Report on the work of the

Dissertation Council on metallurgy, Mineral processing, materials science and nanomaterials

1. Data on the number of meetings held– 10 meetings.
2. Full name of members of the dissertation Council who attended less than half of the sessions: none.
3. List of doctoral student indicating the organization of training:

- Atchibaev R.A. - Kazakh National University named after al-Farabi
- Kapsalamova F.R. - Kazakhstan-British Technical University
- Dairbekova Guldana Siyundykovna - Karaganda Industrial University
- Shongalova Aigul Kabilovna - KazNITU named after K. I. Satpaeva
- Ramazanova Raigul Amangeldinovna - East Kazakhstan Technical University named after D. Serikbaeva
- Bakhytuly Nauryzbek - KazNITU named after K. I. Satpaev
- Meyirbekov Mohammed Nurgazyuly - KazNITU named after K. I. Satpaev
-Zhaslan Rymgul Kuatkyzy -Karaganda Industrial University
- Kemelbekova Ainagul Yerzhanovna - KazNITU named after K. I. Satpaev
- Asembaeva Alia Ryskhalykyvny - KazNITU named after K. I. Satpaev

4. Brief analysis of dissertations considered by the Council during their porting year

№	Full name of the Doctoral student	Topics of work	Code and title of specialty
1	Atchibaev R.	Processes of microstructure formation and physicochemical properties of nano composite coatings	6D074000 - Nanomaterials and nanotechnologies
2	Farida Kapsalamova	Research and development of a new iron-based self-fluxing powder surfacing material for the restoration of parts subjected to high force and shock loads	6D071000 – «Materials science and technology of new materials»
3	Guldana Dairbekova	Development and research of technological bases for obtaining silicon-based anodes for practical application in the field of electronics in order to reduce the environmental impact on the environment	6D074000 – «Nanomaterials and Nanotechnologies»
4	Aigul Shongalova	Promising methods for the synthesis and study of thin-film chalcogenide materials	6D074000 – «Nanomaterials and nanotechnology»

5	Raigul Ramazanova	"Physical and chemical research and development of hydrometallurgical technology for processing hard-to-enrich oxidized zinc ores"	6D070900 - "Metallurgy"
6	Bakhytuly Nauryzbek	Studying the formation of structure and properties of wear-resistant coatings based on titanium carbonitride through their alloying with various elements	6D071000 – «Materials science and technology of new materials»
7	Meyirbekov Mohammed Nurgazyuly	Investigation of ways to increase the impact resistance of carbon fiber	6D071000 – "Materials science and technology of new materials
8	Zhaslan Rymgul Kuatkyzy	«Improving the technology of smelting and improving the quality of metal products using innovative technologies based on the iron-carbon system»	6D070900 – Metallurgy
9	Kemelbekova Ainagul Yerzhanovna	«Investigation of the effects of self-organization of thin layers of zinc oxide on the surface of hierarchical porous silicon for use in optoelectronics»	6D071000 – «Materials Science and Technology of New Materials»
10	Asembaeva Alia Ryskhalykyvny	"Creation of new composite materials based on diamond-like carbon films modified with palladium nanoparticles"	6D074000 – «Nanomaterials and Nanotechnologies»

4.1 Analysis of the subject of the work of Atchibaev R. "Processes of microstructure formation and physicochemical properties of nanocomposite coatings", submitted for the PhD degree in the specialty 6D074000 - "nanomaterials and nanotechnologies".

The dissertation work of the doctoral student of KazNU named after al-FarabiAtchibaev R. is devoted to the study of the patterns of formation of the microstructure of composite coatings based on chromium, modified with nanosized particles (C, SiO2), heterogeneous double Fe-W (Mo), Ti-Co (Mn) and triple Fe-Co-W systems obtained by the electrolytic method, as well as the study of their physico-chemical and mechanical properties. The results were obtained in the work, which consists in the possibility of using a new composition of nanostructured composite coatings based on chromium, as well as nanocrystalline coatings from iron-tungsten and iron-cobalt alloys for anticorrosion protection of surfaces made of carbon St3 and structural AISI304 and 17G1S steels to improve functional properties in neutral and alkaline media

Scientific research on the topic of the dissertation was carried out in the laboratories of KazNU named after al-Farabi and at the Wroclaw University of Science and Technology, Wroclaw, Poland.

Based on the results of the research, a new electrolyte was developed, for which a patent for the utility model "Electrolyte for deposition of nano-coatings with an iron-tungsten alloy" was obtained (RK patent No. 3440 dated 11/11/2019).

Communication of the thesis subject matter with the directions of science development, which are formed by the Higher Scientific-Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of article 18 of the Law "On Science" and (or) state programs. The research results presented in the dissertation work are closely related to the research project carried out within the framework of state grants from the Science Foundation of the Ministry of Education and Science of the

Republic of Kazakhstan IRN AR05130069 "Development of nanotechnology for the synthesis of functional electroplated coatings for electrical equipment components" 2018-2020 (state registration number 0118RK00315).

Analysis of the level of implementation of the results of the thesis in practical activities. According to the results of the dissertation work Atchibaev R. 15 scientific papers have been published, including: 1 article in journals included in the Web of Science and Scopus databases; 3 articles in publications recommended by the Committee for the publication of the main results of research in technical sciences; 10 publications in the materials of international and republican conferences, 1 utility model patent. The main results of the dissertation were reported and discussed at: "Anti – corrosion properties of nanocomposite coatings in amine environments/18th International Sc. GeoConf. SGEM", July 2018, Albena, Bulgaria; "Micro and Nano Technologies / 19th International Sc. GeoConf. SGEM", August 2019, Albena, Bulgaria; International conference "Problems of corrosion protection of materials", 2018, Lviv, Ukraine; Intern. Conf. "Advanced technologies in research and education", February 2018, Severodonetsk, Ukraine.

4.2 Analysis of the subject of the work of Farida Kapsalamova. "Research and development of a new iron-based self-fluxing powder surfacing material for the restoration of parts subjected to high force and shock loads", submitted for the degree of Doctor of Philosophy (PhD) in the educational program 6D071000 – "Materials science and technology of new materials".

In the repair production of critical machine parts and mechanisms, there is a great need for new self-fluxing surfacing materials, which differ from their traditional types by the possibility of applying thin-layer reinforcing coatings without melting the base metal. For this purpose, the gas-thermal method is widely used, which has a lot of advantages of the technological plan. The high cost of coatings obtained by gas-thermal methods is primarily due to the price of raw materials for spraying, which are powders made using complex technologies and with a high content of expensive and scarce metals and compounds. In addition, industrial technologies for their production are complex, expensive, and chemical ones are environmentally dangerous. One of the solutions to this problem is the replacement of the base of the surfacing material with iron and the use of the method of mechanical activation, which has significant technical and economic advantages, as well as the possibility of regulating the composition, which makes it possible to increase the physical and mechanical properties of protective coatings. The problem of developing new compositions and conditions for the synthesis of metal matrix composites is closely related to the need for a detailed study of their physico-chemical properties, as well as thermodynamic characteristics that give important insights into the nature of the interaction of the components of the alloy.

The research carried out in the field of the tasks set ensures the production of a new self-fluxing surfacing powder material 40%Fe-30%Ni-16%Cr-5%Cu-5%Si-3%B-1%C for gas thermal spraying. The developed technological process, which allows the use of mechanical activation, has a technological advantage over existing technologies based on the traditional metallurgical method. The developed new powder composition and the method of mechanical activation used makes it possible to obtain a coating with a hardness of 546.96 HV in the future, which surpasses the prototype and has a high applicability potential.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. The dissertation work was carried out within the framework of the state program of the Ministry of Education and Science of the Republic of Kazakhstan "Targeted development of university science focused on innovative results" for 2012-2014 on the topic "Development of a new alloy for the rehabilitation of critical components and parts of railway rolling stock".

Analysis of the level of implementation of the results of the dissertation in practice. On the topic of the dissertation, 11 scientific papers have been published, including 3 articles in journals indexed in the Scopus database, 3 articles on the list of journals recommended by COXON MES RK and 5 publications in international conferences. The resulting surfacing alloy 40%Fe-30%Ni-16%Cr-5%Cu-5%Si-3%B-1%C has passed experimental testing and is confirmed by the act of conducting experimental tests of the results of research work, where the use of a new wear-resistant surfacing powder alloy ensures the mileage of a freight car on two or more planned repairs.

4.3 Analysis of the subject of the work of Guldana Dairbekova " Development and research of technological bases for obtaining silicon-based anodes for practical application in the field of electronics in order to reduce the environmental impact on the environment ", submitted for the degree of Doctor of Philosophy (PhD) in the educational program 6D074000 – «Nanomaterials and Nanotechnologies».

Electrical energy storage is key to the future of personal electronics, electric vehicles (EVS), and more efficient power systems. Of particular interest is the replacement of the graphitic carbon of the negative electrode (anode) with silicon. Batteries today use a special kind of layered graphite that is limited in the amount of lithium they can absorb. Silicon may represent an economical alternative as it is the second element in the earth's crust after oxygen. In modern portable electronic devices, mono-, polycrystalline or amorphous silicon obtained by trichlorosilane and monosilane methods, as well as silicon-based thin-film structures, are used as a silicon-based negative anode. The use of metallurgical silicon and aspiration material in the production of silicon has not been studied. The existing methods of silicon purification (trichlorosilane and monosilane methods) are environmentally unsafe. Therefore, obtaining high-purity silicon by metallurgical (physical) methods is an urgent task. To solve this scientific and technological problem, it is necessary to improve the technology for the production and production of silicon products, namely, metallurgical and physicochemical processing to obtain electronic quality silicon for the production of lithium-ion battery anodes, to develop innovative methods for applying a mixture of silicon nanopowder to create hybrid silicon-containing anodes, to propose ways of using metallurgical silicon, as well as its waste products, namely the aspiration material of metallurgical silicon in the production of silicon-based anodes.

The conducted studies in the field of the tasks set provide the production of a new upgraded silicon of metallurgical quality with a purity of silicon for the main impurities (Ca, Al, Fe) of 93.15-99.98%, the yield of silicon in the melt reached 75-85%. The developed technological foundations for the production of lithium-ion battery electrodes from silicon-containing nanopowders by laser printing of a block of lithium-ion batteries can reduce the weight of the block, reduce the consumption of current-carrying parts, which will make it possible to use the accumulated electricity in electric transport more efficiently due to the overall reduction in the mass of the electric vehicle. It will also become possible to accelerate the charging of the battery pack, which will allow the use of electric transport on long routes with limited time spent on intermediate stops.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. The dissertation work corresponds to the tasks, vision and expected results of the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020-2025 and the Concept of Industrial and Innovative Development of the Republic of Kazakhstan for 2021-2025 and was completed as part of a project for grant funding for 2020-2022. AR08856059 "Development of metallurgical methods for obtaining silicon for solar energy".

Analysis of the level of implementation of the results of the dissertation in practice. 8 scientific papers were published on the topic of the dissertation, including 1 article in journals indexed in the Scopus database, 3 articles on the list of journals recommended by MES RK, 2

publications in international conferences and 2 patents for the invention of the RK. The results of scientific research presented in the dissertation work, the technology for manufacturing a block of lithium-ion batteries are accepted for implementation in Zhersu Power LLP and in the educational process of NAO KazNRTU named after K. Satbayev.

4.4 Analysis of the subject of the work of Aigul Shongalova. " Promising methods for the synthesis and study of thin-film chalcogenide materials ", submitted for the degree of Doctor of Philosophy (PhD) in the educational program 6D074000 – «Nanomaterials and nanotechnology».

This dissertation presents methods developed in the course of research for the synthesis of promising thin-film materials based on antimony selenide and ternary compounds of copper-antimony-sulfur for semiconductor optoelectronics, as well as the results of a study of their structural and optical properties. These compounds have the potential to be used in solar cells due to the relative simplicity and low temperature of their preparation, the availability of starting materials in nature, and favorable optical properties. A two-stage method for the selective synthesis of a thin film of $Cu_{12}Sb_4S_{14}$ and Cu_3SbS_4 by changing the area of precursors and the sulfurization process is presented. Metal precursors were simultaneously deposited by RF magnetron sputtering using a target consisting of Cu segments and a Sb base. By controlling the evaporation temperature of sulfur during the sulfurization/annealing process, two different crystalline phases were obtained. The identification of crystalline phases was carried out using the methods of X-ray diffraction and Raman scattering. At a sulfur evaporation temperature of 140 °C, the precipitated crystalline phase is tetrahedrite $Cu_{12}Sb_4S_{14}$ with a cubic structure. During the evaporation of sulfur at a temperature of 180 °C, the main phase is famatinite Cu_3SbS_4 with a tetragonal structure. Optical analysis made it possible to estimate the band gap energies, which were 1.47 eV and 0.89 eV for $Cu_{12}Sb_4S_{14}$ and Cu_3SbS_4, respectively. In this case, both phases are characterized by direct allowed transitions. The PL measurement shows a broad peak centered around 0.83 eV for a sample prepared at 180°C. For the sample synthesized at 140°C, no PL signal was detected.

In addition, it was shown that the process of high-frequency magnetron sputtering followed by selenization is suitable for growing Sb_2Se_3 films with a highquality crystal structure and optoelectronic properties. The grain sizes of seleniumantimony precursor films do not exceed 80 nm. Some compositional and morphological differences are observed when comparing films grown on glass, glass/Mo, and Si substrates. Samples on silicon have compositions close to stoichiometric and more regular grains with increasing selenization temperature. As expected, with an increase in the selenization temperature, a general increase in the grain size is observed for all substrates. The area of most small grains remains in the nanometer range. The results of X-ray spectroscopy show that no columnar orientation is observed with this growth method. The Raman scattering method revealed the localized presence of rhombohedral and amorphous Se, which is consistent with the EDS measurements and indicates Se condensation during cooling after the selenization process. Optical measurements carried out on samples with Si substrates made it possible to determine the band gap with a direct optical transition close to 1.06 eV for the used selenization temperatures. Photoluminescence performed on the same samples demonstrates a dominant broad band at ~0.85 eV for the samples selenized at 300°C and 350°C, and a sharper and more intense peak close to 0.75 eV for the sample selenized at 400°C. An intense peak with an energy close to the band gap is an important feature of materials for solar cell applications. However, the electrical characteristics of samples grown on glass substrates exhibit relatively low concentrations of free holes and low mobility. The study shows that in the low-temperature regime, electron transport occurs due to jumps over the nearest neighbors. In the framework of this work, the peak at 250 cm^{-1} was identified in the obtained Sb2Se3 samples. It was found that the peak belongs to the antimony oxide phase, which occurs due to oxidation when using a high-density laser. Spectrum acquisition regimes are established for antimony selenide samples to avoid Se evaporation, where the main requirement is a low laser power density ~ 170 MW/m^2. In addition, it was found that Raman spectroscopic

measurements with a high laser power should be carried out with these samples in vacuum in order to avoid oxidation. One of the important results of the work is the observation and determination of the stability limits of the Sb_2Se_3 compound: high-energy conditions, such as increased power of the exciting laser or sample temperature, easily lead to the formation of the Sb_2O_3 phase, so this fact must be taken into account in the synthesis of compounds.

In addition to the RF magnetron sputtering method, Sb_2Se_3 samples were synthesized by two simple and inexpensive methods of electrochemical deposition and metal precursor selenization. Films with thicknesses of 60–300 nm were studied. For an electrodeposited sample annealed at 270°C, the effective optical band gap of 1.27 eV was determined using the sigmoidal absorption approximation. In this case, for a sample selenized at 350 °C, based on the analysis of the Tauc plot, the band gap was determined to be 1.12 eV with a direct optical transition. In the film selenized at 350°C, the presence of the cubic Sb_2O_3 phase was detected, which is associated with the precipitation inside the reactor during cooling of unreacted antimony particles, which, upon contact with air, can react with oxygen faster than with selenium. X-ray diffraction analysis demonstrates the predominant growth of crystallites in the vertical direction in the sample selenized already at 270°C. Thus, the results of X-ray diffraction indicate the possibility of preferred growth modifications in certain directions, which depend on the growth method and annealing temperature.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. All studies presented in this dissertation were carried out within the framework of the following programs and projects: the target funding program of the Ministry of Foreign Affairs of the Republic of Kazakhstan IRN BR05236404 (2018-2020), projects UID/CTM/50025/2019 and RECI/FIS-NAN/0183/2012 (FCOMP -01-0124-FEDER-027494) within the framework of the COMPETE 2020 Program of the Portuguese Science and Technology Foundation, project IF/00133/2015, grant funding project of the Ministry of Education and Science of the Republic of Kazakhstan AP05133651 (2018-2020), Erasmus 2016/17 program.

Analysis of the level of implementation of the results of the dissertation in practice. On the topic of the dissertation, 12 scientific papers have been published, including 4 articles in journals indexed in the Scopus and Web of Science databases, 1 article on the list of journals recommended by COXON MES RK, 7 publications in international conferences.

4.5 Analysis of the subject of the work of Raigul Ramazanova "Physical and chemical research and development of hydrometallurgical technology for processing hard-to-enrich oxidized zinc ores", submitted for the degree of Doctor of Philosophy (PhD) on speciality 6D070900 - "Metallurgy".

Today in spite of the growing demand for zinc products, its consumption is restrained both by the limited mineral and raw material base of zinc, and by the high cost of zinc. In hydrometallurgy of zinc the raw-material base is limited practically by a single mineral - zinc sulfide (sphalerite). But other minerals of zinc can also be of industrial interest in case they are found to have high reactivity and increased content of a valuable component. Some oxidized minerals, such as zinc silicate (calamine), zinc carbonate (smithsonite) and others, can be attributed to such zinc minerals.

A number of deposits of rich oxidized zinc ores with commercial reserves of zinc are discovered in Kazakhstan and other countries of the world. However, insignificant part of these deposits is involved into processing, which reduces the raw material base of zinc manufactures. And in separate deposits zinc content in ore is comparable with its content in sphalerite concentrates consumed by zinc hydrometallurgy. This circumstance allows speaking about expediency of using rich oxidized zinc ores without their expensive enrichment. Directly in zinc hydrometallurgy at the stage of sulfuric acid leaching, i.e. bypassing the energy-intensive stage

of oxidizing roasting of raw materials. Thus, involving oxidized zinc raw material in processing makes it attractive in terms of cheaper zinc hydrometallurgy.

Despite the existence of a significant base of developments devoted to the study of the problem of oxidized zinc ore processing, to date, no cost-effective technology has been proposed that makes it possible to involve oxidized zinc minerals with commercially acceptable zinc content in the processing.

This work analyzes the technology of processing hard-to-enrich oxidized zinc ores and establishes the problem of expensive enrichment of mineral raw materials, associated with significant losses of zinc with tailings, as well as the application (energy intensive processes) of expensive oxidizing roasting of initial concentrate and waelz-process of cake processing. This work proposes to solve this problem by processing oxidized zinc ores according to the following scheme: sulfuric acid leaching of oxidized zinc ore in a four-stage counter-current mode. This scheme does not require ore enrichment and waelz-processing of cakes for zinc extraction.

The developed technological scheme of oxidized zinc ore processing by hydrometallurgical method will improve the environmental safety of production and will create conditions for involving oxidized zinc minerals with commercially acceptable zinc content into processing.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. The dissertation work corresponds to the priority direction of development of science of RK "Rational use of natural, including water resources, geology, processing, new materials and technologies, safe products and constructions".

Research work was carried out in accordance with the state program of industrial and innovative development of the Republic of Kazakhstan, noted in the Strategy "Kazakhstan-2050", approved by Decree of the President of the Republic of Kazakhstan No. 874 dated August 1, 2014 for 2015-2019 and carried out within the framework of a scientific project of grant funding № 66-312-16 90538/ГФК « Development of a technology for processing oxidized zinc ores with a low content of the main valuable component based on modern hydrometallurgical and enrichment processes» for 2015-2017.

Analysis of the level of implementation of the results of the dissertation in practice. According to the results of the dissertation research, 12 papers have been published, which are 5 articles in journals indexed in Scopus and Web of Science databases (CiteScore percentile of more than 35%), 2 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan and 3 papers in the collections of International and Republican scientific and practical conferences. Also published 2 patents - 1 patent for invention of the Russian Federation and 1 patent of the Republic of Kazakhstan for a useful model. The results of scientific research presented in the dissertation work, the method of processing oxidized zinc ores were used in the RSE " NC CPMRM RK" " VNIItsvetmet" and introduced into the educational process of NJSC D. Serikbaev EKTU.

4.6 Analysis of the subject of the work of Bakhytuly Nauryzbek "Studying the formation of structure and properties of wear-resistant coatings based on titanium carbonitride through their alloying with various elements", submitted for the degree of Doctor of Philosophy (PhD) on speciality 6D071000 – "Materials science and technology of new materials".

Parts, components, machine mechanisms, and cutting tools must provide a level of mechanical strength and chemical stability that ensures both durability and performance. To solve these problems, a wide range of hard coatings are used. In recent decades, a solid solution has been developed between TiC and TiN, namely TiCN. The TiCN coating exhibits excellent mechanical strength and thermal stability. Therefore, the development of efficient methods for the deposition of coatings from TiCN is of great technological importance.

Among the deposition methods, one of the most suitable for the production of superhard and wear-resistant coatings is DC magnetron sputtering, used in both reactive and non-reactive environments under high vacuum conditions. The possibility of varying such parameters and conditions of deposition as potential shift on the substrate, the flow rate of reaction and inert gases, plasma current, pulsed deposition mode, the use of a composite target, and others open up new possibilities for deposition of TiCN coatings with improved mechanical and tribological characteristics. Determining the relationship between the deposition conditions and the microscopic structure and properties of the deposited films is the key to determining the best process conditions for obtaining coatings with desired properties. Based on the above, the topic of this dissertation is relevant.

Extending the service life of machine parts or tools in industry, mechanical engineering and other industries is an important task. The solution of this problem involves the improvement of the technology for obtaining wear-resistant hard coatings. Through the development of the composition, structure and properties of such coatings, it is possible to achieve high rates of increasing the service life and functionality of machine parts or tools. Based on this, the rationale for the need for research work is associated with solving the problem of increasing the wear resistance of machine parts or tools, increasing their surface hardness.

On the other hand, the research topic is directly related to the State Program "Industrial and Innovative Development of the Republic of Kazakhstan for 2020–2025", which is focused on the development of scientific and technological innovations, improving the quality of life of the population and strengthening the economic stability of the country. Scientific work in the field of formation of the structure and properties of wear-resistant titanium carbonitride coatings can help the development of new technologies in the field of metalworking and the creation of new materials with increased wear resistance, which can increase the competitiveness of domestic manufacturers in the global market.

A technology has been developed for the deposition of wear-resistant TiCN coatings with improved mechanical and tribological characteristics by reactive magnetron sputtering of titanium in an argon-acetylene-nitrogen gas mixture.

For the first time in the deposition of hard coatings based on TiCN by the method of reactive magnetron sputtering, composite targets with deposited alloying metal Cr were used; Zr; Al and Ta to increase the hardness and wear resistance of the coating.

The influence of alloying elements Cr has been determined; Zr; Al and Ta on the structure, composition and mechanical, tribological properties of TiCN coatings. The TiCrCN and TiZrCN coatings obtained under the established conditions are characterized by an order of magnitude increased wear resistance up to 10^{-7} $mm^3/m*N$ compared to similar coatings obtained earlier.

For the first time, the structure and properties of TiCrCN and TiTaCN coatings deposited by magnetron sputtering have been obtained and studied.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs.

The dissertation work was carried out in the laboratory "Metallurgy" of JSC "IMOB". The main provisions were developed within the framework of grant projects of applied research on the topic: "Development of wear-resistant, multifunctional, composite coatings based on titanium carbonitride" (No. AP08857049, 2020-2022), funded by the Ministry of Education and Science of the Republic of Kazakhstan under the priority "Rational use of natural resources, including water resources, geology, processing, new materials and technology, safe products and structures".

Analysis of the level of implementation of the results of the dissertation in practice. According to the results of the dissertation research, 6 papers have been published, which are 2 articles in journals indexed in Scopus databases, 3 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science

and Higher Education of the Republic of Kazakhstan and 1 papers in the collections of International and Republican scientific and practical conferences.

As a result of the research work carried out, coatings with high wear resistance were obtained. Titanium carbonitride coatings alloyed with chromium or zirconium, obtained under established conditions, are characterized by an order of magnitude increased wear resistance compared to similar coatings obtained previously. The wear resistance of TiCrCN and TiZrCN coatings reaches 10^{-7} $mm^3/m \times N$. The proposed coating deposition conditions have an economic advantage over previously developed modes due to the use of inexpensive gases and the use of one magnetron with a composite target.

4.7 Analysis of the subject of the work of Mohammed Meiirbekov "Investigation of ways to increase the impact resistance of carbon fiber", submitted for the degree of Doctor of Philosophy (PhD) on speciality 6D071000 – "Materials science and technology of new materials".

Currently, one of the priority directions in the field of materials science is the production of polymer composite materials with high mechanical properties. The reason is that materials used for aerospace purposes require special structural materials. In this regard, the materials must meet the following requirements: light weight, high values of the modulus of strength and elasticity, low coefficient of thermal expansion, etc. In accordance with the above characteristics – carbon fiber, which has significant advantages over metal alloys. However, despite such good characteristics, the use of carbon fiber has not become widespread, the main reason is the high cost of the material and low impact strength.

The next stage of work in the world practice of developing carbon fiber plastics was the search for ways to increase brittleness, i.e. a significant increase in impact strength while maintaining the achieved levels of static strength. To improve the strength properties of carbon fiber, first of all, it is necessary to increase the strength of the two main components. Firstly, carbon fiber is carried out by combining (hybridization) with other fibers. Secondly, an increase in the strength of the binding epoxy resin is achieved by adding modifiers-rubbers.

Combined reinforcement is reinforcement with fiberglass, aramid fibers and other types of fibers. Carbon fiber plastics combined with other types of fibers make it possible to create materials with optimal properties for a specific application.

Increasing the strength of the binder is carried out by modifying the epoxy resin. Modification of epoxy resins occurs by adding various additives to its composition. Mixtures, in turn, are able to interact with functional groups obtained at different stages of polymer formation. Various plasticizers, thermoplastics, carbon nanotubes, rubbers, etc. are used as modification additives. Among the listed modifiers, rubbers are the most accessible and less studied. There are no data on large-scale studies of changes in the size, technology of addition, and composition of these rubbers.

In connection with the development of the domestic space industry in Kazakhstan, the construction of the National Space Center (NSC) of the Republic of Kazakhstan is being completed in Astana. The Kazakh-French "Ghalam" LLP is engaged in the design and production of all types of spacecraft as an integral part of the NSC. Kazakhstan plans to gradually develop the production of components.

In Kazakhstan, the project of a domestic ultralight launch vehicle for the Baikonur cosmodrome has been implemented by JSC "National Center for Space Research and Technology" since 2021.

For these two reasons, on behalf of the domestic Aerospace Committee, the technology for the production of high-quality carbon fiber was taken.

For the production of racks, power elements, as well as individual components, special structural materials of increased strength and impact strength-carbon fiber are needed. Carbon fiber plastics of high strength and toughness do not have production in Kazakhstan, and therefore they have to be imported. According to the international agreement "missile technology control regime" (MTCR treaties) and "Wassenaar Agreements on export control of conventional

weapons" (Wassenaar Agreement), carbon fiber products and dual technologies with a strength of over 415 MPa are included in the categories "secret" and "top secret". Carbon fiber technologies of this category are prohibited for publication and transvert. Therefore, Kazakhstan has to create the technology of production of high-quality carbon fiber for space technology itself.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. The dissertation work corresponds to the priority direction of development of science of RK "Rational use of natural, including water resources, geology, processing, new materials and technologies, safe products and constructions".

The research work was carried out in accordance with the republican budget program 076 "Applied scientific research in the field of space activities, transport and communication" №0115RK01232 "Development of domestic technology for obtaining high-modulus and high-strength products made of carbon fiber for aerospace purposes" for 2015-2017. and the republican budget program 008 "Applied scientific research in the field of space activities" №0118RK0835 "Development of technology for the production of impact-resistant carbon fiber for defense and aerospace products" for 2018-2020.

Analysis of the level of implementation of the results of the dissertation in practice. According to the results of the dissertation research, 9 papers have been published, which are 5 articles in journals indexed in Scopus databases, 2 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan and 3 papers in the collections of International and Republican scientific and practical conferences. Also published 1 patent of the Republic of Kazakhstan for a useful model. The results of scientific research presented in the dissertation work, the technology of production of impact-resistant carbon fiber for aerospace purposes are implemented in "KazTechInnovations" LLP.

4.8 Analysis of the subject of the work of Zhaslan Rymgul «Improving the technology of smelting and improving the quality of metal products using innovative technologies based on the iron-carbon system», submitted for the degree of Doctor of Philosophy (PhD) on speciality «6D070900 – Metallurgy».

It is known that the development of new technological processes or combined end-to-end technologies aimed at reducing undesirable impurities, i.e. obtaining "pure steel", can significantly improve its quality and, consequently, the operational properties of the product. The production of steel with a low content of impurities is determined in each case by the development of optimal technological schemes, taking into account the available equipment and material resources.

According to the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020-2025, the metallurgical industry belongs to medium-technological industries, which requires strengthening scientific and innovative potential at all stages of production of finished products. The world level of steel production covers converter and electric steelmaking production at the level of 95-98%, while the volume of production in converters is 60%, in arc steelmaking units about 40%. In the conditions of constantly growing competition, increasing productivity, reducing production costs, etc., ensuring the quality of metallurgical production products is one of the main tasks facing domestic industries. Thus, there is a constant search for innovative methods and new production methods that require insignificant financial costs, in particular, the development of technical solutions for quality assurance with minimal financial costs is of great interest. One of the main problems that have a negative impact on the quality of steel is the presence of non-metallic inclusions in it. The problem of non-metallic inclusions has not been completely solved and requires further scientific research in this direction.

The basis for the development of the thesis topic is the technology of two-stage steelmaking conversion and the development of additional devices in the initial and final periods of metal production, which allows to reduce the proportion of non-metallic inclusions in steel and reduce the wear of lining materials of the steelmaking unit.

The following low-carbon steel grades used in the converter shop of JSC "ArcelorMittal Temirtau" for the production of slab billets were selected as initial data for the development of the research topic.

The subject of the work includes the analysis of existing technologies and methods of metal smelting, the study of the properties and quality of metal products, as well as the development and implementation of innovative technologies to improve the smelting process and product quality.

In general, the topic of the work covers a wide range of issues related to improving the technology of metal smelting and improving the quality of metal products using innovative approaches within the framework of the iron-carbon system.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. The topic of the dissertation corresponds to the specialized scientific direction «Production and processing of metals and materials»according to the priority «Geology, extraction and processing of mineral and hydrocarbon raw materials, new materials, technologies, safe products and structures».

Analysis of the level of implementation of the results of the dissertation in practice. According to the results of dissertation research, 5 works have been published, including: 1 article in a publication indexed in the Scopus database; 3 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan and 1 work in the collection of an International scientific and Practical conference. 3 patents of the Republic of Kazakhstan and 2 Eurasian patents were also obtained. The results of scientific research presented in the dissertation work, namely, the development of innovative devices for separating metal and slag melts during the release from the converter and in the filling compartment of the intermediate ladle for continuous casting into slab and blum billets, are recommended for implementation in JSC ArcelorMittal Temirtau.

4.9 Analysis of the subject of the work of Ainagul Kemelbekova «Investigation of the effects of self-organization of thin layers of zinc oxide on the surface of hierarchical porous silicon for use in optoelectronics», submitted for the degree of Doctor of Philosophy (PhD) on speciality 6D071000 – «Materials Science and Technology of New Materials».

Reducing the sensitivity of sensory materials as a result of degradation is an urgent problem. The study of EPR signal saturation makes it possible to determine the energy stability of the structures being formed. An actual trend in materials science is the transition from traditional methods of synthesis of film nanostructures to a multi-stage atomic-molecular design, which includes several hierarchical levels. These structures, due to their synergistic effects, have innovative properties.

Of great interest are the effects of self-organization of low-dimensional systems on the surface of solids through the formation of periodically ordered structures. This is due to the fact that the process is determined by quantum phenomena, which suggest new approaches to understanding the nature of matter formation.

Structures based on zinc oxide particles embedded in silicon substrates can be used as components of various semiconductor devices. The formation of ZnO nanoclusters both on the surface and in the pores of the sample is an important process that can be used in gas sensors, since increasing the specific surface area of the sensor increases its sensitivity.

One of the most important properties of ZnO is its intense interaction with light, leading to photoinduced effects. This effect is mainly due to the properties of excitons and point defects.

The high binding energy of excitons makes it possible to exhibit effective luminescence in the near ultraviolet range even at room temperature and to transmit 80-90% of the light in the visible range.

In this work, methods for the synthesis of samples with hierarchical-fractal surface morphology were developed, mechanisms for the formation of structures of various scales were determined, particles with uncompensated charge during the formation of matter were studied, and the luminescent properties of the obtained samples were investigated.

The obtained zinc oxide structures on the surface of hierarchical porous silicon with electronic conductivity made it possible to form a heterostructure with the formation of nanocrystals, the photoluminescence intensity of which is increased by 40 times, which determines the use of these structures in optoelectronics.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs. The dissertation work corresponds to the priority direction of development of science of the Republic of Kazakhstan "Energy and mechanical engineering" with the priority "Alternative energy and technologies: renewable energy sources, nuclear and hydrogen energy, other energy sources", the scientific direction "Nanomaterials and nanotechnologies" with the priority "Geology, mining and processing mineral and hydrocarbon raw materials, new materials, technology, safe products and designs" and the National Scientific Council under the Government of the Republic of Kazakhstan.

Research work was carried out in accordance with the state program of industrial and innovative development of the Republic of Kazakhstan for 2020-2025 and was carried out within the framework of the following programs and projects:

- grant funding project of the Ministry of Education and Science of the Republic of Kazakhstan IRN: AP09260940 (2021-2023) on the topic "Optimization of the structure of thin films for the manufacture of solar cells on a flexible substrate."

- target funding program of the Ministry of Science and High Education of the Republic of Kazakhstan IRN BR21881954 (2023-2025) on the topic: Development of technologies for the synthesis of nanostructured materials for the creation of effective photocatalytic electrodes, photo and gas-sensitive sensors.

Analysis of the level of implementation of the results of the dissertation in practice. According to the results of the dissertation research, 16 papers have been published, which are 3 articles in journals indexed in Scopus and Web of Science databases (CiteScore percentile of more than 25%), 4 articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan and 9 papers in the collections of International and Republican scientific and practical conferences.

4.10 Analysis of the subject of the work of Aliya Assembayeva Creation of new composite materials based on diamond-like carbon films modified with palladium nanoparticles, submitted for the degree of Doctor of Philosophy (PhD) on speciality 6D074000 – «Nanomaterials and Nanotechnologies».

Among disordered carbon structures, diamond-like carbon films can be noted as the form that has provokes the interest of scientists. Amorphous diamond-like carbon films have unique mechanical, tribological, electronic and other properties. Its properties make it one of the indispensable materials in the field of nanotechnology. The field of application of DLC amorphous carbon films is very wide due to the peculiarities of their properties. Among them we can especially emphasize the use of these films as protective coatings due to their tribotechnical and mechanical properties. In addition, they have multifunctional applications in optical, electrical and biomedical systems.

In addition to special mechanical and electronic properties, amorphous carbon

films are characterized by high biocompatibility and chemical inertness. This allows diamond-like films to operate for a long time in aggressive environments without losing their properties and without having a harmful effect on living cells with which they are in contact. It can be noted as a very important area of application, the use of diamond-like films as a coating on implants in contact with blood and as a coating that reduces friction in prostheses placed on joints. Its use as a coating on implants has been found to be commercially viable.

This dissertation work presents the results of studies of the structure and properties of amorphous diamond-like carbon and new composite materials based on them. In order to improve the properties of diamond-like carbon films and to expand the scope of their application it is proposed to cpntrol the synthesis conditions and impurity modification with atoms of other elements. It is established that modification of films allows to achieve the following results: transition of film structure from diamond-like to graphite-like structure, reduction of internal stresses, reduction of dependence of tribological properties of films on environmental conditions, change of optoelectronic properties in a wide spectrum, observation of percolation mechanism of conductivity, etc. Modification with palladium nanoparticles will reveal new physicochemical properties and phenomena that can be manifested by the isolated nanoparticles in DLC nanofilms and expand the field of their application. The study in this direction is important for the creation of new nanocomposite materials that are used in opto- and nanoelectronics devices.

Connection of the dissertation topics with the directions of science development, which are formed by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan in accordance with paragraph 3 of Article 18 of the Law "On Science" and (or) state programs.

The topic of the dissertation corresponds to the main directions of important state programs adopted today in the country. Dissertation work was carried out on the priority direction of science development: Geology, extraction and processing of mineral and hydrocarbon raw materials, technologies, safe products and structures and in the specialized scientific direction: Nanomaterials and nanotechnology new materials. Also the work was carried out in the framework of Grant financing projects AP05131495 "Creation of new composite materials based on carbon media with platinum group nanoparticles", 2018 – 2021, AP08855745 "Development of nanostructured composite materials based on silicon–containing amorphous diamond-like carbon films" 2020 - 2022.

Analysis of the level of implementation of the results of the dissertation in practice. The research carried out in the course of this dissertation work plays an important role in the further development of technologies of non-standard nanocomposite materials for the development of nano- and optoelectronics devices, including devices for the reception and processing of optical signals. The results of the dissertation are published in 16 articles, among them 4 – in international scientific journals (Q1, Q2 and Q3 quartile according to Journal Citation Reports of Clarivate Analytics and/or available in the database Scopus, percentile indicator according to CiteScore) 12 articles are in the proceedings of international research and practical conferences. The dissertator is the corresponding author of the main scientific articles written based on the results of conducted scientific research.

5 Analys is of the work of official reviewers (with examples of the most low-quality reviews)

№	Full name of the doctoral student	Reviewers	
		Full name of the first reviewer (position, academic degree, title, number of publications in the Specialty for the last 3 years)	**Full name of the second reviewer** (position, academic degree, title, number of publications in the specialty for the last3years)
1	Atchibaev R.	Mukhamedshina Daniya - Candidate of Physical and Mathematical Sciences, Professor, Head of the Laboratory of "Innovative Functional Materials" at the Institute of Physics and Technology, at the Kazakh National Research Technical University named after K. I. Satbayev	NurakhmetovTurlybek - Doctor of Physical and Mathematical Sciences, Professor of the Department of "Technical Physics" at the Faculty of Physics and Technology, Eurasian National University named after L. N. Gumilyov
2	Kapsalamova F.R	Aynagul R. Toleuova– PhD (Materials science and technology of new materials), Head of the Department of Internationalization and Strategic Development of the Karaganda Technical University named after Abylkas Saginov	Gulmayra Partizan – PhD (Materials science and technology of new materials), Associate Professor of the Department of Solid State Physics and Nonlinear Physics, Head of Innovation and Intellectual Property Department of the Kazakh National University named after Al-Farabi
3	Dairbekova Guldana	Yar-Mukhamedova Gulmira Sharifovna - Doctor of Physical and Mathematical Sciences, Professor of the Department of Solid State Physics and Nonlinear Physics, Al-Farabi Kazakh National University	Beisenkhanov Nurzhan Beisenkhanovich - doctor of Physical and Mathematical Sciences, Professor of the Kazakh-British Technical University
4	Aigul Shongalova	Kislitsin Sergey - Candidate of Physical and Mathematical Sciences, Head of the Department of Solid State Radiation Physics of the Institute of Nuclear Physics of the Ministry of Energy of the Republic of Kazakhstan	Beisenkhanov Nurzhan - doctor of Physical and Mathematical Sciences, Professor of the Kazakh-British Technical University
5	Raigul Ramazanova	Shevko Viktor Mihajlovich – Doctor of Technical Sciences, Professor, Head of the Department of Metallurgy of the NJSC «M. Auezov South Kazakhstan University», there are 5 scientific publications in the specialty 6D070900 – Metallurgy.	Koizhanova Aigul Kajrgeldyevna - Head of the Laboratory of Special Methods of Hydrometallurgy and Ore Beneficiation named after B.B. Beisembayeva, Institute of Metallurgy and Ore Beneficiation JSC, there are 5 scientific publications in the specialty 6D070900 – Metallurgy.

6	Bakhytuly Nauryzbek	Yerzhan Sovetbekovich Mukhametkarimov - PhD Doctor of Materials Science and Technology of New Materials, Associate Professor of the Department of Solid State Physics and Nonlinear Physics, Al-Farabi Kazakh National University	Gulzira Ibrayeva - PhD Materials Science and Technology of New Materials. Researcher, RSE "National Center for Technological Forecasting"
7	Mohammed Meiirbekov	Lesbaev Bakhytzhan Tastanovich - Candidate of Chemical Sciences, Associate Professor, Chief Researcher, Gorenje Institute of Combustion Problems,	Muratov Mukhit Muhametnurovich – PhD, Associate Professor, Director of the RSE at the Open-type National Nanotechnology Laboratory of the Al-Farabi Kazakh National University
8	Zhaslan Rymgul	Dyusenova Symbat - Doctor of Philosophy (PhD), (6D070900 – Metallurgy), Engineer-technologist of Kazphosphate LLP	Ramazanova Raigul - Doctor of Philosophy (PhD),(6D070900 – Metallurgy), Senior Lecturer of NJSC «East Kazakhstan Technical University named after D. Serikbaev»
9	Ainagul Kemelbekova	Nurzhan B. Beisenkhanov - doctor of Physical and Mathematical Sciences, Professor of the Kazakh-British Technical Universit	Aidar K. Kenzhegulov – PhD, Researcher of the Institute of Metallurgy and Ore Beneficiation
10	Aliya Assembayeva	Bakhytzhan T. Lesbaev – Candidate of Chemical Sciences, Associate Professor, Chief Researcher, Gorenje Institute of Combustion Problems	Gulmayra Partizan – PhD, associate professor of Department of Solid State Physics and Nonlinear Physics at the Faculty of Physics and Technology, Al-Farabi Kazakh National University

6. Proposals for further improvement of the system of training scientific personnel.Increasetherequirementsfortheworkofscientificconsultants(especiallyfrom Kazakhstan)doctoralstudentsintermsoftheproposedtopicsofdissertationresearchandtheirleadershipinthetrainingofscientificpersonnel.

Data on the considered dissertations for the degree of doctor of philosophy PhD, doctorofprofile

DissertationCouncil	**Code and title of specialty**		
	6D074000 – Nanomaterials and Nanotechnologies	6D070900-Metallurgy	6D071000 – Materials science and technology of new materials
Dissertationsacceptedfor defense	4	2	4
Includingdoctoralstudents fromother universities	2	2	1

Dissertationswithdrawnfromconsideration	–	–	–
Including doctoralstudents fromother universities	–	–	–
Dissertations that received negative reviews fromreviewers	–	–	–
Including doctoralstudents fromother universities	–	–	–
Dissertationswithanegativedecisionontheresultsofthe defense	–	–	–
Including doctoralstudents fromother universities	–	–	–
Dissertations aimed at completion	–	–	–
Including doctoralstudents fromother universities	–	–	–
Dissertations aimed at repeated defense	–	–	–
Including doctoralstudents fromother universities	–	–	–

Chairman of the dissertation Council **B. Kenzhaliyev**

Scientific Secretary of the dissertation Council **A. Mamayeva**