

Национальный
исследовательский

**Томский
государственный
университет**

Упрочнение силумина наночастицами тугоплавких соединений

Ворожцов С.А.
к.т.н., зав. лабораторией
нанотехнологий металлургии

vorn1985@gmail.com





ТГУ сегодня

22 факультета
НИИ:
Сибирский физико-технический институт
Институт прикладной математики и механики
Институт биологии и биофизики

Сибирский ботанический сад
Научная библиотека
23 000 студентов
800 аспирантов

Партнеры лаборатории

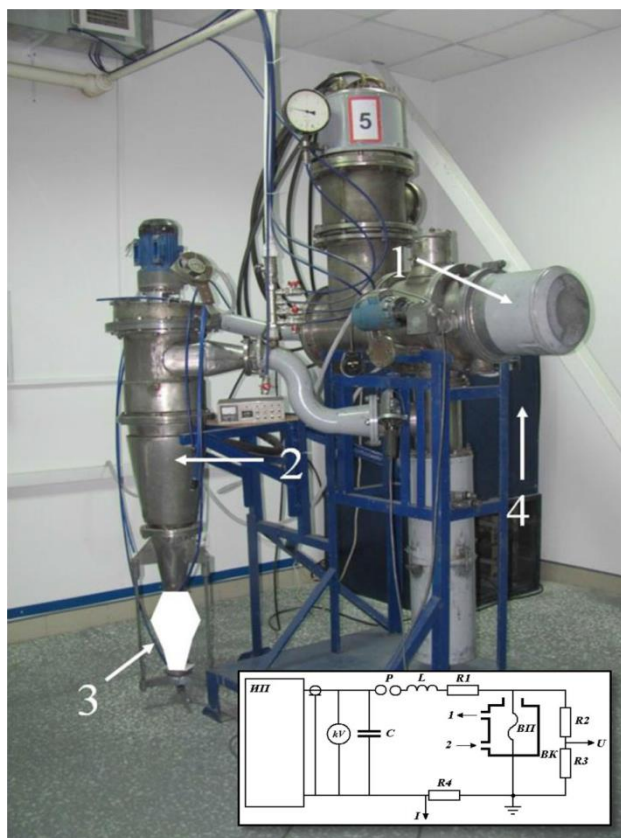


Основные задачи

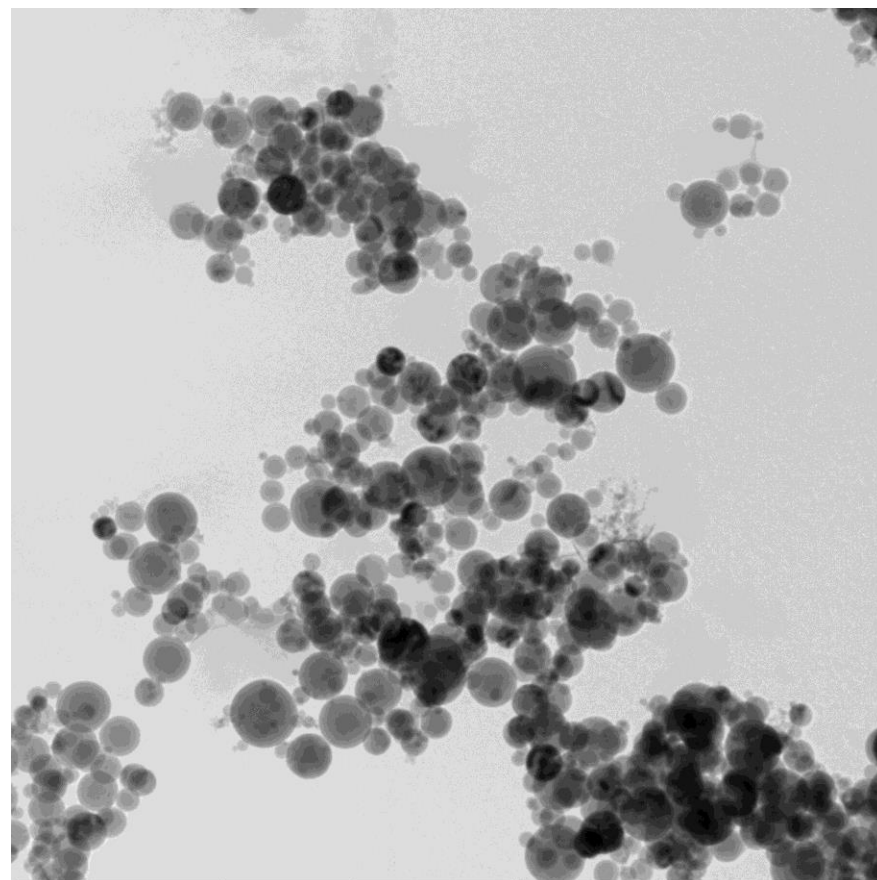
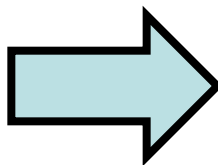
- Синтез наноразмерных частиц (металлических и неметаллических) для последующего изготовления нанокомпозитов и легких сплавов на основе алюминия и магния;
- Всесторонняя характеристика наночастиц;
- Синтез нанокомпозитов, в том числе у партнеров в академических лабораториях и лабораториях за рубежом;
- Получение легких сплавов на основе алюминия и магния, упрочненных неметаллическими наночастицами, в том числе на участках иностранных партнеров;
- Анализ физико-механических свойств нанокомпозитов и легких сплавов на основе алюминия и магния;
- Исследование влияния внешних полей (ультразвук, электромагнитные поля, вибрация, механическое перемешивание) на процессы формирования структуры и кристаллизацию легких сплавов;
- Исследование приложений для использования нанокомпозитов и легких сплавов.



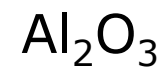
Синтез наночастиц



- 1 – реактор, 2 – транспортировочный узел порошков, 3 – емкость для осаждения продуктов реакции,
4 – высоковольтный генератор.

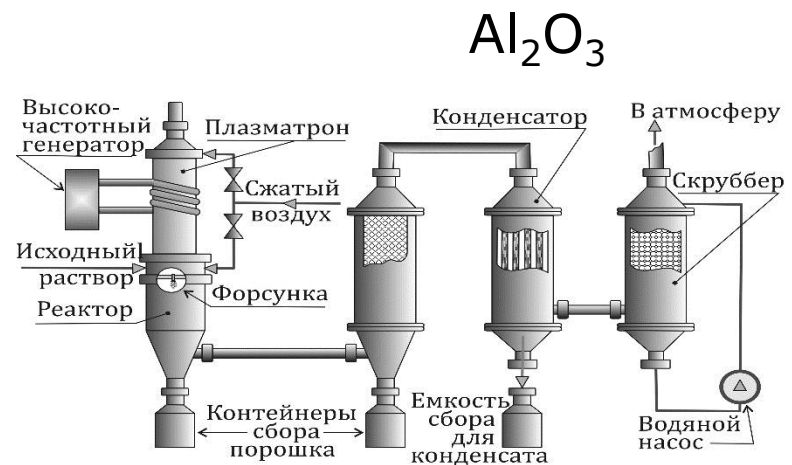
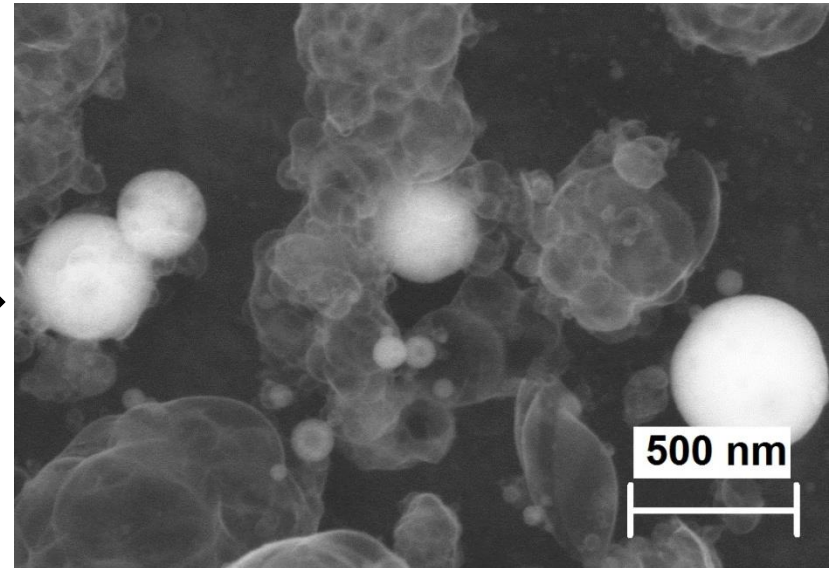
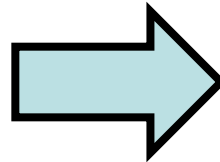


Accelerating Voltage	Magnification	Camera Length	
200 kV	60000 x	-	—500 nm—



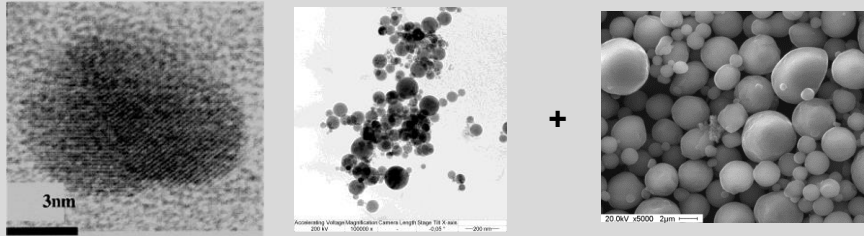
Установка электровзрыва проводника для синтеза нанопорошков нитридов, оксидов металлов производительностью 2т/год.

Синтез наночастиц



Пути решения проблем введения частиц

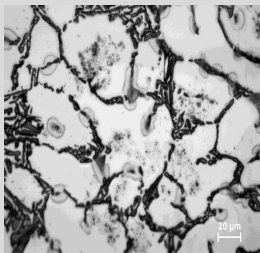
Неметаллические частицы + матричный алюминий



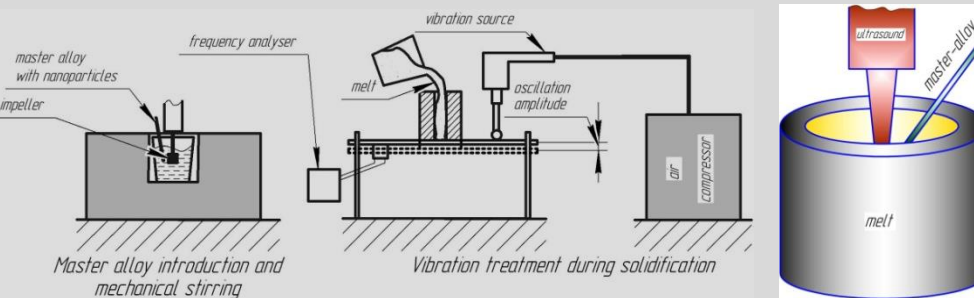
Лигатура



Слиток с частицами

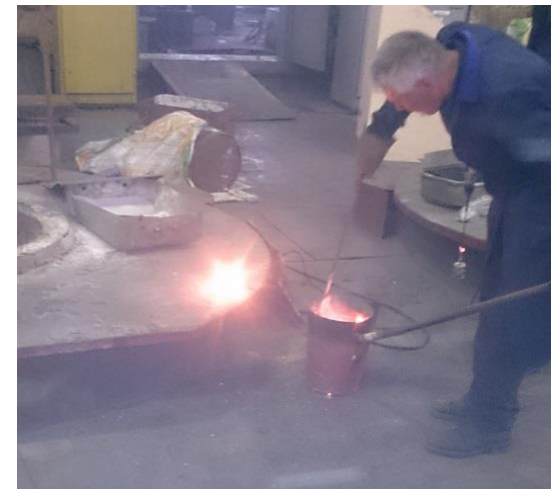
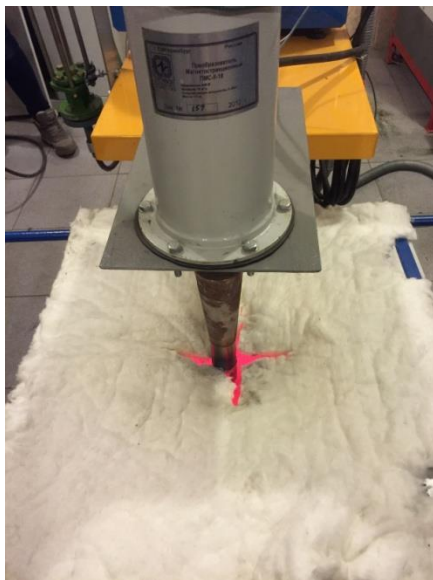


Введение лигатуры в расплав и его обработка внешним воздействием

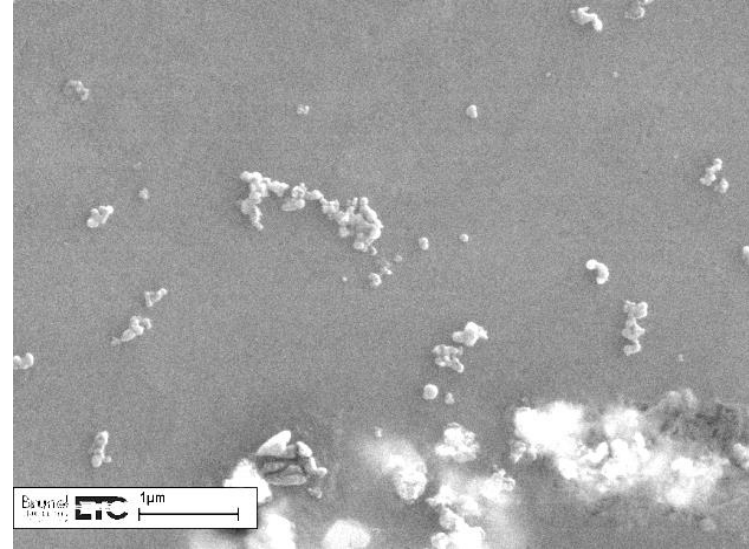
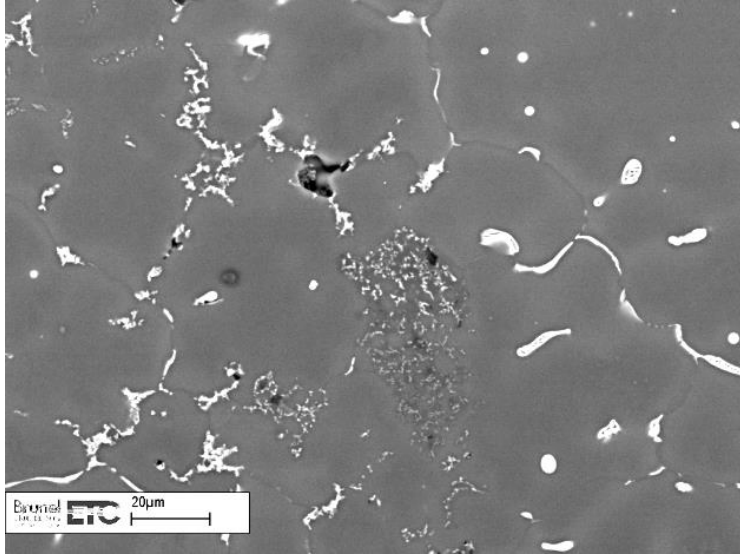


Внешние воздействия на расплав алюминия

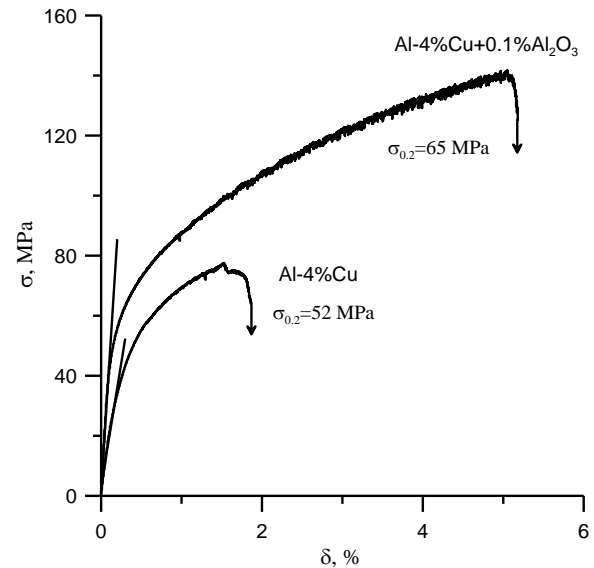
Введение лигатуры в расплав и обработка расплава механическими, ультразвуковыми, вибрационными воздействиями



Результаты исследований сплавов

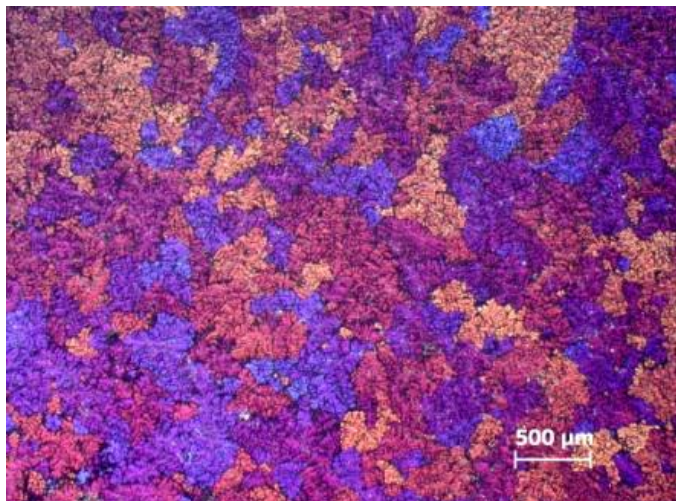


	Hardness, HV	Yield strength, MPa	Tensile strength, MPa	Elongation, %
Al reference	570±10	52±5	77±10	1.5±1
Al+0.1% Al ₂ O ₃	710±10	65±5	140±10	5.5±1

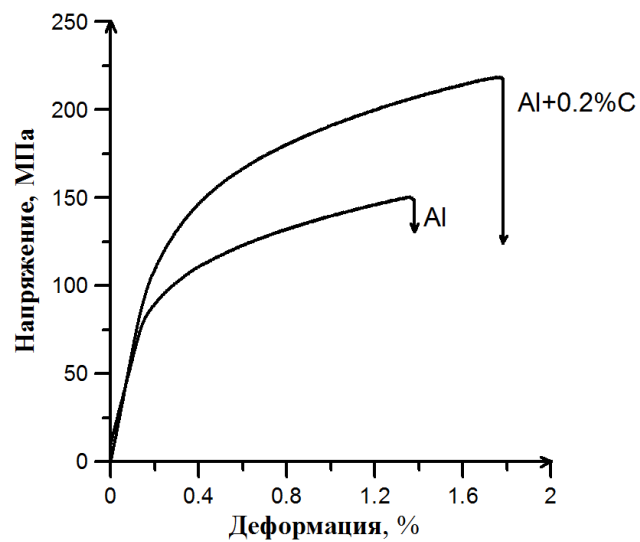
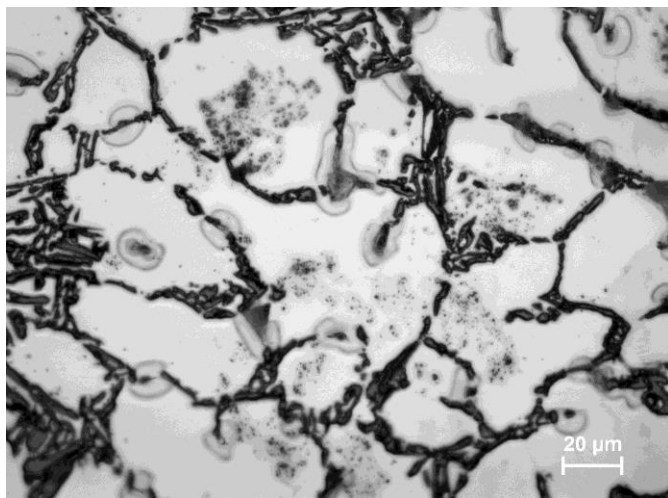
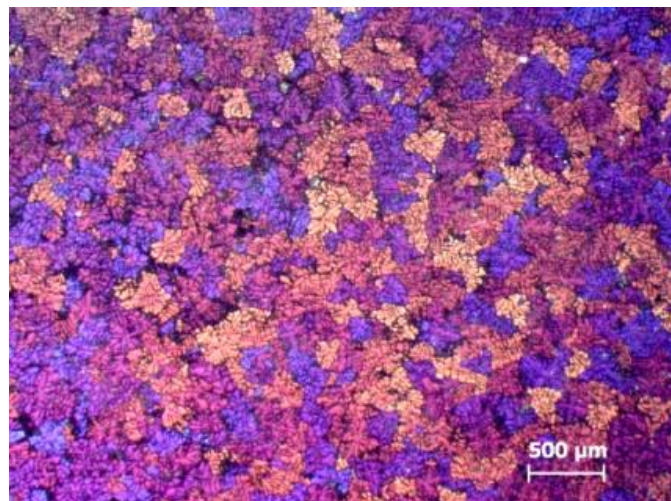


Результаты исследований сплавов

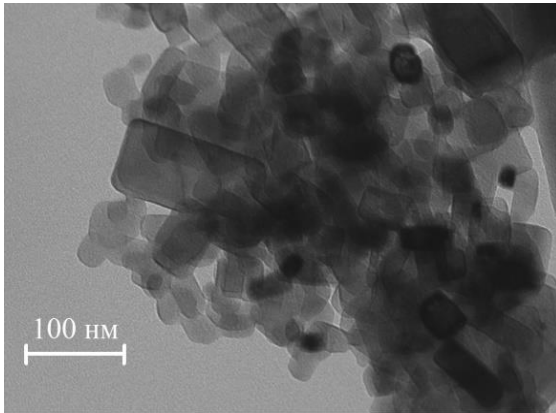
Al исходный



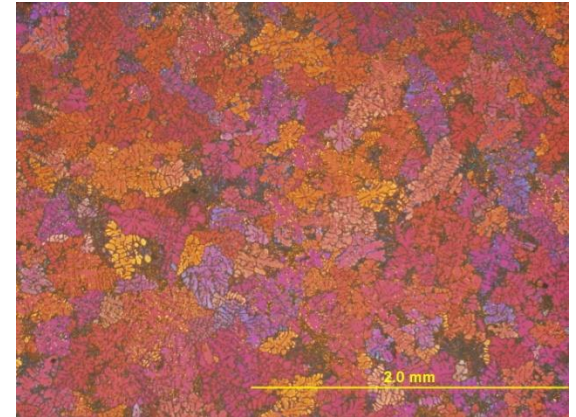
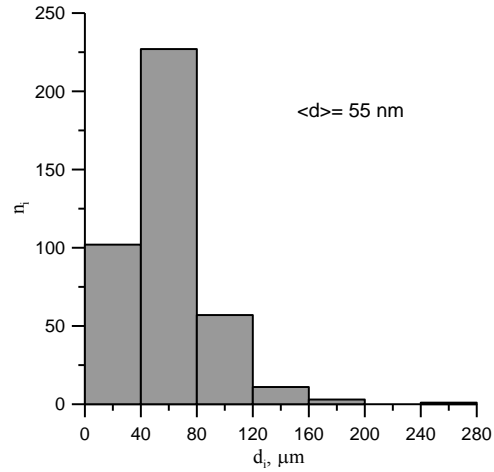
Al+0.2% C



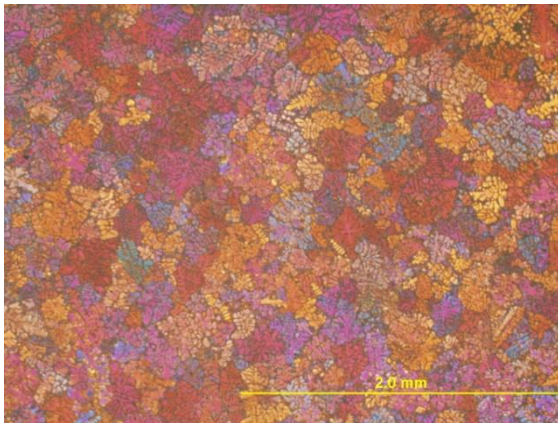
Результаты исследований сплавов



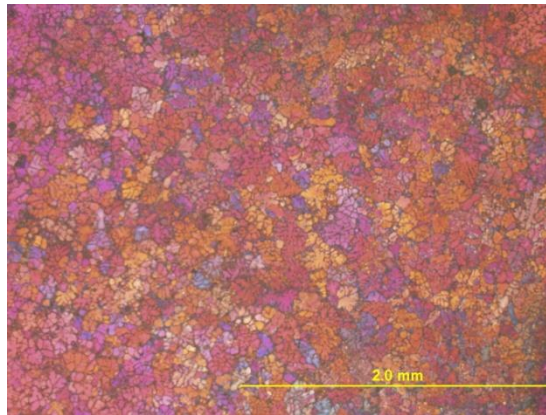
Наночастицы ScF_3



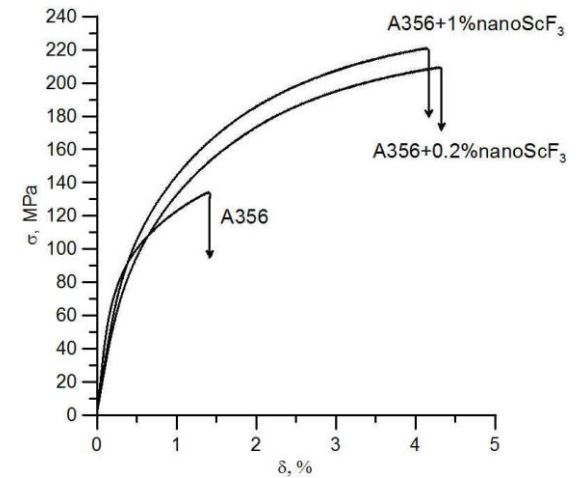
Al исходный



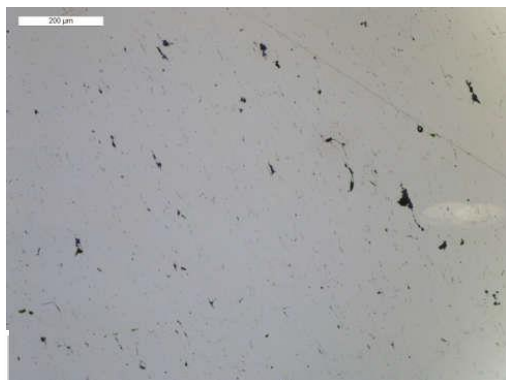
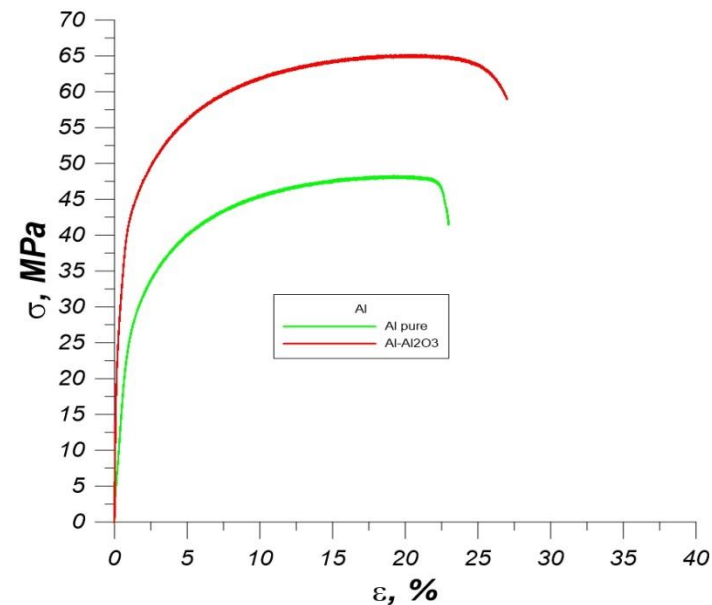
Al + 0.2% ScF_3



Al + 1% ScF_3

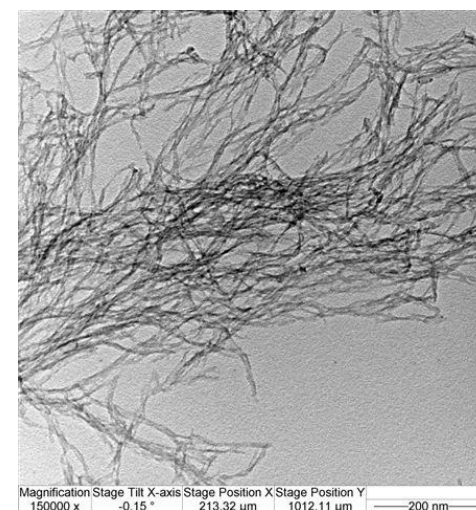
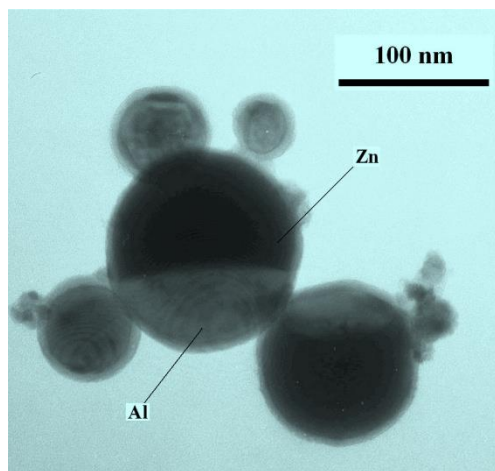
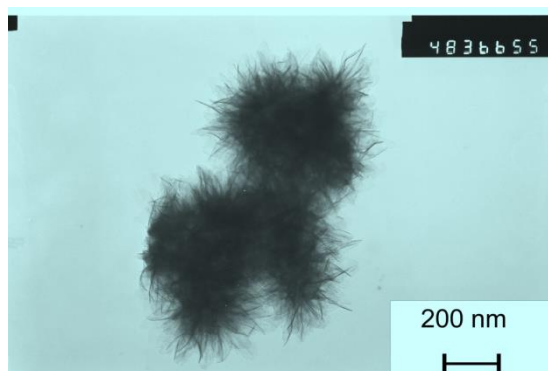
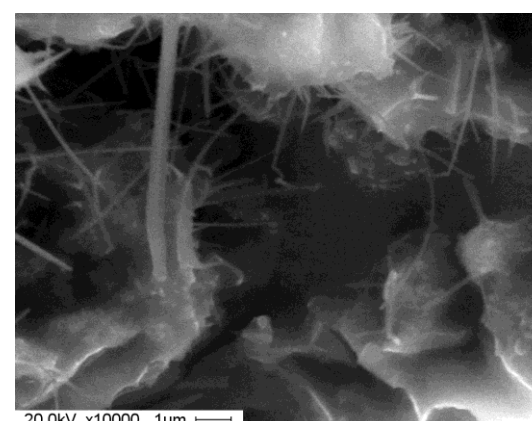
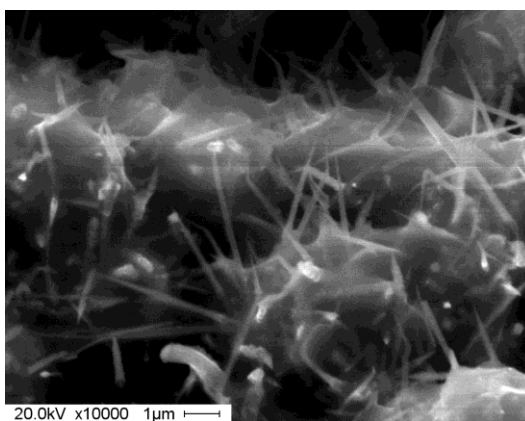
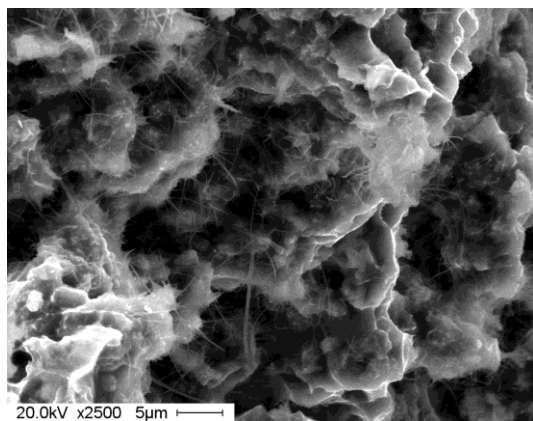


Al кабель с наночастицами Al_2O_3



	Yield strength, MPa	Tensile strength, MPa	Young's Modulus, GPa	Elongation, %	Electrical Resistivity, $\Omega \cdot m$
Al pure	21	48	29	22	$2,7 \cdot 10^{-8}$
Al-Al ₂ O ₃	28	65	82	24	$3,7 \cdot 10^{-8}$

Перспективные наноструктуры для введения в легкие сплавы



Проекты лаборатории

1. Проект ФЦП «Исследования и разработки по приоритетным направлениям развития научно-технологического комплекса России на 2014-2020 годы «Разработка и совершенствование способов получения высокопрочных легких сплавов и металломатричных нанокompозитов с повышенными эксплуатационными характеристиками». Соглашение №14.578.21.0025 (45 млн. руб.)
2. Проект ФЦП «Исследования и разработки по приоритетным направлениям развития научно-технологического комплекса России на 2014-2020 годы «Разработка прототипов технологических решений синтеза наноструктурных лигатур и их использование для получения легких сплавов с повышенными эксплуатационными свойствами». Соглашение № 14.578.21.0098 (15 млн. руб.)
3. Проект 7 Европейской рамочной программы FP7-NMP-2011-LARGE-5 EXOMET. Крупномасштабный интегрированный проект «Физическая обработка литых легких сплавов при внешних воздействиях», CP-IP 280421-2 (EXOMET is co-funded by the European Commission in the 7th Framework Programme (contract FP7-NMP3-LA-2012-280421), by the European Space Agency and by the individual partner organisations) (300 000 €, общий бюджет 19 000 000 €)
4. Проект ФЦП «Исследования и разработки по приоритетным направлениям развития научно-технологического комплекса России на 2014-2020 годы «Научные основы технологии синтеза и применения нового класса лигатур для производства нанокompозитов на основе легких сплавов для их использования в авиакосмической и транспортной отраслях» Соглашение № 14.587.21.0019 (13 млн. руб.)





Physical processing of molten light alloys under the influence of external fields

Large-scale integrating project

Work programme topics addressed: NMP-2011-4.0-1 New technologies based on physical processing of materials for mechanical or electro-technical applications

Proposal No:280421-2

EXOMET CP-IP

Grant agreement under negotiations

Participants
European Space Agency
AVIO Group
EADS Innovation Works (serving Airbus, Astrium and Eurocopter)
Centro Ricerche FIAT (serving Fiat, Alfa Romeo, Lancia, Chrysler)
Jaguar Land Rover
Volvo Group (Tech & Aero)
Precer
Hydro Aluminium
Magnesium Elektron
London & Scandinavian Metal. Co.
Brabant Alucast International
Stone Foundries Ltd.
ALD Vakuum
ESI Group
Meridian Lightweight Technologies

Participants
Tecnalia INASMET
M2i, Delft
GKSS Magnesium Innovation Centre
Fundación IMDEA Materiales
SZFKI Budapest
SIMAP, INP-Grenoble
Imperial College of Science, Technology and Medicine
NTNU, Trondheim
Université de Rouen
BCAST, Brunel University
University of Greenwich
Politecnico di Torino
IRC, University of Birmingham
Tomsk State University
CAST, University of Queensland

Публикации

The Influence of ScF₃ Nanoparticles on the Physical and Mechanical Properties of New Metal Matrix Composites Based on A356 Aluminum Alloy

S. Vorozhtsov, I. Zhukov, V. Promakhov, E. Naydenkin, A. Khrustalov & A. Vorozhtsov

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ISSN 1047-4838
Volume 48
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JOM (2016) 48:3130-3136
DOI 10.1007/s11857-016-2141-3



Springer

On the Mechanism of Ultrasound-Driven Deagglomeration of Nanoparticle Agglomerates in Aluminum Melt

Olgа Kudryashova & Sergey Vorozhtsov

JOM
The Journal of the Minerals, Metals & Materials Society (TMS)
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DOI 10.1007/s11857-016-1811-z

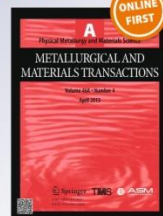


Springer

The Application of External Fields to the Manufacturing of Novel Dense Composite Master Alloys and Aluminum-Based Nanocomposites

Sergey A. Vorozhtsov, Dmitry G. Eskin, Javier Tamayo, Alexander B. Vorozhtsov, Vladimir V. Promakhov, Artem A. Averin, et al.

Metallurgical and Materials Transactions A
ISSN 1073-5623
Metallic and Nonmetallic
DOI 10.1007/s11661-015-2850-3



Springer

Theoretical and Experimental Investigations of the Process of Vibration Treatment of Liquid Metals Containing Nanoparticles

S. Vorozhtsov, O. Kudryashova, V. Promakhov, V. Dammer & A. Vorozhtsov

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The Journal of the Minerals, Metals & Materials Society (TMS)
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DOI 10.1007/s11857-016-2147-7



Springer

The Influence of Al₂C₃ Nanoparticles on the Physical and Mechanical Properties of Metal Matrix Composites at High Temperatures

S. Vorozhtsov, V. Kolarik, V. Promakhov, I. Zhukov, A. Vorozhtsov & V. Kuchenreuther-Hummel

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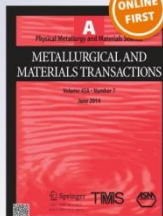


Springer

The ExoMet Project: EU/ESA Research on High-Performance Light-Metal Alloys and Nanocomposites

W. H. Sillekens, D. J. Jarvis, A. Vorozhtsov, V. Bojarevics, C. F. Badini, M. Pavese, S. Terzi, L. Salvo, L. Katsarou & H. Dierz

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ISSN 1073-5623
Metallic and Nonmetallic
DOI 10.1007/s11661-016-2232-2



Springer

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Materials Letters
journal homepage: www.elsevier.com/locate/matlet

Ageing of nanodiamond powder: Physical characterization of the material
Alexander Alexandrovich Gromov^{a,b,c}, Sergey Alexandrovich Vorozhtsov^a, Vasily Fedorovich Kostov^a, Gennady Viktorovich Sakovich^a, Yulia Ignorovna Tsareva^a, Margarita Orlifskaya^a

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Nanodiamond
Ageing
Structure
Nanocomposites

1. Introduction

Nanodiamonds have a round shape, an active surface and a diamond-like hardness that can be used as a number of applications [1-3]. While they have been used in a variety of industrial processes, their use generally is limited to non-ferrous metal matrices. In such a light of these applications, usually carbon nanotubes [4], also they are used as additives, especially in regard to tribology in regard to the tribology of plastic and rubber, and additives to plastic tribology [5]. They may be used as an additive to plastic tribology [5]. They may be used as an additive to plastic tribology [5]. They may be used as an additive to plastic tribology [5].

Corresponding author. E-mail address: gromov@phos.phys.spb.ru (A.Gromov).

Power Technology 102 (2016) 11-24
Contents lists available at ScienceDirect
Power Technology
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Exothermic characteristics of aluminum based nanomaterials
Fahad Nou^a, Alexander Vorozhtsov^a, Maria Lerner^b, Dongsheng Wei^c

ARTICLE INFO
Available online 15 February 2016
KEYWORDS
Aluminum
Nanoparticles
Exothermic
Characteristics

1. Introduction

Increasing use of energy generated from renewable resources, including biomass, wind energy, hydroelectric power, and solar energy, will require stable and efficient energy storage systems. Exothermic reactions are favorable, and prompt heat, compared to other energy storage methods, as they require no external energy input. Exothermic reactions have been investigated for the past several decades [1,2]. However, stationary energy storage applications [3,4]. This reaction, however, is not suitable for use in a power generation system. Exothermic reactions are favorable, and prompt heat, compared to other energy storage methods, as they require no external energy input. Exothermic reactions have been investigated for the past several decades [1,2]. However, stationary energy storage applications [3,4]. This reaction, however, is not suitable for use in a power generation system.

Corresponding author. E-mail address: f.nou@phos.phys.spb.ru (F.Nou).

Materials Science & Engineering A 679 (2016) 60-70
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Microstructure, mechanical properties and creep of magnesium alloy Ek6kronZ2 reinforced with AlN nanoparticles by ultrasound-assisted sintering
Lydia Katsarou^a, Maher Mounib^b, Williams Lehtove^c, Sergey Vorozhtsov^d, Martin Pavese^e, Claudio Badini^f, Jon Mikel Molina-Aldareguia^g, Carmen Cepeda Jimenez^h, Maria Teresa Perez Pradosⁱ, Lige Dieringa^j

ARTICLE INFO
Available online 15 February 2016
KEYWORDS
Magnesium alloy
Microstructure
Mechanical properties
Creep

1. Introduction

Composite materials have been conventionally available for several years and their uses have increased significantly. Magnesium alloys are used in a variety of applications, including in the automotive industry. The use of magnesium alloys in the automotive industry is increasing due to the fact that only small amounts of particles have the ability to improve mechanical properties significantly. This is not only true for mechanical strength, but also for ductility, which is usually severely reduced, as well as for creep resistance [1,2]. Investigations of these uses were performed on materials prepared by powder metallurgy routes. Sintering, pressing, and casting are the most common routes for producing magnesium alloys. The use of magnesium alloys in the automotive industry is increasing due to the fact that only small amounts of particles have the ability to improve mechanical properties significantly. This is not only true for mechanical strength, but also for ductility, which is usually severely reduced, as well as for creep resistance [1,2].

Corresponding author. E-mail address: lydia.katsarou@phos.phys.spb.ru (L.Katsarou).

Accepted Manuscript
Structural and mechanical properties of aluminum-based composites prepared by explosive compaction

Sergey Vorozhtsov, Alexander Vorozhtsov, Olga Kudryashova, Ilya Zhukov, Vladimir Promakhov
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Патенты лаборатории

EU Патент. Metallischer Werkstoff und Verfahren zu dessen Herstellung. Patentanmeldung / Nr. 10 2009 039 323.4.
Anmeldetag: 31.08.2009

Патент РФ №2425163, "Способ введения упрочняющих частиц в алюминиевые сплавы". Оpubл. 27.07.2011 г.

Патент РФ №2487186 "Способ упрочнения легких сплавов". Оpubл. 10.07.2013 г.

Патент РФ №2542044 «Способ получения упрочненных сплавов на основе алюминия» Оpubл. 19.01.2015 г.

Патент РФ №2567779 «Способ получения модифицированных алюминиевых сплавов» Оpubл. 12.10.2015 г.



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университет**

СПАСИБО ЗА ВНИМАНИЕ

Национальный исследовательский
Томский государственный университет

634050, г. Томск, пр. Ленина, 36
+7 (3822) 52-98-52, +7 (3822) 52-95-85 (факс)
rector@tsu.ru

www.tsu.ru

