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Contents

1. TPU develops new types of fuel from oil refining waste

Source: TPU, December 15, 2021

In the laboratory for modeling heat and mass transfer processes at TPU

Scientists of the Tomsk Polytechnic University have proposed rational ways of using oil sludge in the energy sector, which is a massively produced waste of oil production that cannot be easily processed.

Oil sludge is a by-product of oil production and refining, which, according to TPU scientists, are produced annually around the world in millions of tons. They are extremely hazardous to the environment both when buried in landfills and when directly incinerated, and their chemical processing is in most cases economically unprofitable. The fuel "recipes" found by polytechnics will allow introducing a new resource into the energy sector, as well as strengthening the ecology of oil-producing regions.

Scientists of the Tomsk Polytechnic Institute have identified the most effective way to utilize oil sludge - combustion as part of fuel compositions. So, mixing oil production wastes with other types of wastes and various compounds to a state of suspension, it is possible to achieve high relative energy indicators, as well as significantly reduce harmful emissions in comparison with the combustion of only oil sludge.

Having studied the key environmental factors of combustion of slurry fuels based on oil sludge, the group have proven that the addition of water to the fuel mixture significantly reduces the concentration of carbon oxides, sulfur and nitrogen, which cause major harm to the environment.

The analysis of the combustion processes of fuel compositions, carried out by TPU scientists, makes it possible to assess the efficiency and environmental safety of a specific suspension composition, taking into account the temperature regime of combustion, the mass of fuel, time, the amount of generated thermal energy and other factors.

In the future, the research team intends to scale the results obtained by moving from working with experimental stands to pilot and industrial power plants.

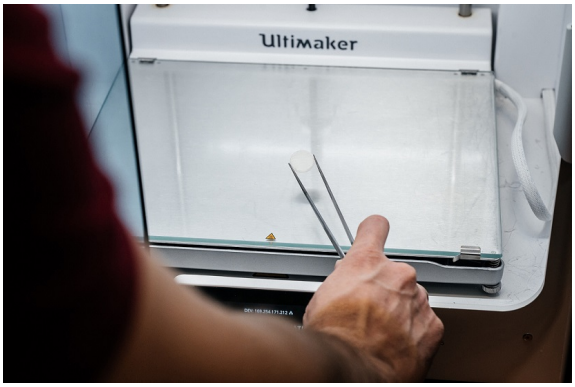
2. TPU scientists have figured out how to reduce the cost of "smart" devices as much as possible

Source: TPU, December 17, 2021

Scientists from Tomsk Polytechnic University have proved the possibility of using the simplest and most economical method of 3D printing (fused deposition modeling, FDM) for the manufacture of ferroelectric and piezoelectric products.

These products are able to change the electrical potential of their surface under the influence of external influences (pressure, temperature,

light). As TPU researchers told RIA Novosti, ceramic materials are used to develop ferroelectric and piezoelectric products, which are expensive, and many of them contain lead. At the same time, it is difficult to process ceramics; it is practically impossible to make porous structures of complex shapes with internal cavities from it.



The method proposed by TPU scientists will allow removing many restrictions and making products of various shapes and sizes. According to a researcher at the Scientific and Educational Center B.P. Weinberg TPU Evgeny Bolbasov, the development will make it possible in the future to create "smart" devices with high efficiency and low cost. For example, biosensors, energy sources and converters for microdevices, individual implants.

Today, several scientific groups in the USA, Europe and China are working on this problem. However, colleagues use complex technical processes and expensive equipment. TPU worked with a widespread and accessible to every 3D printer, which allows them to use our method in any laboratory.

For printing, you can use raw materials and equipment to preserve the indigenous aspect of development, regardless of the external conjuncture.

3. Alkylverdazyls could make photodynamic cancer therapy more effective

Source: TPU, December 29, 2021

Scientists of the Tomsk Polytechnic University, together with colleagues from the University of Aix-Marseille (France), proposed the use of alkylverdazyl molecules (alkylated verdazyl radicals) as a basis for the creation of therapeutic drugs against oncological diseases using the method of photodynamic therapy. Their research has shown that these molecules "work" regardless of the oxygen content in the environment, so they can help solve one of the problems of photodynamic therapy - its effectiveness depends on the presence of oxygen in the cells.

Photodynamic therapy is a minimally invasive treatment for cancer and precancerous conditions. A photosensitizer drug that is sensitive to light is injected into the patient's body; it accumulates in the tumor. Then it is exposed to a laser with a certain wavelength. As soon as the laser beam is focused at the desired point, reactive oxygen species are generated there, and local cell death occurs.

The solution addresses the oxygen dependence of photodynamic therapy. The lack of oxygen or its low concentration makes it ineffective. The solution to this problem is to create molecules that could absorb light and then, independently of oxygen, generate cytotoxic particles from themselves. The latter attack membranes, DNA, proteins and other biomolecules, disrupt the normal functioning of the cell and lead to its death, as revealed by TPU Research School of Chemical and Biomedical Technologies. TPU scientists are engaged in the chemistry of compounds containing radical fragments - stable and unstable.

In particular, they work with verdazyl radicals and their derivatives. These are stable organic

molecules that, under certain conditions, help to solve atypical problems in modern science and technology. The research has already shown that alkylated verdazyls are capable of forming active species under the action of light. And TPU tried them as a basis for a drug for photodynamic therapy.

The study was conducted on breast cancer cells. Experiments have shown that when cells are irradiated with a violet LED, alkylverdazyls absorb light and decay into two radicals: nitrogen-centered verdazyl and carbon-centered alkyl. The latter has a cytotoxic effect. In this case, the decomposition of the substance does not occur, and the cells maintain normal viability in the absence of the necessary light. According to scientists, this makes the presented model selective and controlled by external influences.

4. Tons of used masks will be energy for gadgets

Source: MISIS Univ, January 27,2022

NUST MISIS scientists, together with colleagues from the United States and Mexico, have developed a new technology for obtaining economical batteries from medical waste. According to the authors, the technology will make it possible to turn waste that is difficult to dispose of into raw materials.

According to NUST MISIS researchers, during the coronavirus pandemic, the inhabitants of the planet monthly used more than 130 billion masks, which turned into hundreds of tons of polymer waste. When they are burned, toxic gases are released, so the task of processing these wastes has become very relevant.

NUST MISIS scientists, together with foreign colleagues, have developed a new technology for obtaining economical batteries from used masks, where waste from medicine packages is also used as shells. Thus, the basis for the creation of batteries is medical waste, it is only necessary to purchase graphene.

The new technology makes it possible to obtain thin, flexible, cheap batteries, which, due to their low cost, can also be disposable. They outperform heavier, plated conventional batteries in a number of ways, which require more production costs. The new batteries can be used in household devices, from clocks to lamps.

“To create a supercapacitor-type battery, the following algorithm is used: first, the masks are disinfected using ultrasound, then they are dipped in graphene ‘ink’, which impregnates the mask. Then the material is pressed under pressure, heated to 140 degrees Celsius (when creating conventional supercapacitor batteries, a very high temperature is required for pyrolysis-carbonization, up to 1000-1300 degrees Celsius, and the new technology reduces energy consumption by 10 times). Then, between the two electrodes of the new material, a gasket (also made of mask material) with insulating properties is placed. It is impregnated with a special electrolyte, and then a protective shell is created”, said Professor, Scientific Supervisor of the infrastructure project "High-performance

polymer tandem photovoltaics based on hybrid perovskites" NUST "MISiS" Anvar Zakhidov.

New batteries, compared with traditional counterparts, have a high density of stored energy and electrical capacity. Tablet batteries previously created using a similar technology had a capacity of 10 watt-hours per 1 kg, while NUST MISIS scientists and their collaborators managed to obtain 98 watt-hours/kg.

When the developers decided to add CaCoO-type inorganic perovskite nanoparticles to the electrodes obtained from masks, the energy capacity of the batteries doubled (208 watt-hours / kg). A large electrical capacitance of 1706 farads per gram has been achieved (this is significantly higher than the capacitance of the best carbonized electrodes without graphene additive (1000 farads per gram).

Researchers have previously tried using various porous natural materials and waste materials to make electrodes for supercapacitors. These were coconut shells, rice husks, and recently even newspaper waste, car tires and others. But working with them has always required high-temperature annealing (charring) in special furnaces. Masks turned out to be a simpler and cheaper material for processing, since impregnation with graphene is enough to give them unique properties.

In the future, the researchers plan to use the new technology to produce batteries for electric vehicles, solar power plants and other applications.

5. Magnesium will become the basis of biosoluble implants

Source: MISIS Univ, January 14, 2022

A team of materials scientists from NUST MISIS has presented a new alloy based on magnesium, zinc, gallium and yttrium, which can be used as a material for modern jaw implants. They do not require a second operation, as they gradually dissolve in the body in parallel with the growth of a new area of bone tissue. The results of the study were published in the international scientific journal Materials.

Magnesium and alloys based on it are of great interest to implantologists as a temporary fixation of bone tissue, as they have a high level of biocompatibility and the ability to gradually dissolve in the human body as the healing process progresses. At the same time, Young's modulus (a physical quantity that characterizes the properties of a material to bend or stretch under the influence of force) of magnesium and its alloys are close to the Young's modulus of human bone tissue. This, in turn, prevents the effect of "stress screening", which is characteristic of widely used in surgical practice, but much more "rigid" titanium alloys. Stress shielding effectleads to the fact that neighboring healthy bones are not sufficiently loaded and their gradual destruction occurs and, as a result, a decrease in density. In the future, this threatens to loosen the implant and destroy the bone.

A group of materials scientists from NUST MISIS was interested in gallium as an alloying component for magnesium alloys, as it has been clinically proven that gallium ions are effective against bone resorption and are used to treat

osteoporosis and hypercalcemia associated with oncology. The scientists described the optimal technology for creating an alloy of the magnesium-zinc-gallium-yttrium system, namely the effect of various heat treatment modes on the microstructure, mechanical and corrosion properties of the final composition.

“As a result of a series of laboratory experiments, we found that solution heat treatment improved the mechanical properties of the alloys, and the low corrosion rate in Hanks’ solution was achieved due to the dissolution of cathode phases during heat treatment,” says co-author of the study, head of the NUST Hybrid Nanostructured Materials Laboratory "MISiS", Prof. Alexander Komissarov.

According to the developers, analysis of the influence of various heat treatment modes on the properties of the alloy showed that the optimal temperature and time are 350 °C and 18 hours, followed by quenching in water, respectively. The results of corrosion tests have shown that the addition of yttrium to the composition of the alloy reduces the corrosion rate in solution by a factor of 2.

“Alloys with a ratio of zinc and gallium close to 1 have approximately the same corrosion rate of ~0.6 mm/year. For alloys with a ratio of zinc and gallium equal to 2 and 3.25, the corrosion rate was 0.78 and 1.03 mm/year, respectively. The addition of yttrium reduced the corrosion rate from 0.59 to 0.27 mm/yr due to the inhibitory effect of the layer of corrosion products. Thus, by changing the chemical composition of the magnesium alloy due to the ratio of zinc and gallium in it, it is possible to control the corrosion rate of implants, ” adds the key project executor, associate professor of the NUST MISIS department of LT&C, Ph.D. Vyacheslav Bazhenov.

Thus, magnesium alloy with additions of zinc, gallium and yttrium, heat-treated according to the proposed regime, can be used to create maxillofacial implants due to high mechanical properties and low bioresorption rate. The presence of gallium in the composition of alloys will give them new, unique properties and help restore damaged bone tissue of patients.

At the moment, the developers are preparing to start preclinical studies of implants based on the new alloy at the site of one of the Russian veterinary clinics.

6. New Catalyst for Efficient CO2 Recycling

Source: MISIS Univ, December 27, 2021

The scientific team of NUST MISIS presented a new catalyst based on boron nitride and iron and platinum nanoparticles, which demonstrates a high degree of carbon dioxide processing: CO2 conversion was 25% at a temperature of 350 C, which is 10-15 times higher than for a typical catalyst based on gland. The catalyst can be widely used in metallurgy, chemical and oil refining industries.

The increase in the concentration of greenhouse gases is one of the main reasons for the increase in the average annual temperature and a global problem. Reducing the level of CO2 emissions is one of the most urgent long-term tasks of mankind and a serious challenge for the scientific community.

To date, there are two main methods for the production of catalysts for the processing of carbon dioxide: using noble metals - effective, but expensive, and without them - cheap, with noticeably reduced characteristics.

The scientific team proposed a compromise solution - to take inexpensive iron as the basis of the catalyst, reducing the content of noble metals, in this case platinum, to less than 1 atomic %.

But even when implementing the proposed solution, there is a difficulty - bimetallic iron-platinum nanoparticles at elevated temperatures show a high tendency to stick together (agglomeration). In this case, the specific surface of the particles decreases, which negatively affects the catalytic properties.

“For the first time, we have used boron nitride as a carrier for catalytically active iron-platinum nanoparticles. One of the features of the obtained heterogeneous material is that after synthesis, the size of iron-platinum particles is only 2 nanometers. Due to such a small size, these particles are distributed very evenly over the surface of boron nitride. But, what is even more interesting, during the catalytic process, the size of iron-platinum particles increases, but not much (up to 8 nanometers on average). We believe that this is one of the reasons that allows the material to show such high catalytic properties, ” says Dr. Anton Konopatsky, a researcher at the NUST MISIS Laboratory of Inorganic Nanomaterials.

In the work, the team showed a unique stabilization mechanism for iron-platinum nanoparticles: at elevated temperatures, thin sheets of boron nitride were wrapped around the particles. As a result, heterogeneous particles with a core-shell structure were formed, and their agglomeration slowed down considerably.

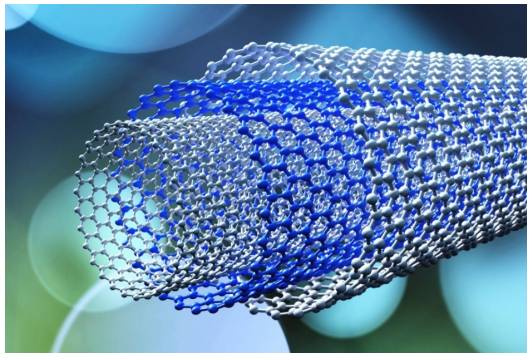
“We used a relatively simple technique to chemically synthesize our catalysts. One of the most important steps was the uniform dispersion of the starting materials in the synthesis medium. Changes in the structure of the synthesized material were observed in situ in a column of a transmission electron microscope at a temperature of 500°C. some approximation? imagine what happens to the material during catalysis,” adds Dr. Anton Konopatsky.

The resulting material can be used in any enterprise with massive CO2 emissions. These are chemical, oil refineries, metallurgical plants, pulp industry and much more.

The main reaction product of CO2 processing using the obtained catalyst is CO (carbon monoxide), which can be reused in industrial processes. However, according to the developers, from an economic point of view, the production of complex hydrocarbons with high added value from CO is of greater interest. It is this task that the team plans to tackle in the continuation of research.

7. Proposed solution to the main problem of carbon nanotubes

Source: MISIS Univ, December 27, 2021



An international team of scientists from Russia succeeded for the first time in demonstrating the possibility of a controlled change in the chirality of carbon nanotubes. This brings these

nanostructures closer to practical applications in electronics and high-precision sensors and makes it possible to create unique nano-transistors less than 3 nanometers in size. In addition, the effect of quantum interference at room temperature was demonstrated.

Attention to carbon nanotubes has not waned since the first observation of their structure in 1991. This is due to possible technological applications based on their unique fundamental properties. One of the features of carbon nanotubes is their chirality, that is, the twist of the structure. An ideal nanotube is a cylinder obtained by rolling a layer of graphene, and the method of folding determines not only the structure, but also the electronic properties of the nanotube. On the one hand, this unique feature attracts the attention of researchers, on the other hand, it creates a huge problem for further potential applications of nanotubes, since it is chirality that determines whether a nanotube is a metal or a semiconductor, and a minimal change in the "chirality index", completely changes the properties of the nanotube.

In the process of synthesis, nanotubes with both metallic and semiconductor properties can grow in one array. This makes it impossible to mass-produce nanotubes for electronics.

Scientists from NUST MISiS (Moscow, Russia), and others have proposed a method that allows modifying the structure of ready-made nanotubes and thus changing their conductive properties. The Japanese side conducted the experimental part, NUST MISIS scientists developed a theory that fully explains the experimental data.

“Our colleagues made a brilliant experiment in which the combination of local heating and mechanical deformation made it possible to change the local chirality of individual carbon nanotubes and thus control their electronic properties. For the first time, it was possible to observe how a nanotube gradually changes its atomic structure. At the same time, what is especially interesting, the structure changed in a completely different way than previously developed theoretical models predicted,” said co-author of the study, leading researcher at the Research Laboratory, Dr. Pavel Sorokin.

As the scientists emphasize, it was previously theoretically assumed that molecular transitions between metal and semiconductor nanotubes can be used as the main structures of nanoscale electronic devices.

The team designed and built an intramolecular transistor in which local chirality was modified by thermomechanical processing in the controlled environment of a transmission electron microscope.

“We have developed a model according to which the dislocations responsible for the change in chirality during plastic deformation are formed as a result of the evaporation of a carbon dimer at high temperature. Calculations of the energy of defect formation have shown that the occurrence of a strict orientation of dislocations is energetically preferable, leading to the gradual transformation of any carbon nanotubes to the chair type during plastic tension, which is fully consistent with the results of the experiment of our colleagues,” explains the engineer of the Research Laboratory “Inorganic Nanomaterials” of NUST MISiS, Dr. Sergey Erokhin.

“The synthesized transistors had a channel length of only 2.8 nanometers and exhibited coherent quantum interference at room temperature. Our colleagues from the Institute of Biochemical Physics, RAS, performed a simulation of the process of electron interference in a nanotube, which describes the experimental data well,” explains Dr. Pavel Sorokin.

8. Artificial intelligence will be attracted to save forests

Source: Siberian Federal Univ (SibFU), February 2, 2022

Russian scientists have learned to identify trees damaged by dangerous pests in the early stages of infection using images from unmanned aerial vehicles (UAVs), using YOLO deep neural network algorithms. The study of the team, which included three scientists from the Siberian Federal University and a representative of LETI, will help save forests from mass extinction.

Preservation of natural forests is the primary task of ecology, since they are a system-forming link in the global ecosystem. One of the factors threatening the well-being of forests has become pests that attack trees, leading to their weakening or even death. Global warming - rising temperatures and increasing frequency of droughts - is only exacerbating the problem. Its main solution, environmentalists believe, is the timely prevention of the spread of pests, for which it is necessary to identify damaged trees in the early stages of their infection.

Programmers came to help environmentalists in solving this problem and the Norwegian or European spruce, which is so common in Sweden, Finland, Denmark, Germany, Bulgaria and other countries, was chosen as a “model” object of study. It is to this tree that mass outbreaks of the European spruce bark beetle (Ipstypographus, (L.)) have caused the greatest harm. From 1850 to the present, mortality in European forests from beetle attacks has increased by more than 8%. In addition, during outbreaks, bark beetles attack even healthy trees, which leads to the mass extinction of European forests. The studies were carried out on the territory of the Chuprene biosphere reserve (Bulgaria), included in the UNESCO list.

When choosing a method, the limiting factors were the large size of forest areas, the presence of hard-to-reach places and the need to automate traditional manual analysis, including to increase the speed of decision-making. Fortunately, high-resolution unmanned aerial vehicle (UAV) images, combined with state-of-the-art detection models, provide a high potential for solving such problems. True, the question remained open - how to process such a gigantic array of data. Scientists had to seriously work on training neural networks, they even had to specially increase the contrast of images so that neural networks could better “see” objects.

The YOLO architecture was chosen as the main deep learning algorithm for object detection. It stands for "look only once" (You Only Look Once). The main difference between YOLO and other Convolutional Neural Network (CNN) algorithms is that it recognizes objects very quickly in real time. The principle of operation of YOLO involves the input of the entire image at once, which passes through the convolutional neural network only once.

First, we prepared a dataset for training and testing YOLO architectures based on drone orthophotos. In the next step, we applied the preprocessing procedure to the dataset. This process consists in increasing the contrast of the input image, which makes it possible to increase the accuracy of detecting individual tree crowns. We then trained and tested the YOLO architectures using versions 2 to 4. Finally, we

presented the results of comparing these architectures and determined the best YOLO architecture for the task of detecting infected trees .

In order for the neural networks to be able to accurately identify what they saw, they had to “show” at least 400 photos taken by the UAV. According to the results of the experiments, the scientists called the YOLOv4 architecture the most preferable. The average accuracy reached 95%, which was the best result. Now, in a similar way, you can “train” artificial intelligence to detect other pests on other types of trees. Which, in turn, will reduce the time for monitoring and taking measures to prevent "forest" epidemics.

9. SFU biotechnologists have developed an effective technology for the synthesis of "green" plastics

Source: Siberian Federal Univ (SibFU), January 20, 2022

Scientists from the Institute of Fundamental Biology and Biotechnology of the Siberian Federal University have developed an effective technology for the synthesis of "green" plastics. They identified strains capable of using plant waste for their metabolism.

The need for new degradable polymeric materials is dictated by global environmental problems associated with the accumulation of synthetic non-destructible plastics in the natural environment. Promising polymeric materials of the 21st century include destructible thermoplastics synthesized by microorganisms, the so-called polyhydroxyalkanoates (PHA). Despite the urgent need for degradable polymeric materials and the high attractiveness of the technology, the increase in their production volumes and expansion of applications is constrained by high cost. The key problem of biotechnology is the optimization of synthesis processes in general. First of all, through the use of new productive strains of microorganisms capable of growing on various available substrates, including waste.

“The availability of high-tech and productive producer strains is a key factor determining the effectiveness of any biotechnology. Currently, hydrogen-oxidizing bacteria of the genus Cupriavidus are considered the most productive industrial PHA producers, which, in addition to autotrophy and PHA synthesis on mixtures of carbon dioxide and hydrogen, have a wide organotrophic potential and are capable of synthesizing PHA of various chemical structures using various substrates. The disadvantages of the vast majority of known representatives of the genus Cupriavidus include a narrow trophic potential in relation to sugars and the ability to assimilate only very expensive fructose for growth., - says expert from Basic Department of Biotechnology, Prof. Natalia Zhila .

Scientists have identified strains that metabolize with different activity not only hexoses, but also sucrose, galactose, maltose, mannose and xylose, which opens up the possibility of attracting waste and hydrolysates of plant materials as a C-substrate.

The most developed and used substrates in biotechnology are individual sugars. Sugar-containing industrial and agricultural wastes, hydrolysates of plant raw materials of various origins are an inexhaustible renewable substrate

resource for the production of target biotechnology products, including PHA. Sugars extracted from Jerusalem artichoke can become a promising and poorly studied substrate for PHA synthesis. Jerusalem artichoke, or Earth pear, is an annual plant characterized by high productivity and the ability to grow in various climatic conditions and on various soils (from arid and desert to frost-prone), not suitable for growing crops. The value of Jerusalem artichoke is due to its chemical composition with a unique carbohydrate complex based on fructose and its polymers, the highest homologue of which is inulin, for the assimilation of which only strains possessing the hydrolytic enzyme inulinase, which is necessary for converting Jerusalem artichoke inulin into fructose and glucose available to bacteria, are suitable. The second potential approach is to carry out preliminary hydrolysis of biofeedstock to convert inulin into hexoses. In 2021, for the first time in biotechnological practice, SFU team obtained and studied sugars extracted by acid hydrolysis from Jerusalem artichoke tubers and vegetative biomass. The mode of acid hydrolysis of Jerusalem artichoke tubers and green biomass has been optimized, providing a high yield of reducing substances (RS), the content of monosaccharides in them with a given ratio of hexoses. All variants of sugar-containing substrates obtained from Jerusalem artichoke, studied in cultures of a series of strains, showed suitability for the synthesis of PHA. With the use of selected strains and optimized modes of obtaining and dosing sugar-containing hydrolysates into nutrient media, productive processes for the synthesis of polymers of various compositions with production indicators comparable to individual sugars have been implemented. Replacing individual hexoses with hydrolysates of tubers and the vegetative part of Jerusalem artichoke reduces the specific cost of C-substrate for polymer synthesis by 1.5-2.0 times.

10. Inverted exoskeleton: scientists of NSTU NETI create high-tech stilts for the recovery of people after injuries or stroke

Source: Novosibirk State Technical Univ, January 11, 2022

Novosibirsk State Technical University NETI entered the program of the Ministry of Education and Science of Russia "Priority 2030". The strategic goal of NSTU NETI is to achieve leadership and technological superiority in Siberia and Russia in three priority areas, one of them being "New engineering solutions and artificial intelligence for biomedicine".

As part of this strategic project, NSTU NETI plans to create two new developments aimed at the rehabilitation of people with disabilities. The head of these developments is Alexey Tsygulin, Associate Professor of the Department of Design of Technological Machines and the Department of Theoretical and Applied Computer Science. One of the developments that NETI team is working on is a traction table with pneumatic actuators. Over time, the spine shrinks, even if there is no atypical influence. If there is a sports load or some kind of injury, then the spine can be compressed unevenly as well. Moreover, the problem becomes more manifested with age. That is, the older a person is, the more difficult the problems are.

According to scientists, the peculiarity of the development is the ability to control the load vector. the computer starts a program that does not stretch the body by a few centimeters but applies an accurately measured effort. This makes a person resist and choose a comfortable position, with a pneumatic drive, with a pneumatic spring configured by a computer. The whole process is controlled by the program. The design can select the vectors of effort and their changes in an accurate and dosed manner. If a person has a backache, in 4-5 sessions this problem goes away. The development has no direct analogs.

Another development of NETI team is a rehabilitation device for patients after stroke and spinal injuries, to make some kind of inverted exoskeleton. That is, fix a person in a device, which is functionally a back and legs. And then the device performs movements characteristic of walking. In this case, the recovery is claimed to be twice as fast. This is also a well-known medical practice. Experts can simulate walking quite accurately, unlike foreign analogs, where a person's legs are controlled by assistants. The development of NSTU NETI scientists evenly distributes the load on the joints and muscles of the patient, which doubles the recovery rate.

11. The development of scientists from St. Petersburg Electrotechnical University "LETI" will allow you to control a computer without the help of hands

Source: ETU “LETI”, February 02, 2022

Today, tens of thousands of people with disabilities cannot fully use a computer due to physical limitations associated with diseases of the musculoskeletal system. For users with similar ailments, the use of a computer mouse causes many difficulties or is impossible at all, since normal operation in most cases requires fully functional upper limbs.

There are a number of technical solutions that allow users to control the position of the cursor and create events that are equivalent to pressing the left or right mouse button without using their hands. This is done in various ways, in particular, by recognizing facial expressions, movements of the pupils of the eyes, eyebrows and turning the head on a signal from a webcam, through voice commands, as well as using neural interfaces.

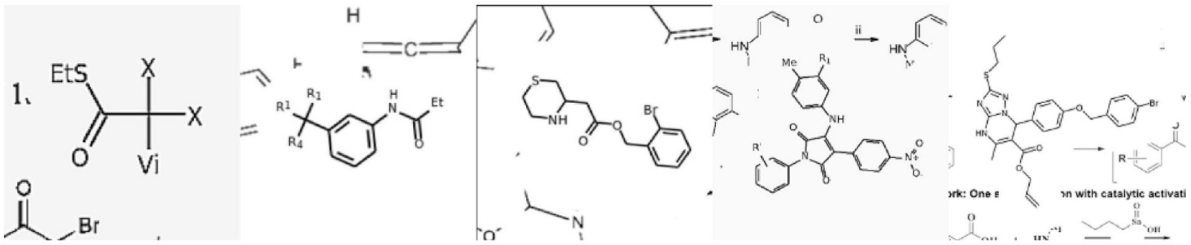
To make computers more accessible to users with disabilities, the project of scientists from the Department of EPU of St. Petersburg Electrotechnical University "LETI" "Development of a computer manipulator for people with disabilities" was launched. An experimental sample of the manipulator was presented by as a compact monoblock that can be mounted on any tripod for smartphones or on the flexible holder that comes with the kit, which allows you to mount the device on various surfaces.

The principle of operation of the device is based on the use of a two-coordinate resistive joystick, on which a plastic mouthpiece is fixed, and a pressure sensor connected to the mouthpiece through a rubber tube. The signals from the joystick and the pressure sensor are processed by the microcontroller, and the processing result is transmitted to the computer via the USB interface. When connected to a computer, the device is recognized as a regular mouse without the need to install additional drivers. The user moves the mouthpiece with their lips, teeth, or tongue, causing the cursor to move on the computer display, and when inhaling or exhaling into the mouthpiece, a left or right mouse click event occurs, respectively. Thus, the functions of a standard mouse are realized without the need for the use of hands.

In the device created by LETI scientists, the joystick and pressure sensor are located in the same housing as the control unit. This solution saves not only on case products, but also due to the possibility of locating the manipulator without a tripod, since it is more profitable for the user to buy a suitable holder on their own: you can use a tripod for a smartphone, which can be found at a price of up to a thousand rubles. The computer arm can also be made wireless by adding a radio module and a battery compartment, which will increase the flexibility in organizing the workplace and allow you not to depend on cables.

12. New neural network will help edit DNA more accurately

Source: Skoltech, December 30, 2021



Russian bioinformatics scientists have proposed a new neural network architecture that is able to predict how accurately the RNA “targeting” the edited gene is selected. This approach will make it possible to more efficiently change DNA using the popular CRISPR/Cas technique, which means it will help in creating new approaches to obtaining genetically modified organisms and developing methods for the treatment of severe hereditary diseases.

Genome editing is a very popular approach in various fields of experimental biology, as well as in agro- and biotechnology. The most commonly used method is CRISPR/Cas.

CRISPR/Cas is one of many ways to protect bacteria from viruses. When infected, the DNA of the pathogen is inside the cell, but since its sequences differ from the sequences of the microorganism, Cas proteins recognize this hereditary material as foreign and cut it. In order for the bacterium to react faster to the virus in the future, fragments of the pathogen's DNA are stored in the cell - almost like a database of virus signatures in a computer antivirus. They are then passed down from generation to generation and are used by Cas proteins to defend against new intrusions.

In 2011 - 2013, scientists from different laboratories around the world (D. Downa, E. Charpentier, F. Jang in the USA and V. Shiksnis in Lithuania) independently adapted the CRISPR / Cas system to change arbitrary DNA sequences in human cells and animals, making genome editing much easier and more efficient. The key elements of the technology are only suggestive, RNA and the Cas9 protein, which cuts the DNA in a place corresponding to its sequence. The cell will then “heal” the incision, but the changes will have already been made. However, the guide RNA does not always hit the right place and can misdirect Cas9's genetic scissors. It is important to turn CRISPR/Cas technology into a modern high-precision instrument, which is especially critical in the case of medical interventions..

Scientists from Skoltech (Moscow), led by Prof. Konstantin Severinov, applied deep learning, Gaussian processes, and other methods to solve the problem of more accurate selection of

optimal guide RNAs. The result was a set of neural networks, which are mathematical models implemented as successive matrix multiplications — large sets of numbers with a complex internal structure. The neural network is capable of learning due to the presence of a "memory" that changes in a certain way every time the system counts in training mode. The models were trained on different data sets containing tens of thousands of experimentally confirmed guide RNAs that worked with high accuracy on human and other animal cells.

The algorithm, proposed by scientists from Skoltech, estimates the probabilities of cutting target DNA in the correct place for given guide RNAs. This can be guided by when choosing an editing tool in any technology based on CRISPR/Cas. Scientists have already proposed a set of RNA guide sequences pre-calculated by their neural network that allows you to accurately change the genes of the 22nd human chromosome. This was made possible by the accuracy of the cut frequency prediction and the addition of an error estimate that no other method previously developed for solving such a problem provided.

"The results of this work can be applied in any application of technologies based on CRISPR/Cas, whether it is the therapy of genetic diseases, agricultural technologies, or experiments in basic scientific research," says Skoltech researcher Bogdan Kirillov, one of the creators of the new method and the first author articles.

In general, the method developed by Russian scientists simplifies the problem of selecting the right tool for high-precision DNA editing, which means it saves time and resources. DNA editing has the potential to help develop therapies for some hereditary diseases.

13. Material Prospective for the Green Development of Hydrocarbon Energy

Source: Ural Federal University, January 21, 2022

Unlike traditional combustion technologies in thermal power plants, oxygen is not supplied from the air, but from solid transition metal oxides. Photo: Unsplash.com

It will reduce the environmental damage caused by burning fossil fuels

Researchers at the Institute of Solid State Chemistry of the Ural Branch of the Russian Academy of Sciences and the Ural Federal University have discovered a new substance for use in the latest environmentally friendly technology for burning fossil fuels. This technology allows, while remaining within the framework of hydrocarbon energy, to significantly reduce the load on the environment.

It is about the technology of chemical cycling with oxygen accumulation - the so-called CLOU-processes (chemical looping with oxygen uncoupling). Compared to conventional combustion technologies at thermal power plants, their undeniable advantage is that the oxygen comes not from the air, but from solid oxides of transition metals. In this case, the combustion products are easily separated, and

the carbon dioxide generated during the combustion of hydrocarbons is utilized by pumping it into storage tanks or sent for industrial purposes.

The properties necessary for CLOU-processes oxides are able to accumulate a significant amount of molecular oxygen at a high rate, up to 20% of their own mass, then release it and then regenerate, keeping their chemical composition unchanged in the oxidation/reduction cycles. In this case, fuel combustion can be carried out without losses for a long time.

CLOU processes are a new word in science and technology, and the scientific world is busy looking for suitable oxide materials. A group of scientists investigated cobalt-modified praseodymium-barium manganite (PrBaMn2O6). It is known that at elevated temperatures manganites can actively exchange oxygen with the environment, being in direct contact with hydrocarbons. Imagine a sponge that first absorbs a large amount of water and then, when compressed, releases it back. In CLOU processes, essentially the same thing happens: manganites play the role of a sponge, releasing large amounts of oxygen in combustion reactions, and then absorbing it back when interacting with air. However, the original (unmodified) manganite gradually degrades when saturated with oxygen, so its oxygen capacity decreases. UrFU group found that the introduction of cobalt atoms in the oxide PrBaMn2O6 stabilizes its structure, it remains when the temperature and composition of the gas environment.

In other words, this material is destroyed neither by oxidation nor reduction. On this basis, chemists first suggested that it could be suitable for use in CLOU-processes, and tested their hypothesis. Scientists have studied in detail the fundamental and functional characteristics of cobalt-modified manganite. Using mathematical modeling methods supported by corresponding experimental results, the authors showed that oxygen is released from the oxide unevenly. As it turned out, the addition of cobalt activates some areas of the material, making it much easier for oxygen to escape.

"By replacing some of the manganese atoms with cobalt, we increased the total amount of oxygen in the oxide that is available for rapid release during hydrocarbon combustion. This resulted in a record-breaking increase in the oxygen capacity of the material, the volume, and the rate of oxygen release compared to the original manganite. Thus, we received confirmation that the investigated compositions have excellent prospects for use in CLOU-processes. Moreover, the work performed and the results obtained are important for the design of new materials: there is an understanding of how to modify their chemical composition in a targeted way to increase the oxygen capacity and oxygen exchange rate," comments Prof Aleksey Suntsov, UrFU.

Traditionally, combustion of hydrocarbons - natural gas, fuel oil and coal - in thermal power plants uses air as an oxidizer. However, three quarters of it consists of nitrogen, which forms toxic oxides as a result of combustion processes - they, in turn, concentrate in the reaction products together with carbon dioxide. The resulting mixture is poorly separable and is often simply released into the atmosphere. By accumulating there, additional amounts of carbon dioxide exacerbate the greenhouse effect and provoke further global warming. This is especially dangerous in connection with the continuous increase of humanity's energy consumption due to the explosive growth of the planet's population and the dramatic increase in the standard of living. At the same time, thermal power plants provide more than 60% of the world's electricity production, and their contribution to humanity's energy supply will not change much in the coming years.

14. Scientists created Sorbent to recycle hazardous Chromium containing waste

Source: Ural Federal University, February 4, 2022

The sorbent helps purify water to drinking water quality. Photo: Ivan Bandura / unsplash.com

The output is pure water and valuable chromium compounds

Scientists of the Institute of Metallurgy of the Ural Branch of RAS and Ural Federal University have synthesized a highly productive composite reusable sorbent for removal of chromium from water. Tests of the sorbent on wastewater of one of the enterprises of the Sverdlovsk region showed the possibility of extracting chromium from wastewater, purifying it to drinking water quality. The chromium compounds obtained in this process are returned to production processes.

Chromium easily penetrates into water, soil, and plants, being a toxic environmental pollutant - mutagen and carcinogen. The method of recycling accumulated chromium-containing waste proposed by Ural scientists is a way to solve the pressing problem not only for Russia, but also for many other countries.

The results of the experiments allow the researchers to claim that the synthesized composite sorbent is extremely effective, and the developed technology of water purification is extremely promising for practical application and is significantly superior to analogues. An article describing the scientific work was published in the journal Hydrometallurgy. The scientists used the clay mineral montmorillonite, traditionally used in sorption technologies, as the basis for the created sorbent. At the first stage of development, the mineral was modified with magnetite nanoparticles.

"This weighed the small and light montmorillonite particles and then allowed them to easily precipitate together with the adsorbed chromium by applying a magnetic field," explains Dr. Denis Ordinartsev, head of the research group and a senior researcher at the Institute of Metallurgy, UB RAS.

At the next stage of the synthesis of the new sorbent, a molecule of the main sorption element from the group of cationic surfactants selective with respect to chromium was introduced into the layered structure of montmorillonite. This led to a significant expansion of the interlayer space of montmorillonite. As a consequence, the sorption capacity of the material increased by 5 times, from 20% in the initial mineral to 98-99% in the obtained composite.

The synthesized sorbent was placed in an aqueous solution containing chromium. During their interaction, the sorbent layers are slightly compressed, firmly holding the chromium particles. When alkali is added to the solution, the reverse process - desorption - occurs: the sorbent releases chromium and is then sent for further use. The remaining chromium in the solution was adsorbed by precipitation on iron ash (homogeneous suspension of nanoscale particles), a substance also selective for chromium. As a result, an aqueous solution purified of chromium and having the quality of tap water was obtained.

At the same time, the scientists obtained two groups of chromium-containing substances - pure chromium compounds formed as a result of adsorption by the synthesized composite sorbent, and chromium-iron concentrate - the product of solution post-treatment with iron ash. Pure chromium compounds are required, for example, in the manufacture of stainless and chrome-plated steel, electrical insulation and corrosion-resistant coatings, in the aerospace industry, and even in the manufacture of leather goods. Chromium-iron concentrate is used, among other things, in iron alloying to produce, for example, chromium iron, notes Prof. Svetlana Estemirova, research participant, co-author of the article, head of the educational laboratory of the Department of Metallurgical Science at UrFU.

15. MAI created the device for conversion of ultrasound into the audible range

Source: Moscow Aviation Institute (MAI), December 17, 2021

MAI experts elaborated a device for ultrasonic waves conversion into the audible range with the structure of the spectrum preserved. First of all, it is planned to use the development in order to study the behavior of insects and bats. It will also be useful for possible gas leakages detection, corona and spark discharges, structure analysis of ultrasonic noise for labor protection purposes, etc.

The project is implemented by Prof. Maria Zolotenkova, the professor of the Signal student design bureau of Institute No. 4, Radioelectronics, Communications and Information Security, and Dr. Vasily Egorov, senior lecturer at the 410 Department of Radiolocation, Radio Navigation and Airborne Radioelectronic Equipment, MAI.

The device is designed to transfer signals of the 20-40 kHz spectrum into the audible range. This allows them to be further processed using sound cards of computers or smartphones, designed to work with signals of the audible range.

The assembled prototype consists of two compact blocks: each of them fits in the palm of a person’s hand. The first unit contains a microphone, a preamplifier and a power supply module with lithium-polymer batteries. The microphone is pointed directly to the ultrasound source, after which the received signal is amplified and fed through the cable to the second module, where the spectral range of audible frequencies is suppressed, and the spectral components of the 20-40 kHz range are transferred to the 0-20 kHz range. The user hears the signal received after such a conversion through headphones. It can also be recorded by standard means of any smartphone or computer.

MAI invention might be used for biological research problems. For example, to study the behavior of bees, whose population decline in recent years has become an urgent problem for the whole world. The device is also well suited for studying populations of nocturnal insects in the small area. And for some technical tasks, such as searching for wasp hives in structural parts of an aircraft.

Special attention was paid to preserving the structure of the signal spectrum and minimizing the introduced distortion and interference within the course of the work.

16. MAI kinetic energy storage device – new emergency power supply source

Source: Moscow Aviation Institute (MAI), January 12, 2022

Scientists of the department 310 "Electric power, electromechanical and biotechnical systems" MAI developed superconducting kinetic energy storage device (KNE). Its efficiency is almost 100%. The project was noted at the XLVII International Youth Scientific Conference "Gagarin Readings", as well as at the European Conference on Applied Superconductivity EuCAS-2021.

Kinetic energy storage device is the energy storage device that converts mechanical energy from the rotating flywheel into electrical energy from the motor generator. KNE are used as emergency power sources, auxiliary power source during peak loads on the power grid and in power supply systems based on renewable energy sources. The superconducting kinetic energy storage device is a promising development in the area of electromechanics. It is able to replace the existing emergency power supplies – diesel generators, as it surpasses them in terms of efficiency, reliability, durability and environmental friendliness.

The uniqueness of the device is in the storage mechanism itself: young scientists used magnetic suspension, superconducting bearings, “ironless” motor-generator, and vacuum-evacuated KNE body. This design minimizes electrical and mechanical losses, as well as eliminates the friction of the rotating parts against air, which makes it possible to achieve the efficiency of 99.99%.

This device uses high-temperature superconducting bearings, which are completely free of friction. Energy losses of any electromechanical device represent the sum of losses, namely: losses in steel - hysteresis losses, losses in copper and mechanical losses - due to friction in bearings, explains one of the researchers. The scientists, got rid of hysteresis losses by making the stator of the motor-generator “ironless”.

There are no analogues to the MAI development on the Russian market. The young scientists are planning to carry out the full cycle of tests of this device and prove its efficiency. It is necessary to pump the air from the KNE body and create vacuum there – then, according to the authors, it is possible to achieve the nominal flywheel speed of 8000 rpm without heating the rotating parts due to friction against the air, while in air the flywheel temperature reaches critical indicators after 5000 rotations already.

17. MAI scientists are developing the effective sensor for hydrogen leakage detection

Source: Moscow Aviation Institute (MAI), January 26, 2022

Moscow Aviation Institute will complete the development of a selective sensor capable of detecting hydrogen leakage precisely. Creation of such a sensor is not easy, still this task is very important, especially taking into consideration the growing use of H2. If compared to Russian

and foreign analogues, the new sensor will become more sensitive to hydrogen leaks, will have a low operating temperature and low power consumption.

Mankind is aimed at transition to environmentally friendly types of energy. And hydrogen the source of energy that looks like it has prospective. It will certainly push coal, fuel oil, diesel fuel, gasoline and natural gas aside.

H2 consumption has been growing recently and it will only continue to increase during the upcoming decades. The policy of achieving carbon neutrality, that is, the rejection of carbon dioxide emissions into the atmosphere, is the exact main reason for that.

More specifically, we can foresee the emergence of a large number of thermal power plants operating on hydrogen. The efficiency of such a station will reach 60%. Approximately the same good indicator is given by the current gas-fired thermal power plants operating on methane, but hydrogen has a number of advantages.

First of all, it has the highest thermal conductivity among all gaseous substances and, which is extremely important, it allows to regulate the operation of gas turbines easily, and, respectively, change the output power quickly. At nuclear power plants, for example, it is absolutely impossible to do this in a short period of time. Hydroelectric power stations are more flexible in terms of capacity change, but a number of places where it is allowed to build them is restricted.

Hydrogen thermal power plants are very convenient to use when the volume of consumption changes dramatically. Perhaps hydrogen power plants and the energy potential of H2 are of high importance for European countries, for they are trying to use renewable energy sources (RES) as widely as possible, but have difficulties in ensuring the energy balance in cloudy weather and during periods when there is no wind.

As the hydrogen revolution is obviously at its dawn, our country also has certain ambitions. Almost all newly built pipelines, including Nord Stream 2, are made using materials and technologies that allow H2 to be pumped. Russia could hypothetically become the major global producer and exporter of hydrogen.

Though, it is still better to mix "transit" hydrogen with other substances, for example, with methane – for safety reasons. At the outlet of the pipe to the territory of the consuming country, this mixture will be separated into two gases. And for export purposes, the easiest way would be to use the underwater pipeline, because for pumping through the land artery, you will inevitably have to create a fairly extensive infrastructure for pumping and servicing.

Broad prospects are opening up for hydrogen in the automotive technology segment. This trend has also affected our country. It is known that in the near future in Moscow it is planned to create an extensive fleet of hydrogen electric buses.

A number of issues regarding the choice of the most optimal methods of hydrogen production have not been resolved yet. There is a so-called green hydrogen, which is extracted from water via electrolysis. In this case, no CO2 emissions are generated, but this method is energy

intensive and quite costly. There is blue hydrogen – it is extracted from methane, but CO2 is evolved.

As far as security is concerned – on the one hand, in any case, this issue must be taken very seriously, on the other hand, the risks of mass use of hydrogen should not be exaggerated. For example, the industry that has long used hydrogen as an element for chemical reactions has, in essence, solved safety issues.

There are certain security gaps in new sectors of industry that are specifically aimed at using H2 as an energy source. In everyday life, and at all, as I think, hydrogen will not be used soon.

Of course, when talking about the attractiveness and future expansion of hydrogen applications, it is impossible to ignore its shortcomings, which most directly affect safety.

The first one is the storage complexity. H2 has the ability to penetrate even through hard surfaces. Its spread is restrained only by a shell made of metals, and even not all of them.

The second one is the flammability, the limit of which is much wider than that of hydrocarbons and methane. The concentration of H2 in the environment must be between 4 and 75% for an explosion to occur. For comparison: for methane, this range is much narrower – from 4 to 15%.

Currently, in Russia and abroad, sensors that are focused on the determination of the concentration of various combustible gases and vapors are widely used. They have both advantages and disadvantages. The approach of the AHP team is to use a selective sensor that measures only H2 and does not sense other gases. Creating a sensor that detects (determines) only hydrogen from a variety of mixtures of other substances is a very difficult task. But, from our point of view, such a product is necessary and in demand, since it will be much better to take into account the most important properties of hydrogen: its fluidity, explosiveness, combustion temperature.

MAI sensor is compact and it will fit in a housing less than one cubic centimeter. The actual size is smaller, and the "sensitive" part of the sensor is quite small – it is a spiral about 0.5 mm long and about 0.3 mm in diameter. It is not used separately, it is one of the components of the equipment of ready-made gas analyzer. In order to easily integrate our sensor into the gas analyzer, a standard housing with a diameter of 8 mm and a height of 10 mm was chosen.

The sensor belongs to the type of thermal catalytic sensors. In addition to this class of sensors, there are electrochemical, semiconductor and optical. Due to a number of features, they cannot detect hydrogen with high efficiency.

For example, electrochemical and semiconductor sensors capture hydrogen concentrations that are “harmless” from the point of view of explosiveness and, on the contrary, often “choke” – lose their sensitivity when the H2 level approaches a truly threatening threshold.

In this respect, thermal catalytic products stand out if compared with other types of sensors. They are the most suitable for measuring hydrogen in air in the range from 0.1 to 2% and higher, which most effectively helps to prevent explosive situations. The essence of the operation of a thermal catalytic sensor is that hydrogen penetrates through the sensor membrane, behind which a sensitive element heated by current is placed. This element, in turn, has a surface coated with a catalyst.

It is necessary to heat the gas in order to cause a chemical reaction and thus detect hydrogen. Heating is precisely the principle of operation of

a thermal catalytic sensor. Without a catalyst, the temperature of about 900 °C is required, and with a platinum catalyst, which is now widely used – about 300-400 °C.

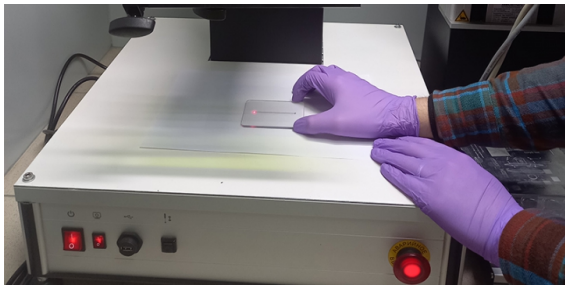
The problem with modern thermal catalytic sensors is that at such high temperatures it is difficult to completely eliminate the possibility of situations when, during a short circuit and other malfunctions, a reaction occurs that can provoke an explosion. It will be much safer, if the heating temperature could be lowered significantly. Today, the most advanced sensors give results at 200°C. The scientist are working to further reduce the temperature of hydrogen measurement.

The strategic goal of the MAI project is to conduct selective measurements of hydrogen in air or in mixtures with other combustible gases at temperatures close to room temperature. In addition to improving safety, it will be possible to reduce energy consumption. As a result, the battery life of the sensor will increase. There is no point in lowering the operating temperature to room temperature. A good result, from our point of view, would be a product that functions when heated to 60-70 °C. Last year MAI developed a catalyst that operates at just over 100°C, but they close to making a better sensor. The catalysts in current gas sensors are platinum group metals, but not all of them have previously been used to monitor hydrogen. We use iridium (Ir) and rhodium (Rh) in its pure form, or mixed with platinum (Pt) and palladium (Pd).

This combination of materials should improve the parameters and performance of our thermal catalytic sensor. This is a fairly low operating temperature, low power consumption, selectivity, sensitivity, reduced response time (reaction to hydrogen), long-term stability of operation.

18. Organ on a chip: a microfluidic system for medicinal products research

Source: MIET, January 24, 2022



Bringing new medicinal products to the domestic pharmaceutical market is a laborious and costly process. Registered medicines have different effect on patients, for example, they can cause side effects or allergic reactions leading to death. Animal preclinical studies are also costly, time consuming, and their physiology does not fully match human physiology. In addition, there is the problem of selecting medicines in hospitals and clinics, taking into account the characteristics of the patient's organism. That is why technology for the selection of an individual course of medical therapy is highly in demand. Organ-on-a-chip microfluidic systems could make the process of drug research and selection less costly and safer and more personalized.

The scientific group of the Institute of Biomedical Systems of MIET has developed a microfluidic system to dose microflows of medicinal products to live cells of various human organs placed on it. The innovation of the development lies in the developed polymer material based on carbon nanotubes. This material provides a nonlinear interaction with laser radiation, which makes it possible to create microchannels with specified geometric parameters. This technology resulted in less

duration and reduced cost of the research, as well as the lower fluid flow rate in comparison with the analogues.

The microfluidic system consists of a transparent composite polymer wafer with a system of microchannels created by laser radiation, a micropump that provides fluid flow through the channel, an AC source with electrodes to control the micropump, and a microscope to monitor the drug delivery process. The general scheme for the manufacture of microfluidic channels for dosing drugs includes: preparation of the substrate, formation of a system of channels and their sealing, and installation of a micropump.

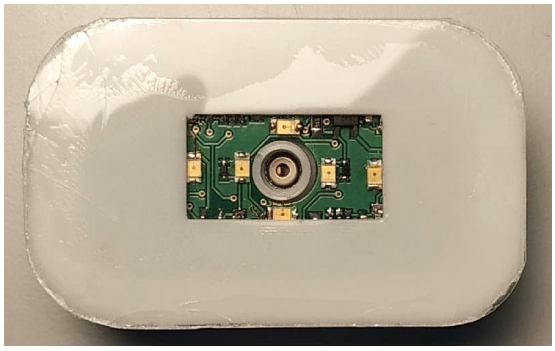
The substrate is a wafer made of a polymer composite material. To create this material, polymethyl methacrylate (PMMA) with carbon nanotubes (CNTs) was chosen as the basis for the microfluidic system. Particular attention is paid to the parameters of laser radiation, which is used to form microchannels. According to the results of mathematical modeling scientists selected power, wavelength and pulse repetition rate. The use of laser radiation of sufficient power leads to the formation of holes. By setting the desired beam trajectory, it is possible to form microchannels of various lengths and shapes.

In the functioning of the microfluidic system, a wafer is placed first with microchannels, a connected micropump and applied cells of a certain organ in an incubator where cells are cultivated. After that, the wafer is sealed and placed on the microscope stage to monitor the dosing process, and using a dispenser add the medicinal product to the microchannel.

Nowadays, there are no domestic analogues of such a microfluidic system in the Russian market of medical devices. The competitiveness of products is high due to the low cost compared to the closest analogues; also the system allows to carry out the fastest analysis of the interaction of human cells with drugs in comparison with analogues. Thus, the introduction of the developed microfluidic system (wafers with microchannels) to the market of medical products will make it possible to replace foreign analogues.

19. Scientists successfully tested a portable non-invasive glucometer

Source: MIET, January 27, 2022



At the end of 2021 scientists tested a portable personalized non-invasive glucometer, which was developed at the Center of National Technology Initiative (NTI) “Sensory” based on MIET. The tests were carried out in the laboratories of the Center..

The device allows to measure the concentration of glucose in the blood without taking out the blood sample. The glucometer is based on diffuse reflectance spectroscopy. It contains a miniature infrared laser that irradiates human tissues. During the propagation radiation is absorbed by glucose and weakens. The lower the intensity of the radiation reflected from the tissues registered on the photodetectors, the higher the concentration of glucose in the tissues and in the blood.

The glucometer is implemented in the form of a small block; it can be fixed on the wrist using a

bracelet. A patient should continuously wear the device for greater effect. It allows to measure the concentration of glucose in the blood every 5 minutes, build a graph in a mobile application and send data to the doctor.

“The key characteristic is the measurement inaccuracy, which, according to the test results, averaged from 18.5 to 19.9%. This accuracy is sufficient to ensure continuous monitoring of glycemia, registering a sharp drop in glucose levels for taking timely measures,” said Dr. Kirill Pozhar, the leading developer of the project, associate professor at the Institute of Biomedical Systems.

20. Scientists created a system for monitoring the condition of cattle based on wearable sensors

Source: MIET, January 28, 2022

MIET engineers have developed a system for monitoring the cattle condition based on wearable sensors. The development is expected to be at least 20% cheaper than foreign analogues and to increase the productivity of one animal by 2-3 liters of milk per day due to the timely response to deviations in food or water consumption. The animal testing as part of the “Smart Farm” project will begin in 2022.

The main partner of the project is the Federal Scientific Agroengineering Center VIM, which is the leading and largest center for digitalization, robotization and developments in the field of artificial intelligence in agriculture.

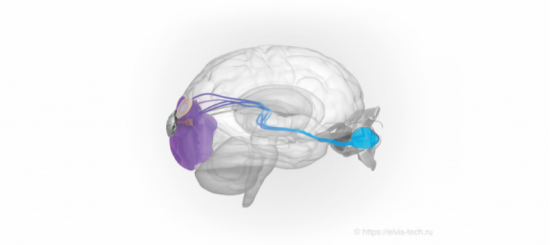
“The data processing algorithm is based on continuous monitoring of a fairly large number of parameters: temperature, motor activity, heart murmurs, acidity. These parameters are collected in real time, based on the developed mathematical models and the obtained dependencies. They make it possible to detect at an early stage a number of diseases, deviations in the diet,” said Dr. Dmitry Pavkin, the head of the laboratory, senior researcher at the Federal Scientific Agroengineering Center VIM.

The developed system consists of a bolus, a lameness sensor and a base station. The dimensions of the capsule are up to 140 mm in length, up to 40 mm in diameter; the weight of the device is maximum 250 gms. “A bolus is a small capsule that is placed in the animal's stomach. It transmits information about the temperature, physical activity and other physiological parameters of the animal via a wireless interface. The lameness sensor is mounted on the leg or neck: it also collects basic physiological parameters and has a communication module for transmitting telemetry data to the base station. Using the lameness sensor, one can determine the location of the animal. The base station receives and transmits telemetry data from boluses and lameness sensors,” explained Dr. Vladimir Zhmylev, an employee of the Competence Center of the NTI “Sensory”, an assistant at the Institute of Microdevices and Control Systems.

Experts add that the system allows specialists to detect estrus and give animal technicians a signal about the parturition. The new development is also expected to increase the efficiency of dairy cattle breeding and the life expectancy of the cattle by at least one lactation period.

21. MIET and Sechenov University developed a device that will help blind people to see

Source: MIET, February 02, 2022



Scientists from the universities participating in the “Priority 2030” program are developing technology and devices for neurostimulation of the cerebral cortex that will help people who have lost their sight to restore their ability to see. The research is on the last stage of preclinical testing - testing on primates.

Sechenov University and MIET have developed a device “Elvis” that allows to “connect” its cameras to the brain of a blind person and transmit the image to the brain directly, without the help of the eyes. The device was created for people who have completely lost their sight, but retained their visual memory and experience.

The technology of neurostimulation of the cerebral cortex is implemented on a three-component wearable device “Elvis”, which forms phosphenes that form visual images in the human brain. People who are blind from birth cannot see phosphenes. But they can be artificially induced in a person who has become blind during his life, which opens up prospects for creating prostheses that can provide a different, useful form of vision.

Elvis consists of three components: an implant with a microchip, which is installed in the human brain and stimulates the visual cortex with weak currents; a hoop with a camera that is mounted on a person's head, and a microcomputer that processes the image from the camera using intelligent algorithms. The device is mobile and is attached to the belt.

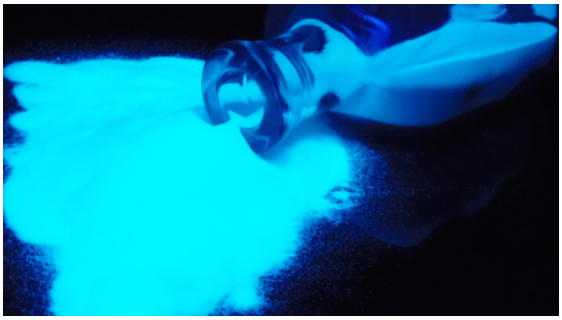
A person sees with no eyes, but the brain. Therefore, the retina and optic nerve can be replaced by a video camera. Object vision is formed in the occipital lobe of the brain called the visual cortex. A cortical implant (microchip) embedded in the cerebral cortex stimulates the primary visual cortex with small currents, due to which a person sees bright flashes - phosphenes that form visual images. Next, the Elvis microcomputer processes the captured image using neural networks and forms a visual image for a person.

Cortical prostheses are a subgroup of visual neuroprostheses capable of inducing visual perceptions in blind people through direct electrical stimulation of the occipital cortex, which is responsible for image recognition. This approach may be the only available treatment for blindness caused by glaucoma, end-stage retinitis pigmentosa, optic nerve atrophy, trauma of the retina, optic nerves, and etc.

Elvis may become the first Russian mass-produced device using electrodes to be implanted in the brain for the long term. The first operation to install a Russian neuroimplant was successfully completed at the Research Institute of Medical Primatology in Sochi. The next stage of testing “Elvis” is planned for 2023–2026. During this period, the developers will produce the first experimental batches of the device and test it on up to 10 blind and deaf-blind volunteers. Test participants will be able to get a new way of vision and become the first in our country to use a full-fledged bionic cortical implant. The introduction of the “Elvis” into medical practice in the Russian Federation is planned for 2027.

22. Scientists will accelerate the search for new luminophores with a high quantum yield

Source: SibFU, January 31, 2022



SibFU's scientists and their colleagues from the South China University of Technology (Guangzhou, China), using the Random Forest machine learning method, have analyzed the dependence of the photoluminescence quantum yield (PLQY) on the crystal structure of existing metal halides.

Halides are compounds of halogens with other chemical elements or radicals. By studying such compounds, the researchers identified the primary role of the distance between metal ions in them and gave a quantitative characteristic of the influence of other structural features, such as the distance between the metal and halogen and the distortion of metal–halogen polyhedra.

Having tested the resulting model on two antimony-based metal halides synthesized for the first time, the scientists proved a high degree of coincidence between the predicted and real characteristics — the difference was about 15%. The program is expected to accelerate the discovery of new luminescent metal halides and make a revolution in the fluorescent lighting market.

For several years, we have been nurturing the idea of being able to use machine learning methods to determine the structure-property relationship in crystals. This task is crucial in solid state physics since the structure of a crystal directly controls its properties. All we need is to understand these laws in order to obtain any materials with desired properties in the future. But this task is very complex, relationships are not easy to detect, but machine learning is successfully coping with this problem," said Prof. Maxim Molokeev, Russian co–author of the work, associate professor of the Basic Department of Solid State Physics and Nanotechnology at the School of Engineering Physics and Radioelectronics of Siberian Federal University.

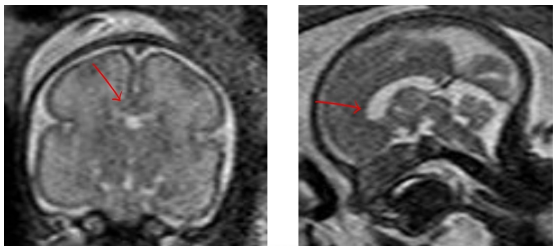
"More than 30 compounds have been studied, and even more of structural characteristics. A person cannot do such a task on their own. This is where machine learning comes in. Of all the existing methods, our international team chose the classic Random Forest method because, in addition to learning and further predicting the quantum yield, it also allows you to find the main components (in this case, the main structural characteristics of the crystal) that have the maximum effect on the quantum yield", the scientist emphasizes.

The researchers managed to recognize these components and discover one of the important laws on how to improve the quantum yield in crystals containing Pb^{2+}, Sn^{2+}, Bi^{3+}, Sb^{3+} ions. After that, the team synthesized two completely new compounds and analyzed their structures. Analysis of the structures using the developed software revealed that the predicted quantum yield was 6.5 and 75.9%.

A real experiment after the calculations showed values close to those predicted: 18.8 and 96.5%, respectively. Along with the standard cross–validation of the model, this experiment confirmed that the Russian-Chinese software can indeed make adequate predictions, and that the discovered laws are correct and can be used.

23. A new discovery can save children with anomalous brain development

Source: Tomsk State University, December 24, 2021



TSU neurobiologists are studying congenital brain anomalies in the human prenatal and postnatal periods. While studying agenesis of the corpus callosum (complete or partial absence of the structure that connects the two hemispheres of the brain), the scientists discovered that its functions can be compensated for by other brain structures. The child's cognitive abilities remain intact. This new data can drastically change clinical practice and reduce the number of pregnancy terminations.

The scientists used myelin mapping technology, a unique non-invasive technology created by neurobiologists at TSU. Myelin is a substance that surrounds nerve cell axons, and the amount of it is an important criterion in assessing the child's or fetus's brain development. TSU scientists and specialists from the International Tomography Center, Siberian Branch of Russian Academy of Sciences (ITC SB RAS, Novosibirsk) are studying the earliest stages of myelin formation during the prenatal development.

"We chose corpus callosum for this study because anomalies in its development are frequent," explains Dr. Aleksandra Korostyshevskaya, senior researcher, chief of the Medical Diagnostics Department of ITC SB RAS, Doctor of Medical Science. "Anomalies of midline brain structures make up 47% of all brain development pathologies, and of all of them 40% are connected with underdevelopment (agenesis) of the corpus callosum. It is hard to say what life has in store for these children. Doctors and parents face a difficult choice: to risk giving birth to an intellectually disabled child or to terminate pregnancy."

It is not always possible to detect the anomaly's details through prenatal ultrasounding. In almost half of the cases, an MRI of the fetus is needed to determine the agenesis of the corpus callosum. However, this is complicated because the fetus constantly moves in amniotic fluid. Specialists at the ITC SB RAS were some of the first to introduce this method of diagnosis, in 2008, and have been perfecting it for more than 13 years.

In collaboration with TSU, the ITB SB RAS scientists developed a new step in global practice - a method of quantitative myelin mapping in a fetus's brain. "We gathered a representative sample of fetuses with agenesis of the corpus callosum," explains Dr. Yarnykh, research adviser of the Research Institute of Biology and Biophysics, TSU, and a professor at TSU and University of Washington. "We compared them to a sample without anomalies and discovered that myelin in central brain structures forms faster in children without the corpus callosum. That means that absence or partial absence of one brain structure is compensated by others, and they connect two hemispheres instead of the corpus callosum."

This evidence of human brain neuroplasticity explains why people with agenesis of corpus callosum can function well in the absence of other anomalies. During examinations, clinicians encounter patients 50-70 years old without corpus callosum. They live a normal life and are well-integrated into society. At the time

of their birth, MRI and ultrasounding were unavailable, and parents did not know of their children's anomaly. The brain of these people compensated for the absence of corpus callosum by "turning on" other parts. To understand the mechanism of neuroplasticity, scientists need to figure out what structures can perform other parts' functions.

"We study fetuses on that stage of development when myelin only starts forming," says Dr. Vasily Yarnykh. "On myelin maps, we can see that with agenesis of the corpus callosum, myelin forms faster in the medulla and spreads to the cerebellum. It is likely that hindbrain structures connect hemispheres in the absence of corpus callosum. Previously it was considered that in that case the functions of the corpus callosum are performed by other zones which form myelin after the child is already born. Our fundamental discovery changes our understanding of brain structures' interactions."

New quantitative evidence from TSU and ITC SB RAS can alter existing clinical practice and give a chance at life to children who previously were promised intellectual limitations and social inadaptability.

"The agenesis of the corpus callosum was previously considered a fatal flaw, and if it was discovered before the 21st-23rd week, the pregnancy could be terminated," says Aleksandra Korostyshevskaya. "It is evident now that if corpus callosum is absent, we should check the accompanying diseases: central neural system pathologies and genetic syndromes. If everything is in order, the fetus has a chance to develop normally. Naturally, we need more large-scale studies, but even the data we have now drastically changed the approach to agenesis of corpus callosum."

24. Scientists develop fastest-ever quantum random number generator

Source: NUST MISIS, January 15, 2021

An international research team has developed a fast and affordable quantum random number generator. The device created by scientists from NUST MISIS, Russian Quantum Center, University of Oxford, Goldsmiths, University of London and Freie Universität Berlin produces randomness at a rate of 8.05 gigabits per second, which makes it the fastest random number generator of its kind. The study is a promising starting point for the development of commercial random number generators for cryptography and complex systems modeling.

Random number generation (RNG) is used in encryption with a multitude of applications, including cryptography, numerical simulation, gambling and game development. Random numbers are at the core of strong, unique encryption keys used to protect cryptographic operations from being breached. RNG can also enhance the performance of AI-powered systems.

Even though computer-generated numbers might seem random, true randomness is extremely hard to achieve. Random number

generators implemented in software based algorithms produce random-looking yet deterministic sequences of numbers, which poses numerous information security vulnerabilities.

In search for true randomness scientists have turned to quantum mechanics. Since randomness is a fundamental property of quantum processes, quantum events can be harnessed to generate truly random numbers. In their experiments, the researchers used the inherently unpredictable behavior of photons to generate randomness. They created an optical generator with a built-in certification protocol to ensure the random nature of the number generation process.

In their experiments, the researchers sent light from the “untrusted” light source into one input of a beam splitter while the other input was the vacuum. The consequent pair of output beams was then measured using two separate optical detectors. Since each photon that hits the beam splitter has an equal chance of being reflected or transmitted, the difference between the numbers of photons recorded by each detector is impossible to predict. It is a truly random number.

To confirm that randomness generated by the device was reliable, the researchers performed another measurement to make sure that the light signal contains a sufficient number of photons. If the number of photons is insufficient, the number of possible unpredictable events will be too low for the obtained randomness to be confirmed true. If the photon input is too high, both detectors will hit their maximum value, resulting in the measurement being fully predictable.

The new RNG generates random numbers at a rate of 8.05 gigabits per second — which makes it the fastest composably secure quantum random number generator ever reported- and provides real-time randomness certification. According to the researchers, the device is significantly faster that the previously existing prototypes. The inclusion of the real-time randomness certification and the use of off-the-shelf components to build the generator makes this technology applicable to commercial RNGs that have rather broad applications. This level of practicality, combined with high performance speed and reliability makes it suitable for use in cryptography, computer studies, statistics, scientific research etc.

25. NSU scientists have established how the color of the grain is related to the terms of its storage and germination

Source: NSU, February 03, 2022

Candidate of Biological Sciences, Associate Professor of the Faculty of Natural Sciences of the Novosibirsk State University and Mathematical Center in Akademgorodok (MMC), together with the Institute of Cytology and Genetics of the Siberian Branch of the Russian Academy of Sciences and the Institute of Genetics and Agricultural Plant Studies (IPK) (Gatersleben, Germany) while using the method of digital image analysis studied morphological characteristics of the grain and color of its shell for 44 recombinant inbred lines (RIL) of common wheat, which were grown in four different seasons: 2003, 2004, 2009 and 2014. For 19 RILs of the same seasons, the researchers evaluated the germination. Such a study of grain stored in a genetic bank for several years has never been carried out by anyone before.

The shell protects the grain from external influences, therefore its safety and functions are closely related to such characteristics as germination, viability, resistance to long-term storage. An important role is played by plant pigments: they perform protective functions at

the molecular level. It is known, for example, that red-colored wheat grains are more resistant to premature germination, but less susceptible to moisture swelling, which affects their germination.

In world scientific practice, remote methods for determining the "health" of seeds are already being developed. However, in these cases, a change in the color of grains that is noticeable to the naked eye and its relationship with germination were studied either under conditions of artificial aging (heating) or during storage for no more than a year . Together with the Institute of Cytology and Genetics of the Siberian Branch of the Russian Academy of Sciences and the Institute of Agricultural Plant Genetics, the scientists looked at how changes in grain color will manifest themselves during a long storage period in the genebank.

Based on the results of ANOVA and correlation analysis, scientists found that storage time does not significantly affect the variability of seed size and shape traits, but significantly affects color traits: approximately 80% of traits (44 out of 48) change significantly during long-term storage. At the same time, the longer the shelf life, the more number of red the grains have. Unlike experiments on artificial aging, in which the shell of the grains darkens, the scientists found that when stored in the conditions of the genebank, it became lighter.

When exposed to environmental conditions, including long-term storage, some of the pigments decompose, their concentration in the shell changes, which can be determined by the change in the color of the grains. The analysis of digital images allows to catch even very slight changes in the color of the grain shell. In the future, this can be used to solve such practical problems as a quick assessment of the physiological state of the grain or the prediction of its germination.

26. A new technology is being developed to create fresh water

Source: NTI Center, January 10, 2022

At the NTI Competence Center "Digital Materials Science: New Materials and Substances" at the Moscow State Technical University. N.E. Bauman have developed a technology for producing composite sorbents based on graphene oxide - superhydrophobic aerogels, which will be used to purify water and air from organic pollution.

Among such contaminants are dyes, solvents and other chemical waste from light industry enterprises. The technology will help fill the growing lack of fresh water. In the future, within the framework of the project, scientists plan to optimize the composition and structure of the airgel. In particular, for bactericidal action, scientists will add silver nanoparticles to it.

The NTI Center “Digital Materials Science: New Materials and Substances ” is a structural subdivision of the Moscow State Technical University. N.E. Bauman, created to implement a digital approach to the "rapid" and "end-to-end" design, development, testing and application of new materials and substances. The NTI Center is forming a national database of data and knowledge on materials and their "digital twins", which ensures the receipt of "digital passports" and accelerated certification of new materials.

27. BRIEF ON URAL INTER-REGIONAL RESEARCH AND EDUCATION CENTER (UIREC)

About the center

The Center was created within the framework of the national project "Science" and combines the potential of educational and scientific organizations, enterprises and companies in the real sector of the economy in conducting applied scientific research and world-class development.

The Center unites the potentials of educational and scientific institutions and organizations of the real economy sector of the Sverdlovsk, Chelyabinsk and Kurgan regions in conducting world level applied research and designs, obtaining competitive technologies and products and their subsequent commercialization, as well as training for solving scientific and technological problems pursuing a goal of breakthrough development in priority areas and increasing the competitiveness of the economies of the subjects in the perimeter of the center.

The project of the scientific and educational center is being implemented in conjunction with projects to create world-class scientific centers on the basis of the Ural Branch of the Russian Academy of Sciences and the innovative scientific and technological center "Tatishchev"

GOALS AND OBJECTIVES OF THE CENTER

1. Strategic goal

Leadership in the creation of advanced production technologies and new materials

- Aerospace complexes
- Innovative transport systems
- Resource-saving energy
- Eco-friendly production technologies and waste disposal

2. Mission

Ensuring balanced advanced development of the leading industrial regions of the country

- Sverdlovsk region
- Chelyabinsk region
- Kurgan region

HOW THE CENTER WORKS

1. Research

Formation of consortiums with the Ural Branch of the Russian Academy of Sciences and other leading world scientific and educational organizations

2. Innovation

Use of advanced innovation and implementation (technoparks, innovation infrastructure of universities) infrastructure of the regions

3. Technology Entrepreneurship

Use of advanced technological and industrial (Tatishchev INTC, industrial parks, SEZ) infrastructure of the regions

4. Markets

Manufacture and launch products in new markets in partnership with International leaders

PARTNERS: 09 Universities, 10 Scientific Organisations, 47+ Industry Partners

1. Education -

- Ural Federal University
- South Ural State University
- Kurgan State University
- Ural State Mining University
- Ural State Law University
- Chelyabinsk State University
- Technical University UMMC
- Magnitogorsk State Technical University
- Ural State Medical University

2. Scientific organizations

- Institute of Mathematics and Mechanics. N.N. Krasovsky Ural Branch of the Russian Academy of Sciences
- Institute of Organic Synthesis. and I. Postovsky Ural Branch of the Russian Academy of Sciences
- Institute of Physics of Metals named after M.N. Mikheev Ural Branch of the Russian Academy of Sciences
- Institute of Metallurgy, Ural Branch of the Russian Academy of Sciences
- Institute of Solid State Chemistry, Ural Branch of the Russian Academy of Sciences
- Institute of Electrophysics UB RAS
- UB RAS
- Institute of High Temperature Electrochemistry, Ural Branch of the Russian Academy of Sciences
- Institute of Mechanical Engineering, Ural Branch of the Russian Academy of Sciences

3. Industrial Partners -

- i-TOR LLC
- FutureLab LLC
- Ural Optical and Mechanical Plant named after E.S. Yalamov JSC
- High Technologies LLC
- EKSI Research & Production Company JSC
- ROTEC JSC
- General Staff LLC
- M-Profile LLC
- AKSALIT Soft LLS
- UmGorod-LLC
- Ural Diesel Engine Plant LLC
- Scientific Production Association Of Automation Association of Automatics Named after Academician N.A.Semikhatov JSC
- Megahim-Project LLC
- NPO Kurganpribor JSC
- ENERGOTECH-Ejector LLC

4. External Partners -

- Troitsk Institute for Innovative and Fusion Research
- Makeyev Design Bureau of State Rocket Center
- Science and Innovation JSC
- Proryv JSC
- Fanuk
- Siemens
- Ural Locomotives
- Roscosmos
- Rosatom
- Sinara Group
- VSMPO-AVISMA etc.

UIREC PRIORITY AREAS

1. Aerospace

- Reduction in space launch cost
- Improving Size, Weight and Power (SWaP) characteristics of aircraft

2. Ecology for cities and industry

- Minimizing environmental impact
- Waste management
- Quality of Life

3. New energy

- Improving energy efficiency and energy savings
- Increasing energy supply
-

BREAKTHROUGH PROJECTS

1. Aerospace -

Develop, design and build experimental prototypes of a propulsion system with a central body, an AI command and control system for a rocket and space complex with a fully-reusable launch vehicle and a Multipurpose Space Platform

Project novelty:

The rocket is fully reusable. The spacecraft payload cost - per-launch is four times lower than that of competitors. Launch preparation time -24 hours (for competitors – 4-6 months)

2. Ecology for cities and industry:

Building a scientific and industrial cluster for the design and production of high-speed rolling stock and urban transport

Project Novelty-

Development of new generation product families (platforms) and individual solutions for high-speed rail and urban transport. Development and implementation of new construction materials. Adaptation to local regulatory requirements and climatic aspects of sales markets composition.

3. New energy -
Advanced technologies for the nuclear industry

Project novelty -

Not-in-kind technologies:

- Sustainable closed - loop reprocessing of spent nuclear fuel using cutting - edge "dry" pyrochemical technologies
- Creating materials for a next generation molten salt reactor

ACHIEVEMENT / OUTCOME: 2021- 2022

- Increased R&D investment from the REC industrial participants
- Scale - up and fine - tune the Digital University model across REC educational institutions (educational platform)
- Tap the potential of the Competence Development Center aimed at the heads of research and science and technology projects and laboratories
- Build a system of technological entrepreneurship to convert research into viable commercial products
- Create a REC-based competence transfer network in the field of digital systems engineering
- Facilitate REC promotion in the professional and academic environment (both nationwide and overseas).