ITMO

CATALOGUE

RESEARCH AND TECHNOLOGY

ITMO

Vladimir Nikiforov

Professor, Doctor of Technical Sciences,
Vice-Rector for Research at ITMO University

The sphere of innovative technologies has become the driving force behind the development of the global economy and a priority for our country's advancement.

Information technologies have been integrated into almost all areas of human activity, including but not limited to such spheres as economics, art, and social environments.

ITMO University has been showing outstanding results in scientific research for many years and holds a leading position in science and education, maintaining high standards and setting directions for the community's development. The University's research and development focuses on scientific and technical areas such as quantum and photonic technologies, robotics and sensors, artificial intelligence and information technologies, as well as biochemical systems and materials.

The University's scientists are also working on diversifying research into socially significant areas, including medicine, ecology, and urban planning.

To expand its partner network and rejuvenate its interaction with industry, the Science and Business Partnership Center has been established. This center is responsible for comprehensive interaction with both Russian and international companies based on principles of open network collaboration and their integration into the University's ecosystem. Additionally, the Technology Transfer Center operates within the university to manage the process of transferring technologies and implementing innovations. Therefore, ITMO University not only preserves its traditions as a major scientific and educational center, but also actively develops new research areas and strengthens international cooperation.

ITs MOre than a UNIVERSITY

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НАУКА
И УНИВЕРСИТЕТЫ
НАЦИОНАЛЬНЫЕ ПРОЕКТЫ РОССИИ

ITMO
TECHNOLOGY TRANSFER CENTER

ABOUT THE CENTER

As part of the federal project “Development of large-scale scientific and technological projects in priority research areas” under the national project “Science and Universities”, ITMO University was recognized as the winner in 2021 of the competition for federal grants in the form of subsidies to support the creation and development of technology transfer centers, which commercialize the results of intellectual activities from research and educational organizations.

OUR GOAL is to promote commercialization of scientific developments by bringing together researchers, entrepreneurs and investors to create and implement innovative products, services and processes that improve the quality of people’s lives, help overcome great challenges, and are aimed at implementing the strategy of scientific and technological development of the Russian Federation and ensuring technological leadership.

OUR SERVICES

MARKETING AND FINANCIAL SERVICES

- Market research: analyzing the market, competitors and consumers, pricing strategies
- Financial modeling and Business modeling
- Complex “packaging” of projects
- Preparation of investment transactions
- Assessment of investment attractiveness of the technological component of the project
- Technological foresight, acceleration and hackathons

LEGAL SERVICES

- Counterparty verification and due diligence, compliance
- Patentability and patent purity checks for intellectual property
- Consulting and methodological support
- Preparation of contracts and agreements
- Legal support for the transfer process

SCIENTIFIC AND TECHNICAL EXPERTISE

- Assessment of the novelty and uniqueness of the technology/development
- Search for technological analogs and competing organizations
- Feasibility study of the project
- Preparation of techno-economic justifications

INTELLECTUAL PROPERTY DEFENCE

- IP valuation
- Patent Landscape
- Patent Search
- Development of patent strategy
- Preparation of application documentation for registration of IP objects

NATIONAL CENTER FOR COGNITIVE TECHNOLOGIES

The National Center for Cognitive Technologies is a National Technology Initiative (NTI) competence center focused on advancing the cross-cutting technology of “Machine Learning and Cognitive Technologies.” Established in May 2018 under the leadership of ITMO University as part of a consortium of leading Russian organizations in science, industry, and higher education, the center was created in accordance with the Russian Government Resolution No. 1251 dated October 16, 2017.

The center primarily performs engineering functions with the mission to develop a balanced domestic ecosystem for the design, deployment, and scaling of AI-driven technologies to create high-tech products and services demanded across various industries.

The National Center for Cognitive Technologies specializes in developing and customizing advanced digital solutions with AI elements tailored to specific requirements:

- Development of PoC (Proof of Concept) and MVP (Minimum Viable Product) solutions (TRL 5-8)
- Scientific consulting and expertise
- 6 instrumental platforms for the deployment and support of AI systems

PLATFORMS

- Platform for creating intelligent systems based on big data
- Platform for enhancing human-computer interaction
- Platform for managing computer models
- Platform for intelligent technologies in mixed reality
- Platform for advancing smart city technologies

PARTNERS

- PJSC Sberbank
- LLC Gazprom Neft Science & Technology Center
- LLC Rocket Group
- V. A. Almazov National Medical Research Center

RESEARCH CENTER “STRONG ARTIFICIAL INTELLIGENCE IN INDUSTRY”

The Research Center “Strong Artificial Intelligence in Industry” was established at ITMO University in 2021 as part of the federal project “Artificial Intelligence” and in accordance with the Russian Government Resolution No. 1120 dated July 5, 2021.
The center focuses on developing and applying AI technologies to address new classes of tasks that are typically within the domain of creative activities performed by industry specialists (designers, engineers, managers). These tasks involve technical objects and processes that are specific to industrial enterprises.

PROJECTS

- iOpt: A framework for heuristic intelligent optimization methods
- FEDOT.Industrial: An open-source framework for automated machine learning
- PROTO LLM: A framework designed to accelerate the development and implementation of AI systems
- AutoTM: Software for automatic hyperparameter tuning of topic models using additive regularization
- Akela digital assistant
- SAMPO: Software for adaptive optimization of production process planning
- GEFEST: A library for generative design of physical objects represented as geometric structures interacting with continuous media

PARTNERS

- PJSC Gazprom Neft
- PJSC Tatneft
- PJSC Rosneft
- PJSC Sberbank

NATIONAL CENTER FOR QUANTUM INTERNET

In 2019, as part of the federal project “Digital Technologies” within the national program “Digital Economy of the Russian Federation” and under Russian Government Resolution No. 551 dated May 3, 2019, ITMO University partnered with JSC Russian Railways to establish the leading research center, the “National Center for Quantum Internet”.

The National Center for Quantum Internet represents a robust domestic ecosystem for the development and deployment of quantum communications. These technologies serve as the foundation for creating high-tech products and services in emerging markets and driving the digital transformation of the industrial landscape. The center integrates quantum photonic technologies, the Internet of Things, wireless communication technologies, sensing systems, machine learning, and artificial intelligence.

PARTNERS

- JSC Russian Railways
- LLC SMARTS-Quanttelecom
- Skolkovo Institute of Science and Technology (Skoltech)
- LLC Amicon

LABORATORIES

- Quantum Communications Laboratory
- Software and Networking Systems Laboratory
- Atmospheric Communication Channels Laboratory

KEY PROJECTS

- Development of a main quantum network section connecting Saint Petersburg and Moscow
- Quantum network management and monitoring subsystem
- Digital platform-based hardware and software solution: “Quantum Communication Platform for the Digital Economy”
- Software suite for managing geographically distributed data centers, including hardware resource virtualization secured by quantum technologies
- Software for data exchange management between telecommunication nodes and dynamic routing in quantum networks using Software-Defined Networking (SDN) technology
- Quantum key distribution system utilizing continuous variables in sidebands of modulated radiation

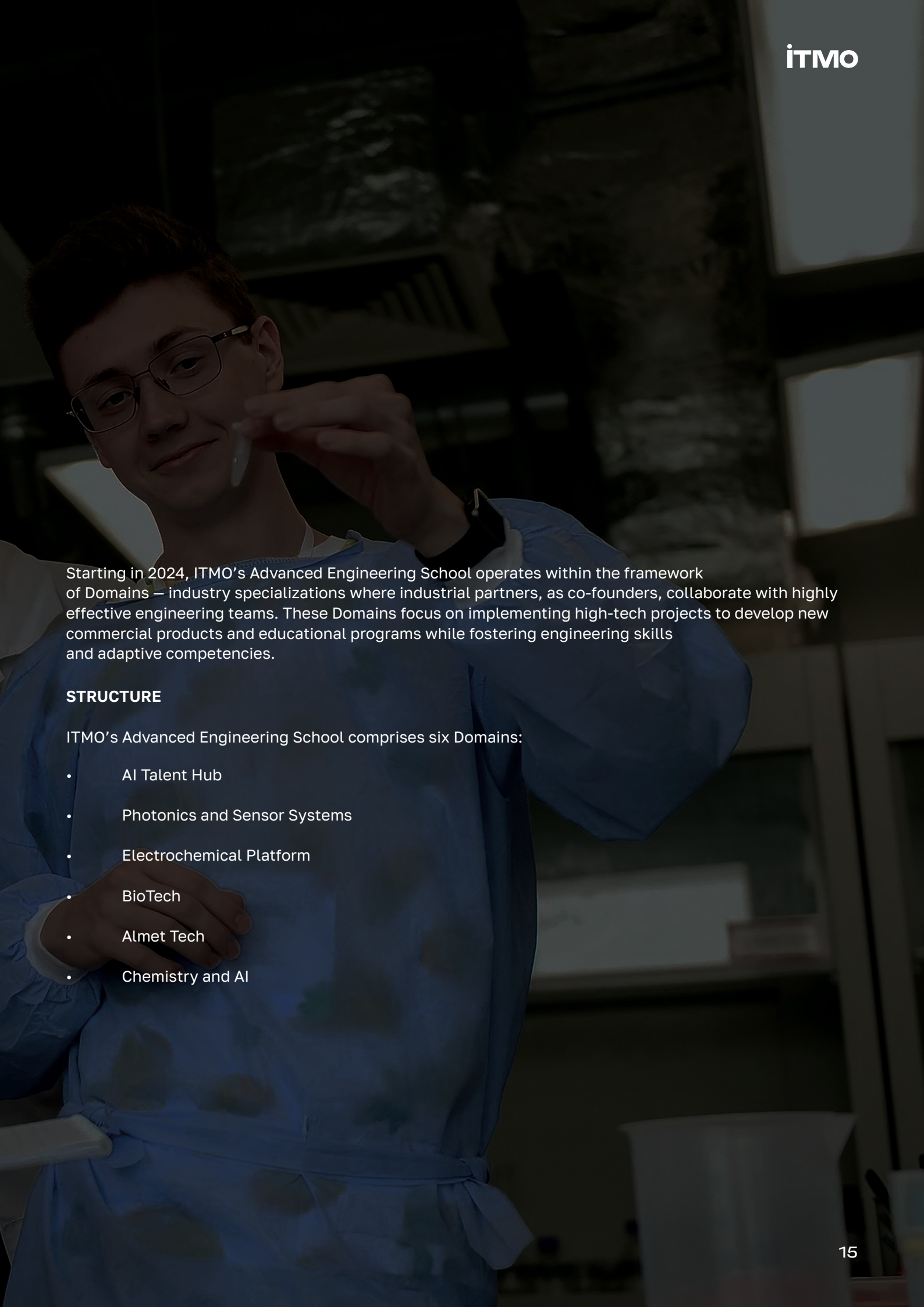
ADVANCED ENGINEERING SCHOOL

In 2022, ITMO University was named one of the 30 winners of the competition organized by the Ministry of Education and Science for establishing Advanced Engineering Schools at universities in collaboration with high-tech companies. ITMO's Advanced Engineering School for Interdisciplinary Engineering was launched in partnership with PJSC Tatneft.

One of the school's key focus areas is biotechnology, a rapidly growing research and educational domain at ITMO University. Over five years, the university has built a comprehensive infrastructure for cutting-edge chemical and biological research from scratch. It now operates 14 state-of-the-art laboratories, including facilities for applied genomics, molecular biology, cell biology, microbiology, applied nanopharmaceutics, and scaling processes.

PARTNERS

- PJSC Tatneft
- JSC UPT
- LLC Genotek
- LLC Biotech Campus
- JSC NPO Kripten
- PJSC Gazprom Neft
- PJSC Corporate Center X5 ("X5 Group")
- Sber AI Lab
- JSC Power Machines
- JSC Fiber Optic Systems



Starting in 2024, ITMO's Advanced Engineering School operates within the framework of Domains — industry specializations where industrial partners, as co-founders, collaborate with highly effective engineering teams. These Domains focus on implementing high-tech projects to develop new commercial products and educational programs while fostering engineering skills and adaptive competencies.

STRUCTURE

ITMO's Advanced Engineering School comprises six Domains:

- AI Talent Hub
- Photonics and Sensor Systems
- Electrochemical Platform
- BioTech
- Almet Tech
- Chemistry and AI

INNOVATIVE INDUSTRIAL CENTER
PJSC GAZPROM NEFT – ITMO UNIVERSITY

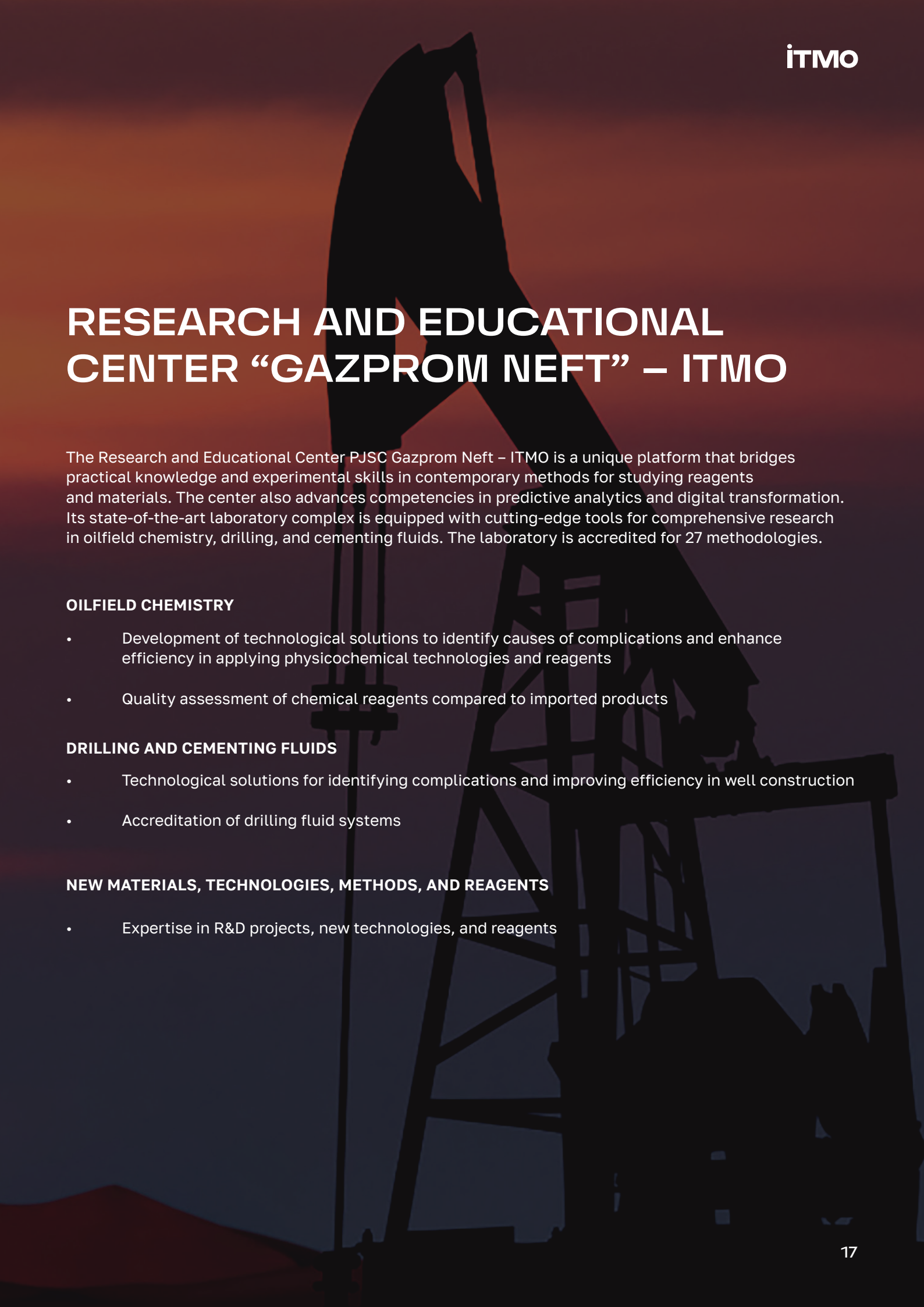
In 2022, ITMO University established the Innovative Industrial Center PJSC Gazprom Neft – ITMO University to conduct research and develop innovative products in cutting-edge and globally relevant fields aligning with the priority areas of technological development in the Russian Federation and aim to achieve technological sovereignty in the oil and gas sector. Additionally, the center focuses on training and integrating top-tier engineering talent and specialists for the sector's digital transformation.

KEY SCIENTIFIC AND TECHNICAL AREAS:

- Industrial Internet of Things (IIoT), sensor systems, and wearable devices
- Unmanned aerial vehicles (UAVs)
- Artificial intelligence and video analytics
- Robotics
- Quantum computing
- Software for industrial systems

PARTNER

- PJSC Gazprom Neft



RESEARCH AND EDUCATIONAL CENTER “GAZPROM NEFT” – ITMO

The Research and Educational Center PJSC Gazprom Neft – ITMO is a unique platform that bridges practical knowledge and experimental skills in contemporary methods for studying reagents and materials. The center also advances competencies in predictive analytics and digital transformation. Its state-of-the-art laboratory complex is equipped with cutting-edge tools for comprehensive research in oilfield chemistry, drilling, and cementing fluids. The laboratory is accredited for 27 methodologies.

OILFIELD CHEMISTRY

- Development of technological solutions to identify causes of complications and enhance efficiency in applying physicochemical technologies and reagents
- Quality assessment of chemical reagents compared to imported products

DRILLING AND CEMENTING FLUIDS

- Technological solutions for identifying complications and improving efficiency in well construction
- Accreditation of drilling fluid systems

NEW MATERIALS, TECHNOLOGIES, METHODS, AND REAGENTS

- Expertise in R&D projects, new technologies, and reagents

ARTIFICIAL INTELLIGENCE AND INFORMATION TECHNOLOGIES

The information technology market continues its rapid expansion, encompassing new domains such as environmental challenges, art, and the economy. In recent years, special attention has been devoted to artificial intelligence (AI), a symbol of progress and remarkable versatility in addressing diverse challenges. Significant strides have been made in the development of large language models (LLMs), which are nearing the capabilities of general AI. Trained on vast datasets, these models are becoming meta-crosscutting technologies capable of transforming various knowledge domains. The adoption of AI technologies is projected to boost global GDP by 14% by 2030.

ITMO University is conducting extensive research on a wide range of issues in the application of information technologies and the advancement of AI.

Key Achievements (2022–2024):

- Approximately 850 publications indexed in Scopus in the field of Computer Science, including Artificial Intelligence.
- 141 registered intellectual property objects.
- Total volume of AI-related R&D projects and services: USD 26 million.
- Overall R&D volume: USD 98 million.

Global and National Rankings:

- Ranked 51–70 globally in “Data Science and Artificial Intelligence” by QS.
- Ranked 78th globally in “Computer Science & Information Systems” by QS.
- Holds an A+ rating for AI specialist training quality by the Alliance for Artificial Intelligence.
- Leads national rankings in Computer Science and AI by the Expert Analytical Center since 2019.
- Second among Russia’s top technical universities for IT graduate salaries (Superjob rankings).

ITMO University stands out as the only Russian institution among the top 100 global universities in Data Science and Artificial Intelligence, showcasing its leadership in IT education and research.

CONTENTS OF THE SECTION

01
SOFTWARE

REMOTE CONTROL AND TECHNICAL SUPPORT SYSTEM FOR ORGANIZATION

DESCRIPTION

The InBetween software suite integrates the functions of a monitoring system and technical support program. The remote control and technical support system allows for real-time monitoring of the organization's infocommunication infrastructure and provides remote technical support, ensuring quick detection and resolution of issues.

The system consists of four components:

- Server side: Collects and stores data from client machines, transmitting it to operators
- User client side: Gathers data from computers and serves as the channel for technical support
- Operator client side: Allows the operator to provide remote technical support
- Mobile application: Enables remote monitoring of computer status even when outside the organization

ADVANTAGES OF THE DEVELOPMENT

- Adaptation to Russian conditions
- Flexibility and configurability
- Security
- User-friendly interface with multi-device support

SOFTWARE PLATFORM FOR MODELING THE OPERATION OF OIL AND GAS COMPLEX FACILITIES

02
PLATFORM

DESCRIPTION

The software platform is designed for modeling the stationary operational modes of oil and gas complex facilities, such as compressor stations, gas pipeline systems, gas processing units (UCPG), and others. It accounts for changes in external and internal operational conditions, including various equipment operating modes and gas composition. The platform enables simulation of facility operations for design, current, and future modes across different seasons of the year.
The software integrates a set of mathematical models for system components, such as compressors, turboexpander units, heat exchangers, separators, shutoff and control valves, dehydrators, and pipelines, into a unified digital platform.

ADVANTAGES OF THE DEVELOPMENT

The platform allows for the creation of digital twins of oil and gas complex facilities with high accuracy in predicting system parameters, including dynamic equipment.

CHARACTERISTICS

- Prediction accuracy: ±2%

APPLICATION AREAS

- Oil and gas industry
- Manufacturing

03
SERVICE

OPTIMIZED DATABASE FOR CHEMICAL LABORATORIES AND PRODUCTION

DESCRIPTION

The web service is designed for searching chemical compounds, including methods for their synthesis and articles describing these methods.
The service aims to optimize the work of researchers in the chemical field at all stages of research, from data collection to the development of new methods and substances. As a result, the process of developing new compounds and working with necessary substances becomes more efficient, contributing to the advancement of chemical technology and related fields such as biotechnology, the food industry, ecology, and pharmaceuticals.
The centralized chemical database includes both compounds and synthesis methods, with references to original sources. By consolidating all reactions and compounds, researchers no longer need to search through a vast number of sources, each containing endless information. Instead, they can simply enter the required compound in the search bar and get all the relevant information, particularly the reactions that can be used to synthesize it.

CHARACTERISTICS

- Number of compounds in the database: At least 1 million
- Number of reactions in the database: At least 1.2 million
- Number of articles and/or article references: At least 400,000
- Query execution speed: No more than 500 ms
- Maximum number of simultaneous users: No more than 1,000

APPLICATION AREAS

- Pharmaceutical and food laboratories
- Educational institutions

ADVANTAGES OF THE DEVELOPMENT

This structured database with multiple entities addresses the issue of information overload in chemistry. The entities, namely “compound” and “reaction,” are automatically populated using a machine learning model that extracts both the compound and the reaction related to it from articles. This approach allows all useful information for a chemist to be collected in one database. Current open-access search engines (e.g., PubChem or SciFinder) only have the entity “compound” and lack information about reactions, which are crucial in chemical development. Thus, chemists can learn about physical properties, toxicity, etc., but not about the possible reactions to obtain that compound.

This database is more informative than existing solutions, as it fills a gap in available chemical data. Additionally, most search engines today (PubChem, SciFinder, ChemSpider, ChemSynthesis) rely on manual data entry, which leads to errors and duplicates. The manual process also hinders the timely updating of data, as thousands of articles are published monthly, making it physically difficult to process all of them. The machine learning model used in this service automates the extraction of data from articles, speeding up the process of compiling information about reactions and compounds, thereby creating an up-to-date chemical database. The database uses the Neo4j graph database to establish connections between entities, replacing traditional relational databases. This allows faster searches and better visualization of data. Currently, no chemical databases employ this approach.

04
SOFTWARE

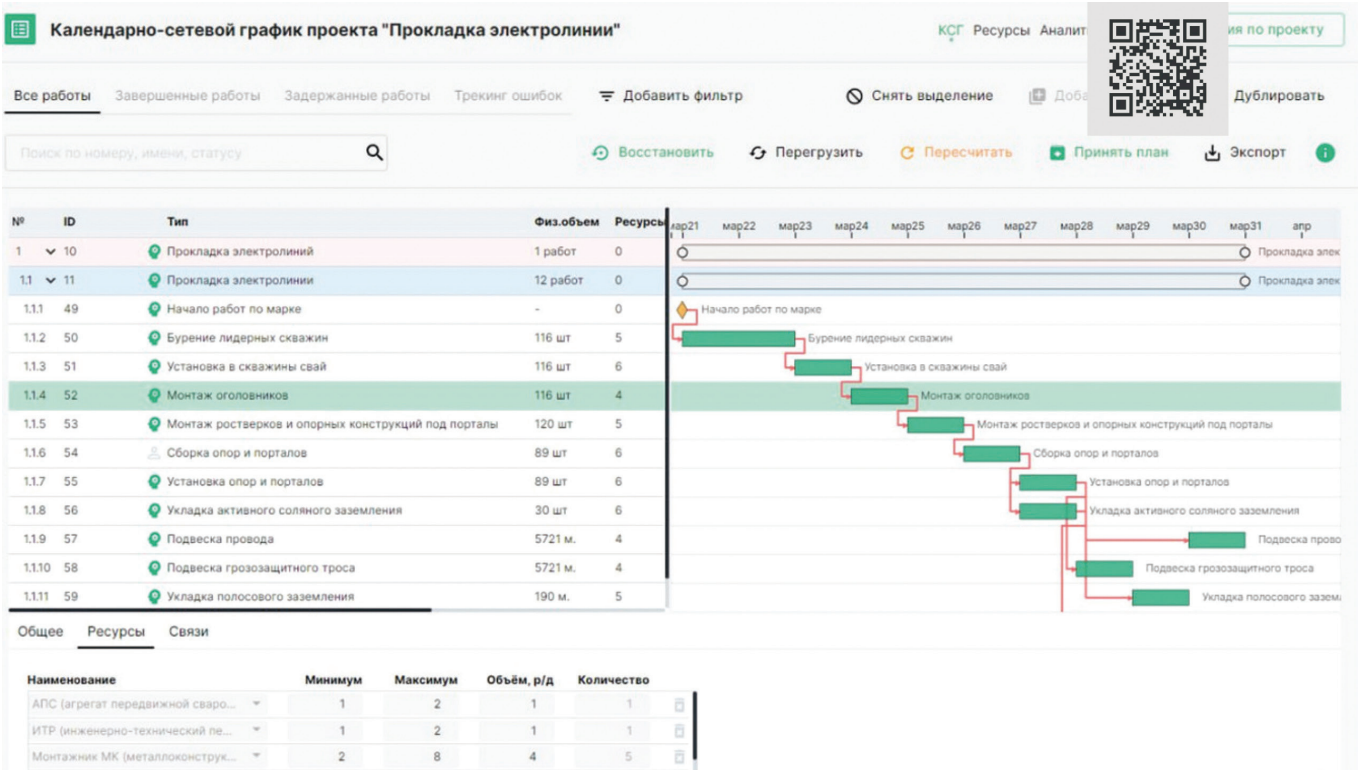
“AKELA”: DIGITAL CORPORATE EXPERT

DESCRIPTION

The software enables the creation of digital assistants for various industry sectors based on large language models. The key areas of application include assisting professionals in industry-specific business processes, training and auditing personnel, generating synthetic data and knowledge, and thematic modeling. When using the product, the user can create an industry-specific query (e.g., related to safety in production) in natural language and receive a generated response from the assistant, which includes domain-specific information and references to the original blocks of the knowledge base.

ADVANTAGES OF THE DEVELOPMENT

- No need for intensive training processes: The software uses zero-shot learning based on RAG (Retrieval-Augmented Generation) principles
- Fast integration into business processes: Quick deployment in the company’s operations
- Multi-domain capability: The ability to work across different departments simultaneously, if needed
- Accelerated decision-making processes and optimization of the unified knowledge base structure



INTELLIGENT DECISION SUPPORT SYSTEM FOR INDUSTRIAL BUSINESS PROCESS PLANNING

05
SYSTEM

DESCRIPTION

The system is designed to optimize the planning of industrial business processes over long time horizons under conditions of uncertainty and incomplete data. It analyzes a set of target project indicators, retrospective project timelines, and generates a set of validated project schedules for different implementation strategies that align with the target indicators.

APPLICATION AREAS

- Extractive and processing industries
- Construction
- Power engineering

ADVANTAGES OF THE DEVELOPMENT

- Automation of strategy and planning tactic selection
- Planning horizons and scales
- Speed of constructing and validating optimal project schedules
- Increased efficiency of plans, reducing labor costs

06
SYSTEM

INTELLIGENT DESIGN AND OPERATION SUPPORT SYSTEM FOR INDUSTRIAL FACILITIES AND STRUCTURES IN THE ARCTIC

DESCRIPTION

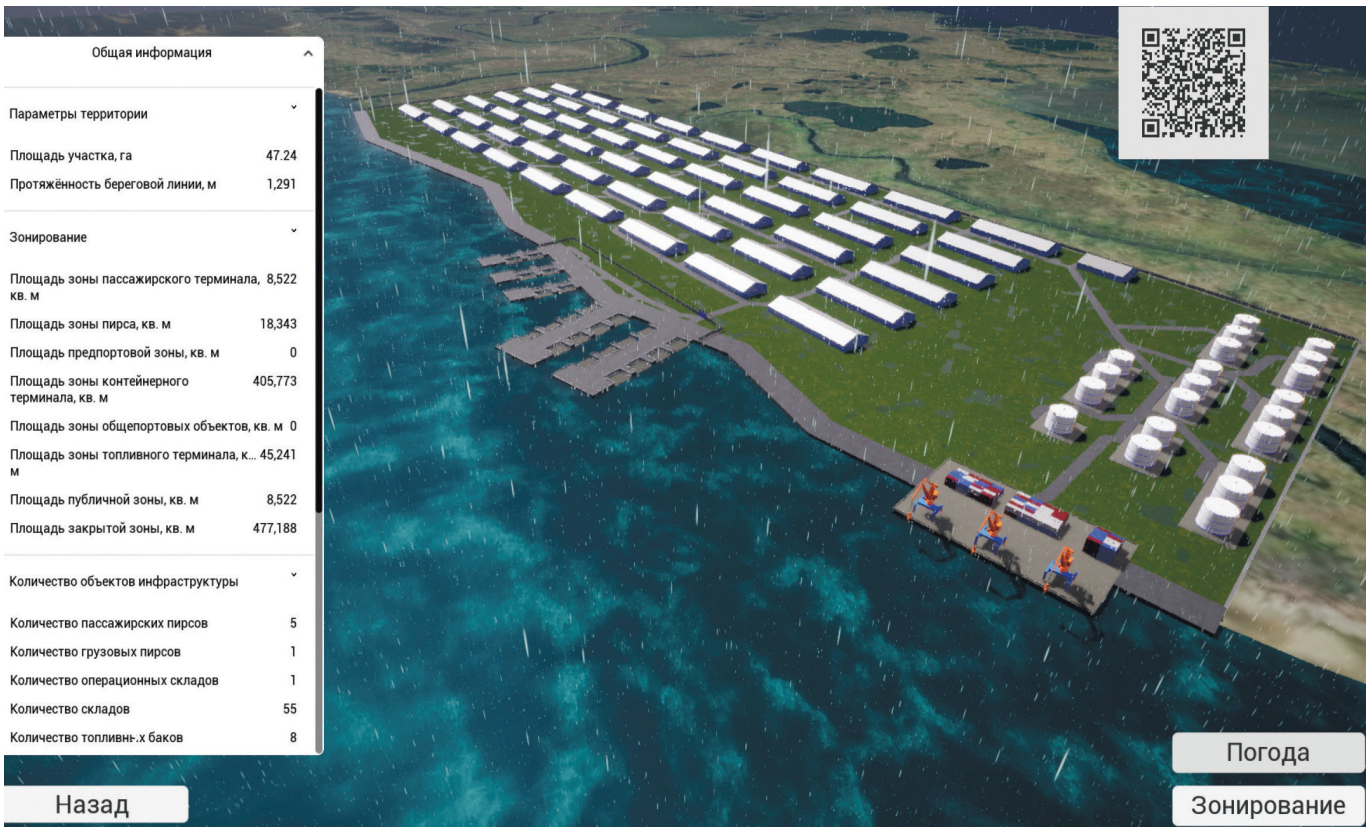
This system is designed for conceptual design of port industrial-logistical complexes in the Arctic zone using generative design methods. Its goal is to assess the development potential of the territory and select fundamental technical and architectural solutions. The software analyzes the boundaries of the territory, the regulatory framework for construction and operation, and creates a digital model of the industrial facility along with a list of technical-economic indicators of the project.

APPLICATION AREAS

- Construction
- Transportation
- Environmental protection

ADVANTAGES OF THE DEVELOPMENT

- Rapid generation of multiple alternative scenarios (digital models) for the development of the territory based on various input data and conditions
- Automatic accounting of operational and extreme environmental conditions (temperature, wind, wave, ice characteristics) during design
- Optimization of design solutions taking into account the regulatory framework applicable in the given region
- Reduction of the conceptual design stage by a factor of 10



LABOR RESOURCE AVAILABILITY FORECASTING SYSTEM FOR INDUSTRIAL ENTERPRISES IN RUSSIA

07
SYSTEM

DESCRIPTION

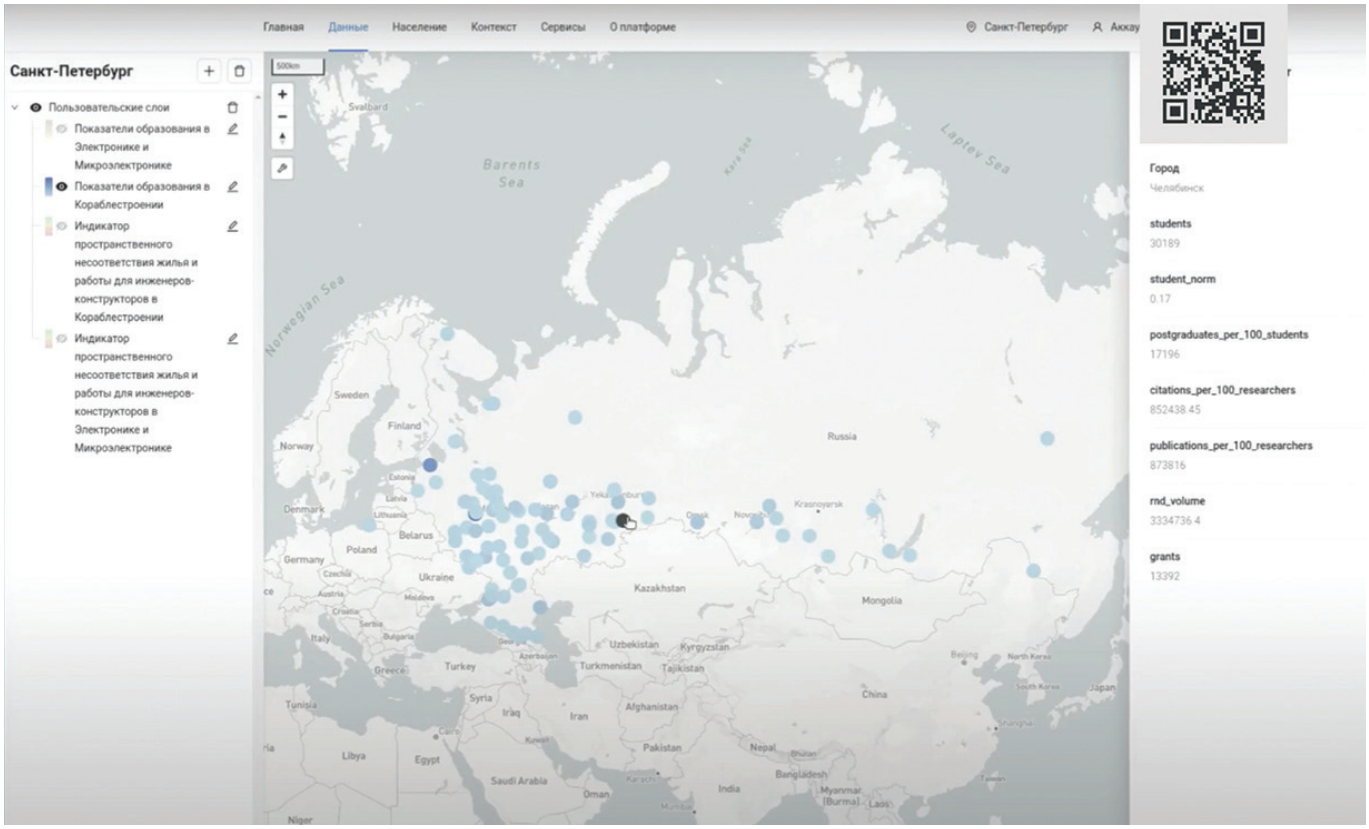
This system is designed to objectively assess the availability of labor resources for the organization of new productions in a specified area, determine the feasibility of managing labor migration, including taking into account transport accessibility, and identify conditions that contribute to the sustainability of the enterprise's workforce potential (living conditions, logistics). The system analyzes open data from Federal State Statistic Service, Russian research data infrastructure platform, the Ministry of Labor, the Ministry of Education and Science, transportation aggregators, and HR companies, forming characteristics of workforce availability and the socio-economic factors that define them (for specific enterprises).

ADVANTAGES OF THE DEVELOPMENT

- Ability to compare the development potential of different industries based on the competencies of available labor resources
- Multi-level model of workforce potential
- Accounting for both objective and subjective factors in the dynamics of labor resources
- Reduction of staff turnover by 10–40% (depending on the industry and region)

APPLICATION AREAS

- Government and municipal management
- Industry



08
PLATFORM

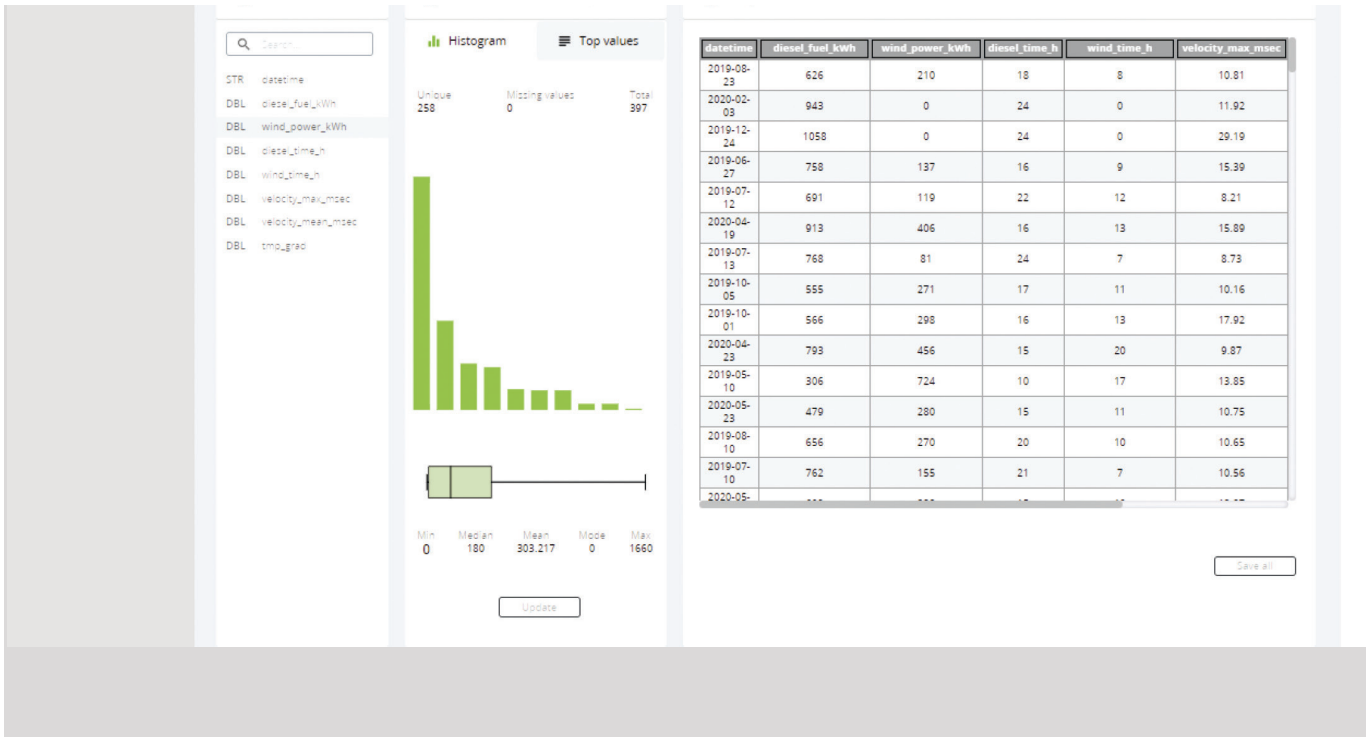
DISTRIBUTED INSTRUMENTAL PLATFORM FOR DEVELOPMENT AND SUPPORT OF DIGITAL ARTIFICIAL INTELLIGENCE OBJECTS BASED ON BIG DATA

DESCRIPTION

The platform is designed to support the full lifecycle of machine learning model creation projects based on big data. It enables efficient organization of the workspace, management of model development and training processes, and utilization of distributed computational resources of various architectures. By analyzing the source data, including task formulation, data sets, available computational power, and the development team, the platform creates a trained and documented machine learning model that can be successfully implemented on distributed computing resources.

ADVANTAGES OF THE DEVELOPMENT

- Support for projects with a flexible role model and organized workspace on top of the distributed computational infrastructure for model development and training
- Effective management of distributed computing resources using “hot” containerization
- Efficient storage and preprocessing of distributed large data sets, considering their structural and semantic specifics
- Reduction of development time by up to 20% and an increase in the efficiency of distributed computational resource usage by 1.5 to 2 times



DATAMALL: INSTRUMENTAL PLATFORM FOR MANAGING THE USE OF INDUSTRY-SPECIFIC BIG DATA

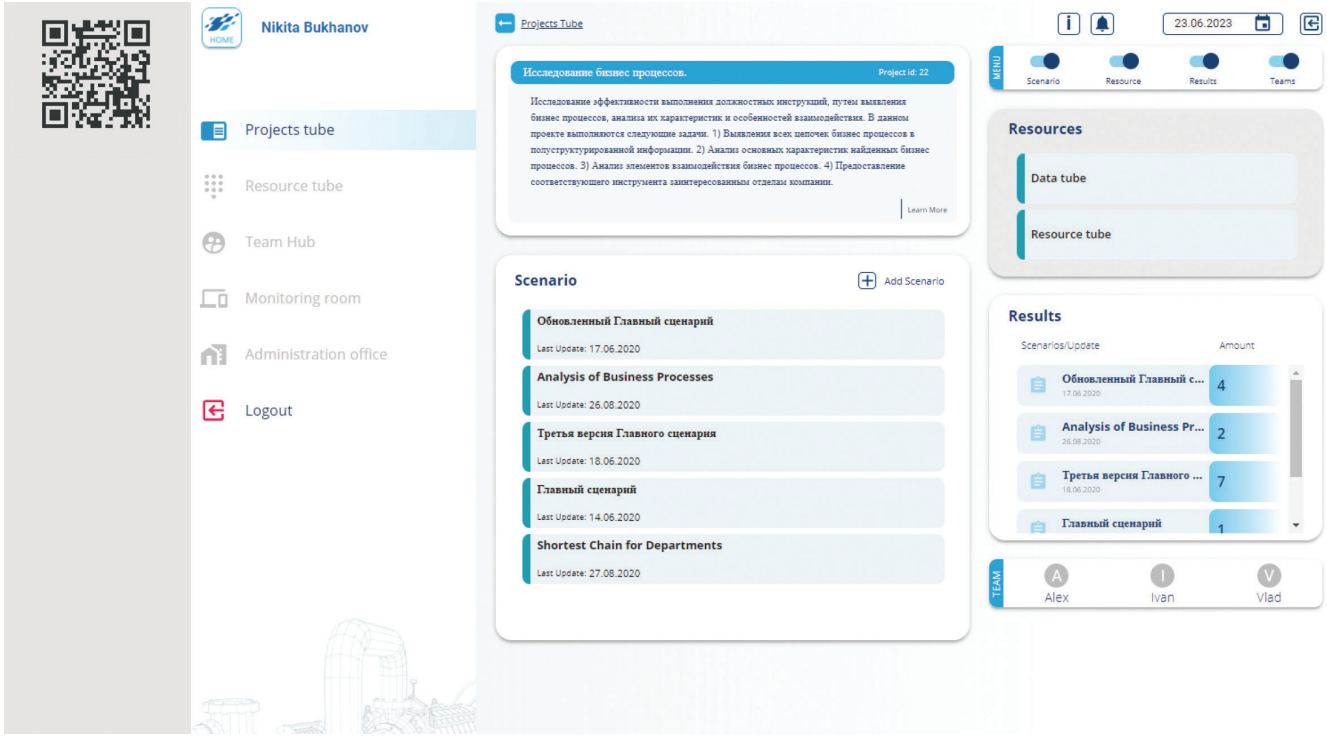
09
PLATFORM

DESCRIPTION

The platform is designed for creating customized industry-specific systems for managing big data processes (including aggregation, sales, and use in AI model creation, etc.), implemented by multiple entities (organizations, project teams, individual developers). After analyzing the requirements for organizing the industry system, specifications of typical projects, and mechanisms for accessing data sets, the platform generates a unified image of the big data set and a set of standardized tools for its usage by the stakeholders.

ADVANTAGES OF THE DEVELOPMENT

- Transparent mechanisms for controlling stakeholders' work with big data, including AI model training
- Integration capability with modern batch and stream big data management systems (Hadoop, Yarn, Storm, Spark, etc.)
- Support for collaborative project execution by distributed teams of contractors
- Reduction of overhead costs



10
FRAMEWORK

FEDOT.INDUSTRIAL: FRAMEWORK FOR AUTOMATIC MACHINE LEARNING FOR INDUSTRIAL TASKS

DESCRIPTION

The framework is designed to automate the development of predictive models for technical systems throughout their lifecycle using evolutionary optimization methods. It supports tasks such as forecasting, classification, and anomaly detection for univariate and multivariate time series, as well as spatiotemporal fields of various natures. FEDOT.Industrial analyzes data reflecting the functioning of technical systems (time series, tabular data, images, text) and outputs an optimized and trained predictive model.

ADVANTAGES OF THE DEVELOPMENT

- Ability to transfer neural network models to computing systems of different architectures (including adaptation and compression)
- Composite structure allowing integration of data processing blocks specific to particular domains into the model
- Automated solution for a wide range of AI tasks in industry
- Acceleration of processes by 10–25 times

APPLICATION AREAS

- Information technology

FEDOT+LLM: HYBRID AI SYSTEM COMBINING AUTOMATIC MACHINE LEARNING AND LARGE LANGUAGE MODELS

DESCRIPTION

FEDOT+LLM is a flexible interface between the user and AutoML, partially replacing AI developers. The user simply describes the task related to data processing in free form, and the system, through a dialog interface, will request additional information, clarify the task, translate it into understandable development terms, write the code, and interpret the results.

This system is the first to use language models at multiple stages of machine learning: initial data collection from the user via a dialog interface, analysis of the obtained data, and result interpretation. AutoML is configured using generative AI based on LLM, and the originality of solutions is achieved through adaptive evolutionary software.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11

PLATFORM

SMILE.CLOUD PLATFORM FOR RAPID PROTOTYPING, DEVELOPMENT, AND TRAINING OF DATA MODELS

DESCRIPTION

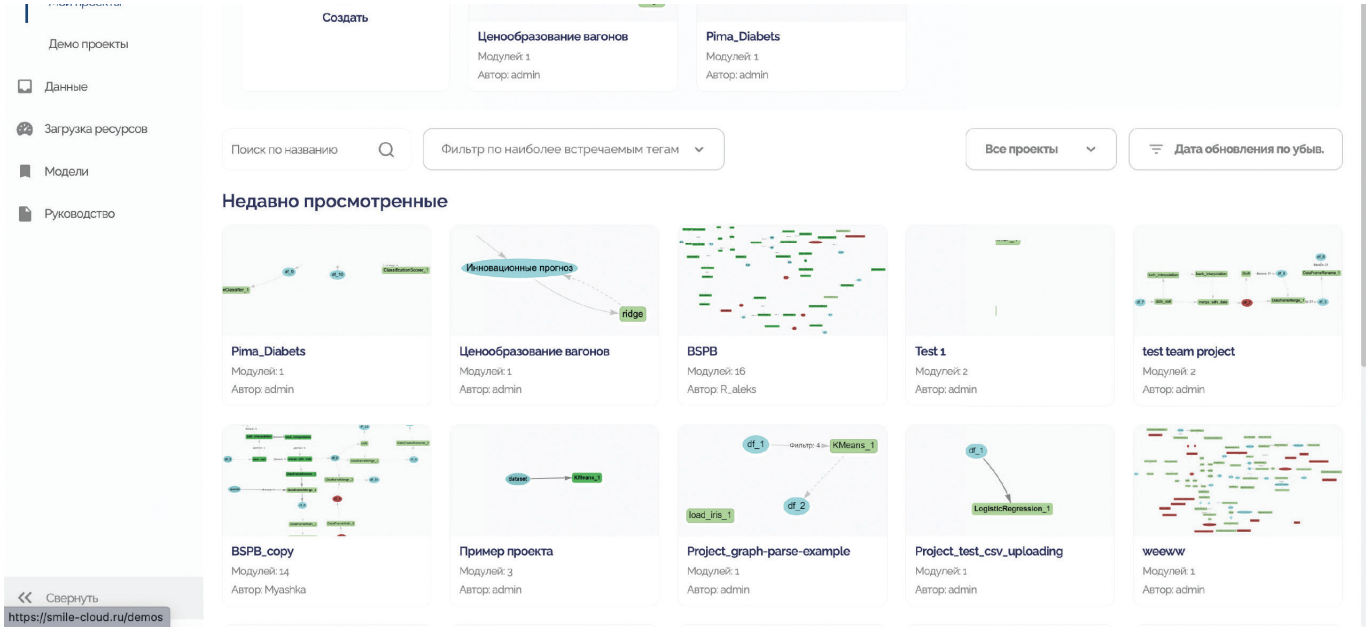
The platform facilitates rapid development, research, and training of various AI models using data provided by industry specialists who lack programming experience or familiarity with machine learning libraries. It also eliminates the need for high-performance computing resources. Based on the data array, a trained composite AI model is generated.

APPLICATION AREAS

- Energy sector
- Healthcare
- Education
- Defense and security
- Finance
- Industry

ADVANTAGES OF THE DEVELOPMENT

- No-code interface: Perform all operations with the model without programming, including advanced data preprocessing and visualization tools
- Customization options: Tailor the platform to specific industries and integrate open-source AI libraries and proprietary models
- Automated model structuring: Automatically constructs the optimal model architecture



INTELLIGENT SYSTEM FOR ASSESSING THE RELIABILITY OF EXPERT OPINIONS “EXPERT”

12
SYSTEM

DESCRIPTION

The system is designed for automated video content analysis using a multimodal approach to assess the reliability and consistency of public speeches, including the detection of manipulations and deepfakes. By analyzing video content (public speech recordings), the system evaluates performances based on criteria such as congruence, aggression, confidence, and coherence. It also calculates an overall trust measure and assesses the probability of deepfake usage.

APPLICATION AREAS

- Media and journalism
- Government and municipal administration
- Education
- Defense and security

ADVANTAGES OF THE DEVELOPMENT

- Versatility in applications: Communication analytics, deepfake detection, speech preparation, personal skills evaluation, and educational content validation
- Efficient resource management: Optimized use of distributed computing resources via «hot» containerization
- Data storage and preprocessing: Advanced handling of large, distributed data arrays, tailored to their structural and semantic characteristics
- Proof-based evaluation: Enables evidence-based assessment of the reliability of publicly expressed opinions

13 SIM4REC: GENERATIVE AI LIBRARY FOR TRAINING RECOMMENDER

LIBRARY

DESCRIPTION

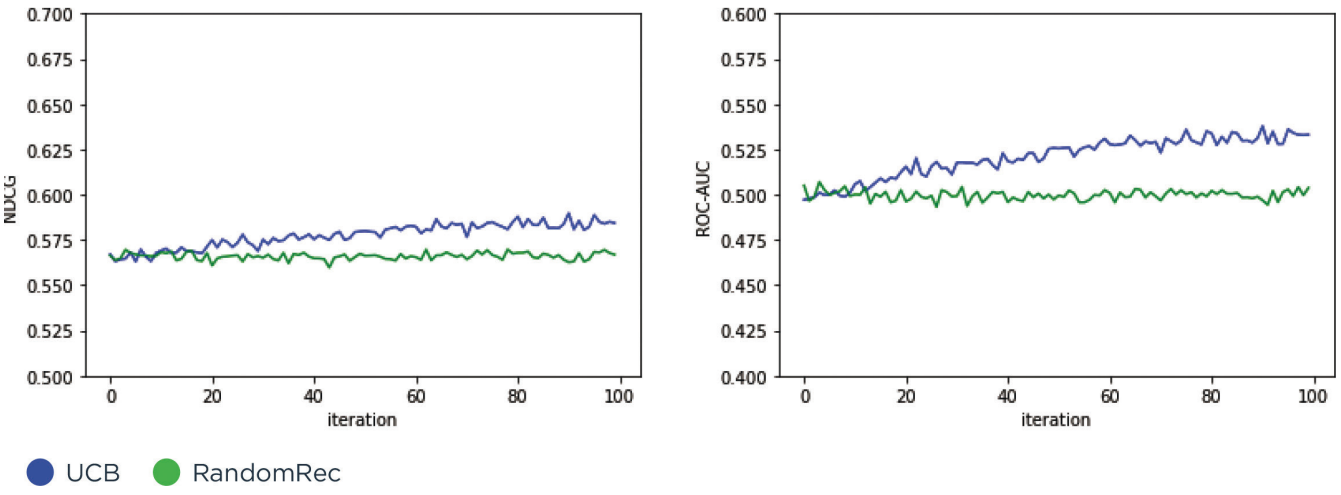
SIM4REC is designed to create synthetic datasets that simulate user behavior in service provision processes (e.g., customers of banks, marketplaces, food services, and entertainment sectors). These datasets are used for training, testing, and benchmarking recommender systems. Based on aggregated data about the socio-demographic structure of users and service processes, the library outputs a trained recommender system or testing/comparison results of different systems.

ADVANTAGES OF THE DEVELOPMENT

- Individual user response modeling: Tailored to socio-demographic characteristics and economic conditions
- Ease of adaptation: Supports diverse interaction mechanisms
- Behavior prediction: Includes forecasts of user behavior changes, including in crisis scenarios
- Efficiency: Reduces training time for recommender systems by 4–6 times and halves the number of users dissatisfied with recommendations during the training phase

APPLICATION AREAS

- Retail
- Service and entertainment industries
- Financial sector



“A-FARM”: A FRAMEWORK FOR MULTISCALE FORECASTING OF THE POPULATION’S FINANCIAL BEHAVIOUR

14
FRAMEWORK

DESCRIPTION

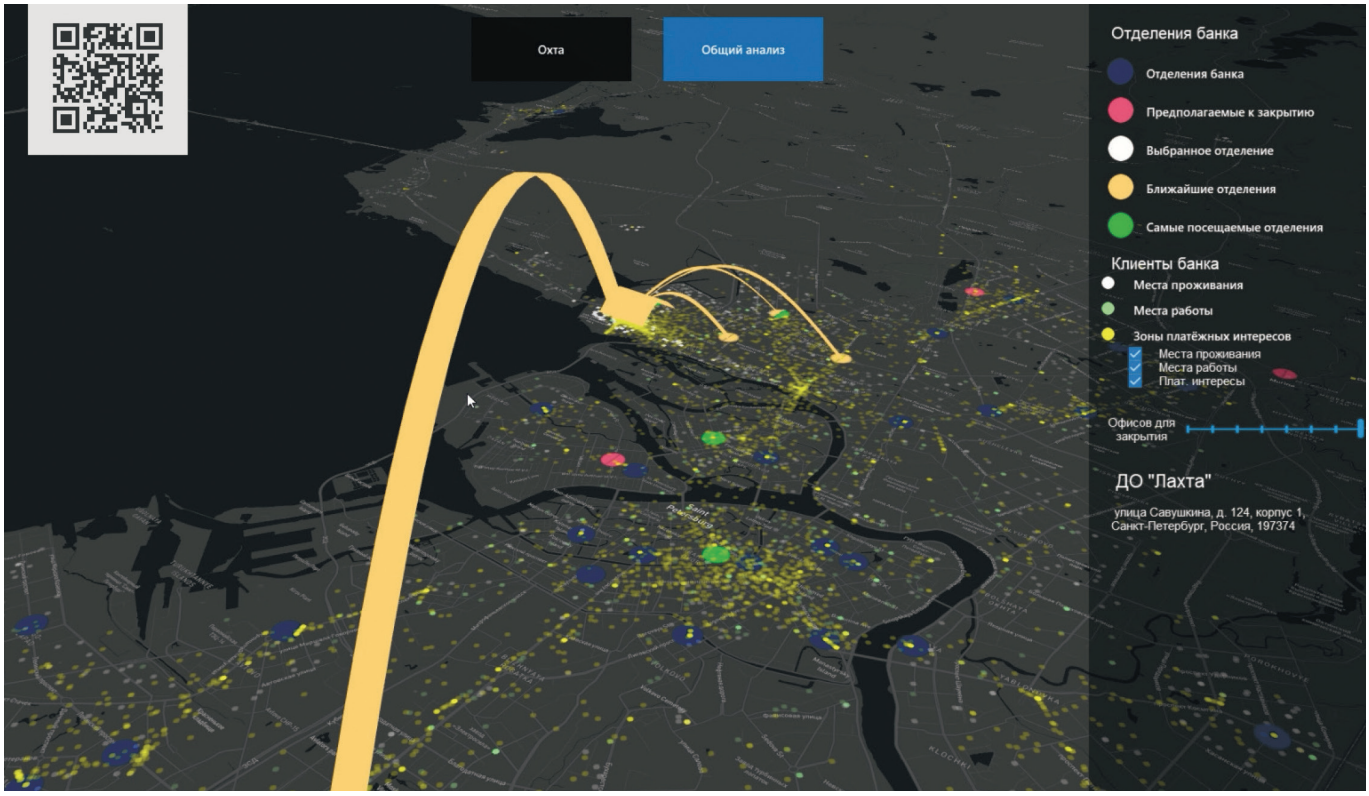
The framework is designed for forecasting behavioral economics processes at both the population level (district, city, region) and the individual level in various macroeconomic scenarios, including crises driven by external and internal factors. By leveraging aggregated data on the socio-demographic structure of the population, macroeconomic indicators, and crisis scenarios, the framework predicts transactional activity across various interest categories.

ADVANTAGES OF THE DEVELOPMENT

- Smart consumer model: Customizable individual characteristics
- Comprehensive context integration: Accounts for informational (news) background, advertising, and macroeconomic context
- Crisis resilience: Effective performance during sharp changes in national circumstances (e.g., COVID-19, geopolitical events)

APPLICATION AREAS

- Financial sector
- Retail
- Government and municipal administration
- Urban planning



15
PLATFORM

DIGITAL URBAN PLANNING INSTRUMENTATION PLATFORM AND A COMPLEX OF SOLUTIONS FOR THE DEVELOPMENT OF URBANIZED AREAS

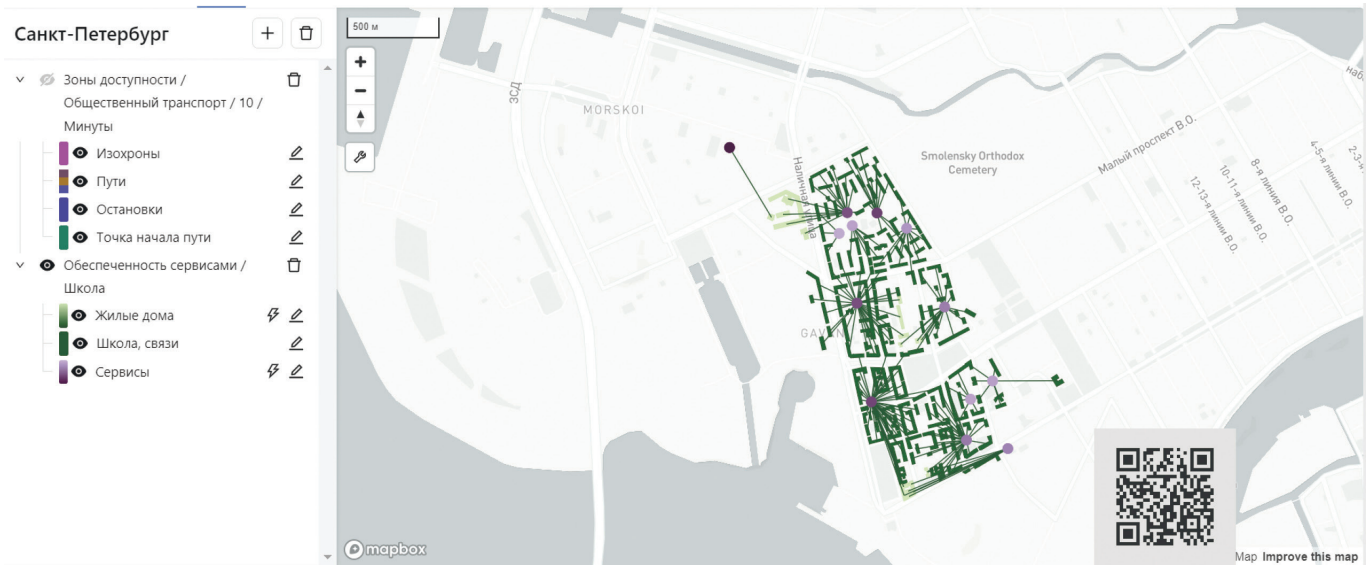
DIGITAL URBAN PLANNING INSTRUMENTATION PLATFORM

DESCRIPTION

The platform is designed to support the processes of comprehensive assessment and planning for the development of urbanized areas based on the information model of the city and population, using AI models on data. The platform performs a comprehensive assessment of the urban environment based on spatial framework data and other open data sources about the city, including social media and citizens' requests. The assessment focuses on metrics related to the population's access to urban services, the degree of support for citizens' values, and various life situations.

ADVANTAGES OF THE DEVELOPMENT

- Open (public) architecture allowing the platform to be enriched with data from different cities and regions
- A wide range of machine learning and spatial analysis models integrated into the digital model of the urban environment and population
- Scenario modeling capabilities for the development of the city ("if-then" scenarios)
- The fundamental possibility of constructing evidence-based models in urban planning
- Improved resource efficiency for urban development by 10–25%



COMPLEX OF SOLUTIONS FOR PLANNING THE DEVELOPMENT OF URBANIZED TERRITORIES BASED ON GENERATIVE DESIGN TECHNOLOGIES AND COMPUTER SIMULATION

DESCRIPTION

This complex is designed to support decision-making in the development of master plans, concepts, and projects for the arrangement, reconstruction, and development of residential, mixed-use, and recreational areas based on AI technologies. The system generates a digital model and master plan for the area based on the boundaries of the territory, the goals of the designer, and the regulatory framework. This includes data on the street-road network, functional zoning, proposed development, and landscaping.

ADVANTAGES OF THE DEVELOPMENT

- Rapid generation of digital models for the development of territories and their elements based on various inputs and conditions
- Comprehensive consideration of regulatory requirements, architectural and urban planning principles, as well as citizens' subjective requests, expectations, and values
- Economic assessment of the implementation of territory development projects
- A 20–50 times reduction in the labor intensity of project design

16
PLATFORM

ITMO.HACK 2.0: PLATFORM FOR ORGANIZING AI HACKATHONS

DESCRIPTION

The platform is designed to automate organizational and technological processes during AI and related digital technologies hackathons. It covers tasks such as team formation, data access, computational resource usage, task management, result evaluation, and participant ranking based on various criteria. For hackathon tasks and their corresponding datasets, a set of hackathon solutions (task code and quality metrics) is generated.

ADVANTAGES OF THE DEVELOPMENT

- Informal automatic result checking (including tracking the problem-solving process)
- Customization options for different industry tasks and formats (hackathon, olympiad, competition, contest, etc.)
- Rapid prototyping of solutions (baseline) using AutoML
- Reduction in labor intensity of organizing and conducting hackathons by 15–25%

APPLICATION AREAS

- Information Technology
- Education

POLAR SUBCODES: SCALABLE DATA NOISE PROTECTION METHOD

17
METHOD

DESCRIPTION

Interference-resistant coding methods simultaneously provide better error-correcting capability and simplify the decoding process compared to widely used LDPC and turbo codes. These methods allow flexible adjustment of encoding parameters (speed, length, error probability, decoding complexity) across a broad range of parameters.

ADVANTAGES OF THE DEVELOPMENT

Provides simultaneous improvements in both complexity and error-correcting ability compared to LDPC and turbo codes.

CHARACTERISTICS

The code (1024, 512) at Eb/N0 = 2 dB ensures an error probability of 2E-6 with a decoding complexity of 4.5E4 addition and comparison operations.

AREAS OF APPLICATION

- Satellite and mobile communications
- Wireless sensor networks
- Cyber-physical systems
- Internet of Things (IoT)
- Cryptography
- Telemedicine

OPEN-SOURCE LIBRARIES IN ARTIFICIAL INTELLIGENCE AND RELATED DIGITAL TECHNOLOGIES

The system of domestic open-source software libraries and frameworks in AI and related digital technologies is created by ITMO University to accomplish technological sovereignty targets. It is deployed on the resources located in the territory of the Russian Federation (with mirroring on Github) and is publicly available to all domestic developers of AI systems. The libraries contain advanced AI techniques related to technologies for creating autonomous objects, generative design, automatic machine learning, and working with incomplete and unlabelled data.

1442
stars for major repositories

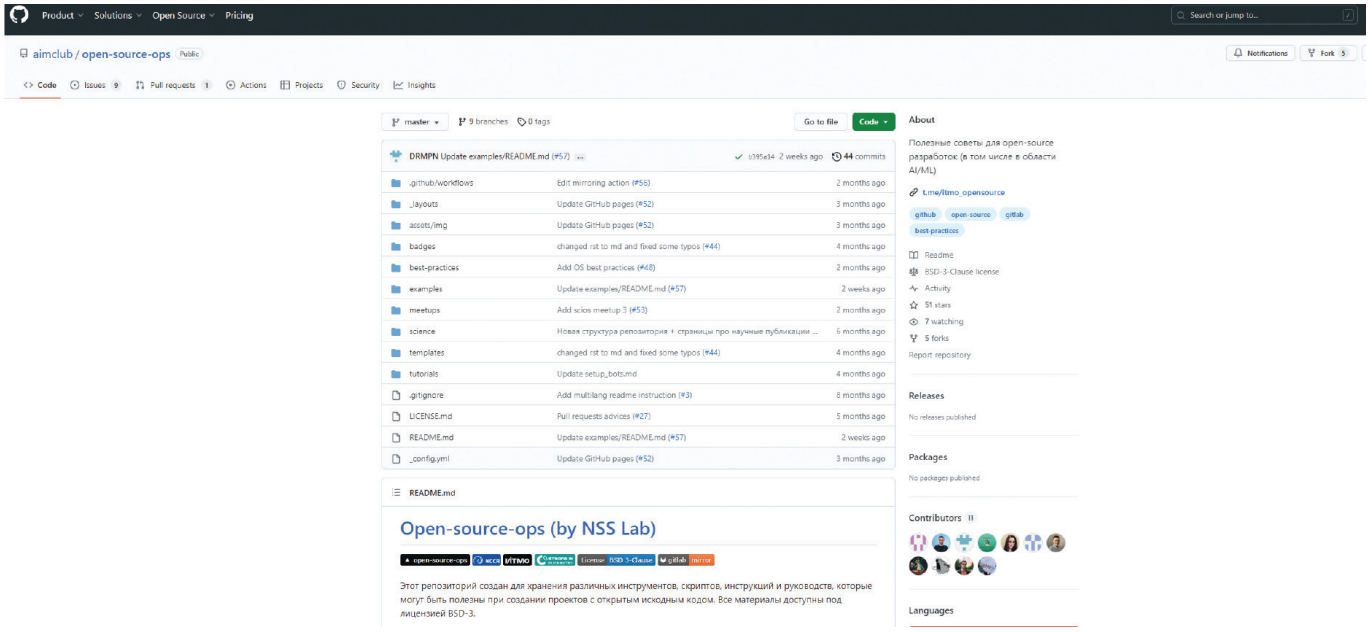
ITMO.OpenSource

ITMO.OPENSOURCE IS ONE OF THE FIRST RUSSIAN COMMUNITIES OF THE ACTIVELY DEVELOPING OPEN-SOURCE CODE TREND

ITMO.OpenSource was created on the basis of Research Center “Strong Artificial Intelligence in Industry” and unites the developers of open-source scientific software created both at ITMO University and outside it. The community creates the conditions for growth and development of talented specialists by popularizing the field of open-source solutions. The project team publishes popular science articles to draw the attention of a wide audience to the use and development of open-source software.

ITMO.OpenSource implements the ITMO Open-Source Mentorship Program, which helps creators of scientific projects to improve the quality of research and final products. The created repository stored on GitHub is a collection of various tools, scripts, instructions and tutorials that can be useful when creating open-source code projects. Various meetups, conferences and workshops, including the regular “Scientific Open-Source Meetup”, are giving researchers from different organizations the opportunity to meet, share experiences, news, findings and achievements, or debate.

A student club ITMO.OpenSource is helping budding specialists to expand their professional network, participate in events and conferences, develop skills and competencies, publish their work, and contribute to the development of open technologies. All communications of the community members take place in the Telegram chat.



FEDOT

AutoML framework to create composite data-based modelling pipelines to solve various tasks

FEDOT.Industrial

AutoML framework for predictive analytics in industrial tasks (time series and images)

iOpt

A framework for automated search of optimal hyperparameter values for complex data-driven mathematical models

EvoGuess

A library for searching decomposition sets and complexity estimates for variants of Boolean feasibility problems related to SAT tasks

GOLEM

A framework for optimising graph structures using metaheuristic methods

ASID

AutoML library based on small and unbalanced samples in tabular format

BAMT

A library for data modelling and analysis based on Bayesian networks, including their application for gap-filling, synthetic data generation, edge significance estimation, etc.

ReDKG

A library for encoding static and dynamic knowledge graphs by constructing vector representations of entities and relations based on reinforcement learning

GEFEST

A framework for automated design of physical objects interacting with continuous media

EPDE

A library for automated discovery of data-based models in the form of differential equations

SAMPO

A library for production process scheduling under the constraints imposed by the subject area based on multi-agent algorithms

StableGNN

A library for automated training and interpretation of graph neural networks under the scarcity of labelled data

Rostok

A framework for generative design of robotic systems (lever and locomotion)

ECG

A library of data analysis methods and AI for ECG processing (digital and analog)

WEB-BAMT

Visual tool for analysing multivariate distributions by constructing Bayesian networks

eXplain-NNs

A library of explainable AI (XAI) methods for analysing neural networks; allows estimating latent spaces and uncertainty

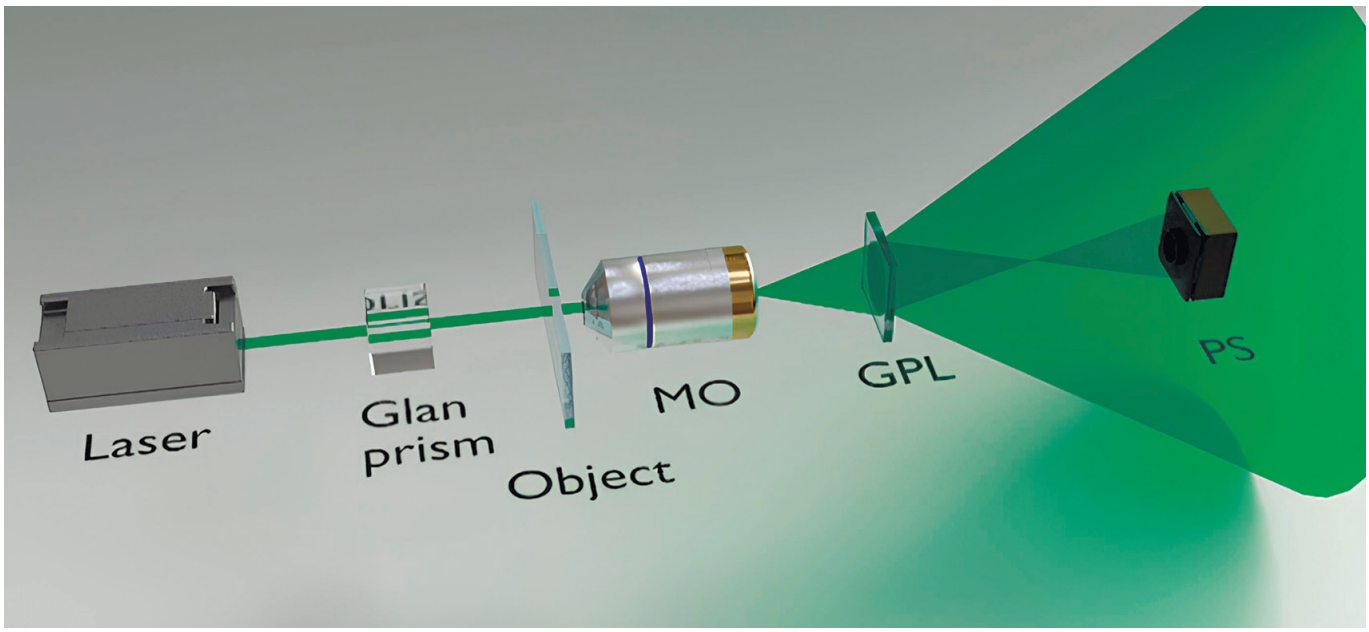
QUANTUM AND PHOTONIC TECHNOLOGIES

Quantum and photonic technologies are critically important fields in the development of science and technology, recognized as priorities in countries with advanced technological infrastructure. These areas cover a wide range of scientific research that permeates almost all aspects of human activity, from telecommunications and healthcare to large-scale manufacturing. The annual growth of the quantum and photonic technology market demonstrates an increase in production volume, which undoubtedly highlights its significant potential on the global stage and its importance for economic growth and technological progress.

The unique scientific profile of ITMO University, characterized by the combination of information, photonic, and cyber-physical technologies and their deep convergence, enables the university to participate in solving global challenges and diversify its research directions into many socially significant areas. Between 2022 and 2024, ITMO University published over 1,100 Scopus-indexed papers and registered 68 intellectual property objects in the field. The total volume of work and services performed by the university in photonics and quantum technologies from 2022 to 2024 amounted to USD 45 million. Ongoing research at institutions such as ITMO University demonstrates the potential of this field for future achievements in science and technology.

Quantum technologies are the foundation of the network security infrastructure of the future, and in the long term, they will be integrated into the “Internet of Things” concept, which will radically change the everyday technological landscape. The university is a technological leader in Russia in the field of quantum network communications (QNC). In 2013, a line of QNC systems was created, in 2015 ITMO University implemented the first quantum network in Russia, and in 2017, ITMO University, in collaboration with partners, successfully launched the first multi-node quantum network in Russia and the CIS in full operation.

CONTENTS OF THE SECTION



18 AXIAL HOLOGRAPHIC MICROSCOPE FOR PHASE VISUALIZATION

DEVICE

DESCRIPTION

Digital phase-shifting holography allows for the reconstruction of both amplitude and phase of the wavefront by recording the interference field. The device includes a lens with a geometric phase effect that helps split the incoming radiation into two beams, introducing phase delay and changing polarization. The microscope uses a polarization camera equipped with an array of micropolarizers at different polarization angles, which is coupled with an array of pixels on the camera. This allows for simultaneous recording of multiple interferograms with different phase shifts in a single exposure. Additionally, the device allows the use of low-coherence light sources for capturing digital holograms. The use of a single-arm interferometric setup ensures the device's resistance to external mechanical vibrations.

CHARACTERISTICS

The lateral resolution of the microscope for optically transparent micro-objects is no less than 1 μm.

ADVANTAGES OF THE DEVELOPMENT

- Capability to obtain both phase and amplitude images
- Speed of phase image reconstruction
- Vibration resistance
- Simplicity of the optical setup
- Ability for numerical focusing of the obtained image in post-processing mode

APPLICATION AREAS

- Research on biological objects and cells
- Study of the structure of transparent materials
- Measurement of three-dimensional sizes of objects with known refractive indices

COMPACT LENSLESS AXIAL HOLOGRAPHIC MICROSCOPE

19
DEVICE

DESCRIPTION

The microscope allows for obtaining images in different planes by applying computational algorithms for wavefront propagation in post-processing mode. This means that no mechanical fine focusing on the object is required, which ensures the formation of clear images of all objects in the frame at the moment of capture. This enables the study of many moving particles simultaneously while obtaining focused images and information about their three-dimensional positioning in space. The device can be used in a configuration with a flow-through cuvette. Additionally, this solution offers a significant advantage over traditional optical and other holographic microscopes in terms of lower cost, compactness, and simple design.

CHARACTERISTICS

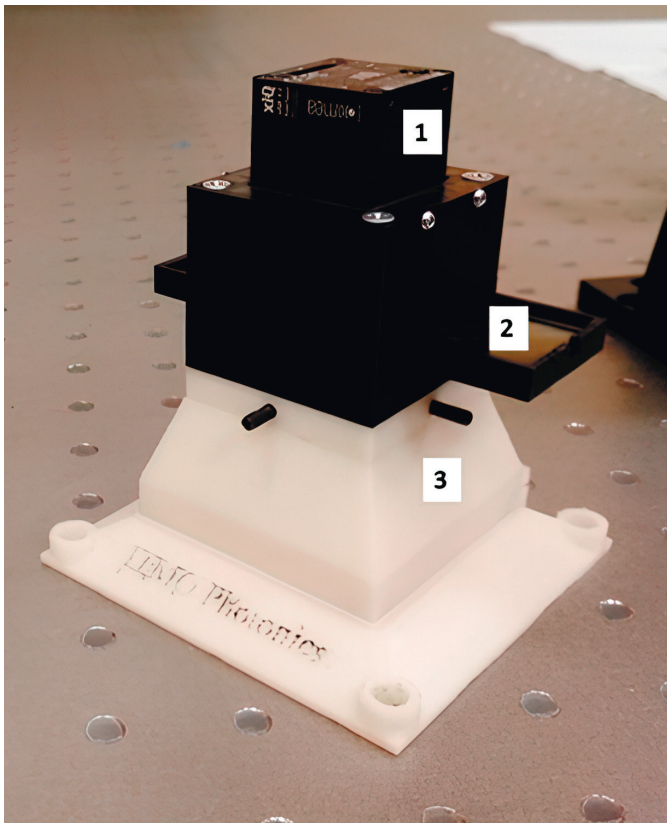
- Minimum resolvable object size: 1.43 μm
- Field of view: 1.45 mm × 1.82 mm

APPLICATION AREAS

- Study of biological objects
- Observation of moving objects
- Visualization of particles distributed in volume
- Holographic cytometry and particle tracking

ADVANTAGES OF THE DEVELOPMENT

- Price
- Compactness
- Simplicity of design
- Field of view size
- Ability for numerical focusing in post-processing mode
- No need for precise mechanical focusing during capture



Axial holographic microscope. Key elements: 1 – Camera, 2 – Sample holder, 3 – Pinhole.

20

DEVICE

HIGHLY RELIABLE RECONFIGURABLE FIBER OPTIC ERBIUM AMPLIFIER

DESCRIPTION

This two-stage fiber optic amplifier, based on the physical properties of optical fiber doped with erbium ions, provides a high level of signal amplification with low noise and uniformity of amplification. The device is characterized by long-term reliability. The amplifier's assembly method allows for partial replacement of its electronic or optical components, significantly improving its maintainability. The fiber-optic amplifier manufacturing structure, formed at ITMO University, serves as a foundation for scientific research, training high-level specialists, and creating jobs in the fields of fiber optics, electronics, and programming.

APPLICATION AREAS

- Fiber-optic communication lines

MULTIFUNCTIONAL RAMAN GAS ANALYZER WITH ULTRASPECTRAL ISOTOPIC RESOLUTION

21
DEVICE

DESCRIPTION

The multifunctional gas analyzer is designed to conduct spectral analysis of the isotopic composition of carbon dioxide (CO2), methane (CH4), and other gases. Thanks to its design, the device can be applied in a wide range of practical applications.

ADVANTAGES OF THE DEVELOPMENT

The main advantage of this analyzer is the absence of the need for sample preparation, unambiguous identification of gas components, and the ability to perform quantitative analysis of the investigated substance over a wide volume fraction range—from 0.01% to 99.99%. Moreover, analyzing the obtained spectrum of the examined gas allows for the determination of the chemical composition of each sample. This is achieved by simultaneously registering Raman signals from all molecular components (including centrosymmetric molecules) of the substance without destroying it.

CHARACTERISTICS

- Measurement range of the volume fraction of 12CO2: from 0.01% to 95%
- Measurement range of the volume fraction of 13CO2: from 0.01% to 95%
- Measurement range of the volume fraction of 12CH4: from 0.01% to 95%
- Measurement range of the volume fraction of 13CH4: from 0.01% to 95%
- Relative measurement error of the volume fraction: no more than 25%

APPLICATION AREAS

- Control of declared natural gas transportation
- Monitoring of the isotopic composition of greenhouse gases in atmospheric air
- Production of pure gases
- Quality control of petroleum feedstock

22 HIGH-Q OPTICAL FIBER FILTER FOR QUANTUM KEY DISTRIBUTION SYSTEMS

DEVICE

DESCRIPTION

High-Q fiber-optic filters are designed to reflect or transmit optical radiation with delay in fiber-optic communication lines. These devices provide high precision in wavelength selection, excellent reflectivity, reliability, and long service life.

The filters are produced using advanced technologies. The core structure consists of periodic refractive index modulation structures, induced in the core of optical fibers, known as fiber Bragg gratings, as well as various specialized structures based on them. Additionally, methods such as lithographic etching of silicon substrates and other techniques are used to create filters outside the internal structure of the fiber.

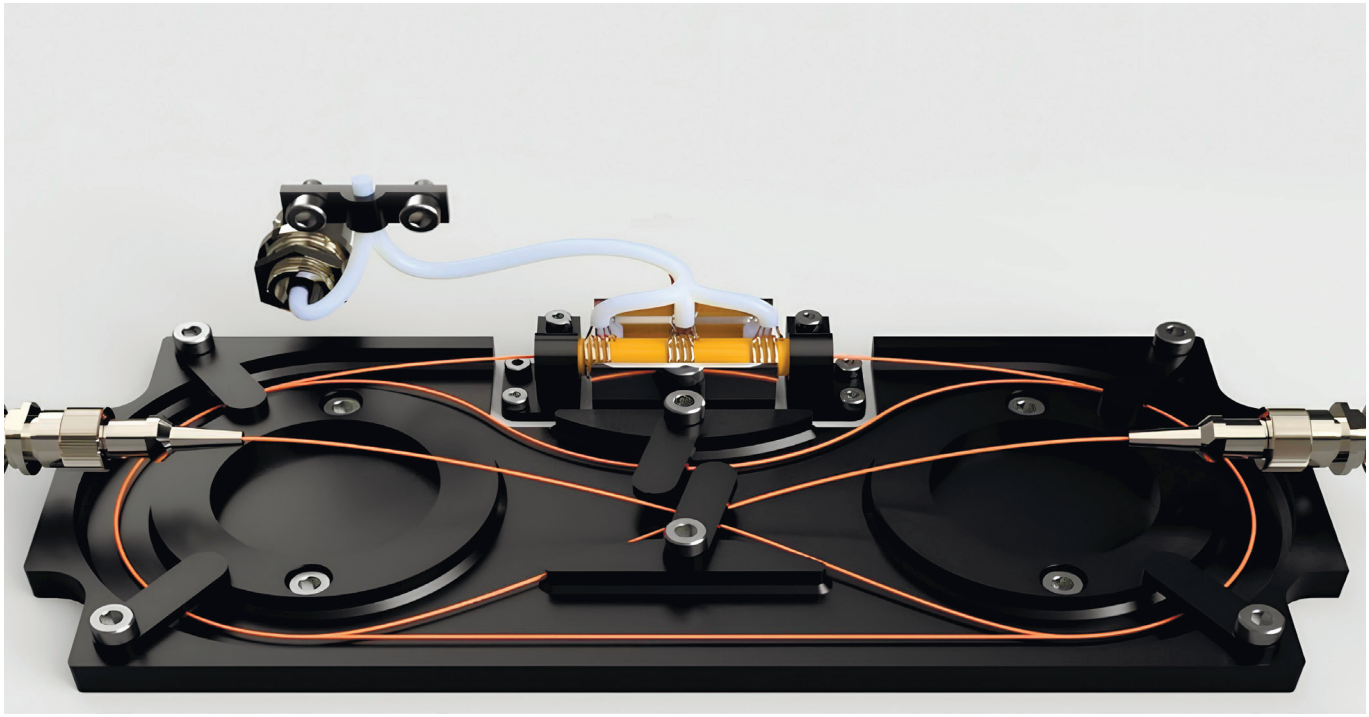
The presented fiber-optic filters possess the best characteristics and high reliability. A scientific and technological laboratory setup has been developed for creating Bragg gratings in optical fibers with the necessary parameters, enabling the production of fiber-optic spectral filters for quantum communication lines.

ADVANTAGES OF THE DEVELOPMENT

- Narrow spectral line, up to 50 pm at half-height at 1550 nm wavelength
- Ability to adjust the resonance wavelength of the fiber filter
- The setup allows tuning the Bragg resonance wavelength (BWR) over a wide range
- The use of a laser beam up to 50 mm in length to create the interference pattern
- Small (about 250 μm) diameter of optical fiber
- Low weight of the optical fiber
- Versatility of the form factor and ease of mounting the optical fiber
- Inductance-free design

APPLICATION AREAS

- Communication systems for signal filtering
- Systems with high-power laser radiation to eliminate scattering signal combinations
- As part of multiplexing and demultiplexing devices
- In quantum key distribution systems
- In fiber laser resonators
- In physical quantity sensors



CHARACTERISTICS

- Spectral width of the central maximum reflection at -2 dB (D): no more than 0.08 nm (BFOF type 2)
- Spectral width of the central maximum reflection at -25 dB (D): no less than 0.03 nm (BFOF type 2)
- Wavelength tuning range (with step no more than 1 GHz) of the central wavelength of the BFOF: at least ± 20 GHz
- Reflection coefficient at the reflection peak: no less than 80% (BFOF type 1.3), no less than 99.9% (BFOF type 4)
- Working wavelength range: 1000–1750 nm
- Time to reach operating mode: no more than 10 minutes
- DC power supply voltage: 5 ± 0.5 V
- Maximum power consumption: no more than 5 W
- Service life: 5 years
- Maximum attenuation at the central minimum transmission: no less than 41 dB (BFOF type 2)
- Dimensions of BFOF (W×D×H) for all types: (54×165×20) ± 2 mm

23
SYSTEM

RADIAL-AXIAL GAP MEASUREMENT SYSTEM FOR BK-1600B ENGINE ROTORS

DESCRIPTION

The system provides real-time measurement of the distance in the area of moving parts at high speed. Additionally, the rotational speed is measured. When applied with multiple sensors, the system can experimentally determine the full movement pattern of rotating parts and register runouts and vibrations with high accuracy.

The gap measurement system is based on the principle of an amplitude fiber-optic sensor, consisting of parallel optical fibers. One channel of the sensor is connected to a high-stability laser light source, and the second channel receives the reflected signal from the measured object and transmits it to a photodetector. The amount of the reflected signal directly depends on the distance between the object and the sensor. The system is pre-calibrated by determining the relationship between the gap and the reflected signal power. This system allows real-time measurement of the gap, such as in a gas turbine engine compressor between the blades and the internal surface of the casing.

CHARACTERISTICS

- Operational gap measurement: at least 1.2 (5) mm
- Measurement accuracy: no more than 0.05 mm
- Time to reach operational mode: no more than 15 minutes
- Measurement frequency output: at least 800 Hz
- Number of fiber-optic sensors: 1–32 units
- Sensor operating temperature: -40 to 350˚C

ADVANTAGES OF THE DEVELOPMENT

- Small size and weight characteristics
- High measurement speed
- Ability to implement a large number of change channels
- Flexibility in mounting and installation on turbine casing
- Insensitivity to electromagnetic interference
- High-temperature design

APPLICATION AREAS

- Gas turbine engine compressors
- Various types of turbines
- Electric motors

SINGLE PHOTON DETECTOR BASED ON AVALANCHE PHOTODIODE ALINAS/INGAAS

24
DEVICE

DESCRIPTION

The single photon detector belongs to the field of signal detection and recording devices for applications in quantum communications and LIDAR systems. The device is distinguished by all the advantages of solid-state semiconductor devices: small geometric dimensions, low bias voltage, low power consumption, high strength and reliability.

CHARACTERISTICS

- The dark current level is 10-20 nA (with an applied voltage of 0.9 of the breakdown voltage of -85 V)
- The spectral sensitivity of the devices in the range of 1550 nm is 0.85–0.88 A/Tue
- The value of the dark count speed parameter is 300 counts/s

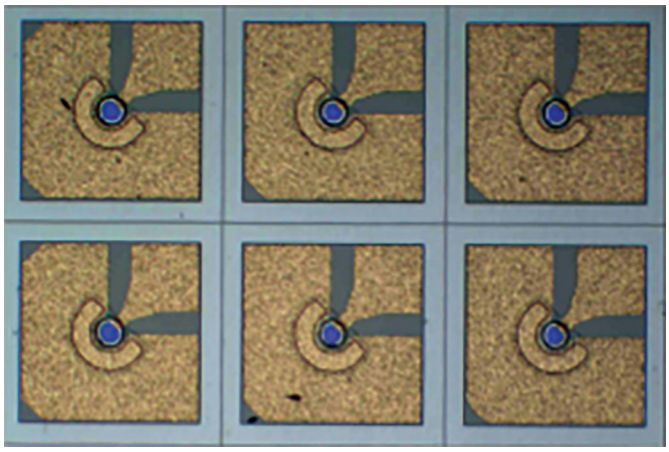
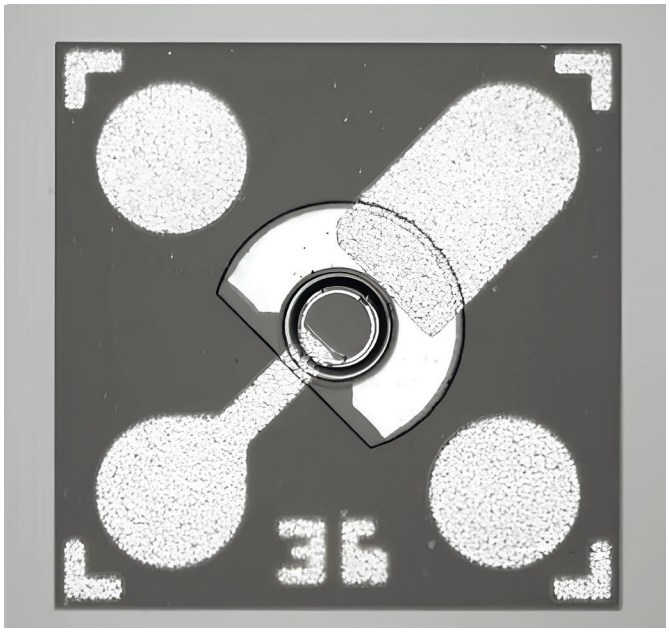


Image in an optical microscope of a fragment of the InAlAs/InGaAs LFD structure.

ADVANTAGES OF THE DEVELOPMENT

- Small geometric size
- Low bias voltage
- Low power consumption
- Strength
- Reliability



APPLICATION AREAS

- Communications
- Information technology
- LIDAR systems

25 COHERENT OPTICAL TIME DOMAIN REFLECTOMETER

DEVICE

DESCRIPTION

Coherent optical time domain reflectometer is an optical instrument designed for the following purposes:

- monitoring of distributed optical losses in the fiber-optic tract of the communication line with optical amplifiers;
- registration of events in the fiber-optic tract of the communication line and determining their location with a given accuracy;
- control of the performance of optical amplifiers in the fiber-optic tract of the communication line in terms of the level of optical amplification;
- support for the simultaneous operation of two COTDR reflectometers at one optical communication line with its opposite ends through the use of various removable modules of optical sources;
- transfer of information about the results of control to the control system by the Ethernet protocol.

CHARACTERISTICS

- Type of optical fiber: ITU-T G.652 / G.654
- Length of the measured communication line: up to 20,000 km
- Fixed wavelength of the main optical source: 1558.98 Nm / 1559.79 Nm / 1549.32 nm / 1551.72 nm / 1566.31 nm / 1567.13 Nm
- Fixed wavelength of auxiliary optical source (Dummy): 1559.39 Nm / 1560.20 Nm / 1549.72 Nm / 1552.12 Nm / 1566.72 nm / 1566.72 nm
- Duration of pulses: 3, 10, 30, 60, 100 μs
- The accuracy of the distance measurement: ± 10 m ± 0.5 × 10-6 × line (m)

APPLICATION AREAS

- Refletometry of optical fibers
- Monitoring of fiber-optic communication lines

ADVANTAGES OF THE DEVELOPMENT

- Domestic production, high accuracy of measurements, a high dynamic range (more than 35 dB)
- The range is corresponding to he best foreign counterparts (the single analogue in the world is the coherent reflectometer Anritsu MW90010A)
- Mounted as a rack unit, the implementation of optical switching between independent fiber lines is possible

NANOINK. PRINTED SOLAR MODULES USING CIGS TECHNOLOGY

26
PRODUCT

DESCRIPTION

CIGS (Copper Indium Gallium Selenide) is an innovative solar panel technology with a thickness of less than 5 microns. Due to this, they are lightweight, flexible, and semi-transparent, while their efficiency is comparable to silicon-based counterparts. A key feature of CIGS panels is their ability to operate efficiently under diffused light, and they can be manufactured in various shapes, broadening their potential applications, including integration into architectural structures and low-power electronics. While CIGS solar cells are already available on the market, their cost remains high due to the manufacturing process, particularly because of the use of magnetron sputtering.

CIGS solar panels have several distinguishing features:

- Simplified manufacturing and reduced cost of CIGS solar panels
- Printing technologies allow the use of standard roll-to-roll equipment, commonly used in various industries
- Scalable ink synthesis technology for printing CIGS modules and proven ink application technology
- Use of inexpensive and accessible materials for creating efficient solar cells

CHARACTERISTICS

- The technology for creating solar panels replaces the expensive magnetron sputtering method for the photoactive layer with printing technologies, reducing the cost of solar cell production by 50%
- Printing technologies enable the creation of panels of virtually any size and are better suited for manufacturing solar cells with complex shapes
- The modules are made using a hot injection method to synthesize CuInGaS nanocrystals

ADVANTAGES OF THE DEVELOPMENT

- Elimination of expensive vacuum sputtering
- Proven efficiency and stability
- Print any shape
- Suitable for mass production setups

APPLICATION AREAS

- Internet of Things (IoT)
- Wearable electronics
- Asset tracking and monitoring
- Integrated solar cells

27 RANDOM NUMBER GENERATORS BASED ON OPTICAL TECHNOLOGIES

DEVICE

OPTICAL TRUE RANDOM NUMBER GENERATOR

DESCRIPTION

The device belongs to the latest generation of systems for protecting classified information with a high degree of reliability. The core of the development is based on the principle of quantum optics, which allows the secure transmission of encryption keys over fiber-optic networks. The optical random number generator operates on a non-deterministic physical process — polarization mode noise of a vertical cavity laser. The key feature of this device is its ability to reliably detect eavesdropping on the channel at the key generation stage. The random sequences generated by the device have successfully passed the specialized DIEHARD test and several other tests.

The project was developed by ITMO University in collaboration with the B.I. Stepanov Institute of Physics (National Academy of Sciences of Belarus) and Quantum Communications LLC.

CHARACTERISTICS

- Shift*: < 0.000015
- Compact dimensions:
  External device – 56x243x295 mm
  Embedded device –52x85x160 mm
- Generation speed: Up to 240 Mbit/s
- Autocorrelation**: < 0.00003

*Shift is defined as the difference between the measured probability of ones and the ideal probability: b = |p(1) - 0.5|. Compliance with NIST SP800-90B, C; AIS 31; FIPS 140–2.

**Maximum among the first 100 coefficients. The bias and autocorrelation are evaluated for a random binary sequence of 10 Gbit in length.

ADVANTAGES OF THE DEVELOPMENT

- Balance between speed and security level
- Guaranteed true random numbers
- Reliable statistical analysis in real-time
- Real-time monitoring of system component failures
- Various output interfaces
- Device function check indicator

APPLICATION AREAS

- Banking sector
- Communication (IP telephony)
- Mathematical computations

RANDOM NUMBER GENERATOR BASED ON VERTICAL-CAVITY SURFACE-EMITTING LASER

DESCRIPTION

The random bit generator belongs to the field of encryption devices that protect information from unauthorized actions, changes in the content of information messages during data storage and transmission. The device provides high-speed generation of random number sequences while maintaining small dimensions, relatively high energy efficiency, and using only one optical channel.

CHARACTERISTICS

The rate of generation of random number sequences is up to 128 Gbit/s when using a single optical channel.

APPLICATION AREAS

- Communication
- Information technology
- Mathematical modeling
- Cryptography
- Distributed computing

28 DEVICE

MODERN INFRARED SPECTROMETRY DEVICES FOR HYDROCARBON ANALYSIS

FLOWING FOURIER-TRANSFORM INFRARED SPECTROMETER

DESCRIPTION

The Flowing Fourier-transform infrared spectrometer in the near-infrared range is designed for online monitoring of the quality of light petroleum products such as gasoline, kerosene, and diesel fuel. Fourier-transform spectrometers are installed at critical points of pipelines for continuous quality control of transported petroleum products. The spectrometer is equipped with a fiber-optic measuring probe, allowing measurements directly within the pipeline.

CHARACTERISTICS

- Spectral measurement range in wavenumbers (cm^{-1}): from 12,000 to 4750
- Spectral resolution, no worse than (cm^{-1}): 4.0
- Maximum spectral resolution for water pairs in the atmosphere, cm^{-1}: 2.0
- Tolerance limits for main absolute measurement error in wavenumbers, cm^{-1}, no more than: ±0.1
- Tolerance limits for photometric accuracy, no more than: ±0.1%
- Measurement cycle time for one channel, sec: no more than 30
- Ambient temperature range, °C: from 5 to 50 (temperature change no more than 2°C per day)

ADVANTAGES OF THE DEVELOPMENT

The distinctive feature of this development is the use of domestically produced components while maintaining accuracy parameters at the level of global counterparts.

APPLICATION AREAS

Quality control of light petroleum products in pipeline transport, oil refineries, and other infrastructure facilities.

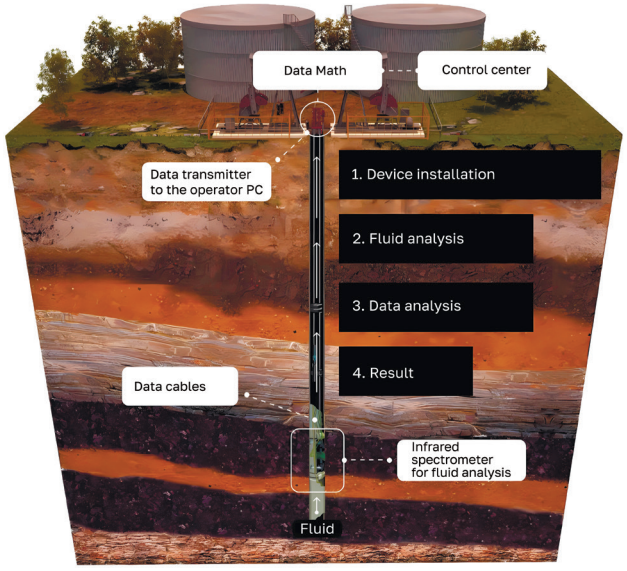
PROFLUID – MULTI-CHANNEL IR SPECTROMETER FOR DYNAMIC HYDROCARBON ANALYSIS

DESCRIPTION

The IR spectrometer is a device based
on a technology used in the oil and gas industry for analyzing the composition of reservoir fluids. The device uses infrared radiation to measure the absorption of specific wavelengths of light by different molecules in the fluid.
The obtained spectrum provides information about the molecular structure and composition of the fluid, which can be used to determine properties such as density, viscosity, and chemical composition.

ADVANTAGES OF THE DEVELOPMENT

One of the key advantages of the IR spectrometer is its ability to analyze reservoir fluids in real time. This allows engineers and geologists to make informed decisions about optimizing production, such as adjusting production rates or changing extraction strategies based on the composition of the reservoir fluid. Furthermore, the IR spectrometer does not damage the reservoir fluid, enabling it to be reused or analyzed further.



CHARACTERISTICS

- Maximum operating temperature: 150 K
- Maximum operating pressure: 50 MPa
- Minimum well diameter: ~10 cm
- Number of distribution channels: 1
- Energy loss: >5%

APPLICATION AREAS

Spectrometric analysis of liquids or reservoir fluids in real-time to determine gas factors and fractional composition.

29

DEVICE

OPTICALLY CONTROLLED METASURFACE-BASED REPEATER FOR FR1 5G NETWORK

DESCRIPTION

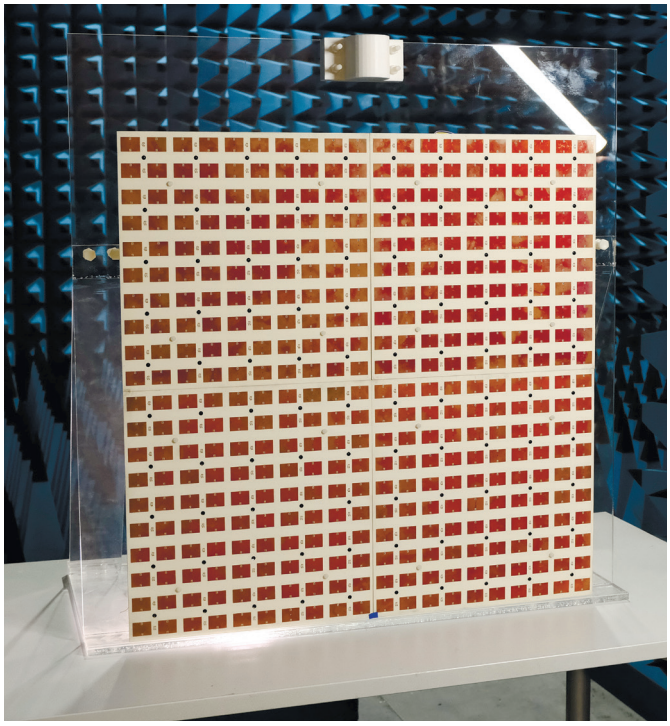
The device is designed for use in 5G wireless communication networks and Wi-Fi 5 GHz networks to enhance the signal strength for subscribers, particularly those outside the direct line of sight of the base station (BS) transmitter or router. The device includes detection modules that can be adapted for use with managed grids in other frequency ranges. Managed metasurfaces are considered one of the most promising components for the widespread implementation of 5G systems.
The device contains a specially designed detection unit that tracks the position of receivers, analyzing data from a camera to improve the signal-to-noise ratio and the quality of the received signal.

CHARACTERISTICS

- Metasurface size: 300x300 mm
- Number of metasurface elements: 100
- Operating frequency: 5 GHz
- Maximum gain of the metasurface under normal irradiation: 25 dB
- Metasurface operating sector: +/- 60 degrees from normal
- Gain fall-off at the edges of the scanning sector: no more than 8 dB
- Weight of the metasurface: no more than 3 kg
- Power consumption: no more than 7.5 W
- Presence of a camera
- Field of view: at least 120 degrees
- Required resolution: at least 3 MP
- Computing hardware: single-board computers Raspberry Pi or NVIDIA Jetson series
- Software: Linux OS, Programming languages: C/C++, Python
- The software must support real-time image input and processing using neural network algorithms
- Processing time: no more than 1 second
- Number of simultaneously tracked objects: at least 3
- Accuracy of angular coordinate determination: 5 degrees

ADVANTAGES OF THE DEVELOPMENT

- Remote control
- Modular design
- Simple design solution
- Low power consumption (a few watts)
- No dependence on the relative positioning of the receiver and transmitter



QUANTUM NETWORK MANAGEMENT AND MONITORING SUBSYSTEM

30
COMPLEX

DESCRIPTION

The Quantum Network Management and Monitoring Subsystem is a software suite designed to manage and monitor geographically distributed telecommunication networks, including quantum networks. The subsystem consists of a number of software components (software agents) in the form of virtual machines. It is based on open-source technologies and projects, including Gentoo Linux OS, Zabbix, GLPI, PostgreSQL, Graylog, OpenLDAP, Rabbitmq, and others.

SUBSYSTEM COMPONENTS:

- Web interface for the administrator's automated workspace
- Management subsystem
- Monitoring subsystem: The number of parameters is measured in thousands; any logical combination of parameters can be used to generate alerts with varying levels of severity
- Technical accounting/inventory subsystem (including descriptions, costs, acquisitions, contracts, procurement and repair personnel, etc.)
- External system interaction subsystem with the ability to integrate with the OSS stack
- Access control subsystem
- Event logging subsystem

DISPLAYED DATA:

- Architecture of the monitored network
- Status of connections between network nodes
- Status of network nodes
- Telemetry of quantum communication parameters
- Network availability coefficient (calculated over a specified time interval)
- Informational messages for administrators
- Detailed data on each network object: CPU load, RAM, disk status, network interface traffic, temperatures, ICMP ping availability, uptime, as well as many specific parameters such as UPS data (battery charge, voltage, power, etc.)
- The ability to add new parameters available via SNMP
- Periodic checks (with configurable intervals) and administrator notifications

ADVANTAGES OF THE DEVELOPMENT

- Software components consist of separate software agents, which operate in an isolated environment (a significant advantage during development and operation) in the form of virtual machines
- Interaction between software components is carried out via a specially developed protocol
- Zero-trust principle at the interaction points between different components of the subsystem
- Data transmissions between components are encrypted

31 DEVICES AND TECHNOLOGIES FOR LASER PROCESSING

DEVICES AND TECHNOLOGIES

DEVICE LASER BRUSH

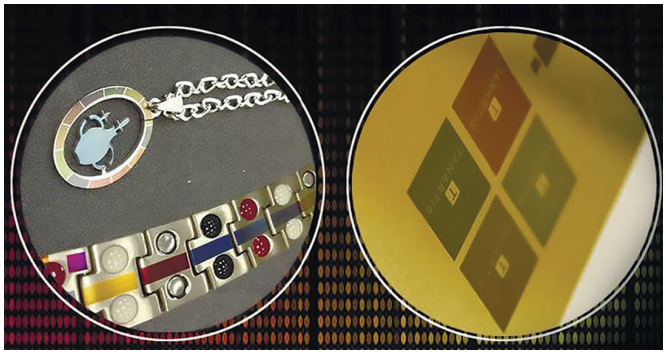
DESCRIPTION

Laser Brush is a tool designed for manual laser artistic processing of metals. The laser replaces the artist's brush, and the metal serves as the canvas. This development allows for the creation of colored strokes and precise control over line thickness, surface relief, and the ability to work on various shapes, sizes, and surfaces. The device ensures that the operator/artist can work safely and comfortably in a manual mode. Color formation does not require consumables (including dyes) — the color is created through optical effects, such as light interference in the thin laser-induced oxide film.

ADVANTAGES OF THE DEVELOPMENT

- Brightness and durability of the image
- Environmental friendliness
- Mobility of the device

COLORIT TECHNOLOGY



DESCRIPTION

Advanced color laser marking technology for stainless steel and titanium metal products that does not require the use of dyes.
The use of laser emission makes it possible to create an image by means of producing a thin metal oxide high-resolution film with nanoscale thickness without directly contacting the material. It can also be used to color precious metals by laser generation of nanoparticles on a material's surface. The color emerges thanks to the phenomenon of plasmonic resonance in the created nanoparticles.

ADVANTAGES OF THE DEVELOPMENT

- Easy use
- The technology and its software can be adjusted for any fiber laser-based equipment
- No direct contact with the material

LASER TECHNOLOGY FOR INCREASING THE HARDNESS OF THE SURFACE LAYER OF METALS AND THEIR ALLOYS

DESCRIPTION

The technology for improving the mechanical properties of materials will increase the surface hardness of samples while minimizing critical changes in the core structure. This method provides an optimum combination of strength and wear resistance, which is especially important for parts and components subjected to high mechanical and thermal stresses. The increased surface hardness contributes to significantly reduced wear and friction damage, which in turn leads to longer product life. Adoption of the technology can lead to an increase in overall production efficiency, as longer intervals between maintenance and replacement of parts contribute to reduced downtime.

CHARACTERISTICS

- For steel components, up to a 4-fold increase in hardness is possible
- For titanium components, hardness can be increased up to 10 times

ADVANTAGES OF THE DEVELOPMENT

- Localized treatment
- Creation of structures of various sizes and shapes with increased hardness

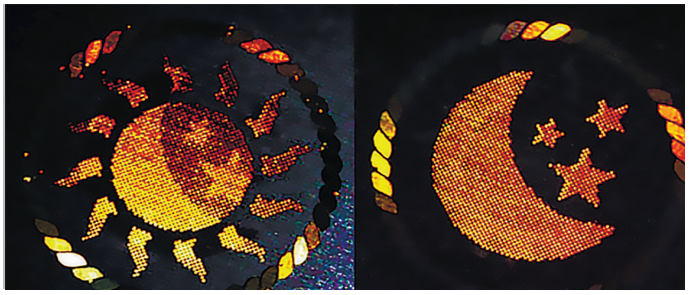
HOLOLIPSS. TECHNOLOGIES OF WRITING PROTECTIVE HOLOGRAMS ON THE METAL SURFACE

CHARACTERISTICS

- Recording resolution range 700 - 1000 lin/mm
- Production rate not less than 2 cm^2/min.
- Maximum size of the recorded protective hologram 80×80 mm

ADVANTAGES OF THE DEVELOPMENT

- High resolution writing and write speed
- One-step writing process
- Possibility to record on various surfaces with complex shapes and details



DESCRIPTION

Holograms have many levels of protection, both invisible and visual: physically unclonable pattern of structures, dynamic visual effects, including motion of color or image (“kinegram effect”), image switching effect and 3D effect. The technology makes it possible to realize industrial laser writing of protective holograms based on LIPPS, which are integral with the metal surface. The one-stage marking process allows the method to be integrated at any stage of production.

32
DEVICES AND TECHNOLOGIES

EQUIPMENT AND TECHNOLOGIES FOR LASER FUNCTIONALIZATION OF THE SURFACE OF MEDICAL PRODUCTS

DESCRIPTION

Improving the quality of medical services, developing new medicines, medical equipment and instruments is a critical condition for maintaining the health, ability to work, length and quality of life of the population of our country. The complex of new domestic technologies and high-performance equipment is designed for the production of medical devices with the necessary functional properties.

Two types of the presented automated laser complexes are able to cover the needs of enterprises for specialized processing in the production of medical instruments, implants for various purposes (dental, traumatological, etc.), orthopedic components (screws, abutments, scan-body, gum shapers, membrane.

Laser technology provides the following set of functions:

- improving biocompatibility (implants for various purposes)
- increase in bacterial resistance (medical instruments, orthopedic components: abutments, screws, membranes, etc.)
- identification of products (medical instruments, orthopedic components: abutments, screws, membranes, etc.)
- reduction of surface roughness of products after 3D printing (implants for various purposes)

ADVANTAGES OF THE DEVELOPMENT

- non-contact impact on the material and high processing productivity
- no consumables
- the possibility of local application of a given surface microgeometry with nanorelief and the ability to create a multifunctional structure on the surface of various implants
- successfully passed all stages of preclinical studies (biocompatible, antibacterial)

1) **Laser Complex for Surface Functionalization of Dental Implants BioStruct.** The complex is designed for implementing the technology of surface structuring of dental implants to enhance their biocompatibility.

2) **Laser Complex for Surface Functionalization of Implants and Other Medical Devices of Complex 3D Shapes.** This complex is designed for surface functionalization of medical devices with a 3-dimensional shape, as well as other products, with the aim of:

- Improving biocompatibility
- Increasing bacterial resistance
- Identifying products
- Polishing the surface of products after 3D printing

3) **Laser Surface Structuring Technology for Improving the Biocompatibility of Implants.** This technology is intended to enhance the biocompatibility of dental implant surfaces by forming a micro-relief with the required geometric shape and chemical composition through laser irradiation.

4) **Laser Surface Modification Technology for Medical Devices to Impart Antibacterial Properties.** This technology is designed to impart antibacterial properties to the surfaces of medical alloy products by creating an oxide film/nano-relief through laser irradiation. It ensures reduced bacterial adhesion and prevents bacterial biofilm formation on the surface after laser treatment.

5) **Laser Technology for Non-Contact Application of Bioinert Identification Marks on Medical Devices.** This technology is intended for creating bioinert identification marks on the surface of medical alloy products by forming interference oxide films under the influence of laser radiation.

6) **Laser Surface Modification Technology for Traumatology Implants to Reduce Roughness After 3D Printing.** This technology is designed for laser surface modification of traumatology implants to reduce the roughness left after 3D printing.

7) **Software for Processing CT Scan Images and Designing a 3D Model of a Personalized Medical Device.** The software is intended for processing CT scan images followed by designing a 3D model to replace a defect, which will then be used for the creation of a personalized medical device.

These works are carried out with the support of the Foundation for Assistance to Small Innovative Enterprises.

33 NON-CLONABLE PROTECTIVE TAGS

PRODUCT

DESCRIPTION

The tag consists of micro- or nanoparticles randomly embedded into a thin layer of transparent polymer mass or randomly attached to various types of surfaces (metal, plastic, glass). As a result, the micro- and nanostructures, which exhibit bright luminescence in the visible range when excited by ultraviolet or contrasting light, create a unique pattern of bright points with random positions. Optical reading of this pattern using a smartphone and processing through application software will verify the authenticity of the tag. The physical non-clonability of the tag lies in the impossibility of replicating it, as its creation algorithm involves a series of non-deterministic, stochastic processes: as a result, each newly produced tag has a unique pattern of micro-particles and serves as a unique identifier for the specific product unit it is attached to.

CHARACTERISTICS

- The algorithm for creating the security tag includes a non-deterministic process
- The security tag can be applied to solid (glass, metal) and flexible (plastic, textile) surfaces
- The tag has an arbitrary shape, with an area of up to 9 cm^2 and a thickness ranging from 1 to 5 mm
- The tag consists of micro-particles ranging from 30 to 500 micrometers in diameter, randomly mixed in a transparent protective shell made from epoxy resin derivatives with high adhesion to glass, plastic, metal, and paper
- The security tag is resistant to water contact for up to 30 minutes, stable under sunlight exposure, and withstands temperatures from -20°C to 80°C
- The tag is read in the optical range of 400-700 nm using a smartphone with a camera of at least 30 MP and digital zoom of no more than 5x through photographing (scanning), with authenticity verification conducted via developed software that processes the reading result and compares it with a database; the database size ranges from 1 GB to 4 TB
- The software is written in Python, JavaScript/Kotlin and developed for Android / iOS smartphone operating systems

ADVANTAGES OF THE DEVELOPMENT

- Non-clonability
- Uniqueness of identifiers
- Multiple levels of protection

APLICATION AREAS

- Light industry
- Automotive industry
- Medical and pharmaceutical industries

“EUTECTIC COPPER” AN INNOVATIVE METHOD FOR PRINTING ELECTRONICS

34
METHOD

DESCRIPTION

Innovative approach to electronics manufacturing, addressing key challenges in photolithography and sputtering. This method leverages eco-friendly deep eutectic solvents and laser technology, ensuring a unique and cost-effective process. A simplified three-step procedure is used to reduce production costs, speed up manufacturing, and require only one setup for all stages.

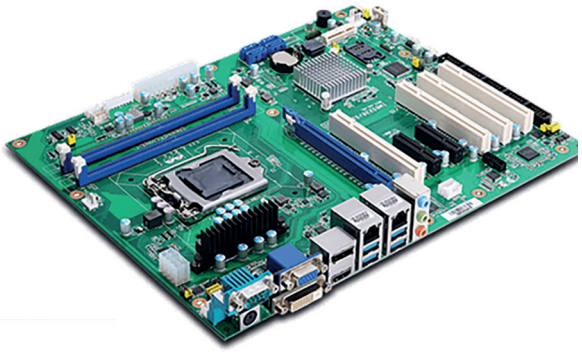
The methodology of the technology is as follows: the metallic or dielectric substrate is pre-treated with a laser. Then, a deep eutectic solvent is applied to it. In areas where tracks and metal are required on the holes, the substrate is treated with laser radiation. After that, the solvent residues are removed with warm water, leaving a metallic contour on the substrate. This technology has already been perfected for applying copper tracks to dielectric substrates and for metallizing holes in them.

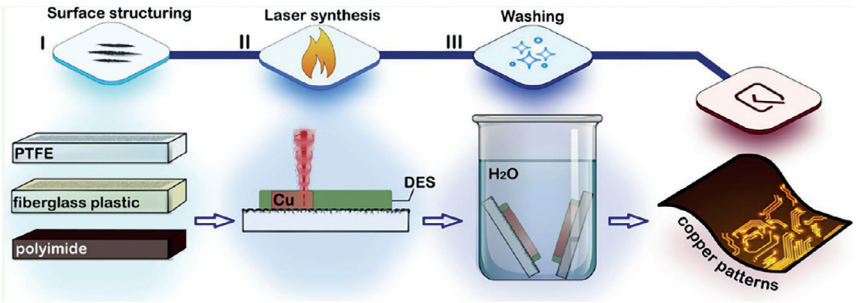
CHARACTERISTICS

- Structure formation speed – up to 6.5 mm/s
- Resistance of 0.15 ($\Omega \cdot (mm^2))/m$, which is 100–1000 times lower than values obtained with similar methods
- Track width – 300–800 μm
- Height – at least 30 μm, with the potential for increase
- The method has demonstrated adaptability for substrates made of various materials

ADVANTAGES OF THE DEVELOPMENT

- Low cost
- Simplified process and high production speed
- Low consumption of components
- One setup for all operations, no special skills required to work with the method



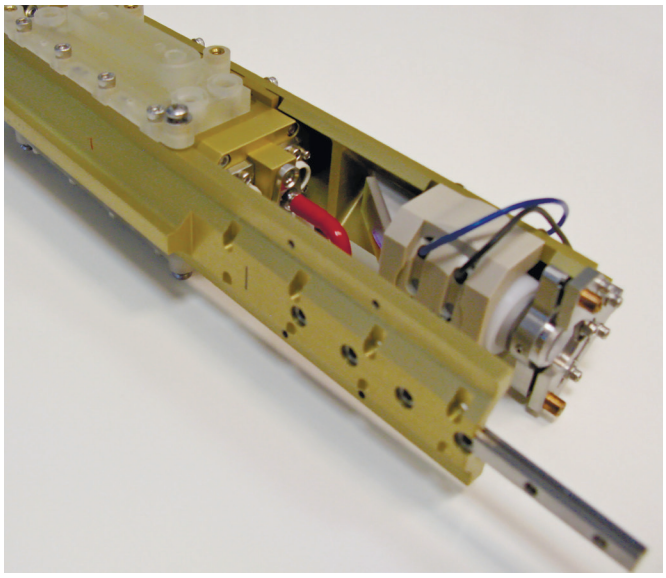


35 DEVICE

POWERFUL COMPACT SOLID-STATE LASER

DESCRIPTION

Its design allows the operator to directly manipulate the emission source without an expensive emission delivery system that places considerable restrictions on the spatial accessibility of the targeted object. It can be used in laser distance measurement, laser materials processing, laser cleaning of monuments, cosmetology.

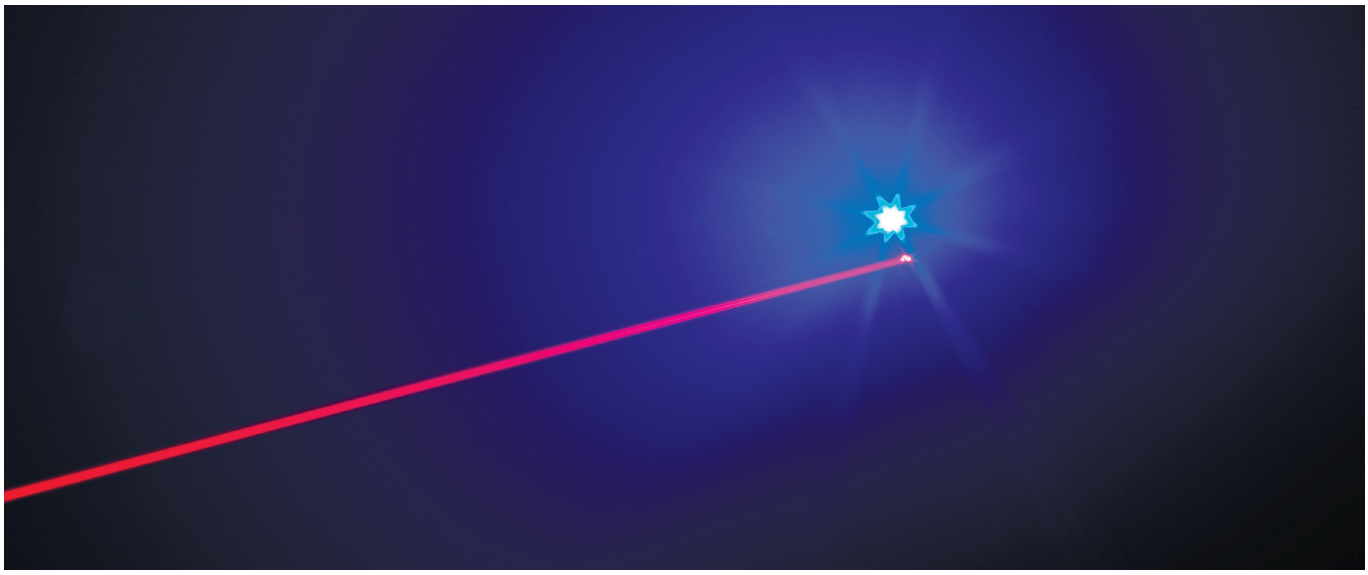


CHARACTERISTICS

- Pulse duration: 3 ns
- Size: 40x70x280 mm
- Pulse rate: 10 Hz
- Lasing energy: 0.6 J at a lasing wavelength of 532 nm
- Lasing energy: 1 J at a lasing wavelength of 1064 nm

ADVANTAGES OF THE DEVELOPMENT

- High peak intensity
- High spatial emission quality
- Extremely compact size allows manual manipulation of the handpiece

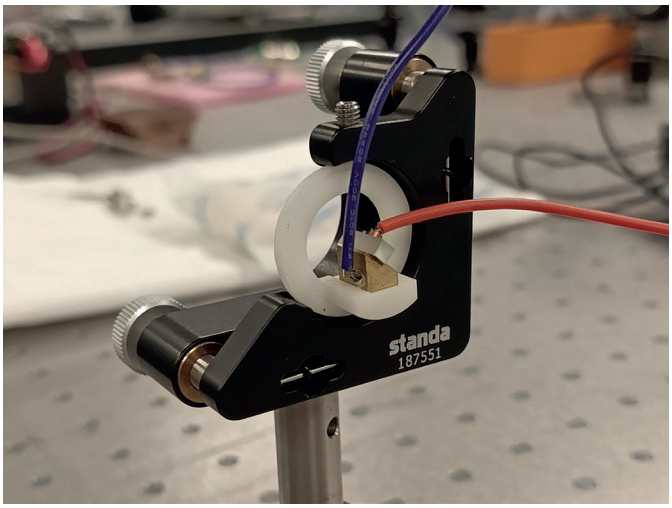


TEMPERATURE-INSENSITIVE ELECTRO-OPTIC MODULATOR BASED ON KTP CRYSTAL

36
DEVICE

DESCRIPTION

Electro-optic modulator based on noncritical birefringence direction cut KTP crystal allow to reduce the sensitivity of modulator to temperature gradient and requirements for thermal stabilization system. It will also allow the use of a single crystal modulator scheme, which can significantly reduce the complexity and cost of manufacturing such modulators.

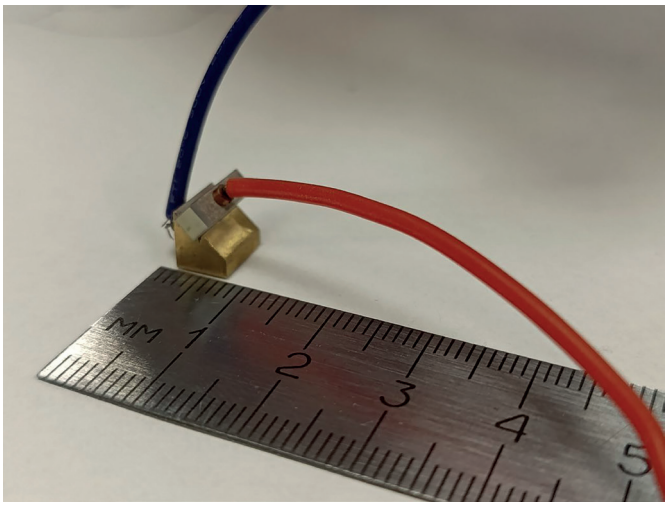


CHARACTERISTICS

- Quarterwave voltage for 1064 nm – 3650 V
- Crystal dimensions – 2.5x2.5x10 mm

ADVANTAGES OF THE DEVELOPMENT

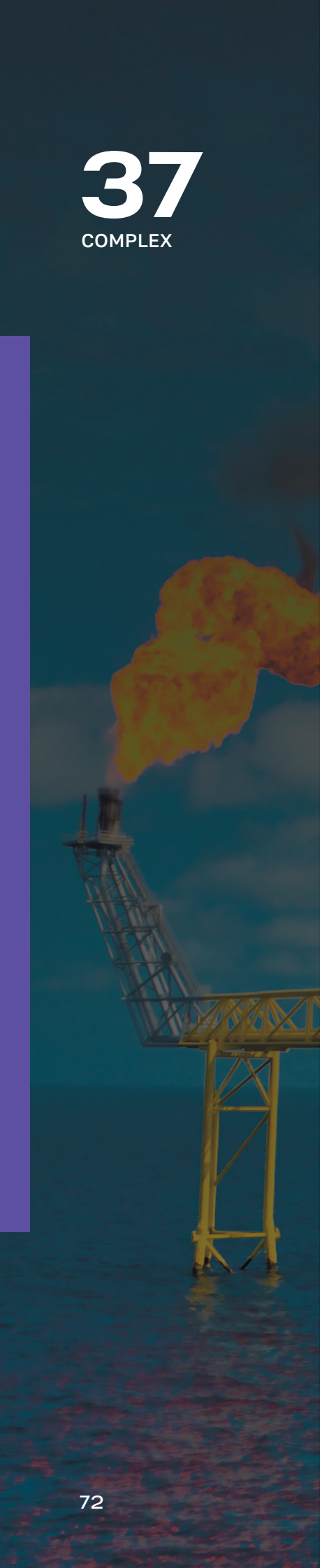
- Broader operating temperature range
- Simple and cheap single crystal modulator scheme (compared to traditionally used two-crystal scheme for KTP crystals)



APPLICATION AREAS

Application in solid-state laser systems for industry and aerospace applications.

37
COMPLEX



LIDAR FOR REMOTE UNDERWATER EXPLORATION AND MONITORING OF HYDROCARBON DEPOSITS

DESCRIPTION

The laser spectroscopy assembly can conduct remote, non-contact, continuous areal and profile scanning with simultaneous identification of areas of gas anomalies by identifying the concentration of a set of indicative chemical elements and compounds. The use of an innovative and ecologically safe technology of remote underwater exploration and monitoring of hydrocarbon deposits in severe climate conditions of the continental shelf makes it possible to effectively search for oil and gas deposits and increase the work efficiency at the less explored Russian aquatic areas with minimal time investments.

The assembly consists of two parts: a submersible watertight frame and a control device that's located on a surface craft. With the help of a strobe electro-optical converter which sends the image to a CCD matrix the assembly registers emission that's scattered by an underwater object. Then, a program processes the image and transfers the spatial distribution of intensity into spectra.

Based on the characteristic features of the resulting spectra, it is possible to find and identify hydrocarbons that are present in water. The conduct of geological exploration in the waters of Russian seas is feasible within the limits of a technically accessible area of development of hydrocarbon deposits (at depths of no more than 50 meters).

The laser spectroscopy assembly for remote underwater exploration and monitoring of hydrocarbon deposits was developed in collaboration with Krylov State Research Center, Vavilov State Optical Institute, and All-Russian Research Institute of Oil Geology.

ADVANTAGES OF THE DEVELOPMENT

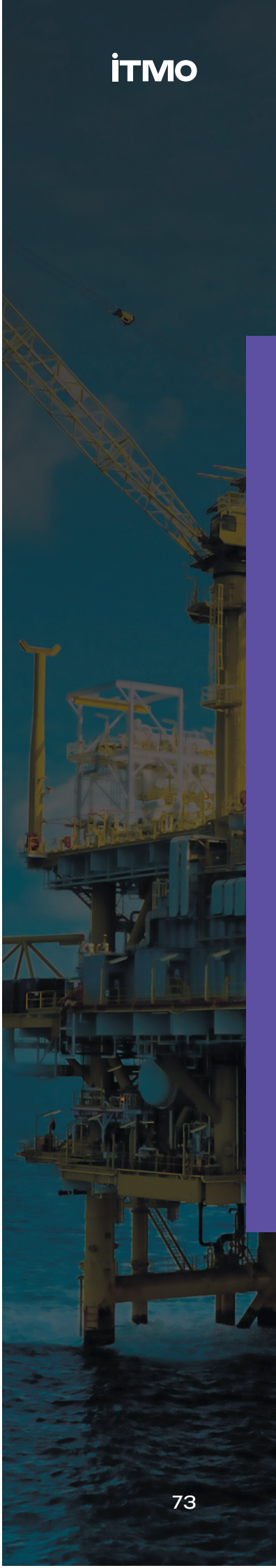
- The high sensitivity and spectral selectivity allow for detecting hydrocarbons with high precision
- The measurements and analysis can be carried out with speed thanks to non-contact operation methods and no need for taking samples

CHARACTERISTICS

- Laser source: solid-state Nd:YAG laser system Solar LQ115-02
- Emission wavelength: 532 nm
- Impulse duration: 8.65 ns
- Pulse rate: 1 Hz
- Pulse energy: 45 mJ
- Registration system: Nanogate electro-optical camera
- Registration wavelength range: 380–800 nm
- Sample impulse duration: 0.01–20 ms
- Camera jitter: less than 0.5 ns

APPLICATION AREAS

- Geological exploration of hydrocarbon deposits on the continental shelf
- Environmental monitoring of water areas in hydrocarbon extraction zones
- Production and technical control of the condition of main oil and gas pipelines
- Maritime safety, the ability to detect underwater objects in turbid seawater



38 FIBER OPTICAL GYROSCOPE

DEVICE

DESCRIPTION

The fiber optical gyroscope (FOG) is an optoelectronic device that measures the angular velocity and the angle of rotation of the device that it's fixed with. Its operating principle is based on the Sagnac effect. Russian and international companies are interested in the optical gyroscope for the prospects of its application as a rotation-sensing element in navigation, control and stabilization systems. In some cases, these devices can completely replace complex and expensive electromechanical (rotor) gyroscopes and three-axis gyro stabilized platforms. The fiver optical gyroscope can be made very compact in accordance with customer's requirements. Among its other advantages is low power consumption, which is of importance when the device is used on board a moving object.

The fiber optical gyroscope was developed in collaboration with Concern CSRI Elektropribor with financial support from the Ministry of Education and Science of the Russian Federation (project № 02.G25.31.0044).

ADVANTAGES OF THE DEVELOPMENT

- FOG measures a wide dynamic range of angular velocities
- Instant operational readiness
- Capability to work in the conditions of high mechanical overload
- Low production costs and high reliability (no rotating mechanical elements and bearings)

CHARACTERISTICS

- Operation in conditions of high humidity - up to 95 ± 3% and temperature - 40 ± 2°C
- Variation range of angular velocities ±40 °/s
- Precision, FOG 0001 – no more than 0.001°/h at averaging time of 900 s, precision class 0.001°/h
- Precision, FOG 001 – no more than 0.01°/h at averaging time of 100 s, precision class 0.01°/h
- Temperature – equipment in operation: -15...+55°C
- Maximum temperature of deactivated equipment: -40...+70°C

APPLICATION AREAS

- Navigation and spatial orientation of specialized watercraft and submersibles
- Course plotting
- Control and stabilization systems

OPTOELECTRIC DOCK DEFLECTOMETER

39
DEVICE

DESCRIPTION

Optoelectric dock deflectometer is intended for identifying the vertical bend value of floating drydocks during their operation.The control of the bend value is executed for three points. One of them is the base unit positioned in the center of the top deck of the right tower, and the other two are registration marks at the fore and aft of the right tower correspondingly.

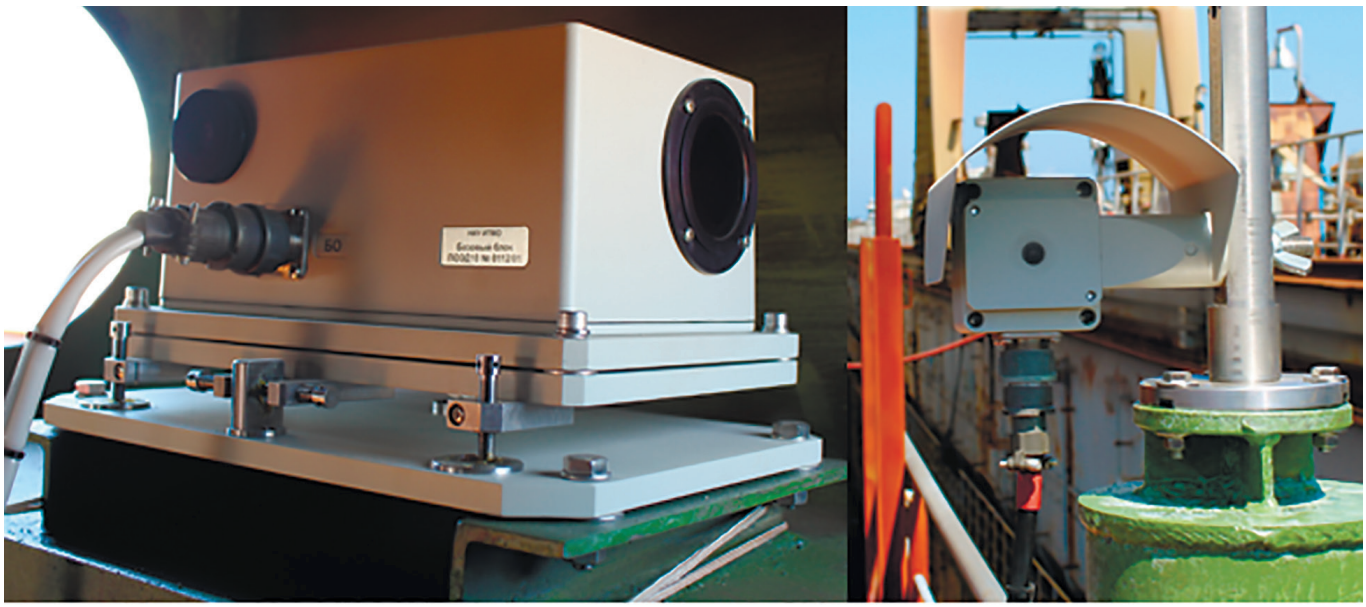
The deflectometer has successfully passed the voluntary certification of the Russian Maritime Register of Shipping.

CHARACTERISTICS

- Deflection measurement range: ±200 mm
- Registration mark positioning range (lengthway, distance): 20...100 m
- Size of the registration mark: 109×45×79 mm
- Root-mean-square deviation of random component of measuring error at up to 100 m: 4 mm
- Measurement data update frequency: 1 Hz

ADVANTAGES OF THE DEVELOPMENT

- Can be connected to a floating dock's diving controls
- High-precision control (shift range of up to 200 mm at the margin of less than 4 mm at distances from 20 to 100 m) in severe weather conditions
- Full automation of measurements and their indication



40 SYSTEM

OPTOELECTRICAL SYSTEM FOR COLOR ANALYSIS OF MINERAL RAW OBJECTS

DESCRIPTION

The system does selection of ore samples according to color, transparency, inclusions.
Based on the results, it automatically forms a database, identifies the optimal color model for the processing of the analyzed material, and the sampling thresholds (for every color model).

ADVANTAGES OF THE DEVELOPMENT

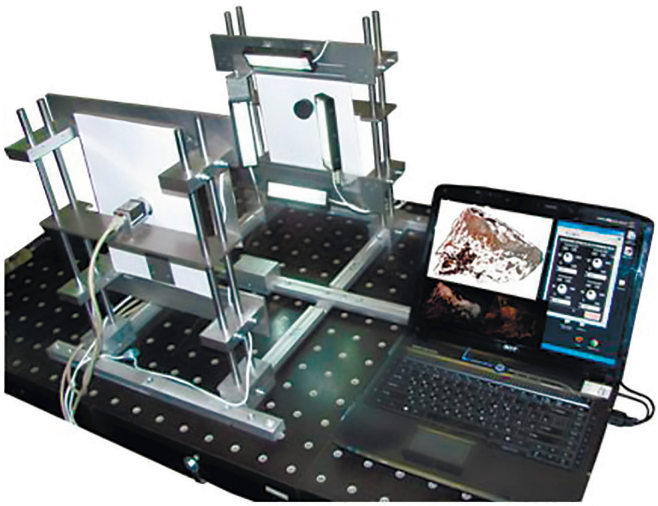
- A common compact solution for geologists, mineralists, enrichment specialists
- Assessment of the effects of optical separation without a separator, fewer costs at the preliminary stage
- Searches for solutions for raw minerals with low color contrast: increases the competitive ability of the optical separation method
- An increased precision of raw mineral analysis thanks to the device's unique feature

CHARACTERISTICS

- Automated calculation of optimal sampling thresholds
- Possible selection features: color, inclusion transparency
- Single sample processing time: no more than 20 s
- Size range of samples: 10–150 mm
- Maximum resolution of the sensor element: 1280×960 pixels
- Color modes: RGB, YUV and HLS

APPLICATION AREAS

- Technological assessment of ore preparation characteristics by optical means without direct sampling on specific separator models
- Simplification of the process of adjustment of optical separators for specific ore types
- Search for new selection segregation features (including the development of algorithms for their registration and analysis)



FIBER OPTIC MARINE SEISMIC TOWED STREAMER

41
DEVICE

DESCRIPTION

The fiber optic hydroacoustic towed streamers (antennae) are intended for geophysical research, search and exploration of hydrocarbon deposits.

ADVANTAGES OF THE DEVELOPMENT

- Wide frequency range starting from 3 Hz
- Dry weight of cable – 0.5 kg/m
- Distance between phase centers – 1.56 m at 96 sensors; that of known counterparts – 3.125 m and more
- The towed streamer is executed as a single piece, i.e. has no additional connectors
- The towed streamer's small outer diameter contributes to a decrease in hydrodynamic noise, hydrodynamic resistance, the device's dry weight and the requirements to a deployment-retrieval system
- The streamer's offboard part has no electronic components and that contributes to its higher durability and fault-tolerance as well as electromagnetic interference immunity

APPLICATION AREAS

- Exploration, prospecting, development of mineral deposits, and their extraction

CHARACTERISTICS

- Towed streamer's outer diameter – 25 mm
- Number of sensors – 96
- Distance between sensor's phase centers – 1.56 m
- Overall length of the streamer's active part – 150 m
- Feeder cable length – 100 m
- Frequency range – from 3 to 2500 Hz
- Minimal detectable pressure – less than 300 μPa/√Hz at 2.5 Hz at sea state of 0 points
- Dynamic range – over 120 dB at 2.5 kHz
- Permitted temperature range of offboard equipment operation – from -15 to +50 °C
- Operating temperature range of offboard equipment – from -4 to +35 °C
- Maximum permitted tensile load – 50 kN
- Maximum operational tensile load – 20 kN
- Minimum cable bend diameter – 1.5 m
- Maximum submersion depth – 100 m
- Density - 1.024 g/cm3

42

DEVICE

SPECTRAL CONTROL DEVICE FOR CONTAMINATION OF MEAT PRODUCTS

DESCRIPTION

The device allows monitoring of meat surface contamination by two methods. The first allows for express analysis of contamination during carving. It's intended for the assessment of 106 CFU/cm2 concentration of pathogenic microorganisms on the condition that the bacteria have been on the meat surface for no less than six hours. The method is contactless and can be used to conduct contamination analysis at different points of the carcass over the course of a short period of time.

The second method is intended for more sensitive detection of bacteria on the meat surface. Its operating principle is based on using a special fluorescent colorant that can mark such bacteria as S. aureus, S. pneumoniae, P. aeruginosa, S. typhimurium and E. coli. The method makes it possible to detect 102 CFU/cm^2 concentrations of bacteria in a short time.

CHARACTERISTICS

The technical properties have been confirmed by tests at St.Petersburg Pasteur Institute.

Fecal contamination registration method:
- Concentration, CFU/ml – 10^6
- Bacteria – E. coli and others
- Measurement time – 6 h

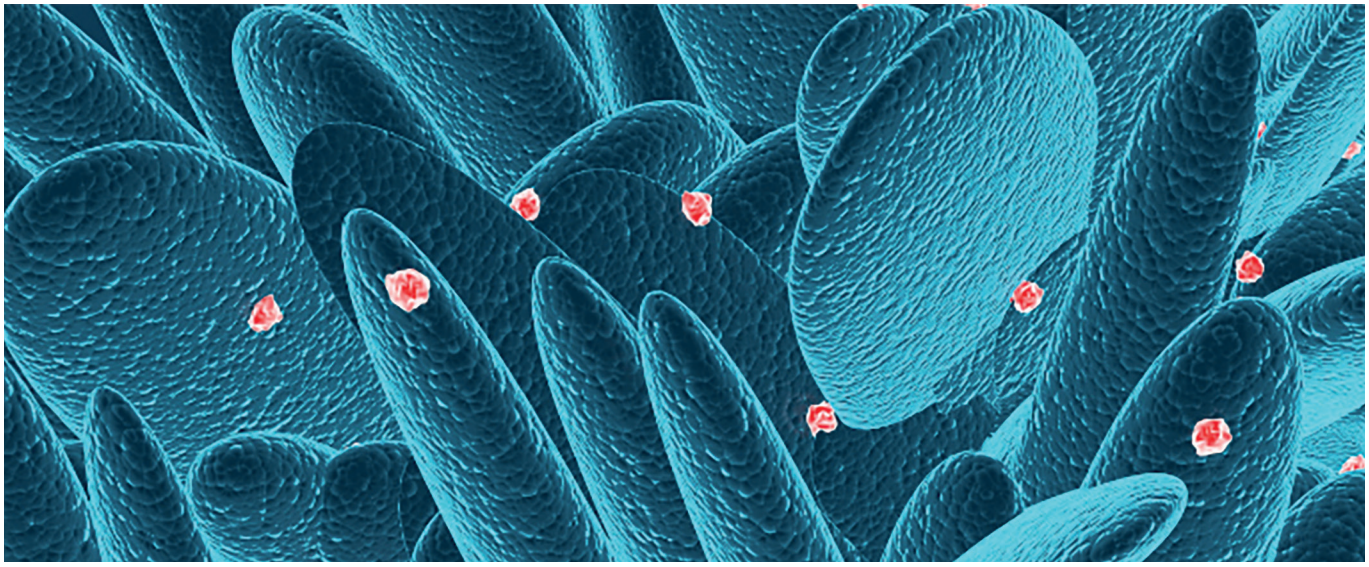
Contamination control via the colorant method:
- Concentration, CFU/ml – 10^2
- Bacteria – E. coli and other
- Measurement time – 2 h

ADVANTAGES OF THE DEVELOPMENT

- Reduction of measurement time
- Easy accessibility and cheapness of consumables
- Ease of use

APPLICATION AREAS

- Food industry
- Retail



VIRUS PARTICLE DETECTOR

43
SOFTWARE

DESCRIPTION

The viral particle detector is an innovative development that uses Surface-Enhanced Raman Spectroscopy (SERS) for fast and accurate diagnosis of viral diseases.

The software analyzes the SERS spectra of biological samples and determines the presence of viral particles. The database of SERS spectra of viral samples allows the use of machine learning algorithms to identify different types of viruses.

The device could become an important tool in the fight against viral diseases by providing quick and accurate diagnostics, which will aid in the development of effective treatment and prevention methods.

ADVANTAGES OF THE DEVELOPMENT

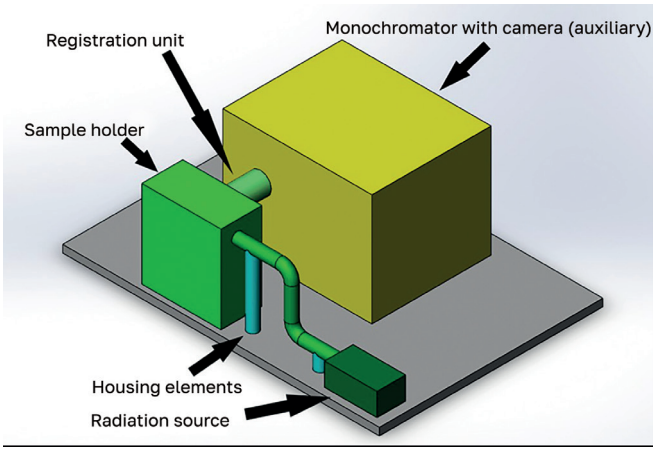
- Rapid detection of virus in a sample
- Universal platform for different viruses
- The creation of a domestic detector of viral particles will increase the effectiveness of the use of drugs and increase the degree of personalization of medicine
- There is a need to create a universal platform for testing the population and identifying virus carriers

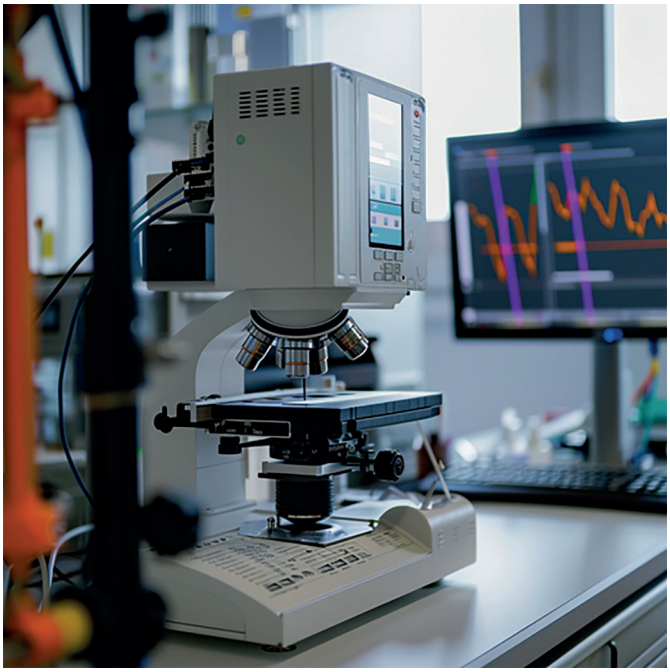
APPLICATION AREAS

- Healthcare

CHARACTERISTICS

- Detection threshold for viral particles: no more than 0.5 μg/ml
- Detection accuracy (the ratio of correctly identified samples to the total number of samples): at least 80%





44 DIGITAL-OPTICAL TELEMEDICINE SET

COMPLEX

ODESCRIPTION

The optical-digital telemedicine kit is intended for automated image formation, registration and processing of images for diagnostic purposes based on digital microscopy and endoscopy methods. The kit provides for recording, preliminary analysis and compression of video information for transfer via telecommunication channels.

The microvision system provides for formation and visualization of micro images of biological tissue and biomedical preparations. The video-endoscopic system is intended for the conduct of endoscopic examinations of the gastrointestinal tract, formation and visualization of endoscopy image, documentation and data archiving.

The network system serves the purposes of documentation and data archiving, compressing data for transfer via telecommunication channels, and computer-based microimage analysis with the complex use of data from various types of images. The system is compatible with modern videoconference systems which makes it possible to conduct conferences and consultations and high-efficiency data exchange in local, regional and global telecommunication networks.

The optical-digital telemedicine kit was developed in collaboration with JSC LOMO.

ADVANTAGES OF THE DEVELOPMENT

- Process automation
- Remote control
- Online consultations and medical counseling sessions

APPLICATION AREAS

- Medicine

45

COMPLEX

RANGE OF MULTISPECTRAL ANALYTICAL INSTRUMENTS FOR IN VITRO DIAGNOSIS AND LABORATORY RESEARCH

DESCRIPTION

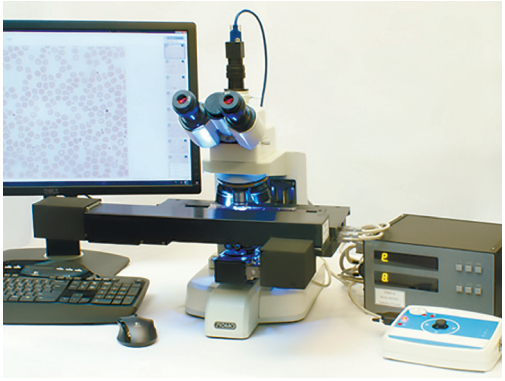
ITMO University and JSC LOMO together developed a modular range of competitive multispectral analytical instruments for laboratory diagnostics of biological tissue samples, blood and other biological fluids.

The instruments' specifications correspond to, and in some cases exceed those of their counterparts by leading manufacturers. It's worth mentioning that most manufacturers make use of third-party components. The experience of JSC LOMO in the development of complex optoelectronic systems will allow for producing a range of devices with a high level of localization and provide for the competitive advantage.

CHARACTERISTICS

Basic modular scanning analyzer (MSAB):

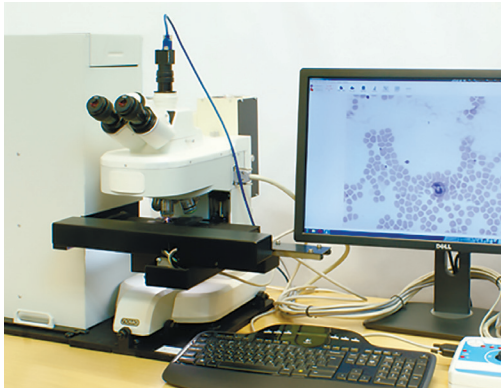
- lighting system – bright-field in transmitted light with an opportunity to install an epi-illuminator
- number of accessory lens sockets – no less than 3
- maximum lens resolution – no less than 100x
- number of pre-loaded samples – no less than 8
- resolution of the receiver of the emission receiver unit, MP – no less than 2
- frame rate of the receiver of the emission receiver unit, fps – no less than 15



Modular Scanning Analyzer basic (MSAB)

Expert modular scanning analyzer (MSAE):

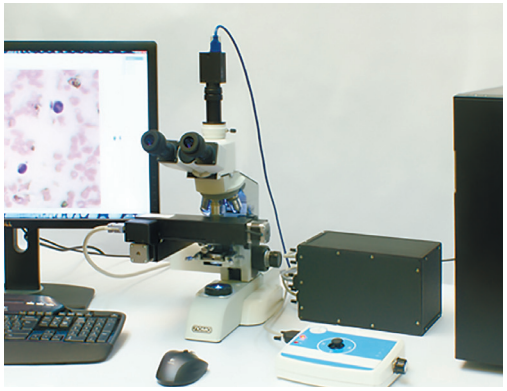
- lighting system – bright-field in transmitted light, multispectral reflective light system
- number of accessory lens sockets – no less than 5
- maximum lens resolution – no less than 100x
- number of pre-loaded samples – no less than 10
- resolution of the receiver of the emission receiver unit, MP – no less than 3
- frame rate of the receiver of the emission receiver unit, fps – no less than 30



Expert modular scanning analyzer (MSAE)

Practice modular scanning analyzer (MSAP):

- lighting system – bright-field in transmitted light with an opportunity to install an epi-illuminator
- number of accessory lens sockets – no less than 2
- maximum lens resolution – no less than 100x
- number of pre-loaded samples – no less than 2
- resolution of the receiver of the emission receiver unit, MP – no less than 2
- frame rate of the receiver of the emission receiver unit, fps – no less than 15



Practice modular scanning analyzer (MSAP)

ROBOTICS AND SENSORS

Today, robotics is one of the fastest-growing fields in science and technology, significantly impacting manufacturing processes and the competitiveness of enterprises. The introduction of robots in various industries such as healthcare, automotive, and logistics improves production efficiency and reduces costs. Research teams at ITMO University are engaged in the development of advanced instruments and systems, performing the full cycle of work from formulating the design concept to releasing complete sets of design and technological documentation, organizing small-scale production at advanced industrial enterprises. This approach enables high-tech solutions that enhance productivity and optimize industrial manufacturing processes.

Sensor technology is a fundamental principle of modern technologies that involves more precise and efficient control and management systems. Innovative sensors improve productivity and measurement accuracy across various fields. The development of new sensor technologies also supports the growth of the Internet of Things (IoT), where devices interact with each other, instantly collecting and transmitting data in real-time, opening new opportunities for creating intelligent systems and integrating them into everyday life.

From 2022 to 2024, ITMO University has published over 250 papers indexed in Scopus and registered 20 intellectual property objects. The total volume of work and services performed by the university in the field of robotics and sensor technology over the same period amounted to USD 7 million. In 2019, ITMO University first entered the Top 100 of the international ARWU (Shanghai) ranking in the field of Automation and Control and continues to hold leading positions annually. ITMO also ranks among the leaders of the Russian subject ranking RAEX for preparing specialists in the field of “Mechanical Engineering and Robotics”.

CONTENTS OF THE SECTION

46
COMPLEX

HARDWARE-SOFTWARE COMPLEX FOR CLASSIFICATION, DETECTION OF DEFECTS, AND FLAWS IN INDUSTRIAL PARTS

DESCRIPTION

The part classification complex, based on computer vision algorithms, allows the automatic determination of the part type, part number, defects, and characteristics (area, dimensions), as well as the identification of defective parts. A photograph of the part is used as the input for the system. The result is presented as a classification of the part.
The hardware-software complex enables the addition of new part types for classification (introducing new product catalogs into the system) and has the capability to generate data for label printers. The system achieves an accuracy of 99.9%.

CHARACTERISTICS

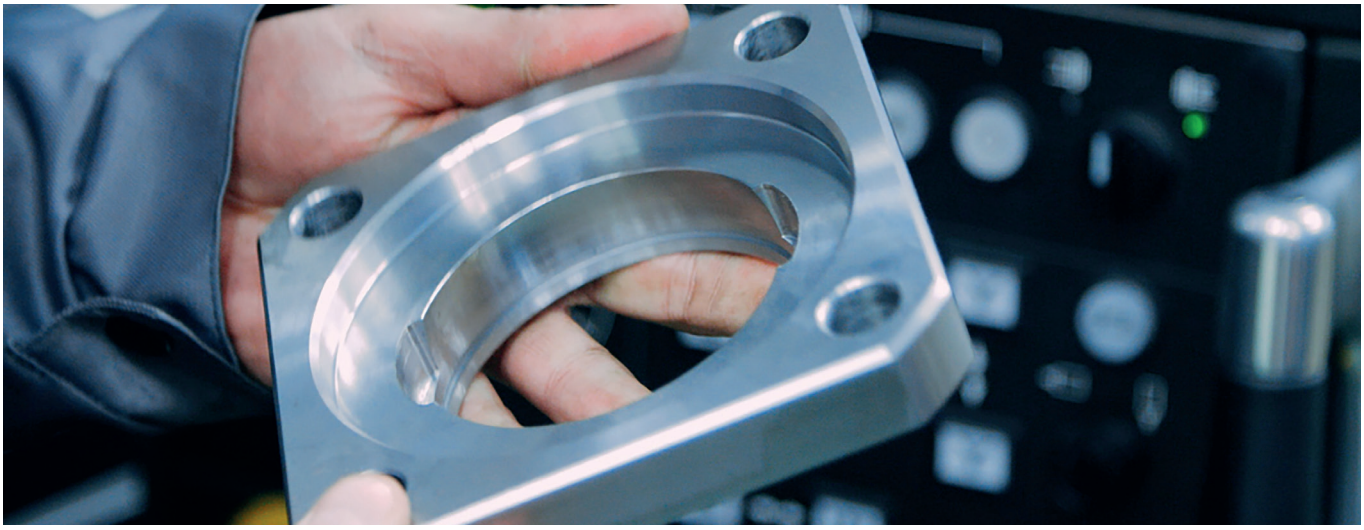
- IP cameras
- Computing server/computer for analysis and output of results
- Software “Part Classification System”
- Lighting, specialized surface (optional)

ADVANTAGES OF THE DEVELOPMENT

- Allows classification of any parts and objects, defect detection, and geometric dimension recognition
- Works with standard IP cameras, which can be selected individually
- Quick system tuning (retraining) for new part types without the involvement of developers
- Simple and user-friendly interface (web/desktop)
- Integration capability with the customer’s internal infrastructure for automating control of various devices.

APPLICATION AREAS

- Industry
- Processing
- Machine Engineering

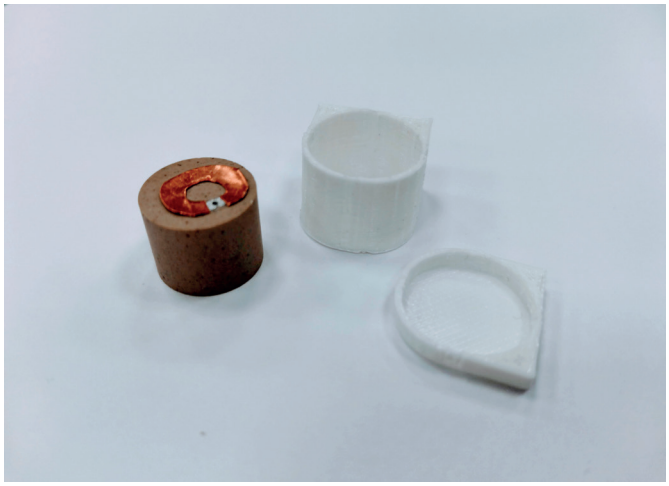


47
PRODUCT

CERAMIC RFID TAGS

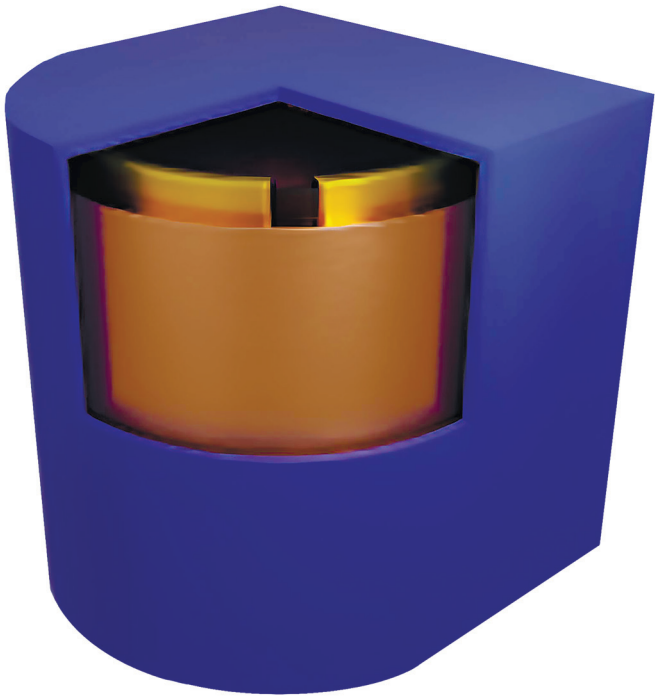
DESCRIPTION

The tag is a ceramic cylindrical resonator with an open metallic ring placed on the surface. A chip from a commercial tag is placed in the gap. The reader sends a signal to query the tag, exciting a magnetic dipole mode within it. The induced displacement currents in the resonator are converted into a conductivity current in the ring, initiating the operation of the microchip. The scattered modulated signal follows the reverse path — from conductivity current to radiation in the far field. The magnetic nature of the resonator mode ensures effective coupling with the ring through inductive coupling.



ADVANTAGES OF THE DEVELOPMENT

- Compact size of the tag
- High reading range
- Ability to provide isotropic response



CHARACTERISTICS

- Size: approximately 1.5 x 1.5 cm
- Reader power: 2 W

APPLICATION AREAS

- Medicine
- Logistics
- Internet of Things (IoT)

48 RECEIVERS AND SOURCES BASED ON PEROVSKITE MATERIALS

TECHNOLOGY

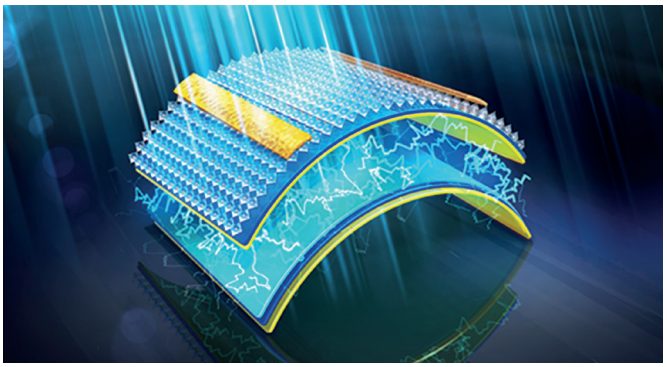
PEROVSKITE SCINTILLATOR LAYERS AND COMPONENTS FOR VARIOUS X-RAY APPLICATIONS

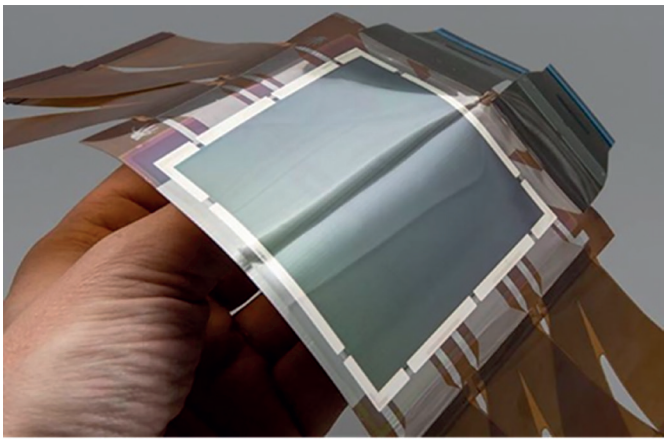
DESCRIPTION

Scintillators are chemical substances — phosphors — that can emit visible light when exposed to ionizing radiation. This radiation can include α, β, γ rays, electrons, nuclear fragments, X-rays, and more. Perovskites are a class of materials with highly advanced optical properties. Due to their composition, which includes heavy elements, they can effectively absorb X-rays and have the potential to become the foundation for a new generation of detectors. The use of this new material eliminates the need for constant trade-offs between brightness, resolution, speed, range, size, and cost.

ADVANTAGES OF THE DEVELOPMENT

- High sensitivity
- Fast operation
- Simple and cost-effective manufacturing
- Flexibility: perovskites enable the creation of flexible and non-brittle detectors
- Tunability: perovskites are a broad class of compounds, allowing parameter optimization over a wide range, while maintaining a unified production and processing methodology





APPLICATION AREAS

- Industry
- Medicine
- Instrumentation

ORGANIC AND PEROVSKITE PHOTOMATERIALS FOR THE CREATION OF FLEXIBLE PHOTODIODES AND PHOTODETECTOR MATRICES

ОПИСАНИЕ

Matrix image sensors based on organic and perovskite semiconductors form photodiode pixels and integrate them with active pixel transistor arrays based on metal-oxide semiconductors (MOS-TFT). Thin-film transistor arrays (MOS-TFT), acting as an analog-to-digital integrated circuit for reading photo signals, open up new possibilities for using organic and perovskite materials in advanced optical imaging technologies. The developed matrix photodetector sensor is 400x400 pixels with a density of 508 ppi, suitable for optical fingerprint sensors and X-ray sensors.

Economically efficient technologies for creating organic and perovskite photodiodes (PD) with improved absorption from the blue to the near-infrared (NIR up to 1200 nm) range are also presented, thanks to the use of dielectric resonant Si particles. In addition, the main operational parameters of the matrix photodetector sensor (MFD) are modeled, where the “1T-1C” architecture is proposed for the photodetector pixel model, which involves connecting a single transistor with a photodiode to the charge accumulation reading circuit and one charge capacitor.

CHARACTERISTICS

TTechnical Parameters:

- Pixel pitch: 50 μm
- Pixel array: 750*800
- Pixel density: 500 ppi
- Dark current: ~10 pA/mm²
- Pixel capacitance: ~0.1 pF
- Reading speed: 15 fs

Target Parameters:

- Resolution: Min. 512x960 pixels, 500 ppi
- Pixel size: 50.8 x 50.8 μm
- Area: Up to 300 x 400 mm² (Gen 2.5)
- Pitch: 75 μm
- Mode: Dynamic/static
- Electronics: ROIC and software
- Image: Yes

ADVANTAGES OF THE DEVELOPMENT

- Capability to manufacture flexible devices
- Easy scalability
- Ultra-thinness
- Unique optical characteristics
- The manufacturing process is compatible with continuous production technologies and has low cost

49 TECHNOLOGY

WIRELESS CHARGING TECHNOLOGY FOR INDOOR ENVIRONMENTS

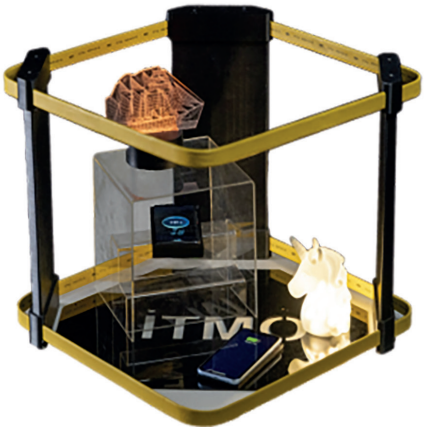
DESCRIPTION

The technology provides wireless energy transfer within a room or small enclosure to power household electrical and electronic devices at any point in space, ensuring safety for individuals within the area.

The technology involves the development of a volumetric resonance structure that creates a high-amplitude, homogeneous radiofrequency magnetic field and a low electric field throughout its volume. To achieve this, subwavelength resonance structures — metamaterials — are used. These are artificial materials with unique electromagnetic properties not found in nature. Such structures allow the control of the distribution of radiofrequency electromagnetic fields. The generated uniform magnetic field ensures the required coupling coefficient for wirelessly charging multiple devices, randomly positioned within the WPT (Wireless Power Transfer) room. The suppression of the electric field enhances the allowable transmitted power and ensures safe charging of the receiver device's batteries.

ADVANTAGES OF THE DEVELOPMENT

- Addresses the issue of «energy mobility»
- Insensitivity to the spatial positioning of receivers relative to the transmitter
- Wireless and safe resonance method capable of operating over greater distances than existing inductive-based alternatives.



HARVESTER FOR WIRELESS DEVICES

50
DEVICE

DESCRIPTION

Harvester is IOT autonomous power devices for wireless devices with commercially available solar cells: perovskite, organic and CIGS solar cells.

The use of solar cells makes it possible to partially or even completely abandon traditional batteries, and depending on the application conditions, different photovoltaics technologies can be implemented.

ADVANTAGES OF THE DEVELOPMENT

- Proprietary DC converter with minimal energy losses
- Unique supercapacitor recharging circuit
- Flexible design

CHARACTERISTICS

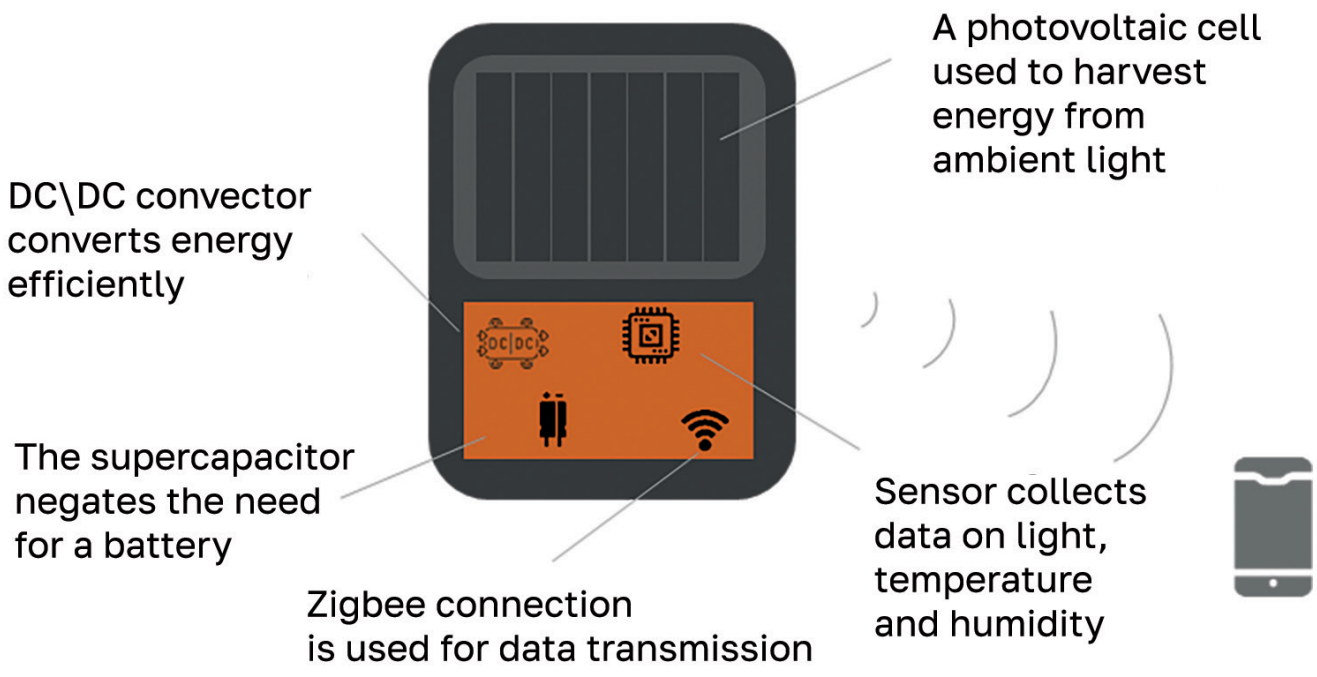
A wireless device with a harvester can operate in ambient room light and in outdoor conditions without having to change the battery with a service life of more than 5 years.

The low-power harvester has the following characteristics:

- operating voltage: from 1 to 3 V,
- capacitor capacity: <1 F,
- does not require a control board for the battery.

The medium-capacity harvester has the following characteristics:

- operating voltage: from 1 to 5 V,
- capacitor capacity: from 1 to 5 F.



51
PRODUCT

VERSATILE PADS FOR MRI

DESCRIPTION

Versatile pads for MRI made of natural and artificial dielectrics for high-field and ultrahigh-field MRI scanners are placed inside the scanner, in close proximity to the human subject, and take the shape of the area of interest. These pads provide a local enhancement of the signal-to-noise ratio, thus enabling higher-resolution MR images, which facilitates earlier detection and accurate diagnosis of diseases. Using MRI pads allows performing MRI procedures faster because of the lower acquisition time.

APPLICATION AREAS

- Medicine
- Magnetic resonance imaging

CHARACTERISTICS

Local enhancement of the signal-to-noise ratio at least by 2-3 times

ADVANTAGES OF THE DEVELOPMENT

- Enhancing image quality
- Reducing the number of artifacts
- Reducing duration of procedure

METACOIL.
MULTIPURPOSE WIRELESS MRI COILS

52
PRODUCT

DESCRIPTION

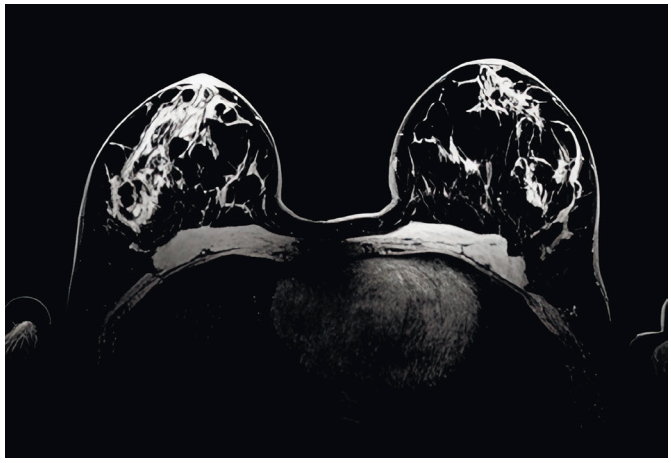
Wireless metamaterial-based radiofrequency coils “MetaCoil” increase MRI’s sensitivity and help produce informative, higher quality images, and their further use contributes to shorter queueing time, which decreases the need for buying new tomographs and therefore cuts budget expenses. What’s more, the coils are compatible with all types of MRI and are easy-to-use.

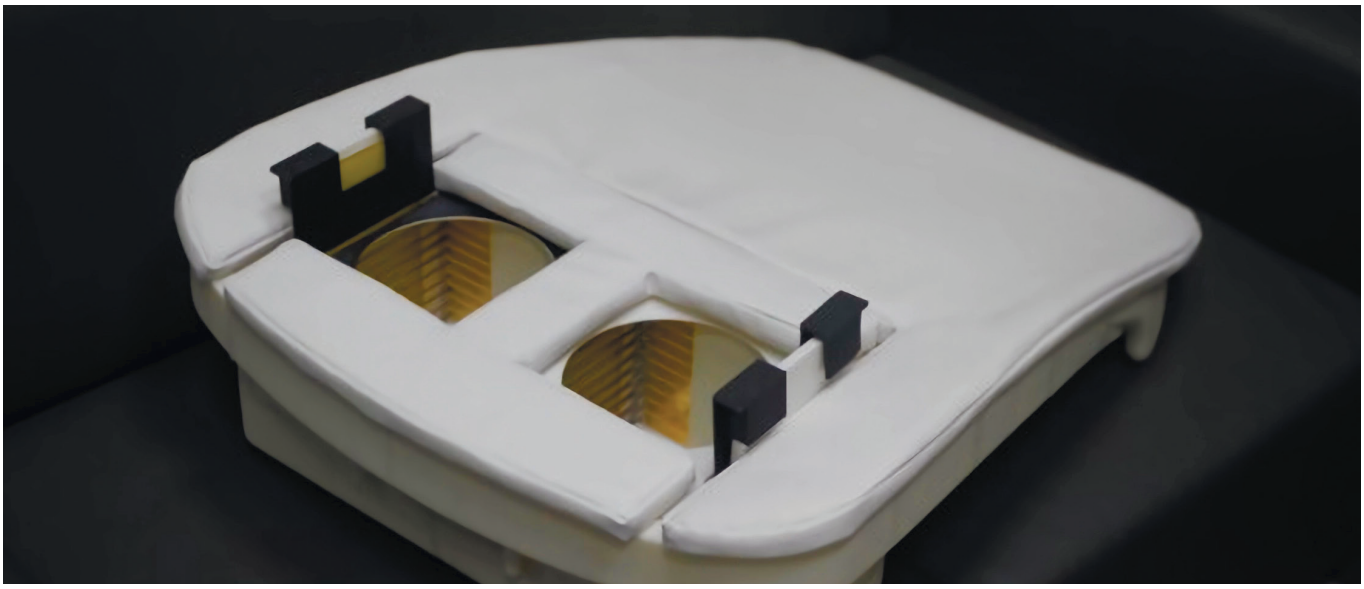
CHARACTERISTICS

- Operating frequency: 64 and 123 MHz
- Fixed resolution scanning 2 times faster
- Weight up to 5 kg

ADVANTAGES OF THE DEVELOPMENT

- Reduces the radiofrequency load on the patient’s body by up to 60 times
- Wireless, no cable connection required
- Improves the quality of MR images by 2 times
- Versatile





53
DEVICE

SYNCHRONOUS MOTOR WITH AXIAL MAGNETIC FLUX AND PERMANENT MAGNETS

DESCRIPTION

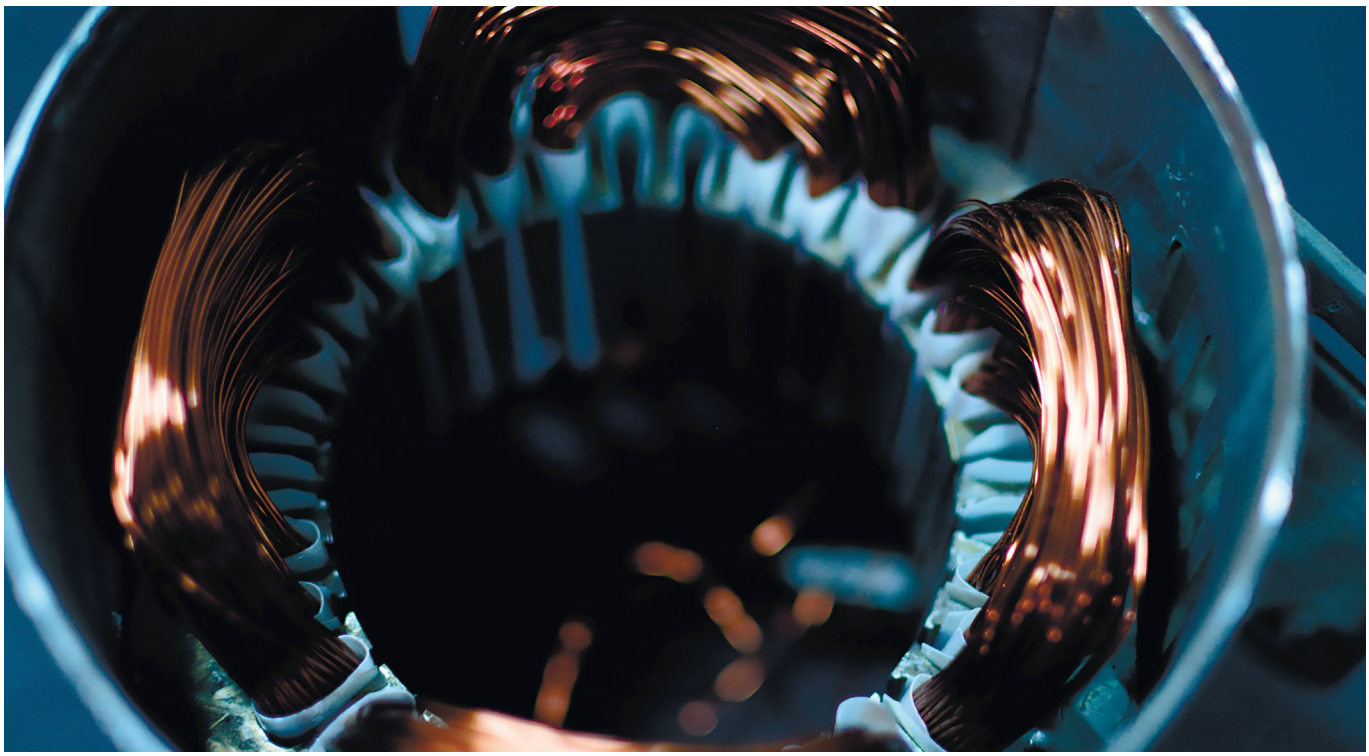
The synchronous motor with axial magnetic flux and permanent magnets is designed for use in precision direct-drive systems of robotic complexes. The motor employs rare-earth magnets with an axial magnetic flux direction in the air gap. This design eliminates cogging torque ripples and provides a high specific electromagnetic torque.

ADVANTAGES OF THE DEVELOPMENT

- High static quality factor (compared to counterparts)
- No electromagnetic torque ripples
- Compact axial length of the housing
- Smooth operation with low noise levels

CHARACTERISTICS

- Torque: At least 5 N·m
- Rotational speed: At least 500 RPM
- Nominal phase current: No more than 20 A
- Rotor: Dual-disk configuration
- Stator: Slotless, non-magnetic
- Armature winding: Three-phase
- Supply voltage on motor windings (RMS): No more than 380 V
- External motor diameter: No more than 300 mm



NEW-GENERATION PRECISION QUICK-OPERATING ELECTROMECHANICAL ACTUATORS

54
DEVICE

DESCRIPTION

Electromechanical actuators, as opposed to the traditional hydraulic and pneumatic actuators, have:

- better positioning precision
- simpler controls in comparison with counterparts
- simpler maintenance
- lesser size thanks to the absence of a hydraulic/pneumatic circuit
- minimal environmental footprint

ITEMS:

- **A product range of linear electromechanical actuators that includes five-unit sizes with an advancing movement of the output rod with a generated force of 1 to 300 kN**
- **A product range of rotary electromechanical actuators that includes five-unit sizes with an advancing movement of the output rod with a generated force of 300 to 10000 kN**

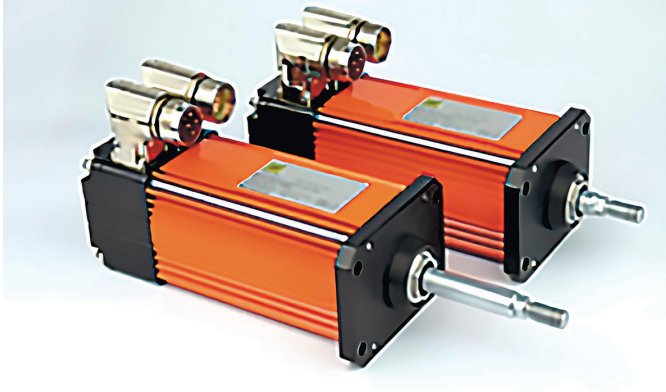
The actuators were developed in collaboration with JSC Diakont.

ADVANTAGES OF THE DEVELOPMENT

- Great technical characteristics thanks to the use of highly efficient processing methods and technologies for strengthening bearing elements of roller-screw gear
- The most advanced and efficient method for transforming rotational motion into forward motion thanks to the use of roller-screw gear

APPLICATION AREAS

- Electrical energy industry (nuclear power stations and thermal power stations)
- Engineering industry
- Shipbuilding and aircraft engineering
- Metal and steel-rolling industry
- Oil and gas, chemical and petrochemical industry



55 DIGITAL ELECTROMECHANICAL DRIVES OF THE NEW GENERATION

DEVICE

DIGITAL ELECTRIC POWER DRIVES FOR NEW GENERATION QUANTUM OPTICAL SYSTEMS

DESCRIPTION

The power electric drive is intended for pointing of quantum-optical systems of new generation.
The device has:

- high positioning precision
- smoothness of motion within the speed ranges from zero to tenths of degrees
- broadband dynamic flexibility essential for minimization of environmental perturbations

Thanks to the use of a gearless electric drive based on torque motors and high-precision optical angle sensors, ITMO researchers developed guidance systems for optical telescopes that correspond to the international requirements and provide for a pointing accuracy on the level of arcseconds.

The research is conducted by ITMO University on the order of JSC High Precision Systems (main customers: ROSCOSMOS, The Ministry of Defense of the Russian Federation).

CHARACTERISTICS

- Maximum axis rotation speed: up to 100 °/s
- Maximum axis rotation acceleration: up to 100 °/s^2
- Moments of inertia of rotating parts: from units to tens of thousands kg-m^2
- Data exchange via CAN-interface
- Mean squared error at the speed of 0...5 °/s: no more than 1”

ADVANTAGES OF THE DEVELOPMENT

- Works with precision absolute optical sensors via the BISS interface
- Elimination of the stepwise motion pattern of the tracking axis at infralow speeds
- A wide range of tracking speeds (18000) at small mean squared error values that call for a high Q factor in the system speed (from 200 to 2000)

DIGITAL ELECTRICAL POWER DRIVE OF AN OPTOELECTRONIC ASSEMBLY FOR DETECTION AND MEASUREMENT OF THE TRAJECTORY PARAMETERS OF SPACE DEBRIS

DESCRIPTION

The digital electrical power drive is intended for controlling a rotary support of an assembly for near-Earth space monitoring, which is intended for automatic detection of spacecrafts and space debris, measurement of their angular position and their correspondence with the objects from the assembly's database, as well as transferring of such information to a data collection and processing center. The digital electrical power drive offers a wide range of rotational speeds of the two rotary support axes with a high pointing accuracy, analysis of the support's condition, and processing of signals from sensors and auxiliary devices that the support is equipped with.

ADVANTAGES OF THE DEVELOPMENT

- High positioning accuracy and tracking accuracy
- Capacity for identification and adjustment in case of changes in weight and size
- A wide range of rotational speeds
- The support can be controlled via a local control console
- Works with various OS: Windows, AstraLinux

APPLICATION AREAS

- Systems for monitoring objects in the atmosphere and near-Earth space
- Optical telescopes, radio telescopes, laser systems, rangefinders

56
DEVICE

DEVICES AND METHODS FOR MEASURING THERMAL CONDUCTIVITY, TEMPERATURE CONDUCTITY, AND HEAT CAPACITY OF NON-METALLIC MATERIALS AND LIQUIDS

THERMAL CONDUCTIVITY AND DIFFUSIVITY METER FOR NON-METALLIC MATERIALS ITS-λ-20

DESCRIPTION

The automated device is designed for determining the thermal conductivity λ and thermal diffusivity λ of homogeneous dense solid non-metallic materials under normal conditions: open environment and room temperature of approximately 20 °C. The device consists of a thermal measurement cell and a specialized thermophysical controller TFK-2.2.

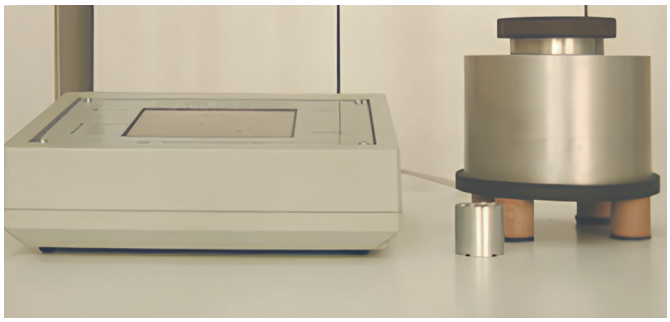
CHARACTERISTICS

- Measurement Range: thermal conductivity λ (0.15...1.0) W / (M × K), thermal diffusivity a - (1.0...5.0) × 10-7 m^2/s
- Temperature Range for Measurement: (25 ± 5) °C
- Test Objects: Homogeneous dense solid non-metallic materials
- Sample Dimensions and Shape: Flat plates sized (30×30) + 0.1 mm, thickness (4.0...15) + 0.1 mm, cut or stamped from the test material. Flat surfaces must be ground on a lapping plate, with wedge tolerance not exceeding 0.05 mm
- Experiment Duration: 3 to 30 minutes (depending on sample properties)
- Measurement Accuracy: thermal conductivity: ± (5–7)%, thermal diffusivity: ± (7–10)%
- Power Supply: 220 V, power consumption up to 10 W
- Operator Interaction: Real-time monitoring of experiment progress via a graphical display

THERMAL CONDUCTIVITY AND HEAT CAPACITY METER FOR LIQUIDS ITS-λC-20

DESCRIPTION

This automated device is designed to determine the thermal conductivity λ and specific isobaric heat capacity c of liquid petroleum products and polymer solutions under normal conditions. The device includes a thermal measurement cell, a specialized thermophysical controller TFK-2.2, and a set of metallic ampoules with through concentric holes.



CHARACTERISTICS

- Measurement Range: thermal conductivity λ: (0.10...0.70) W/m×K
- Specific heat capacity c: (2.0...4.2) kJ/kg×K
- Temperature Range for Measurement: (25 ± 5) °C
- Dimensions: Fits on a laboratory table with an area of 0.5 m^2
- Experiment Duration: 3 to 30 minutes (depending on sample properties)
- Measurement Accuracy: Specific heat capacity: ± (5–7)%. Thermal conductivity: ± (7–10)%
- Power Supply: 220 V, power consumption up to 300 W
- Sample Dimensions and Shape: Samples are filled into specially designed metallic ampoules with concentric holes

Controller TFK-2.2 Capabilities:

- Input of initial experiment parameters
- Measurement of temperature sensor readings across eight independent channels (thermocouples, micro-thermistors, resistance thermometers)
- Control of a heating element connected to the controller
- Maintenance and control of heating power at a specified level
- Conversion of electrical signals from sensors into the temperature gradient of the sample relative to the isothermal block
- Graphical display of sensor readings during the experiment
- Storage of experimental data for one experiment in the internal memory
- Data transfer to a PC via RS-232 and Ethernet interfaces

57 COMPLEX OF MEASURING MATERIALS' THERMAL PROPERTIES

COMPLEX

DESCRIPTION

The complex of measurement devices allows to conduct complex measurements of thermal properties of materials.
The complex incorporates:

- a thermophysical controller that provides for automation of devices and sets for thermophysical research with a capacity for user programming of experiments and data processing procedures
- a device for measurement of heat conductivity of inorganic materials. It can be used to study the heat conductivity of such objects as polymers, friction materials, semiconductors and other inorganic materials in the shape of plates and disks
- a device for measuring thermophysical properties of wet materials. The device is intended for measuring heat capacity, thermal conductivity, temperature conductivity, enthalpy as a function of temperature and cryoscopic temperature of wet materials when they get frozen and unfrozen
- a device for measuring heat conductivity and heat capacity of non-metal materials. The device is intended for measuring heat conductivity and heat capacity of homogeneous solid non-metal materials when they get cooled or heated

ADVANTAGES OF THE DEVELOPMENT

- High measurement precision
- A capacity to display experimental data in real-time

APPLICATION AREAS

- Laboratory research
- Approval of thermal properties of manufactured produce

SENSORY TAGS FOR PRODUCT QUALITY MONITORING

58
TECHNOLOGY

DESCRIPTION

Sensor labels are designed as sticker sensors with ink that changes color depending on environmental parameters such as oxygen, pH, or temperature. Each sensor label consists of multiple layers: a flexible polymer substrate with an adhesive layer, an active layer with nanoparticles, and a protective transparent layer. The sensor is activated when the barrier between the active substance and the product is breached. The technology has been tested and adapted to meet the specific technical requirements of industrial clients in the food retail sector.

CHARACTERISTICS

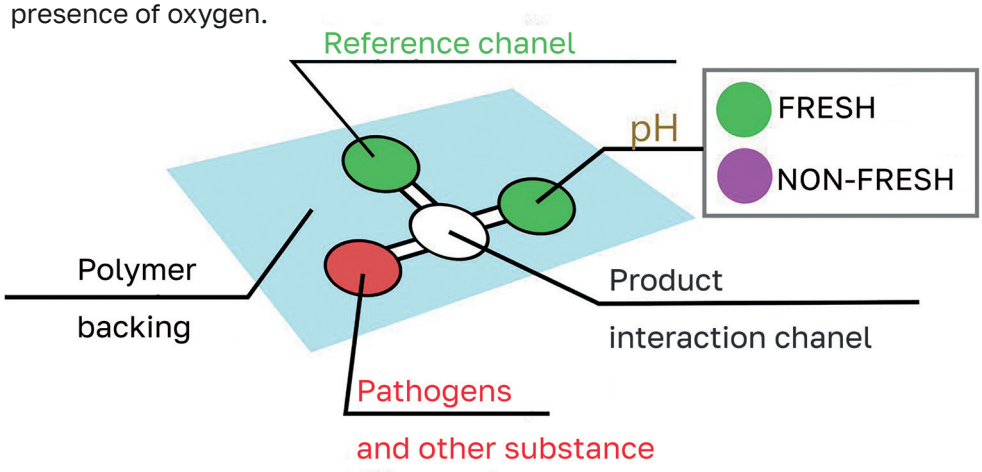
- Sensor sizes from 1 cm
- The sensor reacts calorimetrically to changes in the following parameters:
  - temperature: irreversible transition point 0C,
  - pH in the range from 1 to 10,
  - presence of oxygen.

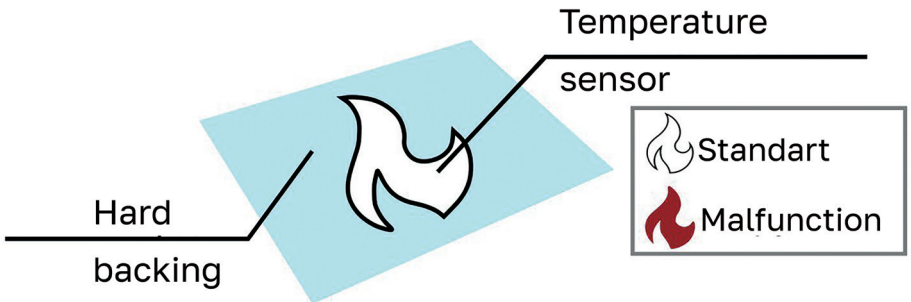
ADVANTAGES OF THE DEVELOPMENT

- Type and type (ink or flexible sticker)
- Ability to monitor product shelf life in dependence on changed environmental conditions or internal processes
- Eco-friendly
- Possibility of automated application and reading of the sensor

APPLICATION AREAS

- Food industry
- Pharmaceuticals
- Medicine





59 COMPLEX

SENSOR COMPLEX FORRECONSTRUCTION OF 3D SCENES

DESCRIPTION

The technological core of the complex comprises algorithms based on deep convolutional neural networks and methods of global numerical optimization, applied for model identification and data integration from measurement devices. The algorithms provide accurate estimation of dense metric depth maps with automatic calibration using sparse RGB-D points, determined through visual-inertial odometry algorithms, following the single-view stereo matching concept. In addition to the camera, the hardware part of the complex includes a single-board computer with a processor and FPGA core, a lithium-polymer battery for autonomous power supply (replaceable with a power board for connection to an external DC power source), a touchscreen display for human-machine interaction (optional when used in robotic systems). All components are assembled in a single case.

ADVANTAGES OF THE DEVELOPMENT

An important advantage of the complex is the use of a standard video camera instead of specialized RGB-D sensors of foreign production, which are now difficult to acquire.

APPLICATION AREAS

The complex is implemented as a standalone solution and is intended for use in information and control systems of unmanned vehicles and mobile service robots to solve navigation and mapping (SLAM) tasks. It can also be used as standalone equipment for 3D scene reconstruction.

HYBRID HOLONOMY MOBILE ROBOT

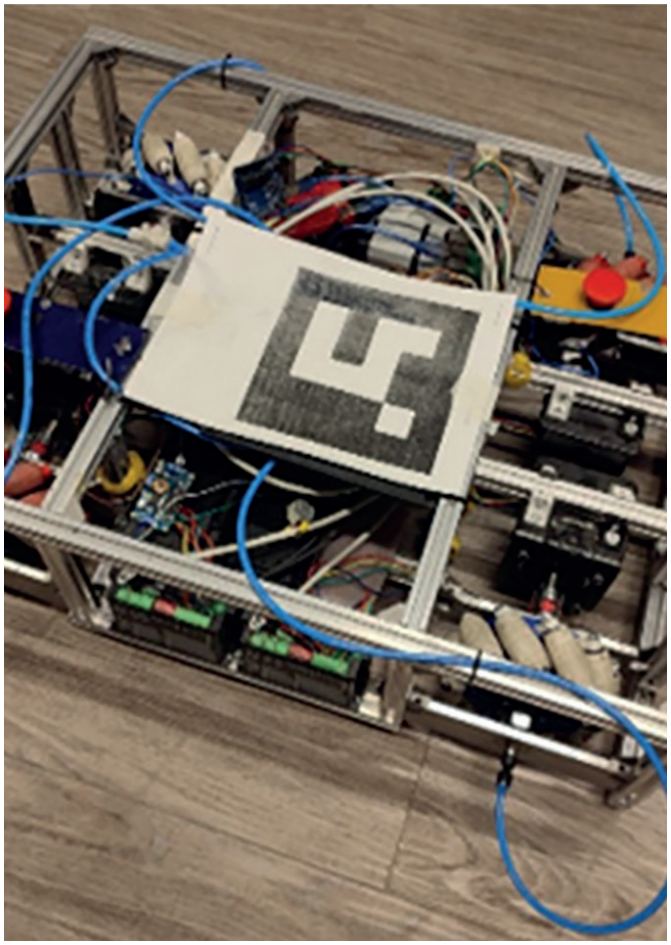
60
DEVICE

DESCRIPTION

Robotic mobile platforms with hybrid holonomy combine the advantages of both types of robots, namely the high maneuverability inherent in mecanum robots and the energy efficiency and safety of ordinary wheeled robots. Hybrid holonomy refers to the possibility of the robot functioning in the mode of a conventional wheeled robot and an omnidirectional robot on wheels of the “mecanum” type.

ADVANTAGES OF THE DEVELOPMENT

- Hybrid holonomy combines the capabilities of traditional wheeled robots and robots with “mecanum” type wheels. This approach assumes the possibility of switching between holonomic and non-holonomic modes for steady movement on inclined or uneven surfaces, as well as to reduce energy costs, which is especially important for autonomous robots.
- Robots with hybrid holonomy can effectively bypass obstacles and adapt to terrain changes, increasing the safety of operation in difficult conditions.



CHARACTERISTICS

- The weight of the robot is 35 kg
- Length x Width x Height 760×450×255
- Payload 30 kg
- The maximum speed is 1 m/s

APPLICATION AREAS

- Warehouse and production logistics
- Construction industry
- Medicine
- Agriculture
- Environmental monitoring
- Industry and instrument making

61 VIDEO INSPECTION SYSTEM FOR COLD-ROLLED STEEL ROLLED PRODUCTS

SYSTEMA

DESCRIPTION

The system for detecting and classifying surface defects in rolled metal products integrates two types of illumination - diffuse and side illumination - to provide analysis of defects with different structures. The use of color high-speed cameras with high contrast (Weber - not less than 0.25) makes it possible to detect small defects up to 0.5 x 0.5 mm. Based on the Faster R-CNN convolutional neural network, a model optimized for real-time application has been created, which combines several classifiers tuned for different lighting conditions. This improves the recognition accuracy to under- and over-reject rates of no more than 3% and 5%, respectively, and up to 10% and 15% when defect classes are taken into account.

The image preprocessing method improves the quality of optical inspection by calculating the statistical characteristics of each image and subtracting the average intensity value to equalize the illumination. This approach increases the contrast of the defect image and minimizes distortion from uneven illumination. In addition, the system saves the processed images for further analysis and training of neural networks.

CHARACTERISTICS

- Cameras: High-speed color (4K, ≥1000 fps)
- Lighting: Combined (ambient and side illumination), automatically adjusted for accurate detection
- Algorithms: Pre-processing for contrast enhancement and detection of defects from 0.5×0.5mm, Faster R-CNN neural network for recognition and classification
- Accuracy: Undersampling - up to 3%, oversampling - up to 5%
- Performance: Processing time down to 0.01 sec/image
- Integration: Ethernet, RS-485 interfaces, MES/ERP compatibility
- Software: Linux/Windows, adaptive retraining, light control
- Operation: Temperature range -10°C...+45°C, IP65 protection

ADVANTAGES OF THE DEVELOPMENT

- Increase of speed and accuracy of rolled products certification
- Automating the certification process without sacrificing quality
- Import substitution and independence from foreign suppliers
- Support for different lighting conditions for optimal certification
- Reduction of certification costs through automation
- Easy integration and scalability for different types of rolled products
- Adaptive training and system modernization
- The system provides high attestation accuracy and stable operation under industrial conditions

ENERGY-EFFICIENT SYNCHRONOUS ELECTRIC MOTOR WITH BUILT-IN INTELLIGENT POSITION SENSOR AND SELF-DIAGNOSTICS FEATURES

62
DEVICE

DESCRIPTION

The electric motor is designed to convert electrical energy into mechanical energy for use in robotics and digital automation systems as part of an electric drive. It is ideal for applications requiring high-precision control of actuators with superior reliability. The motor features an integrated position sensor that not only measures the rotor's angular position and speed but also includes self-diagnostics functionality.

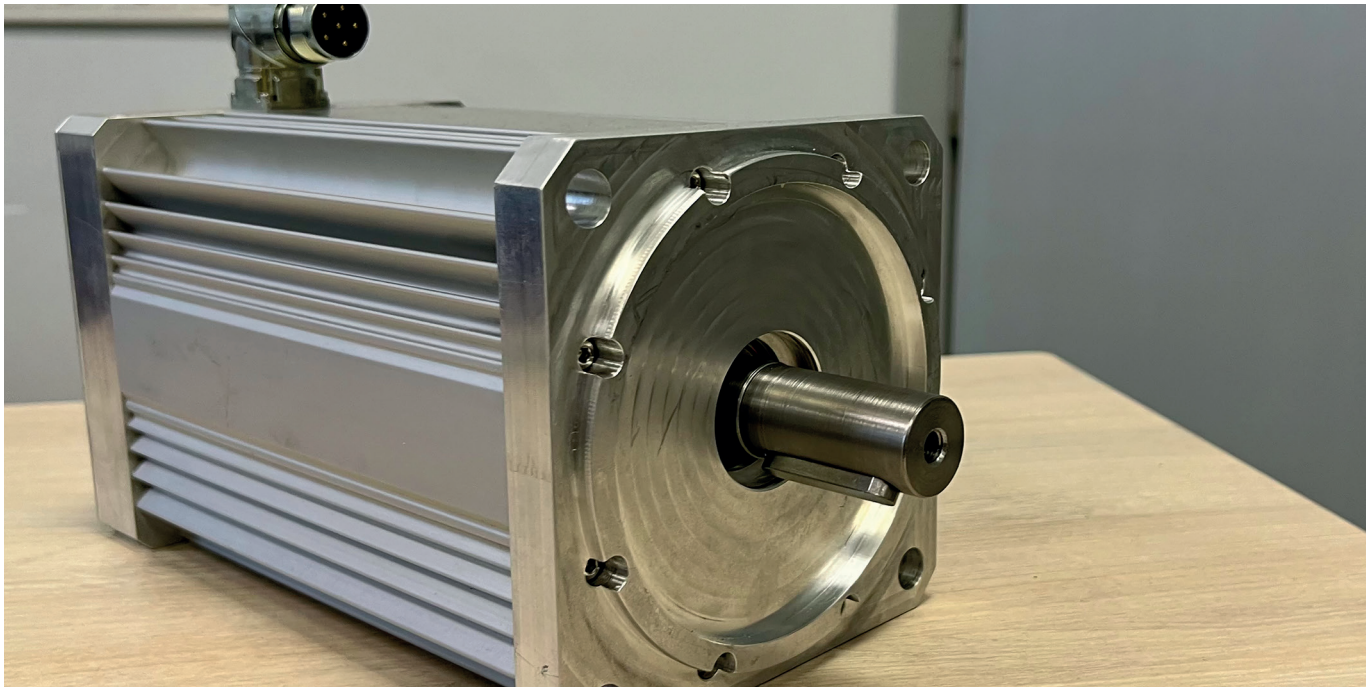
Based on sensor data, as well as measurements of currents and voltages in the stator windings and temperature readings, the embedded software calculates current parameters of the motor model and its state variables. This information is then used to detect faults, identify abnormal conditions, and evaluate the performance of the motor and the sensor itself. This enables proactive monitoring of the motor's condition, providing early warnings of operational changes that could lead to malfunctions.

CHARACTERISTICS

- Rated Power: 7800 W
- Rated Torque: 29.8 N·m
- Rated Speed: 2500 RPM
- Energy Efficiency Class: IE5

ADVANTAGES OF THE DEVELOPMENT

- High responsiveness
- Compact design
- Energy efficiency
- Reliability



BIOCHEMICAL SYSTEMS AND MATERIALS

ITMO University is actively developing new fields related to biotechnologies, biochemical substances, and materials. The research programs emphasize a multidisciplinary approach, combining expertise in biotechnology and information technologies — from molecular biology to advanced materials. This enables the resolution of contemporary challenges and the development of innovative solutions for various industries, including medicine and environmental science. ITMO University researchers conduct studies across a wide range of topics — from developing algorithms for genome assembly to cellular engineering and biotechnologies for specialized food products.

Over the past decade, ITMO University has risen to the top three leaders in the field of chemical technologies in Russia, thanks to the achievements of the Chemical-Biological Cluster (CBC), which is a network of world-class research laboratories and an educational center for chemistry and biotechnology. The CBC serves as the core of “new chemistry” at ITMO University, uniting the most cutting-edge scientific directions in the field: nanopharmaceuticals, functional nanomaterials, applied computational chemistry, infochemistry of self-organizing systems, food bionanotechnology, microbiology, experimental oncology, molecular robotics and biosensor materials, applied genomics, and more. In the life sciences field, ITMO University has published approximately 350 papers indexed in Scopus over 2022–2024, registered 20 intellectual property objects, and achieved a total research and service volume of USD 12 million in biochemistry during this period. ITMO University ranked 4th in Russia in the subject-specific university productivity rating in Chemistry by the Analytical Center “Expert” in 2024. In the QS World University Rankings by Subject in 2024, ITMO University entered the Top 10 universities in Russia in Chemistry, taking the 6th position.

CONTENTS OF THE SECTION

63 FOOD TECHNOLOGIES

A technology for producing high-quality decorative breading with the use of advanced technologies in the field of pastry and crumbling

A production technology for carbonated drink from milk whey

Recipe of salt substitute for use in the food industry

Method for production of technical bioethanol from perennial herbaceous plants (cow parsnip, cattail, reed)

Technology of manufacturing zephyr enriched with iodine from fresh water brown algae, with the addition of kelp, based on pectin from topinambour

DEVELOPMENTS

- A range of gluten-free products with added plantain fiber (psyllium husk) for maintaining a healthy diet. Gluten-free products help maintain normal blood sugar levels and improve digestion because psyllium is practically not absorbed by the body.

- Antioxidant complex derived from brown algae which has immunostimulant, antioxidant and antimicrobial effects. The complex can be used as one of the antioxidants in foods or as a dietary supplement.

- A machine for conducting absorption processes, aerobic cultivation of single-cell organisms, water, heat and fermentation processing of grain raw materials and other technological processes of food, chemical and chemico-pharmaceutical fields of industry.

- The technologies and equipment for infrared drying with a designated wavelength of germs of various grains with a productivity of 750 kg per hour. The devices allow for efficient dehumidification of wheat germs in various temperature ranges on a teflon tape in continuous operation and reduce the inherent moisture of the product to 5-6% at low temperature while keeping the natural properties.

- The technology and equipment for infrared processing with a designated wavelength of seed grain with a productivity of 400 kg per hour, which makes it possible to conduct intensive processing of seed grain prior to planting at 43-46 0C in a continuous mode. The process stimulates growth processes, increases the viability and yield of grain crops.

- A device for dehydrating recycled carbohydrates that's intended for creating a looped recirculating system aimed at complete exclusion of natural water from the operating cycle of washing oil product-contaminated equipment.

- A reagentless technology and equipment (modular with adjusted productivity) for producing highly efficient protein feedstuffs for animal farming that have long shelf life in conditions of uncontrolled temperature from fish breeding (natural losses) and fish processing wastes.

- A paper-based analytical platform for the instrument-free multiplex determination of several practically relevant plant metabolites simultaneously in a single sample. The work proceeds at the level of determining the optimal amount of detection (lower limit of detection and minimum sample volume) with optimal stability of analytical methods.

64
TECHNOLOGY

TECHNOLOGIES FOR PRODUCING PRODUCTS FROM ALTERNATIVE RAW MATERIALS

DESCRIPTION

Projects focused on creating recipes and technologies from alternative protein sources are highly relevant today, as the most common animal protein substitute — soy — contains phytoestrogens and has several contraindications for consumption. There are recipes for producing fermented food products based on legumes (such as natto) and technology for producing plant protein from oilseed meal (sunflower, flax, hemp). Additionally, researchers at the university have developed technology for producing cookies and yogurt from pea isolate, as well as meat sausages using pea protein isolate. The core idea behind these developments is to replace traditional soy with raw materials that are more widely available in Russia.

ADVANTAGES OF THE DEVELOPMENT

- Natural and hypoallergenic composition
- Low cost
- Simplicity of production

TECHNOLOGY OF PECTIN AND INULIN PRODUCTION FROM TOPINAMBOUR USING FOOD GRADE ACID

65
TECHNOLOGY

DESCRIPTION

The technology of obtaining pectin and inulin as a by-product from underutilized raw materials (topinambour) is designed for further introduction into the food industry using organic acids. Functional complex with biological substances is a 100% natural product, the production process is safe for human consumption because food acids (citric, oxalic) are used. By-products are pectoinulin and inulin, these products can be separated into pectin and inulin using finer filtration. Inulin from topinambour can be used as a component of therapeutic and preventive foods for people with diabetes mellitus.

ADVANTAGES OF THE DEVELOPMENT

- Natural composition
- Uniqueness for Russia
- Cost efficient production
- Longer shelf life

APPLICATION AREAS

- Food industry
- Therapeutic food products
- Confectionery industry

66
PRODUCT

FISH BOUILLON CONCENTRATE

DESCRIPTION

Fish bouillon concentrate is a prepared product for home use, which simplifies the process of preparation of dishes: there is no need to cut and boil fish, remove the specific odor and wash soiled dishes. Frozen product reduces not only the time of cooking fish dishes, but also financial costs. The peculiarity of the product lies in its composition: natural cod broth is enriched with collagen and vitamin D3. One package of concentrate closes 100% of the daily norm of vitamin D3.

CHARACTERISTICS

The composition of concentrated fish broth:

- Cod spines
- Purified water
- Frozen carrots
- Frozen onions
- Dried bay leaf
- Black pepper peas
- Extra salt
- Dried dill
- Lemon juice
- Sprouted wheat

ADVANTAGES OF THE DEVELOPMENT

- No similar products
- Fast preparation
- High content of complete proteins, in particular collagen, macro- and microelements and vitamins

TECHNOLOGY FOR OBTAINING FEED VITAMIN B12

67
TECHNOLOGY

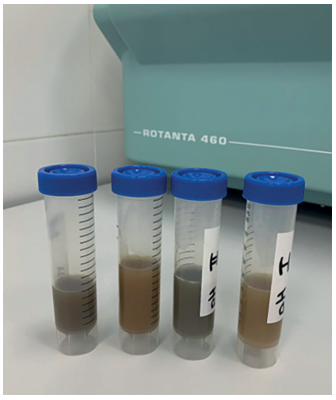
DESCRIPTION

Mechanisms of vitamin B12 synthesis by a consortium of microorganisms from alcoholic production waste - post-alcoholic bard, in order to further obtain a feed concentrate with vitamin B12 content of 0.1%. The product is a technology that increases the commercialization of distillery waste.

A related result of integration of the development into existing production facilities will be import substitution of feed vitamin B12 (and subsequently other vitamins), which is currently supplied entirely from abroad.

ADVANTAGES OF THE DEVELOPMENT

- There is no production of vitamin B12 in the EAEU
- Vitamin B12 is one of the obligatory nutrients that must be present in sufficient quantities in the composition of feed
- It is necessary to ensure normal metabolism, formation and functioning of the nervous system, regulation of protein, fat and carbohydrate metabolism, as well as to ensure normal hematopoietic function



CHARACTERISTICS

- Feed concentrate with vitamin B12 content of 0.01%
- The concentrate is packed in 10 kg bags
- Shelf life is 2 years from the date of production
- The product is stored in the manufacturer’s package, in a dry well-ventilated room, in a place protected from direct sunlight. Storage temperature ranges from 5˚C to 25˚C

APPLICATION AREAS

- Agricultural industry
- Farming
- Industrial scale production.

68 DINNERWARE MADE OF BIODEGRADABLE MATERIALS

PRODUCT

DESCRIPTION

The main component of such packaging is food industry waste the addition of various binding components and plasticizer. This packaging is made of fully biodegradable components, which reduces the environmental impact. Also, the use of food processing waste solves the problem of its utilization.

CHARACTERISTICS

- List of ingredients: brewer's spent grain, pectin, citric acid, glycerin
- The packaging withstands interaction with water at 100 °C for 30 min
- Shelf life 1 year

ADVANTAGES OF THE DEVELOPMENT

- The manufacturing of this material will aid in processing of resyclable materials and disposal of brewer's spent grain
- The material presented is biodergadable
- No existing domestic analogs

TECHNOLOGY FOR ACCELERATED AGEING OF WHISKY DISTILLATES

69
TECHNOLOGY

DESCRIPTION

The technology involves carrying out the process of extraction of whisky distillates with the use of ultrasound and determining the optimal parameters of impact on the distillate to obtain a finished product on the physicochemical and organoleptic properties similar to whisky aged in the traditional way.

APPLICATION AREAS

- Food industry
- Chemical industry
- Cosmetic industry
- Forest chemicals industry
- Pharmaceutical industry

CHARACTERISTICS

- Volume of the experimental setup 5 l
- Power 1000 VA
- Frequency of ultrasonic vibrations, kHz 20±2

TECHNOLOGY FOR THE PRODUCTION OF SPARKLING BEER USING WINE YEAST

70
TECHNOLOGY

DESCRIPTION

The technology of sparkling beer production with the use of degorgement and remuage allows to obtain a drink produced from traditional raw materials (barley and wheat malt), which without the use of flavor additives has a trademark, similar to the flavor profile of champagne wines, pleasant acidity on the aftertaste.

CHARACTERISTICS

- Alcohol content in prepared product ranges from 6.0 to 12.0% vol
- Content of natural carbon dioxide not less than 0.55%
- Level of residual visible extract not more than 0.5 %

APPLICATION AREAS

- Brewing industry

71
TECHNOLOGY

SMART PACKAGING FOR FOOD PRODUCTS

INTELLIGENT PACKAGING FOR CHILLED FISH AND SEAFOOD

DESCRIPTION

The **MEMBRANE** is an innovative intelligent packaging technology for chilled products at fish processing plants, incorporating the following components:

- EPS (expanded polystyrene) boxes
- Transparent two-layer PE (polyethylene) film
- CO2 absorber
- Modified atmosphere (MA) packaging
- Scaly or liquid ice for preserving fish and seafood freshness and prolonging shelf life

CHARACTERISTICS

- MA composition: N 35%, CO 15%, O 50% at storage or transport temperature from 0 to +2°C
- EPS container: density 21 g/l, wall thickness 25–30 mm
- Transparent two-layer PE film: 40 μm, 13 MPa
- Adhesive activator for EPS: food-grade EVA ethylene-vinyl acetate, used in polyolefins (e.g., Kristal Lim FDA* 105) when heated to 70–80°C
- Industrial design of EPS boxes allows for stacking of various sizes on one pallet to create a stable stack

ADVANTAGES OF THE DEVELOPMENT

- Prolonged shelf life up to 33 calendar days for trout family fish
- Reduction in transportation and logistics costs by 22% and packaging weight by 38%
- Expansion of supply geography and range from Kaliningrad to Vladivostok: new shipment quantities from 0.5 kg to 4 kg for portioned packaging of steaks and fillets
- Stable temperature control throughout the entire supply chain
- Environmental friendliness: 100% EPS

SMART PACKAGING FOR FOOD PRODUCT QUALITY CONTROL

DESCRIPTION

A methodology for creating a sensory-sensitive element compatible with product packaging to produce «smart» food packaging, with a focus on meat products, ensuring food safety.

ADVANTAGES OF THE DEVELOPMENT

- Visual indication of meat spoilage

APPLICATION AREAS

- Meat industry

CHARACTERISTICS

- Sensor base: soft materials
- Selectivity to anaerobic bacteria and their metabolic products in meat products
- Object of analysis: meat products
- Sensitive element of the sensor: molecular additive

72
TECHNOLOGY

ENERGY-EFFICIENT AND ENVIRONMENTALLY FRIENDLY HEATING AND COOLING SYSTEMS

DESCRIPTION

The technology of energy saving and environmental safety is based on the method of complex optimization of the developed heat and cold supply systems based on lithium bromide absorption thermal transformers using renewable energy sources and thermal energy accumulation.

CHARACTERISTICS

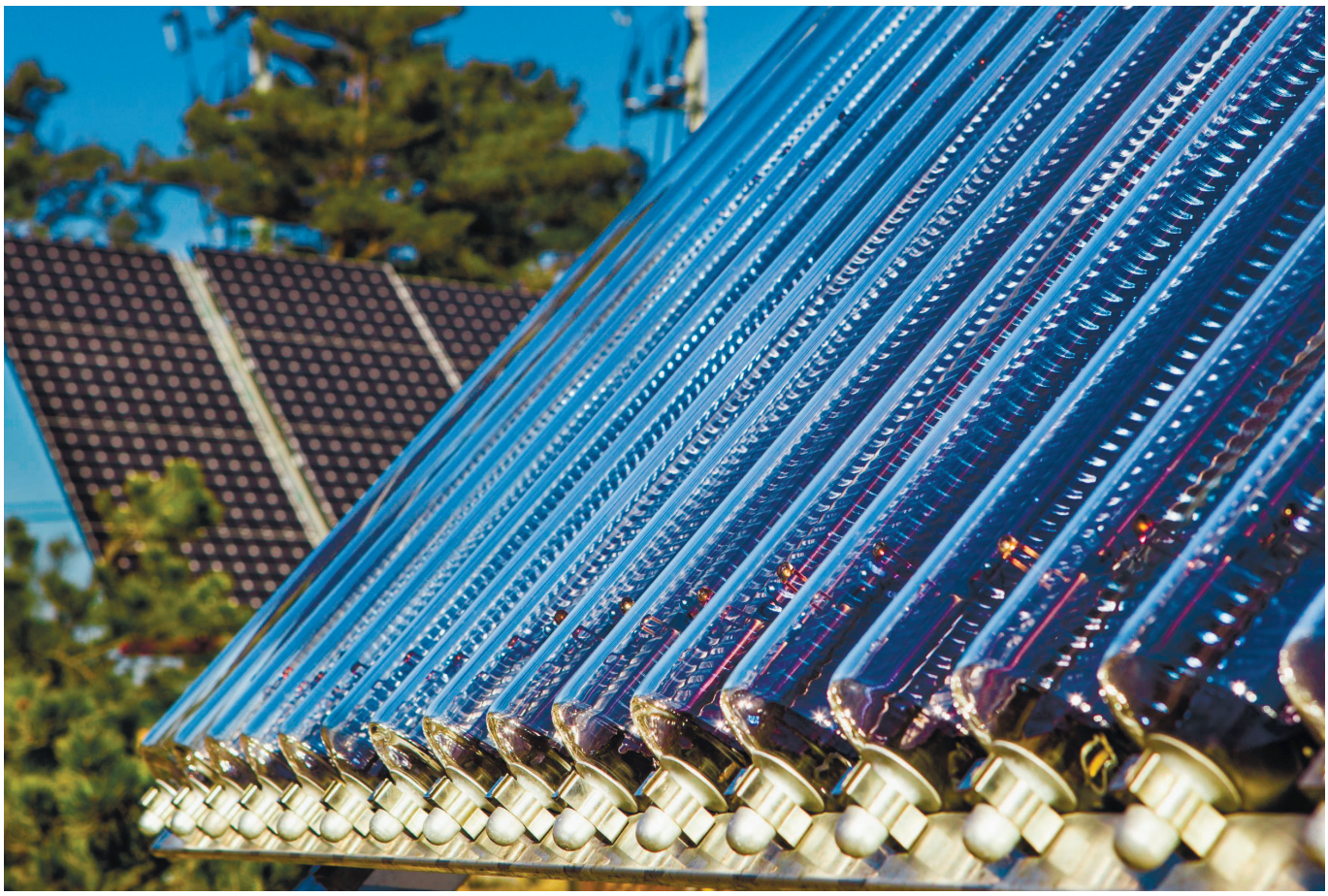
- Cooling capacity 100...4000 kW
- Cooled environment temperature -5 ...+7°C and higher
- Heating capacity 230...9000 kW

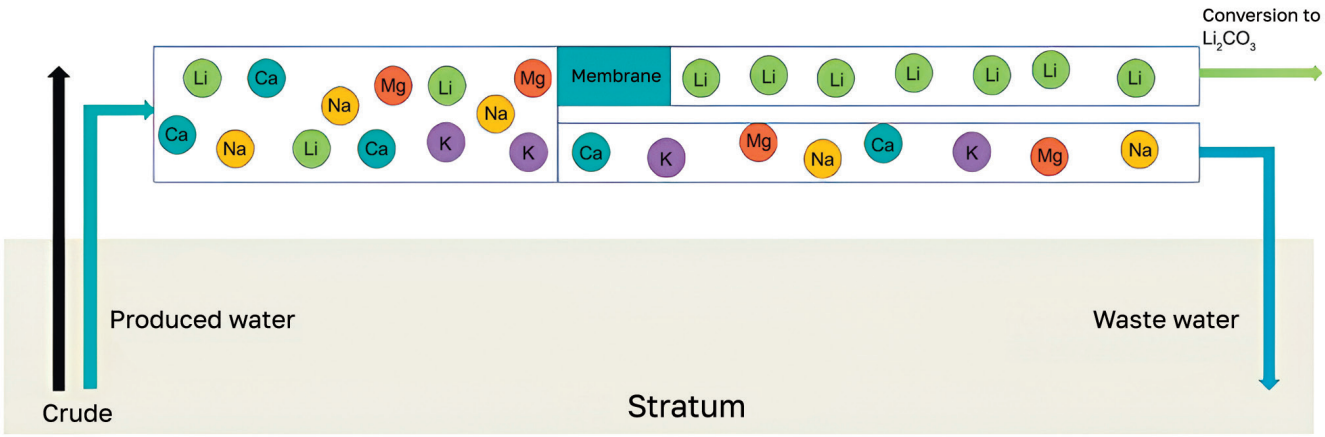
ADVANTAGES OF THE DEVELOPMENT

- Energy saving through the use of renewable energy sources
- Universal mathematical model
- Progressive accumulation of thermal energy

APPLICATION AREAS

Systems of heat and cold supply and air conditioning of enterprises of various branches of industry, including the agro-industrial complex, and the housing and communal sector.





POLYMER MEMBRANE FOR EXTRACTING LITHIUM FROM ASSOCIATED WATER OF OIL AND GAS CONDENSATE FIELDS

73
MATERIAL

DESCRIPTION

The polymer membrane is designed for use in direct lithium extraction (DLE) technology. This membrane reduces the number of stages required for lithium extraction using the DLE method due to its unique pH-modulating property, which allows the production of pure lithium carbonate without the need for additional chemical agents.

ADVANTAGES OF THE DEVELOPMENT

- Reduction in the number of stages in the DLE process
- Lower reagent consumption for lithium precipitation in the form of salts

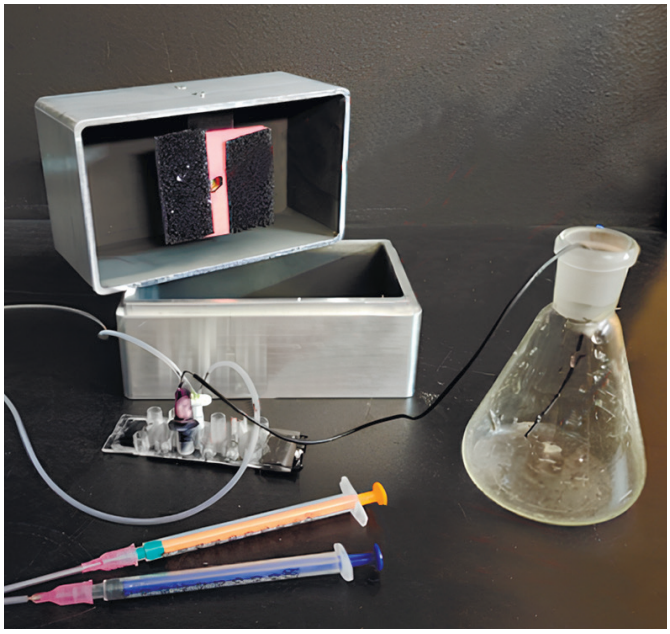
APPLICATION AREAS

- Lithium extraction from associated water (brine) of oil and gas condensate fields

74
TECHNOLOGY

TECHNOLOGIES FOR DETECTING NUCLEIC ACIDS

ULTRA-SENSITIVE LUMINESCENT NUCLEIC ACID DETECTION TECHNOLOGY



DESCRIPTION

A compact, ultra-sensitive technology for detecting the presence and quantity of nucleic acids can be used for various applications, including the detection of human, plant, or animal pathogens, as well as assessing food quality. The technology can be adapted for use in point-of-care settings or sample collection sites. It is compatible with microfluidic chip technology.

DVANTAGES OF THE DEVELOPMENT

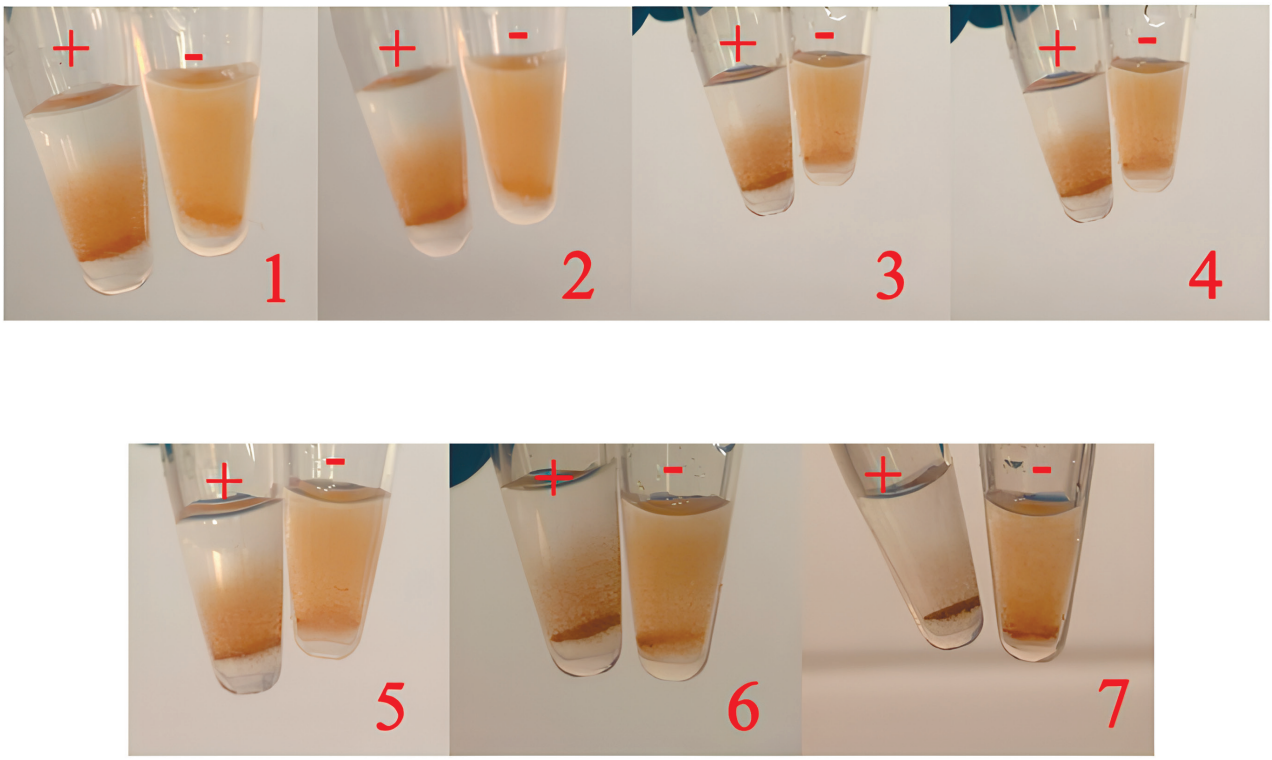
- High sensitivity
- Simplicity and speed of result generation

APPLICATION AREAS

- Pathogen detection in food products
- Detection of infectious agents in humans
- Pathogen detection in animals and plants

CHARACTERISTICS

- Result within 20 minutes
- Sensitivity of 10 zeptomolar
- Selectivity down to single nucleotide polymorphisms
- Device cost around 300,000 rubles



COLORIMETRIC VISUAL NUCLEIC ACID DETECTION TECHNOLOGY USING NANOPARTICLES

DESCRIPTION

The colorimetric visualization technology can be used with various nucleic acid amplification methods within kits and test systems.

CHARACTERISTICS

- Less than 10 minutes required to obtain results
- Various types of nanoparticles
- Sensitivity to single nucleotide polymorphisms

ADVANTAGES OF THE DEVELOPMENT

- Simplicity and speed of result generation

APPLICATION AREAS

- Pathogen detection in food products
- Detection of infectious agents in humans
- Pathogen detection in animals and plants

75
MATERIAL

INNOVATIVE CONSTRUCTION MATERIAL BASED ON CARBON WASTE OF VARIOUS ORIGINS

DESCRIPTION

Aesthetic black roofing elements with variable shapes and sizes are produced from solid carbon. The product has increased resistance to aggressive factors, which extends its service life.

APPLICATION AREAS

- Construction

ADVANTAGES OF THE DEVELOPMENT

- Uses readily available components
- No need to create new technological equipment to start production
- Aesthetic appearance of the product
- Extended service life

ENERGY-EFFICIENT TECHNOLOGICAL CONDITIONING SYSTEM

76
SYSTEM

DESCRIPTION

The system is designed to maintain constant temperature and relative humidity levels in rooms or other work areas, despite changing heat gains and moisture emissions. The device is a sectional frame-panel ventilation unit of the recirculation type. Key components of the system, including the automatic control system, are located in separate sections for ease of transportation, installation, and maintenance. The device can be connected to an air distribution network or installed directly in the serviced room.

APPLICATION AREAS

The primary application area for the system is the industrial sector, where the proposed development addresses the technological requirements for the production and storage of products or raw materials. The greatest effect is achieved when there is a need to maintain a constant low relative humidity — this task is typical for a wide range of chemical, food, pharmaceutical, and other industries, as well as warehouse facilities. The technology may also be in demand in the sports and entertainment industry for maintaining the microclimate of ice arenas.

CHARACTERISTICS

- Processed air flow rate: at least 2400 m^3
- Temperature deviation in the serviced volume: no more than 1°C
- Relative humidity deviation in the serviced volume: no more than 5%; for initial conditions of processed air at +20°C and 60% relative humidity
- Dehumidification capacity at +20°C and 60% RH: at least 17.4 kg/h, power consumption: no more than 6.5 kW
- At +20°C and 30% RH: dehumidification capacity at least 11.3 kg/h, power consumption: no more than 5.5 kW
- At +25°C and 60% RH: dehumidification capacity at least 20.9 kg/h, power consumption: no more than 6.5 kW

ADVANTAGES OF THE DEVELOPMENT

- Low energy consumption and high dehumidification capacity under peak and nominal loads
- Ability to simultaneously control and maintain both temperature and humidity parameters, including control of relative humidity at low air temperatures
- High precision and stability in maintaining controlled parameters, low average annual and peak energy consumption

77

TECHNOLOGY

TECHNOLOGIES AND DEVICES FOR PRODUCING LIQUEFIED GAS

NATURAL GAS LIQUEFACTION TECHNOLOGY AT GAS DISTRIBUTION STATIONS

DESCRIPTION

Russia is the largest producer of natural gas in the world, extracting over 710 billion cubic meters annually. Around 500 billion cubic meters are consumed domestically, with the remaining portion transported through high-pressure pipelines (from 3.5 to 12 MPa). Pressure increase is necessary for effective gas transportation, as it becomes denser in a compressed state.

In urban networks, gas must be at low pressure (no more than 1 MPa) to be used as fuel or raw material. Pressure reduction occurs at gas distribution stations, where the temperature drops by 35°C due to the Joule-Thomson effect. To prevent the gas from freezing, a heating technology is used, burning a small portion of the gas (about 1%). In Russia, approximately 5 billion cubic meters of fuel will be required for heating.

The Joule-Thomson effect allows for low temperatures to be obtained by reducing gas pressure, reaching cryogenic temperatures for liquefying natural gas. This enables the avoidance of heating costs and the production of liquefied natural gas without additional energy expenditure. The output of liquefied natural gas can range from 3% to 20% of the supplied gas. Even with a minimal yield of 3%, using the throttling effect at all gas distribution stations in Russia could annually produce over 10 million tons of liquefied natural gas without additional energy costs, supplying liquefied natural gas to all regions of the country. The natural gas liquefaction technology at gas distribution stations eliminates the need for fuel gas to heat the flow before throttling and allows for the production of liquefied natural gas without additional energy expenditure.

APPLICATION AREAS

- Oil refining industry
- Chemical industry
- Pulp and paper industry

VARIATIONS OF NATURAL GAS LIQUEFIERS BASED ON SCHEMES WITH NITROGEN CIRCUITS AND PRE-COOLING

DESCRIPTION

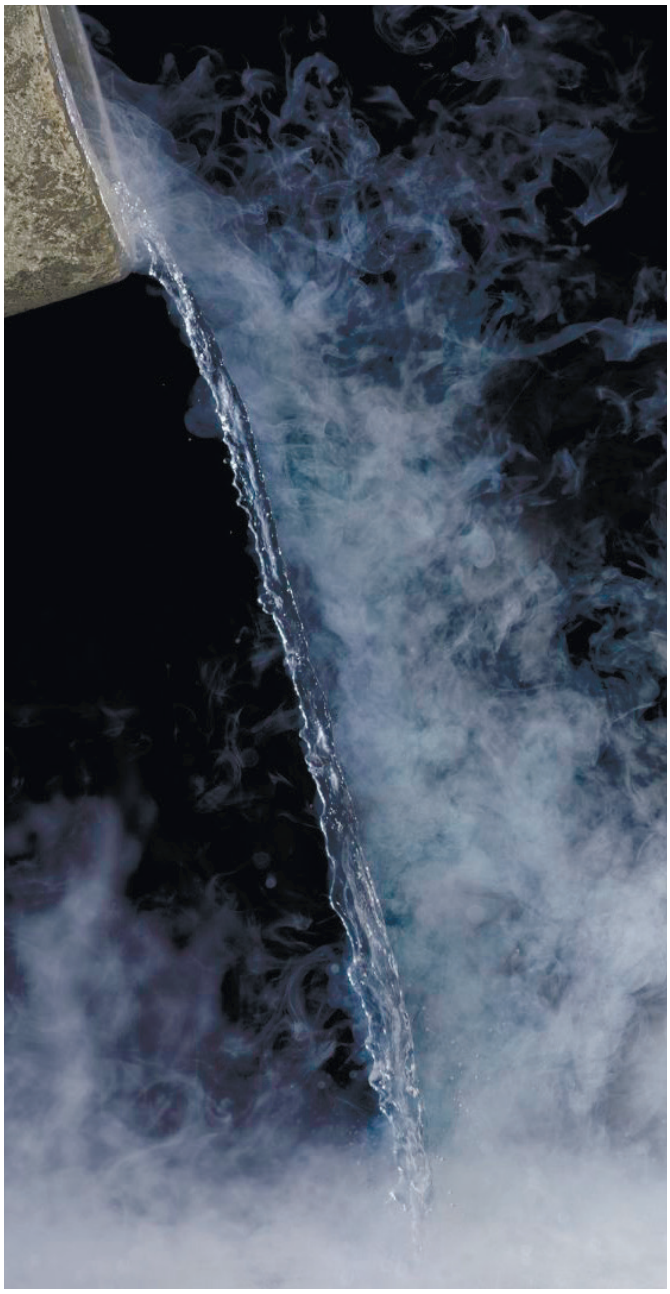
The technology offers new configurations for small-scale liquefiers.The components of the development include:

- Working models of technological schemes
- Comparative analysis of competing solutions
- Heat exchange equipment with specific design and operational parameters
- Methodology for optimizing the production of multi-stream heat exchangers

CHARACTERISTICS

- Technological scheme solutions are adapted for small-scale liquefied gas production (<160,000 tons) and the production of by-products such as ethane, propane, and helium

- The specific energy consumption for implementing the proposed scheme solutions ranges from 7.72 to 10.08 (kWh)/kmol. The liquefaction efficiency of natural gas is 0.77–0.95%



ADVANTAGES OF THE DEVELOPMENT

- Energy efficiency

- Financial cost-effectiveness

APPLICATION AREAS

The development is applicable for organizing small-scale LNG production at liquefaction complexes near gas distribution networks, gas distribution stations, and small to medium-sized fields.

78 DUAL-ACTION THERMAL COLLECTOR

DEVICE

DESCRIPTION

Primary renewable sources of high-temperature solar energy and low-temperature potential from outer space can be effectively used for both heating and hot water supply, as well as for cooling in passive radiation cooling systems. The developed combined-type collector for daytime heating and nighttime cooling of the heat carrier reduces the metal consumption and capital costs by half, as well as the occupied area of the structure, which is especially important in urban environments.

ADVANTAGES OF THE DEVELOPMENT

- Space savings
- Environmental friendliness
- High efficiency
- Low cost
- Made from domestic materials

APPLICATION OF AREA

- Emission coefficient of the coating when heated by solar radiation is no less than 0.8
- Radiation coefficient during nighttime radiative cooling is no less than 0.7

NOTES

ITMO more than a UNIVERSITY

ITMO TECHNOLOGY
TRANSFER PLATFORM

If you have a collaboration proposal, please address
ITMO University Thecnology Transfer Center

+7 (812) 480-99-99
Kronverksky Pr. 49, St. Petersburg,
197101, Russia

tt@itmo.ru