion droplets. The holder will be mounted on the available transmission electron microscope when such objects are to be characterized.

Thanks to the newly purchased equipment, the laboratory will have the potential to carry out business activities, as there has been an interest from companies as St. Goben, Unilever, BASF, Wake, which the Department of Chemical Engineering and Pharmaceutical Engineering has long-standing cooperation with, and from Bulgarian companies such as Balkanpharma, Troyan, for which the department has been characterizing their products, particularly disperse systems.

The interest in using the cryogenic transmission electron microscopy holder is not only from Bulgarian and foreign companies, but also from researchers from European universities, whom the Department of Chemical Engineering and Pharmaceutical Engineering collaborates with, such as the Catholic University of Leuven.

ULTRAMICROTOME

The ultramicrotome is designed to produce micro- and nanosections for examination with an existing Transmission Electron Microscope. The objects of study are hydrogen storage materials, materials with electrocatalytic properties, materials for lithium-ion battery electrodes, etc.

The ultramicrotome is placed in the Transmission Electron Microscopy Laboratory of the Faculty of Chemistry and Pharmacy.

The newly acquired equipment will allow for complex studies of the microstructure, physicochemical and catalytic properties of the materials synthesized in the laboratory.

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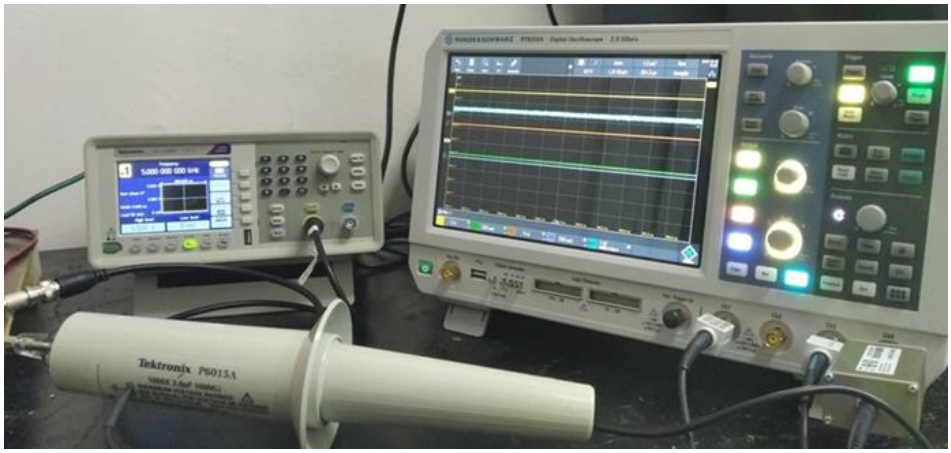
SYSTEM FOR PLASMA DEPOSITION OF NANOSTRUCTURES AND PLASMA TREATMENT OF FLUIDS



The delivered system for deposition of nanostructures in the Plasma Technology Laboratory consists mainly of a vacuum chamber, a gas supply system and gas cylinders, a vacuum pump, a microwave generator, microwave waveguide sections, a quadrupole mass spectrometer.

The high voltage discharge gas treatment system modules include a vacuum gas treatment chamber, a module for supplying and controlling the flow of gas mixtures, signal and high voltage sources, high voltage discharge electrical diagnostics modules.

The purpose of the infrastructure is to develop technologies for depositing thin layers and nanostructures of graphene and metal oxides on various substrates, for industrial applications, to develop technologies for the treatment of dangerous gases for specific industries and companies, and to analyze the composition of gas mixtures, translucent and opaque solid samples.

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COMPLEX „GEO MILEV“

UPRIGHT LIGHT MICROSCOPE *AXIOSCOPE 5*, ZEISS

Precise, high-end upright light microscope, working in transmitted or reflected light, LED illumination system and four different contrast techniques: bright field, dark field, differential interferential contrast and circular-differential interferential contrast.

Reliable and suitable for broad range of studies in materials science, including crystal growth grains, phase boundaries, morphology of surfaces, thin films, defects and interstitials. Magnification – up to x1000.

DYNAMIC MODE SALT SPRAY CHAMBER *Q-FOG* (Q-LAB CORPORATION)

Dynamic mode salt spray test chamber consists of a housing of polymeric material with an internal volume, allowing testing of different type materials and coatings in the form of samples as well as real objects or parts of them. It contains a built-in electronic control unit with a certain number of test programs.

The system allows for additional creation of combinations of available tests, as well as new experimental programs with different test characteristics.

The apparatus allows also standardized tests to be carried out in continuous, cyclic and/or multistage mode.

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EQUIPMENT FOR SYNTHESIS, MODIFYING AND ELECTRO-OPTICAL CHARACTERIZATION OF MICRO PARTICLES

The components of the original electro-optical equipment are optical module (light source, lens, electro-optical cells and photomultiplier), electrical module (generator and high-voltage amplifier *PZD2000A*), two-channel oscilloscope *Rohde & Schwarz* for registration and observation of the signals from both modules and centrifuge *MPW-352R* for preparation and separation of microparticles.

Electrical and optical modules of the equipment for synthesis, modifying and electro-optical characterization of micro particles.

The centrifuge *MPW-352R* is applicable for separation of components (particles) with different density and dimensions in samples, under the influence of the centrifugal force. The device is equipped with cooling system able to ensure precise control of the temperature.

The presented original electro-optical equipment is suitable for measurement of changes in the intensity of the scattering light from suspension of colloidal particles in applied electric field and allow to determine the electrical, optical and geometrical properties of non-spherical particles in the presence of low molecular electrolytes, surfactants or polymers.

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LIGHT FLASH THERMAL CONDUCTIVITY MEASUREMENT DEVICE, LFA 467 HYPERFLASH® (NETZSCH, GERMANY)

Light Flash Apparatus, LFA 467 HyperFlash® examines the thermophysical properties of a wide range of materials (polymers, ceramics and metals) over a wide temperature range (-100 ° C to 500 ° C). The innovative Light Flash technique (LFA) is a fast, non-destructive and contactless method of measurement and defines a set of thermophysical characteristics, such as: thermal diffusion, specific thermal capacity, thermal conductivity. Works with small samples and allows precise measurements in a short time. The apparatus is intended for the study of new materials, with potential applications in mechatronics, electronics and other engineering fields.

The equipment is the only one in the country and will expand the potential of scientific teams to participate in national and international projects as well as to carry out business activities.

Tests related to thermal conductivity measurements of samples of new polymer nanocomposites with fillers graphene and carbon nanotubes have been started at the Institute of Mechanics, BAS. Nanocomposites were obtained by mixing in melt, and then filament for 3D printing are obtained.

SH-4000M MODULE FOR VISUALIZATION; LINEAR DRIVE MODULE (HORIZONTAL MOVEMENT), BRUKER; LUBRICATION PROCESS RESEARCH MODULE, BRUKER; ELECTRICAL CONTACT / SURFACE RESISTANCE MEASUREMENT MODULE, BRUKER

Four new modules have been delivered to the available UMT-2 Universal Mechanical Testing Instrument (Bruker), such as: Lubricant Testing Module; friction module; ECR module and desktop scanning electron microscope. The new modules extend the research capabilities of the available equipment in the field of tribological research, and also allow visualization of the surface of the material subjected to friction and wear.

They are suitable for the study of a wide range of materials, e.g. polymers, metals and ceramics, as well as for characterizing surfaces applied to automotive parts and components, electronic components, coatings.

The newly acquired Module for Lubrication Testing Module is the only one in Bulgaria and offers a variety of applications for testing the lubricant properties of new lubricants (oils and lubricants).

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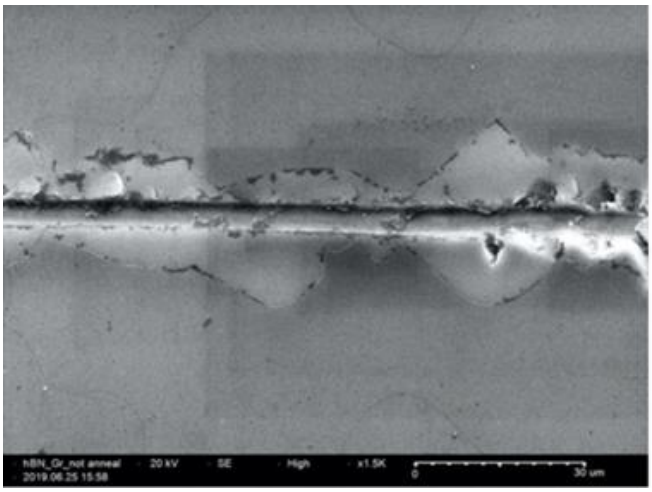
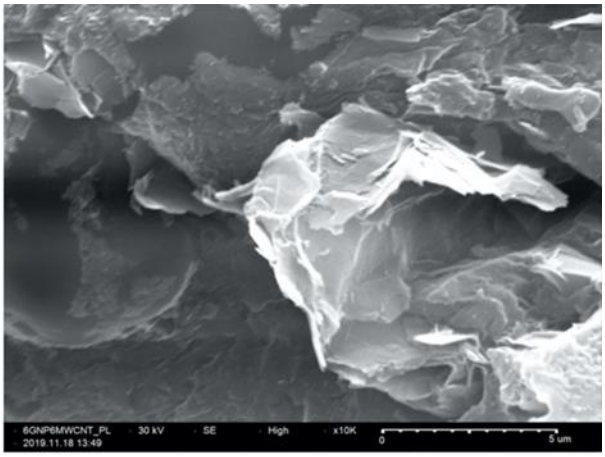
Training was carried out by the manufacturer and a team of 2 young scientists working with the apparatus was appointed.



Initial tests were initiated and the first results were obtained from the visualization of scratch marks, which examined the adhesion of thin nanoscale multilayer coatings.



Surface data were also obtained after the fracture of 3D printed structures of polymer nanocomposites with fillers, graphene and carbon nanotubes, which show the degree of dispersion of the nanoparticles in the polymer.

DYNAMIC CONTACT MODULE II (DCM II) OPTION OF NANOINDENTER *G200*

To be precise and widely applicable, nano indentation testing must be dynamic. Static and quasi-static approaches limit both the types of samples that can be tested and the mechanical properties that can be determined. The DCM II option is a fully dynamic indentation head for ultra-low-load (30 mN max load) mechanical properties characterization.

The DCM II extends the range of load-displacement experimentation down to the surface contact level. This option extends the maximum loading capability to 30 mN

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and offers a full 70 μm range of indenter travel with 0.2 pm displacement resolution. Tip exchange is designed for quick removal and easy installation of a variety of application-specific tips.

With the DCM II option, researchers can study not only the first few nanometers of indentation into the surface of a material, but also the pre-contact mechanics. Real-world testing shows that the G200 equipped with the DCM II option typically delivers noise levels less than 1 Å, supporting high resolution measurements.

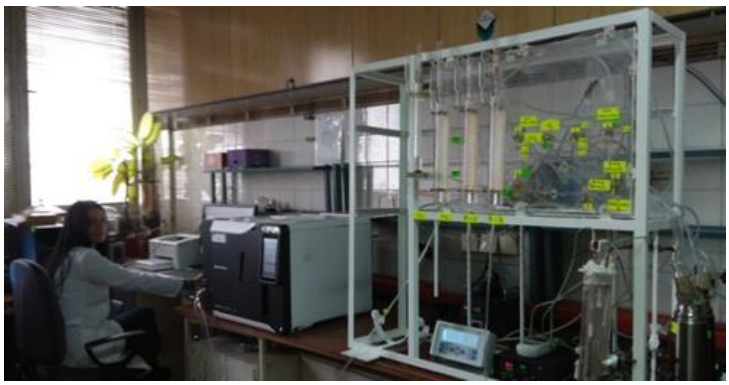
The system allows dynamic nanoindentation testing of **s**emiconductor, thin films, MEMs (wafer applications); hard coatings, DLC films; composite materials, fibers, polymers; metals, ceramics, biomaterials.

HIGH-SPEED SPECTROPHOTOMETER *OCEAN OPTICS USB2000 +*

The studies that will be carried out with the purchased at the Institute of Catalysis – BAS high-speed spectrophotometer *Ocean Optics USB2000 +* include: characterization of synthesized novel photochromic compounds for use in optical markers and biosensors; investigation of the kinetics; determination of the discoloration rate constant; calculating the lifetime of the $\tau_{MC\text{-}SO}$ of the open color form; the influence of solvent and substituents on the kinetics of photochromic conversion.

SYSTEM OF GAS CHROMATOGRAPHS *NEXIS GC-2030*

The gas chromatographs provide gas chromatographic separation of a wide range of volatile organic compounds and gas mixtures as well as quantitative analysis of individual components by universal detection with a flame ionization and a thermal conductivity detectors. The direct connection of gas chromatographs to flow catalytic systems via six-port gas valves permits the accurate detection of the reaction products during catalytic processes, while the thermal conductivity detector allows the analysis of products containing CO, CO_2, H_2 gas mixtures and others. The system also includes a gas chromatograph, equipped with an auto sampler, which considerably increases the number of samples to be analyzed thus improving the efficiency of the equipment.



The new equipment will be used for the analysis of various organic compounds and gas mixtures obtained from biomass processes carried out in liquid and gas phases, for targeted synthesis of new functional organic materials for use in cutting edge technologies, as well as for product analysis in environmental studies for the elimination of volatile organic compounds (toluene, ethyl acetate, hexane, ethylbenzene, etc.).

SCANNING ELECTRON MICROSCOPE *HIROX 5500* WITH EDS FROM BRUKER

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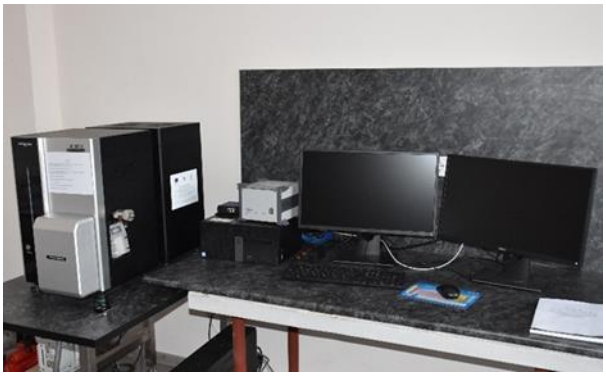

The Scanning Electron Microscope HIROX 5500 is intended for comprehensive studies and characterization of new metallic materials, alloys and composites at micro- and nano-levels. It consists of two modules: Scanning electron microscope for surface topography imaging and fracto-graphic studies and EDS system for determining the micro-composition and distribution of metallic and non-metallic phases, inclusions, defects, coatings, etc.

3D MICRO COMPUTED TOMOGRAPHY *SKYSCAN 1272* FROM BRUKER

The 3D Micro Computed Tomography is intended for rapid and non-destructive examination of porous metal and non-metallic materials and various products made of them as well as surface and volume cracks obtained during normal use or during tests of mechatronic components, etc.

Detailed information can be obtained about the presence of different phases in the volume of the investigated material and about the geometrical characteristics of irregularly shaped phases and their structure. The specially developed optical system and measurement methodology allows for high resolution studies on samples with different sizes and shapes.

OPTICAL EMISSION SPECTROMETER FOR METAL ANALYSIS *Q4 TASMAN* FROM BRUKER

The Q4 TASMAN allows for quantitative analysis of Fe-, Al- and Cu-alloys. There is a possibility of further upgrading in order to be able to determine also Ti-, Mg-, Zn-, Ni- and Co-alloys. The multi-CCD optics has high resolution for wavelengths offering accurate detection of all necessary elements for the respective matrices.

The Q4 TASMAN allows for the measurement of samples of different sizes weighing up to 10 kg. Cylindrical samples (wires and springs) with 1.5 – 10 mm in diameter can be also measured.

INTERNATIONAL COOPERATION

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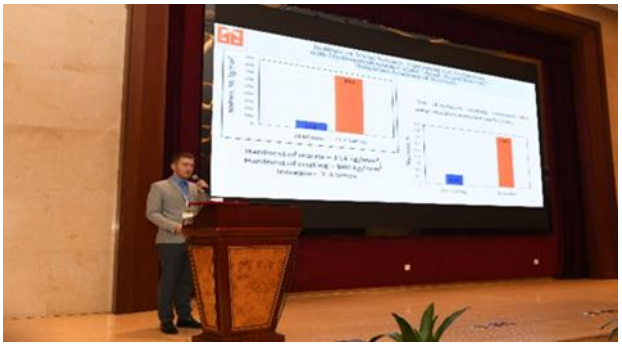
TECHNOLOGY COOPERATION AGREEMENTS

between the Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Center at BAS and the Inner Mongolian Metal Materials Research Institute, China

2019 Bulgaria-China new materials technology transfer forum was held in Ningbo, China from October 28 to November 1, 2019. The forum was attended by scientists from the Institute of Metal Science, Equipment and Technologies with the Center for Hydro- and Aerodynamics at BAS, which is a partner in the project "National Center for Mechatronics and Clean Technologies". As a result of the funding received under the project, new equipment and additional modules to the existing apparatuses have been delivered to the Institute. This allows high level of complex research of metals, alloys, metal composites and ceramics and extends the Institute's capacity to carry out effective international scientific and technological cooperation.

During the forum, the Bulgarian scientists presented to the Chinese colleagues and the five industrial companies the developed technologies for metal and ceramic materials and technological solutions for creating specific functional coatings on them, as well as the results obtained from the research in the field of nanomodified metal materials. The most important part of the visit was the official establishment of a Technology Transfer Center in Ningbo, in which the Institute of Metal Science, Equipment and Technology with Hydro- and Aerodynamics Center plays leading role.

After



discussions, the Inner Mongolian Metal Materials Research Institute in Ningbo and the Institute of Metal Science, Equipment and Technology with Hydro- and Aerodynamic Center signed several technology cooperation agreements:

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1. Aluminum Foams research Project;
2. Preparation and Application of High-Performance Aluminum Composites Reinforced by Nanoparticles;
3. Research and Application of Nanodiamond Composite Coating Technology;
4. Research and Application of Carbide Ceramic Balls.

During the signing of the agreements the Chairman of the Agency for International Experts Collaboration at State Administration in Ningbo said, "This is an important international cooperation between China and Bulgaria in the field of new materials, which will effectively help the scientific exchange and transfer of modern achievements in the field of new materials."

INFORMATION DAY

PROJECT *NATIONAL CENTER OF MECHATRONICS AND CLEAN TECHNOLOGIES* IN 2019

The first Information Day within the frames of the project *National center of mechatronics and clean technologies* was organized on December 18, 2019. Invitations to attend this important event were sent to partners, industrial bodies, national administrative authorities and universities. The aim of the forum was to promote the activities of the project and achieved results.

The First Information Day entitled **The Project *National Center for Mechatronics and Clean Technologies* in 2019** was held at the Institute of Mechanics of the Bulgarian Academy of Sciences. A welcome speech to mark the beginning of this forum was addressed by the Chairman of the Project Management Board and Vice-Presidents of the Bulgarian Academy of Sciences Corresponding Member Konstantin Hadjiivanov. The event was attended by Zlatina Karova, Head of Transnational Scientific Initiatives Unit at the Ministry of Education and Science. Mrs. Karova presented congratulatory on behalf of the Deputy Minister Karina Angelieva to the participants.

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After the opening of the forum, Prof. Plamen Stefanov, Project Coordinator, presented the results of the first stage of the implementation of the plan for the establishment of the Center of Excellence in Mechatronics and Clean Technologies. They included construction and renovation activities and the purchase of new equipment for the modernization of the laboratories in the research partner organizations.

Presentations by Corresponding Member Toni Spasov and Prof. Georgi Todorov were about the tasks performed on the campuses they manage, Complex "Lozenets" and Complex "Studentski grad", respectively, and Eng. Iskren Kandov reported about the work on the creation of the Laboratory "Robotized Mechatronic Technology" in the Technical University, Gabrovo. Assoc. Prof. Lilyana Kolaklieva informed about the activity for renovation and expansion of the existing clean room at the Central Laboratory of Applied Physics (CLAP) in Plovdiv. The clean room class 100000 will be fully equipped at the end of the first quarter of 2020.

During the first two years of the project implementation, new equipment has been purchased and existing equipment has been completed in five institutes of BAS: Institute of Physical Chemistry, Institute of Organic Chemistry with Center of Phytochemistry, Institute of Mechanics, Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Center and Institute of Catalysis. These institutes as well as the CLAP in Plovdiv are part of the "Geo Milev" Campus - the third complex in the structure of the National Center for Mechatronics and Clean Technologies.

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Prof. Evgeni Ivanov from the Institute of Mechanics presented the capabilities of the unique apparatus, the first of its kind in Bulgaria, for studying thermal conductivity of small-sized samples. The presentation of Prof. Lyudmil Drenchev, Director of the Institute of Metal Science, Equipment and Technologies with Hydro- and Aerodynamics Center was focused on the planned in the frame of the project and already delivered apparatuses for complex investigation of metals, alloys and metal composites, including a chamber for cyclic corrosion testing with the largest capabilities in Bulgaria and a unique computerized X-ray microtomograph.

The First Information Day concluded with a visit to the Laboratory for Thermal Conductivity Research at the Institute of Mechanics.

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