

**PROPOSAL
FOR THE RESEARCH,
DESIGN AND DEVELOPMENT
ACTIVITIES**





Proposal for the Research, Design and Development Activities

Contact us for suggestions:

Vice-Rector for Science
 Vladimir Kruzhaev
 Phone: (343) 375-48-90
 E-mail: vvkruzhaev@urfu.ru

Head for Interaction with Enterprises
 Sergey Yaroshenko
s.v.iaroshenko@urfu.ru

No	Activity	Purpose of the activity, expected results, the expected performers
1	Development of a voltammetric sensor based on carbon nanotubes for the identification of metal traces	<p>Currently in the production of voltammetric sensors (electrodes and sensors) carbon materials are widely used, since they are typical of chemical stability and a wide range of operating capacities. Carbon nanotubes are considered as a new generation electrode material, which along with the benefits inherent in conventional forms of carbon have a highly organised nanostructure, better electrical conductivity, large surface and a variety of electronic properties.</p> <p>As demonstrated in a number of works published in recent years, the modification of glassy carbon and thick-film electrodes (TFE) with carbon nanotubes (CNT) made it possible to lower the limits of detection of heavy metals by the anodic stripping voltammetry (SV). Taking into account the high adsorption capacity of CNTs, we first proposed the use of the material in the adsorption SV based on the adsorption concentration of the complex compound of the ion of the determined metal with a selective metal organic reagent on the TFE surface.</p> <p>Due to the large specific surface area, good conductivity and high adsorption capacity of CNTs, the modified TFEs developed with the help of them will reduce the limit of detection of heavy metals in solutions by stripping voltammetry. Since no data on the effect of the geometric parameters of CNT (diameter, length, aspect ratio, number of layers etc.) on the sensitivity of electrodes are available, an important objective of the project is to study the impact of the morphology of CNTs on the analytical characteristics of the proposed electrodes.</p>

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2	Study of the catalytic properties of potassium thiocyanate, nickel salts (II) and cobalt (II) in the solution in an aprotic medium and gold and silver nanoparticles of different composition in an aqueous-organic emulsion for the electrochemical oxidation of cholesterol.	<p>The project is aimed at developing azymous receptors for the determination of cholesterol namely a synthesis of gold and silver nanoparticles of different composition (nanoalloys, and 'core-shell' particles), their immobilisation on the working electrode and a study of their electrochemical reactions in the aqueous-organic emulsion, a study of the electrochemical transformation of nickel and cobalt and potassium thiocyanate in an aprotic medium and catalytic electrochemical reactions occurring in the presence of cholesterol. The novelty of the proposed project consists in forming on conductive substrates (based on carbon-containing electrodes and modified carbon nanotubes) of the fundamentally new azymous receptors containing metal nanoparticles, potassium thiocyanate or nickel salts (II) or cobalt (II) followed by the catalytic electrochemical oxidation of cholesterol and receipt of an analytical signal. Data will be obtained on the mechanism of electrochemical transformations of new receptors with the desired properties, catalytic electrochemical reactions and effect of several parameters on their course.</p> <p>In this project, cyclic voltammetry methods will be used for a better understanding of the processes occurring at the electrode-solution interface.</p> <p>In the course of the project implementation it is expected:</p> <ol style="list-style-type: none"> To synthesise gold nanoparticles (AuNP), silver (AgNP), gold-silver nanoalloys (Ag/AuNP) and 'core-shell' nanoparticles (Ag@AuNP and Au@AgNP) to be used as electrocatalysts for the electrochemical oxidation of cholesterol. To study the electrocatalytic activity of gold nanoparticles (AuNP), silver nanoparticles (AgNP), gold-silver nanoalloys (Ag/AuNP) and the 'core-shell' nanoparticles (Ag@AuNP and Au@AgNP) immobilised on the surface of the working electrode in the aqueous organic emulsions, potassium thiocyanate and the salts of nickel (II) and cobalt (II) in the solution volume in an aprotic medium.

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3	Creation of effective heat transfer and temperature control systems based on heat pipes to cool thermally charged elements in different areas of the industry (LED lighting, space vehicles, supercomputers, nuclear power, lasers etc.	<p>The innovative idea of the project: Two-phase thermal control systems with the capillary and (or) gravitational mechanism for coolant transport</p> <p>The uniqueness of the project: No additional sources of energy to transfer the coolant, simplification of the technology to produce cooling (temperature control) systems, an innovative system for the collection, transport and release of heat, low power consumption, price, weight and size properties, high reliability and long life due to the absence of mechanical components</p>
4	Development of thermally stable precision casting alloys	<ol style="list-style-type: none"> Development of precision casting alloys for the manufacture of parts with a pre-determined temperature coefficient of linear expansion (TCLE) from $0.5 \times 10^{-6}K^{-1}$ to $8.5 \times 10^{-6}K^{-1}$ in the temperature range of 20-1000 C, the reduced TCLE in the temperature range from 20 -200 °C to 20-500 °C and the increased corrosion resistance with respect to the technical requirements for the material parts of ships and submarines Development of casting technologies for new alloys <p>Development of technologies for the manufacture of welded-cast structures of new alloys</p>
5	Technology development of the hydropneumoabrasive surface treatment technology for removal of the oxidation film before welding. The effect of hydropneumoabrasive surface cleaning on the coating's adhesion properties.	<ol style="list-style-type: none"> Study of the impact of the hydropneumoabrasive surface preparation on weld quality. Comparison of adhesion properties between the coatings put on the surface obtained through hydropneumoabrasive cleaning and a classical method. Development of the hydropneumoabrasive equipment to remove oxide film before welding. Testing the hydropneumoabrasive surface cleaning modes depending on the strength properties of materials.

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6	Development of optimal manufacturing technologies to produce body sub-products	<ol style="list-style-type: none"> 1. Development of methods to optimise the cutting of sheet materials into the hull blanks 2. Development of algorithms for routing the tool for thermal material cutting machines with computer numerical control (CNC) 3. Development of software for the optimization of time and cost of cutting with CNC-controlled machines
7	Development of a maintenance-free meteorological set based on custom-tailored radioacoustic atmospheric sounding	<p>The system is designed to automatically collect meteorological data (wind speed profiles, wind direction, temperature, humidity and pressure). It is expected to develop a prototype of the compact mastless maintenance-free meteorological set based radioacoustic atmospheric sounding allowing for the remote non-contact measurement of wind and temperature profiles in the atmospheric boundary layer (up to 1 km), atmospheric humidity and barometric pressure and transmit the data via radio.</p> <p>Developer: The Ural Federal University named after the first President of Russia B. N. Yeltsin.</p>
8	Research into the protective properties of zinc-rich coatings and development of a method for producing metal powders, fillers	<p>Based on experimental studies and model description of the growth of dendritic deposits of zinc it is expected to choose the electrolysis conditions for finely divided precipitates, justify the choice of the polymeric binder and carry out a comparative analysis of the properties of zinc-rich tread compositions.</p> <p>The use of powder obtained through electrolysis will reduce the critical volume fraction of the pigment in the paint and coatings composition by 3 times while maintaining the protective properties and electrical conductivity of coatings</p>

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9	Development of a method to evaluate the resistance of steel to local forms of corrosion	<p>The pitting and local corrosion are especially dangerous because of the complicated detection. Affections in this type of corrosion occur only in some places, and are accompanied by small losses in weight but lead to perforation of the pipe wall and the occurrence of an emergency.</p> <p>In the developed method, the pitting resistance of steels is determined by the results of a series of research. At a certain anode potential there can be recorded periodic current oscillations which is characterized by the formation of pits. A mathematical analysis of current oscillations will develop and determine a criterion for pitting</p>
10	Research into cavitation to improve the efficiency of chemical, petrochemical and biochemical technologies	<p>Identification of mechanisms to improve the chemical, petrochemical and biochemical technologies under the cavitation influence of optimal parameters.</p> <p>Development of projects and production of prototype models of equipment.</p>
11	Development of methods for monitoring and evaluation of the technical condition of sophisticated technological systems	<p>Identification of the data parameters characterising the technical condition of the sophisticated man-made objects.</p> <p>Development of systems for the collection and monitoring of the data parameters characterising the technical condition of the sophisticated man-made objects.</p> <p>Development of algorithms for processing the measurement data collected by monitoring systems.</p> <p>Development of software tools for the analysis of measurement data and evaluation of the technical condition of sophisticated technological systems.</p>

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12	Contactless radio-wave sensor for the measurement of vibration parameters and displacements	<p>Creation of a radio-wave proximity sensor to measure vibration and movement of objects under the low- and very high temperature conditions or in the corrosive and explosive environments over long distances.</p> <p>The idea of development: the use of non-linear multi-frequency radar in conjunction with artificial non-linear scatterers located at controlled points (dimensions 1÷2 cm in diameter, 0.1÷0.2 mm thick, resistant to the temperature of thousands of degrees) and provide a measurement range up to 100 m, and the viewing angle of tens of degrees.</p> <p>Application: measurement of dynamic vibrations during testing and launching at several test points of the object at the same time.</p>
13	Development of an automatic system for the contactless measurement of geometrical parameters of large items during manufacture	<p>The system is designed for the automatic contactless measurement of the geometrical parameters of large-sized items used in production, control of the maximum dimension of bulky cargo in transportation systems etc. It is expected to develop a prototype system, which, based on optical proximity sensors, enables instant remote measurement of the geometrical parameters of large products with high precision, the transmission of data to the automated production control system over a communication channel and through a radio channel as well.</p>
14	Development of a technology for coating of metal compounds on the polymer film surface by ion-plasma sputtering	<p>Purpose of the work: To develop a technology for metal compound coating by ion-plasma sputtering on the surface of thin polymer films.</p> <p>Designation: The developed composite materials have applications in various industries. The nanocomposite track membrane production is one of the project of this direction. It could be used in the processes of gas filtration, selective electrochemical filtration of solutions etc. (the enterprises in the area of gas production, oil production, as well as those of the radiochemical, environmental, hydrogeological and microbiological profile).</p>

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15	Development of a technology for the creation of composite films and coatings with specific physical and chemical properties applied through plasma methods	<p>Purpose of the work: To develop composite films and coatings with specific physical and chemical properties applied through various plasma methods</p> <p>Designation: Composite films and coatings to be applied by plasma methods for different purposes: protective, strengthening, biocompatible, hardness, wear-resistant, heat-resistant, corrosion-resistant.</p>
16	Integrated optimisation of energy consumption for a remote residential facility in order to ensure sustainable energy supply through alternative renewable energy sources	<p>Performed is a comprehensive optimisation of energy consumption remote for a residential facility which includes the optimisation of architectural and planning solutions, the issues related to the choice of thermal protection materials for the facility, the selection of the optimal voltage level of the (internal) power network, the selection of an optimal level of power including the need for back-up heat and electricity. Developed is an optimal structure of energy supply for the facility by a combination of different energy units and systems</p>
17	Research into the wave potential of seas and oceans based on the research of the wave buoy	<p>Purpose of the work: Obtaining the wave energy map for seas and oceans.</p> <p>Designation: Development of a multi-purpose wave energy generator for different areas of the world ocean.</p>
18	Technology to build a combined robotic unit designed to ensure the operation of the river transport, harbour basins and fairway.	<p>Development of a flexible technology to create algorithms and software providing integrated management of the distributed systems. The units allowing unified connection to decision support systems include a set of stand-alone and/or remote-controlled stations for monitoring, process control subsystem for communication, analysis of the state and response to changing circumstances. The proposed functionality encompasses meteorological, hydrological, environmental and event-related tasks (for search and rescue operations) monitoring the fairway and water areas of the river basin.</p>

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