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STATE ATOMIC ENERGY CORPORATION ROSATOM

Perspectives of development of additive technologies on the enterprise of Rosatom state atomic energy corporation

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Additive manufacturing describes the possibility of making three-dimensional products of any shape directly from a digital model

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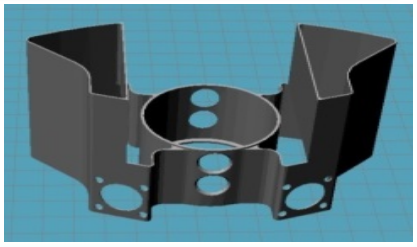
Additive manufacturing (technology) — a process of combining material to create the object from the data of the three-dimensional model, usually layer by layer. It is flexible production without using any tools. The technology does not depend on the shape of the product (only modes can be changed)

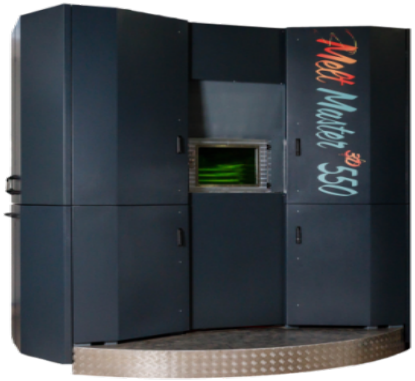
Schematic diagram of additive manufacturing

Preparation of powder

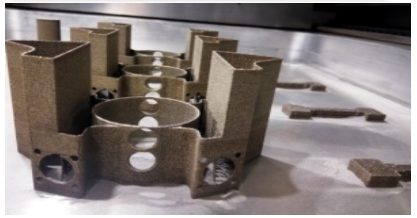
Preparation of CAD - model



Production



Final product



Geometry control

Intra-industry needs for the introduction of production based on additive technologies

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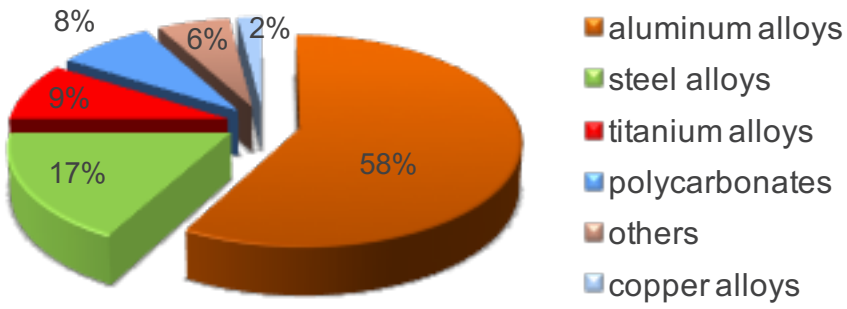
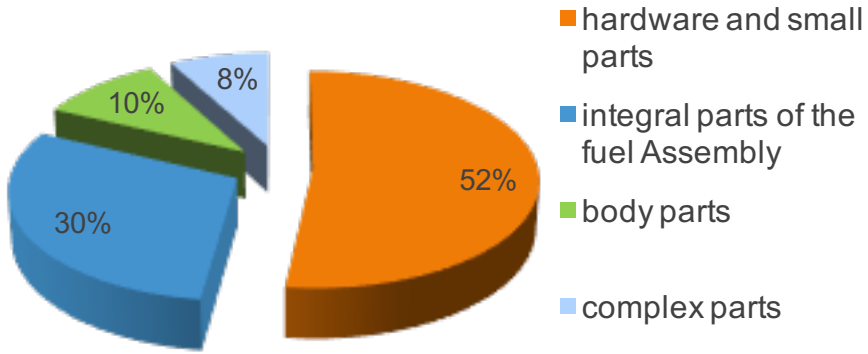
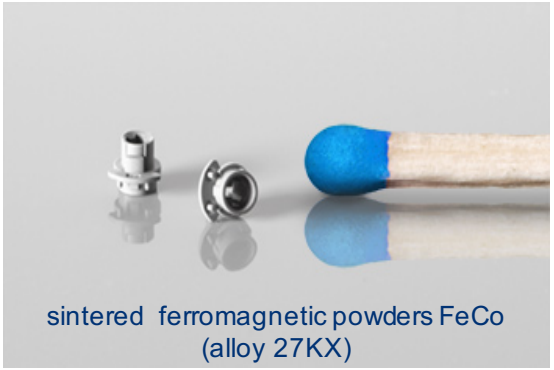
Materials



Product range

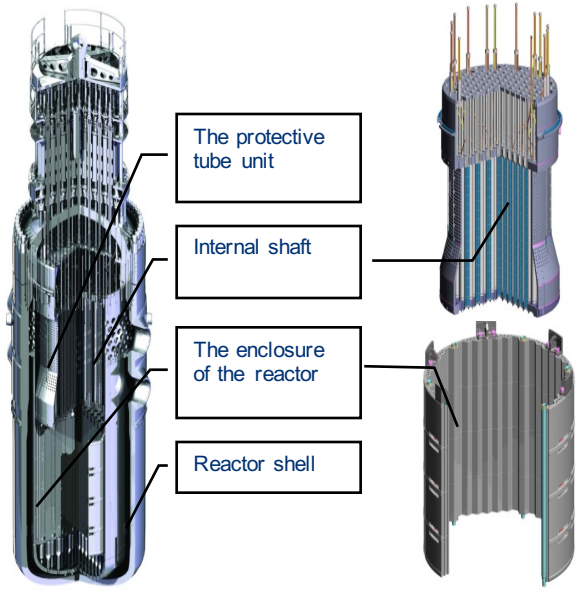


Average:
- the required nomenclature of the parts up to 200 units;
- the required volume of production – more than 11 000 pieces



miniature technical devices and electronic components using additive and MIM technology

Consumable and repair kits



The results of the development of additive technologies on the enterprise of Rosatom state atomic energy corporation

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Industrial equipment

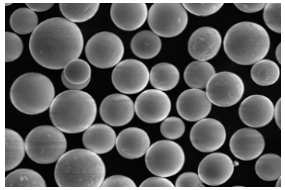
Designed series industrial printers and hardware:

- One–and many, high-performance lasers (400 W and 1000 W)
- a large area of the building (80 thousand cm3) (500x400x400)
- high build speed (more than 43 cm3/h)
- the ability to use 2 powders in printing process
- modular design

further development

- 3D polymer printer;
- ceramic 3D printer;
- 3D-принтер HEM (high energy materials)

Materials



Developed powders for AT:

- Tried and tested experimental batches of powders of titanium VT1-00 alloy VT-6, the powder particles have the required spherical shape and a size of ~10-40 microns
- Implemented the project for the production of powders of metal alloys according to the technology of gas atomization (Al, Cu, Ni, Co, Ti and various.steel) a size of 10-150 microns

further development

- Powder of heavy, heat-resistant alloys
- Ceramic, composite (laminated, encapsulated) powders
- Polymeric materials

Standardization and services

НАУКА И ИННОВАЦИИ
управляющая компания

Росстандарт

РФЯЦ ВНИИЭФ

ВИАМ

- Created Technical Committee 182 "Additive technology" on the base of «VIAM» and «Science and innovation»
- Won a competition in the 218 decree of the government of the Russian Federation for the production of implants and augmented by AT- technologies
- Began works on the development of the «virtual printer»

further development

- Direct control systems Development
- On the grounds of the state Corporation "Rosatom" is planned to organize 3 Centre of additive technologies (service center) «factories of the future»

Typical range of equipment – printers MeltMaster (1 laser)

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Settings\ Name	MeltMaster3D-D75	MeltMaster3D-150	MeltMaster3D-300	MeltMaster3D-550
Chamber size, mm	D75 x 80	150 x 150 x 150	300 x 300 x 300	550 x 450 x 450
The number, power lasers, pieces / kW	1 / 0,2	1 / 0,2	1 / 0,5	1 / 0,5 2 / 0,5 + 1
optical system	F-Theta, high-speed scanner	F-Theta, high-speed scanner	F-Theta / 3-axis optics	3-axis optics / 2 x F-Theta
The cost of the basic equipment, RUB/EURO	13 000 000/ 200 000	17 000 000/ 250 000	33 000 000/ 500 000	59 700 000/ 900 000
Delivery time, months	3-4	4-5	4-5	5-6

Advantages of industrial printers:

- high-performance lasers (400 W and 1000 W); large build area (up to 111 thousand cm3) (550x450x450);
- high build speed (more than 43 cm3/h);
- use 2 powders during printing;
- modular design.

JSC "NPO "TSNIITMASH" - development, JSC "TVEL" - production

Typical range of equipment – process management

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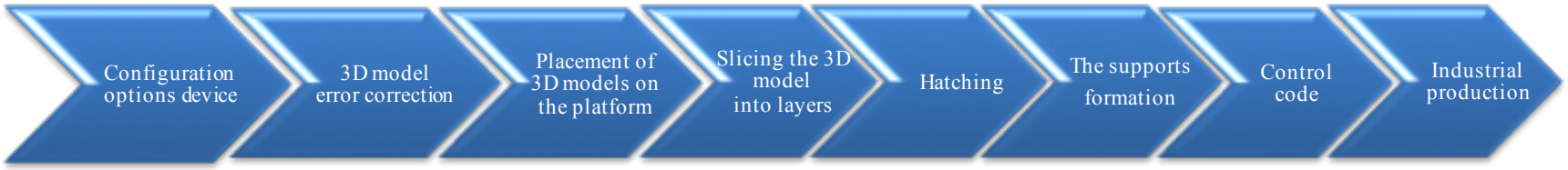
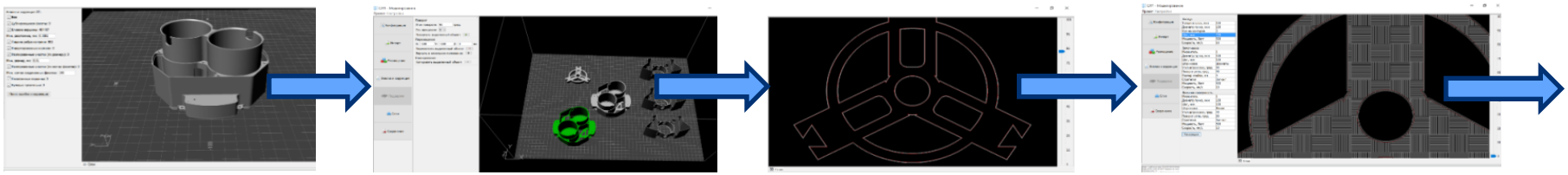
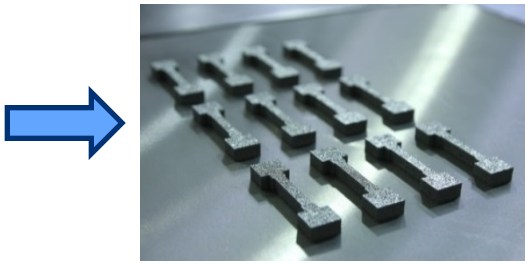
Developed original software package, including two software product

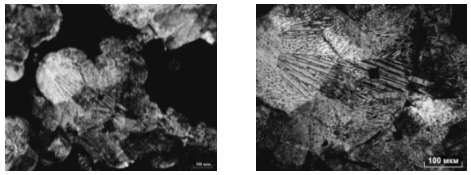
- "SLM-Modeling" - block 1-7
- “SLM-Production" - block of 8



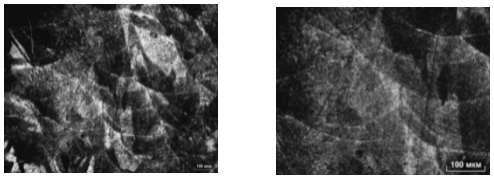


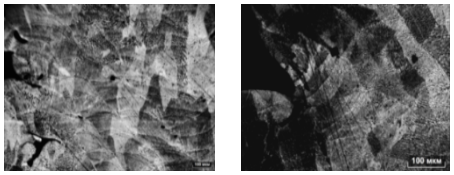


Experimental models for conducting mechanical and microstructural research



The microstructure of samples with macropores (specific energy is 1.5 j/mm2)

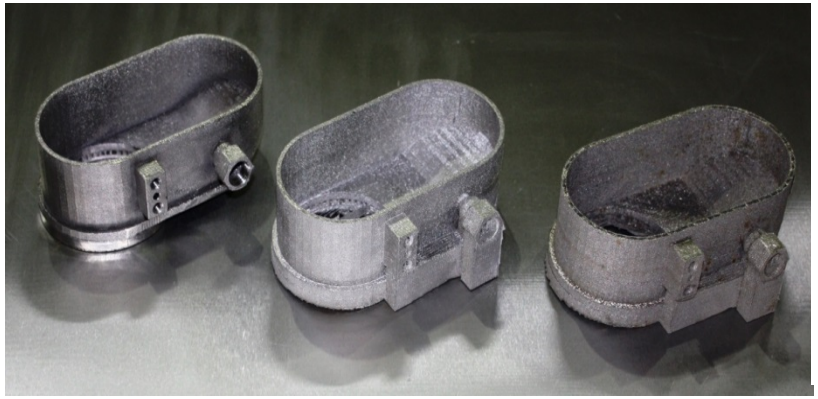


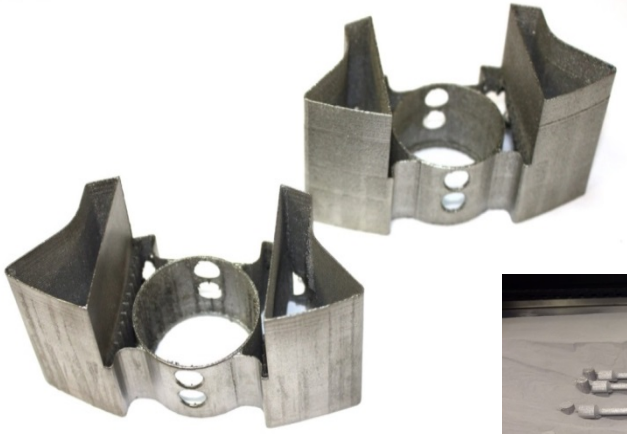


The microstructure of samples with pores (specific energy of 3.8 j/mm2)

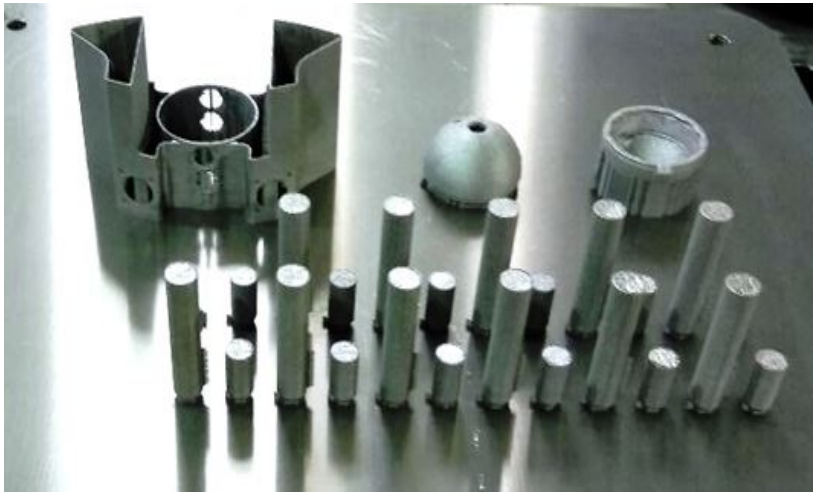
The microstructure of the samples with micropores (specific energy 19 j/mm2)

Examples of products





Stainless steel



Titanium

Software development – «Virtual printer»

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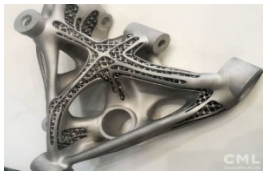
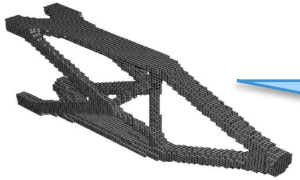
✓ The radiation transfer to calculate the distribution allocation of thermal energy between the layers of powder and the substrate
✓ Heat transfer with phase transitions
✓ Mass transfer in the melt powder environment

✓Related problem of heat and mass transfer to simulate the redistribution of alloying elements, forms a molten bath

✓heat and mass transfer at the stage of cooling and the analysis of the processes of solidification for predicting the mechanical properties of the product
✓the optimization problem (prediction of optimum modes of SLM)





«Virtual 3D printer»-
multiscale mathematical system with feedback and adaptive control capabilities of pre-emption and response to the additive technology of SLM, linking together the concepts of process - structure - properties of produced products and integrated with CAD tools.

Internal cooperation of Rosatom state Corporation for supplementing competencies in the field of AT

JSC «Science and innovations»
Co-chair TC 182 "Additive technology"]
Divisions – members: Science and innovations, TVEL, AEM, NWC

GIREDMET

spherical titanium powders and alloys with a size of ~20-40 microns

VNIICHT

powders of steel 12KH18N10T size of about 20-40 microns

UEIP

Manufacturer:
- by gas atomization of aluminium alloy powders, bronze (~20-40 μm)
- by the plasma centrifugal atomization, the powders heat-resistant Nickel alloys with a size of ~40-100 μm and titanium alloys ~150-200 μm

RFNC-VNIITF

Laser technology

UEIP

Production of devices for additive technologies

NPO TSNIITMASH

Development of a 3D printer for metal products, vacuum devices and surfacing, additive manufacturing

RFNC-VNIIEF

Modeling and additive/digital manufacturing testing dependencies process – structure – properties/ virtual printer

NIIGRAFIT

Technology layer-by-layer manufacture of CFRP/composites

PA Start

Manufacturing of metal powders. Production for PIM technology. Additive manufacture of articles from metal powders, carbon-filled composite materials, ceramics

NIIEFA

Tomographic control

Development of technology of receipt of powders, production of powder

Software development, production of components, technology and application of additive manufacturing

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Attachment

Production verification. Development of an atlas of standard forms for topological optimization of structures formed by the method of SLP

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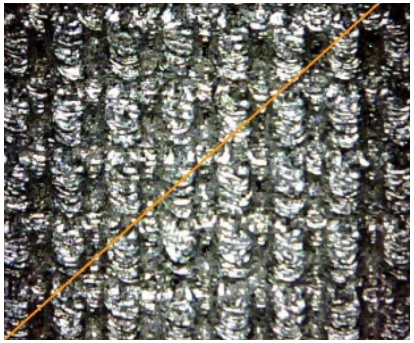
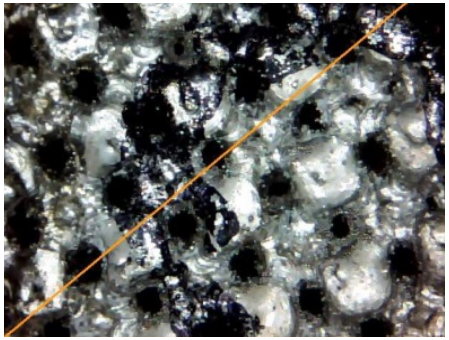
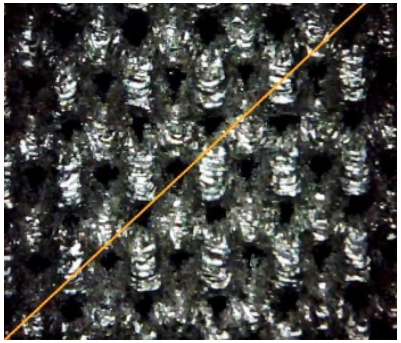
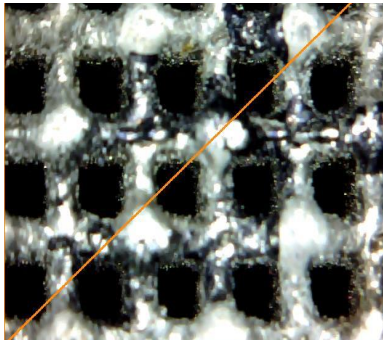
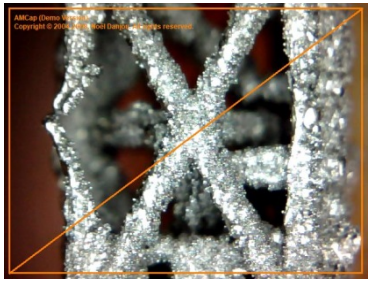
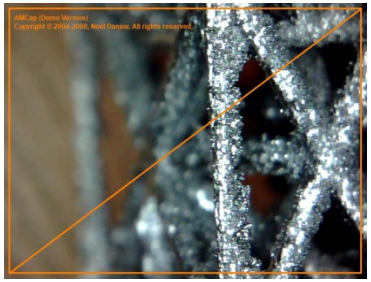
Titanium - the size of cells 600-800 microns

Results of experiments of printing samples of cellular structures for preclinical studies. Samples are made on a metal printer MeltMaster 550

The possibility of manufacturing honeycomb structures with dimensions:
Beam: ⌀300 µm, length up to 6 mm;
Cell: ⌀400-600 µm with homogeneous structure of elements

Creation of high-tech digital production of additive products for the medical industry based on additive technologies

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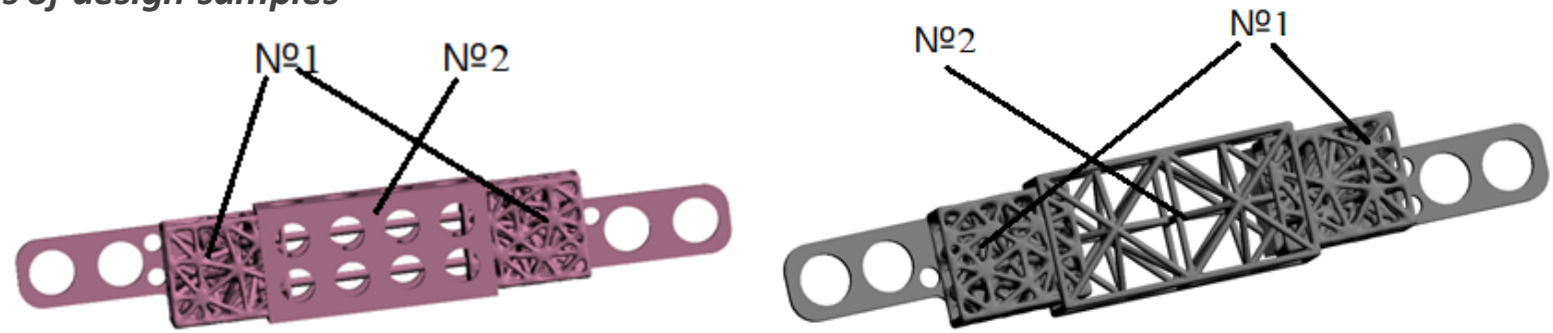
Print Party 8.1

2 types of design samples



Samples should be made from areas for osseointegration, measuring 600, 800 and 1000 microns

Sample table:

Type number of samples	The size of the cells in the osseointegration zone (left-right)	1 month	3 month	6 month	Total
Center part with holes					
1	600-800	2	2	2	6
2	600-1000	2	2	2	6
The central part of the girder					
3	600-800	2	2	2	6
4	600-1000	2	2	2	6

Production verification
OMS Implants

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3D-models of implants in the project

3D models of the segment of the lower jaw. General view of the structure with a shell

3D model of the segment of the lower jaw. General view net structure

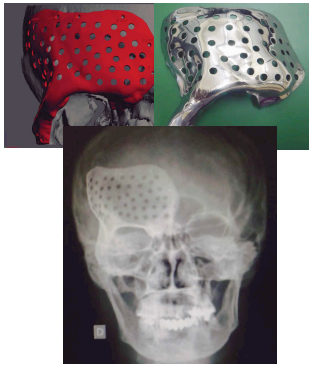
Prototypes of industrial implants in the project

Segment of the lower jaw.
The prototype of the implant is printed on a 3D printer MeltMaster3D-550 (CNIITMASH) made of titanium VT1-0

Analogues in the market

Implant polymeric segment of the cheek-orbit complex CloverMed, Russia

Forming the contour of the mandible from the titanium plate, Taiwan



Clinical case of using an implant cranioplasty, obtained by an additive method (SLP), Bioconnect, Brazil

Segment of the lower jaw.
The prototype of the implant is printed on a 3D printer MeltMaster3D-550 (CNIITMASH) made of titanium VT1-0

Current results of work on the project
Back cages

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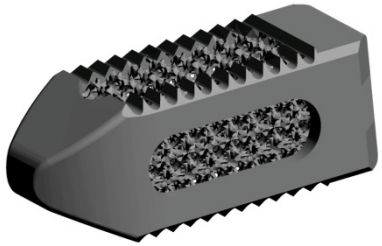
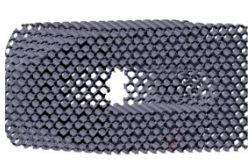
3D-models of implants in the project



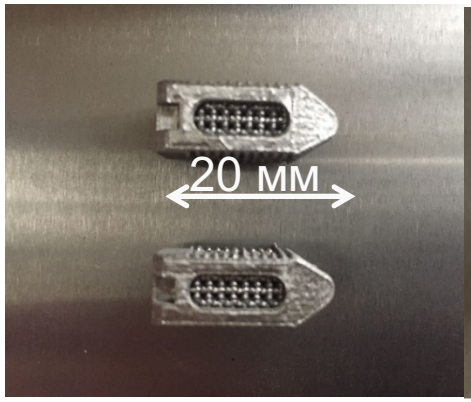
3D model of the spinal lumbar cage

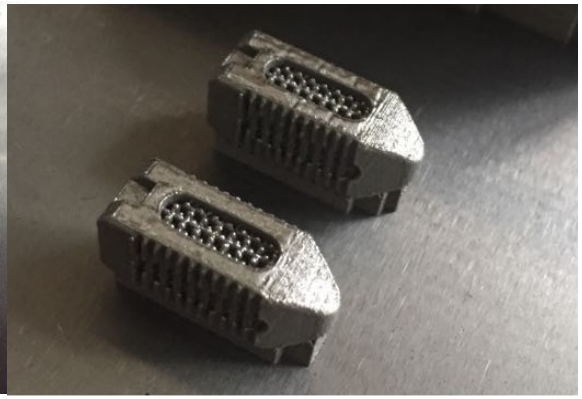


3D models of cages of the spinal lumbar spine of the open-type cellular structure

Cage spinal lumbar.
Implant of the new product line of Stryker, USA, 2016-2017

Prototypes of industrial implants in the project

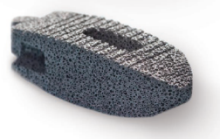




Cage spinal lumbar.
The prototype of the implant is printed on a 3D printer MeltMaster3D-550 (CNIITMASH) made of titanium VT1-0

Foreign analogues

Spinal cage.
Implants of the new product line of TeseraImplants, USA, 2017



Spinal cage.
Implant of a new product line from Zimmer, USA, 2017

Examples of titanium products

Examples of stainless steel products