AP19675471 " Developing the technology of synthesizing composite ceramic materials of the AlxFeySi system using the additive method", sc. s. - V. A. Andreyachshenko

Relevance:

The use of aluminum alloys has an undeniable advantage over many other alloys, primarily due to their low weight, good performance properties, high electrical conductivity, anti-corrosion properties and sufficient mechanical characteristics. However, to achieve a high level of these characteristics, alloying with expensive, usually rare earth elements, is required. This approach leads to a sharp increase in the cost of finished parts. Ceramics of the MeSi type (silicides) have high hardness and wear resistance. To solve the problem of improving the quality of aluminum-based parts, it was decided to develop a composite ceramic material AlxFeySi. The uniqueness of the material lies in the possibility of forming the Al8Fe2Si phase, which has a highly symmetrical crystal lattice, providing the ability of the resulting composite ceramic materials to perceive plastic deformation.

Project objective:

To develop a technology for synthesizing composite ceramic materials of the AlxFeySi system using an additive method to improve the quality of the structure of materials and parts based on them.

Expected and achieved results:

Achieved results for 2025:

The properties of the obtained composite ceramic materials were studied, numerical characteristics of the mechanical properties of the obtained composite material were obtained: hardness, strength, ductility; the phase composition was determined, the obtained microstructure was studied. Mathematical models of the influence of process conditions on the final properties of the composite are being developed.

The microstructure was studied and numerical characteristics of the mechanical properties of the studied composite material after synthesis, heat treatment and plastic deformation were obtained: hardness, strength, ductility characteristics. The alloy composition has a predominant effect on the manufacturability of the synthesis process, the alloyability of the charge components and the quality of the resulting ingots. The amount of silicon and manganese in the alloy, in addition to that introduced in the charge, is controlled by the selection of flux for the process. The influence of the alloy composition on the temperatures of phase transformations and the conditions for the formation of the α intermetallic phase was revealed. It was found that none of the alloying elements increased the volume content of the α-phase in the intermetallic alloy with a composition close to the composition of the α-phase. The main effect of impurity/alloying elements is to change the temperatures of phase transitions and the features of phase formation, which in turn determine the type and morphology of the structural components, and the microstructure as a whole. It was revealed that plastic deformation contributes to the heterogenization of the structure with the separation of β and θ phases. In this case, the level of mechanical properties is particularly affected by the feature of phase transformation during cooling, especially the conditions of solubility of the θ phase with its subsequent release.

Received publications for 2025

1. Andreyachshenko, V., Bartenev, I., Malashkevichute-Brillant, Y. Synthesis of an aluminum alloy rich in iron and silicon by surfacing with a consumable electrode, Acta Metallurgica Slovaca, 2024, 30(3), 133–136 (Процентиль 53).

2. Andreyachshenko, V., Toleuova, A.R., Alina A.A. The influence of manganese on phase formation in the Al-Fe-Si system, Труды университета 2025, 1, 3-9, DOI 10.52209/1609-1825_2025_1_3

Expected results:

- The properties of the obtained composite ceramic materials will be studied, numerical characteristics of the mechanical and operational properties of the obtained composite material will be obtained: hardness, wear resistance, strength, plasticity; the phase composition will be

determined, the obtained microstructure will be studied. Mathematical models of the influence of technological conditions on the final properties of the composite will be developed. The form of completion is an analysis of the mechanical and operational properties of the obtained composite.

- Participation in an international conference with the publication of a report will be accepted.

- An article and (or) a review will be published in peer-reviewed scientific journals indexed in the Science Citation Index Expanded of the Web of Science database and (or) having a CiteScore percentile in the Scopus database of at least 35 (thirty five).

Research group

№ п/п	Ф.И.О. (при его наличии), образование, степень, ученое звание	Индекс Хирша, идентификаторы ResearcherID, ORCID, Scopus Author ID (при наличии)
1	Andreyachshenko Violetta Aleksandrovna, PhD, Associate Professor (Associate Professor) in the specialty metallurgy, Head of ILIP "KORMS"	Hirsch index (Scopus) - 10 Hirsch index (WoS) - 7; ResearcherID: H-4328-2013; https://orcid.org/0000-0001-6933-8163; Scopus Author ID 55308057400
2	Bartenev Igor Anatolyevich, Candidate of Technical Sciences, Associate Professor, Associate Professor of the Department of TOMiS	Hirsch index (Scopus) - 2, Hirsch index (WoS) – 2, Scopus Author ID: 57207457067, ORCID: 0000-0001-8982-7319
3	Ibatov Marat Kenesovich, Doctor of Technical Sciences, Professor of the department. TTiLS	https://orcid.org/0000-0001-5062-7790, ResearcherID: N-9320-2017 Scopus Author ID: 57189211438, Hirsch index (Scopus) – 4, Hirsch index (WoS) - 3
4	Alina Arailym Altynbekovna, PhD, senior teacher of the department NTM	https://orcid.org/0000-0003-3577-4914, Scopus Author ID: 57218196165, ResearcherID:DRQ-4173-2022, Hirsch index (Scopus) – 1, Hirsch index (WoS) – 1.
5	Malashkevichute-Bryan Elena Iozasovna, master, senior teacher of the department NTM	Scopus Author ID: 5876248370 Hirsch index (Scopus) – 1, Hirsch index (WoS) – 1
6	Yerzhan Aidana, Master, PhD student in Metallurgy	https://orcid.org/0000-0002-6942-2020 Scopus Author ID: 56901129500, Hirsch index (Scopus) – 1, Hirsch index (WoS) – 1.
7	Tulepova Moldir Abylseitkyzy, Master, PhD student in Metallurgy	-

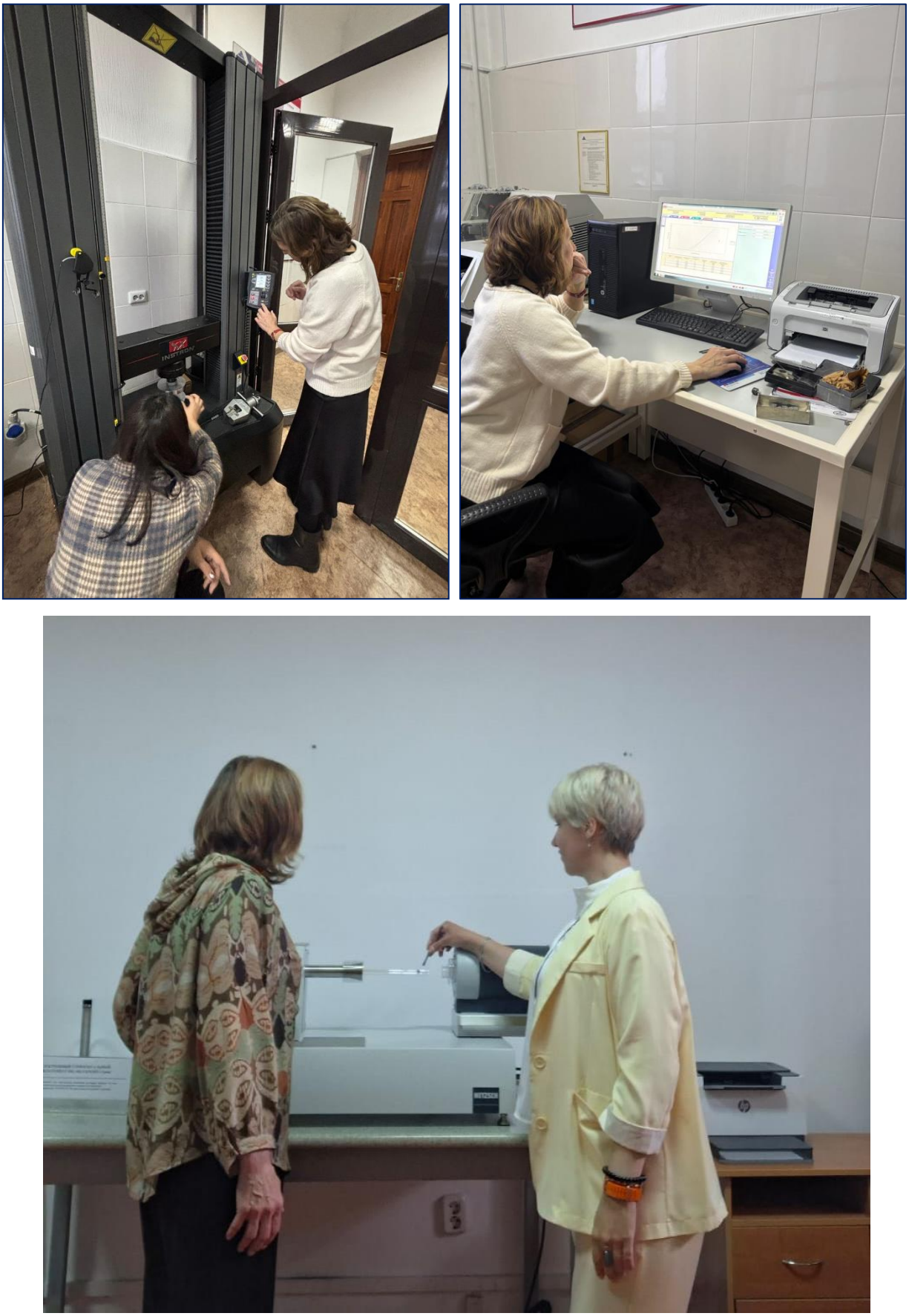

Figure 1 – Work of the research group on the study of composite ceramic materials of the AlxFeySi system

List of publications

1. Андреященко В.А. Влияние флюсов при получении металлокерамических материалов системы Al-Fe-Si// ВЕСТНИК КГИУ № 2 (41) 2023 г., с. 25-30.

2. Андреященко В.А., Толеуова А.Р. Современный методы синтеза металлокерамических материалов системы Al-Fe-Si//Материалы Международной научно-практической конференции «Инновации и комплексная переработка минерального сырья - актуальные составляющие диверсификации экономики», посвященной 30-летию Национального центра по комплексной переработке минерального сырья Республики Казахстан, Алматы, 2023г., с. 107-109.

3. Толеуова А.Р., Андреященко В.А. Компьютерное моделирование фазовых процессов в алюминиевой матрице//Материалы Международной научно-практической конференции «Инновации и комплексная переработка минерального сырья - актуальные составляющие диверсификации экономики», посвященной 30-летию Национального центра по комплексной переработке минерального сырья Республики Казахстан, Алматы, 2023г., с. 82-83

4. Андреященко В.А. Изучение технологии синтеза металлокерамического материала системы AlxFeySi / /Труды университета №1 (94), 2024, 50-56;

5. Толеуова А.Р., Андреященко В.А. Компьютерное моделирование процесса формирования алюминиевой матрицы с помощью программы Thermo-Calc // Вестник ВКТУ №1, 2024, с. 244-251, DOI 10.51885/1561-4212_2024_1_244

6. V.A. Andreyachshenko; M.K. Ibatov Study of phase transformations in the Al 60 Fe 40-x Si x system//AIP Conf. Proc. 3251, 040001. https://doi.org/10.1063/5.0234066

7. A.Zh. Aiken; V.A. Andreyachshenko Evolution of microstructure and properties in Fe, Si-Rich AlFe-Si alloy// AIP Conf. Proc. 3251, 040006. https://doi.org/10.1063/5.0234067.

8. Андреященко В.А., Айтжан А.Т. Подавление альфа-бета трансформации в сплавах системы AlFeSi// Труды Международной научно-практической конференции «XVI Сагиновские чтения. Интеграция образования, науки и производства», Т.3, 14-15.

9. V.A. Andreyachshenko Application of ThermoCalc for the design of an alloy based on the Al-Fe-Si system//Proc in LINDI 2024

10. V.A. Andreyachshenko, M.K. Ibatov Optimization of the three-component Al-Fe-Si system composition// METALLURGICAL RESEARCH & TECHNOLOGY, 121, 3, 315. https://doi.org/10.1051/metal/2024035

11. Andreyachshenko, V., Bartenev, I., Malashkevichute-Brillant, Y. Synthesis of an aluminum alloy rich in iron and silicon by surfacing with a consumable electrode, Acta Metallurgica Slovaca, 2024, 30(3), 133–136 (Процентиль 53).

12. Andreyachshenko, V., Toleuova, A.R., Alina A.A. The influence of manganese on phase formation in the Al-Fe-Si system, Труды университета 2025, 1, 3-9, DOI 10.52209/1609-1825_2025_1_3

Information for potential users

The results of the Project are applicable for the manufacture of machine components operating in harsh conditions and subject to intensive wear. The use of the new alloy as a structural material allows for a significant reduction in the weight of finished products (more than 2 times) compared to steel products, while the hardness of the new composite material is higher.

Scope

The scope of application of the Project results is the automotive and mechanical engineering industries. The target consumers of the obtained results will be mechanical engineering and automotive manufacturing enterprises, machine components operating in harsh conditions and subject to intensive wear.

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