INSTITUTE OF LASER AND WELDING TECHNOLOGY

DIRECT LASER METAL DEPOSITION

HETEROPHASE POWDER

LASER METALLURGY

Technology for the future

Direct laser deposition

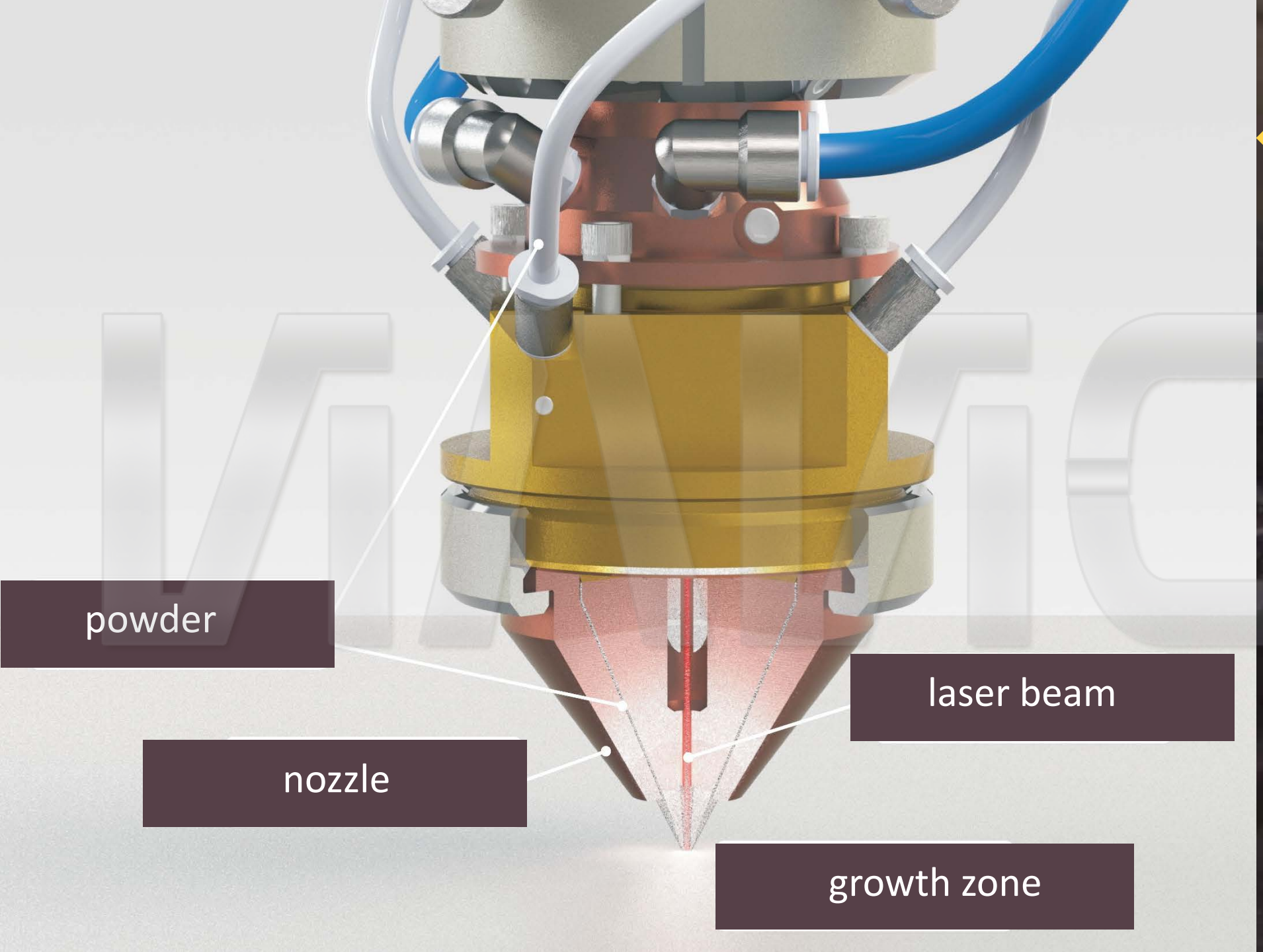
- technology for manufacturing of details with complex form from powder materials using 3D model.

Potential use different materials in a single part and obtaining details with gradient properties

Dimensions of details are almost unlimited.

The process productivity is 10 times higher in comparison with layered synthesis technologies.

Mechanical properties of the obtained product at a level of hot rolled metal, there are no pores, cracks and lack of fusion.



Process

The product is formed from metallic powder supplied by compressed gas-powder jet to the laser action zone. This provides heating, partial melting of the powder and heating of the substrate.

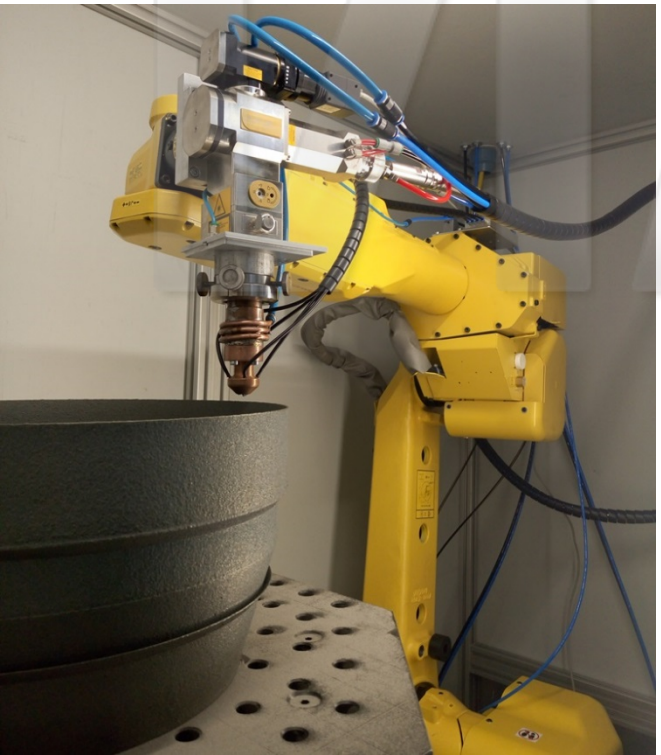
Controlled melting of the powder particles provides the formation a fine-grained structure of metal;

In this case, the principles heterophasic powder laser metallurgy are realized.

Advantages

First Russian equipment, which realize direct laser deposition technology.
World leader in the field heterophasic powder laser metallurgy (HPLM).

The technology solves a number of problems for modern engineering, improves process efficiency by 10 times and reduces the cost of manufacturing parts by 3-5 times.



Problems of engineering industry development:

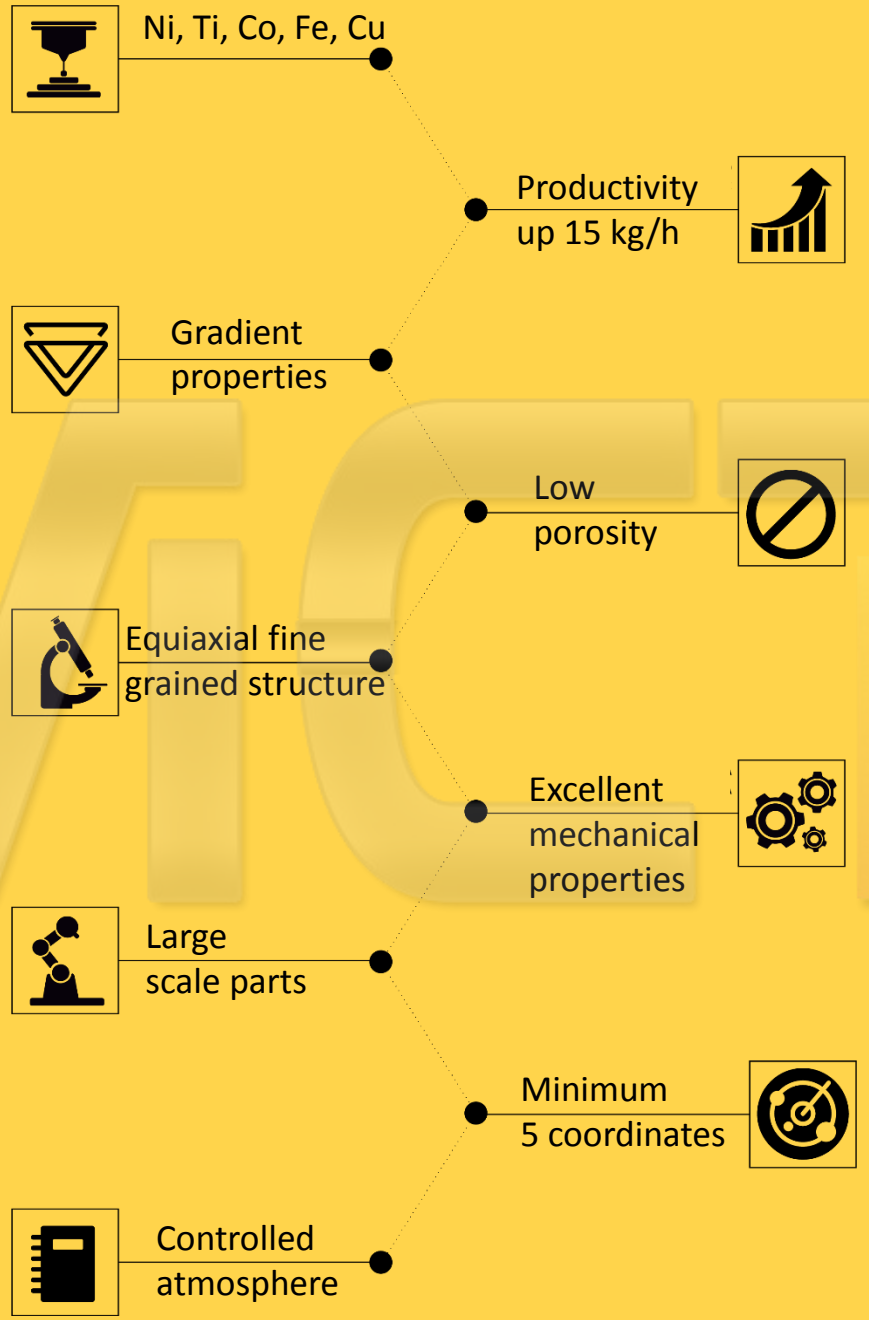
Details become more complex
Equipment, tools and equipment are rising in price;
requirements personnel qualification grow
There is a deficit of workers;
manufacturing cycle increases;
materials utilization rate falls down
Costs of manufacture increases

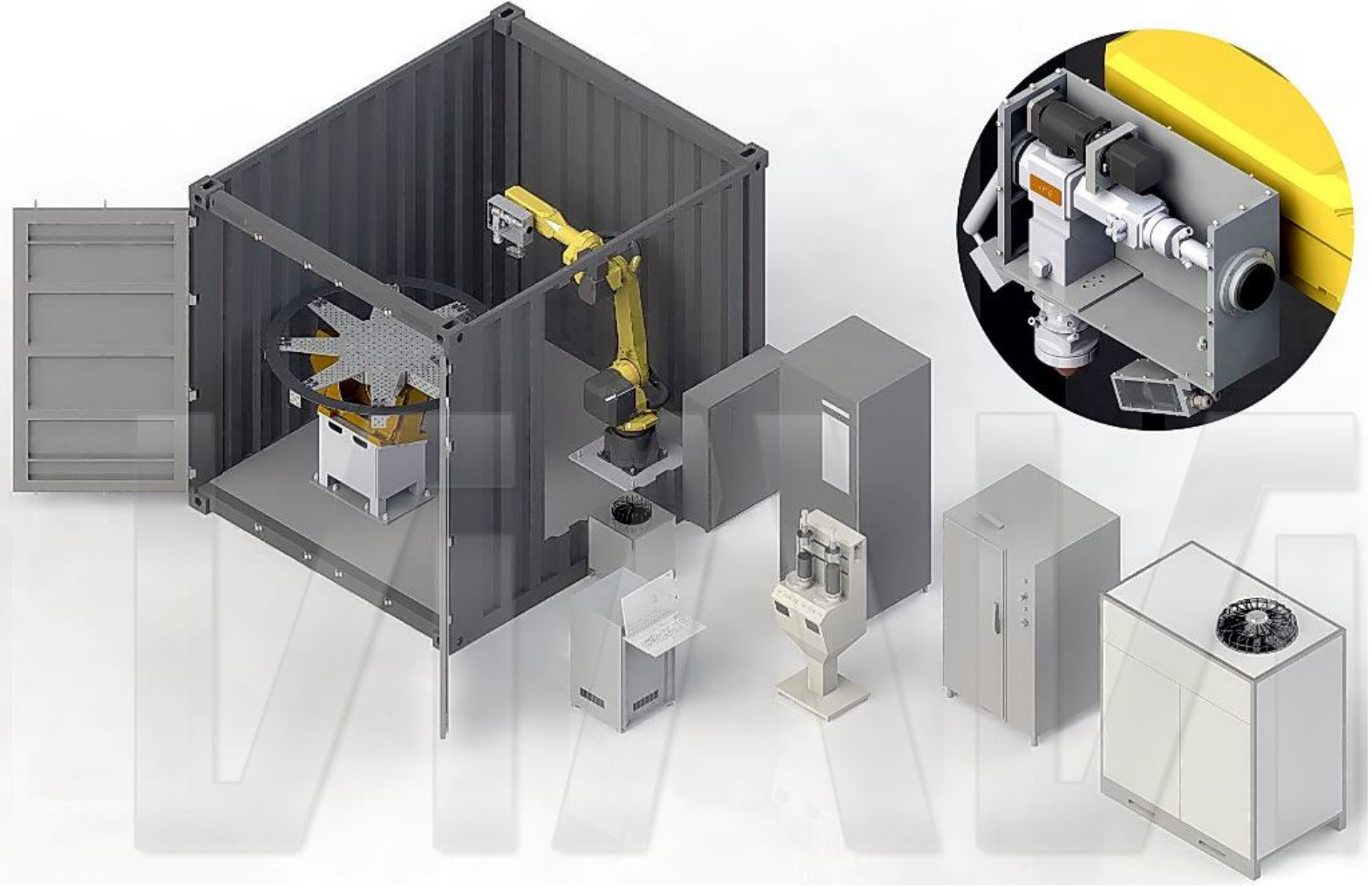
Benefits of implementing the HPLM technology :

Productivity of manufacturing parts with complex shapes from intractable materials increases
Full automation and "digitalization" of manufacturing
manufacturing material consumption decreases;
cost saving
Enhancement of technological and engineering capabilities


Productivity
- up 15 kg/h
Large
scale parts

Application:
Engine building
Shipbuilding
Power and transport engineering
Rocket and space industry
Aircraft engineering
Medicine



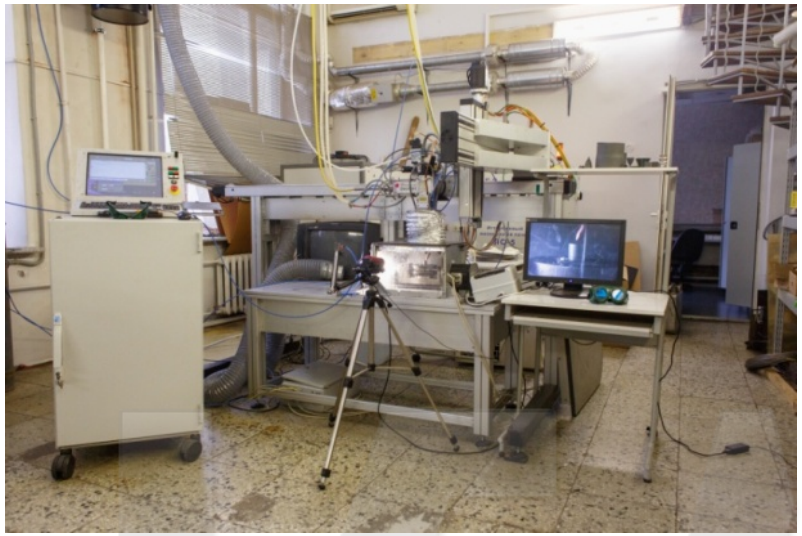


Technological complexes

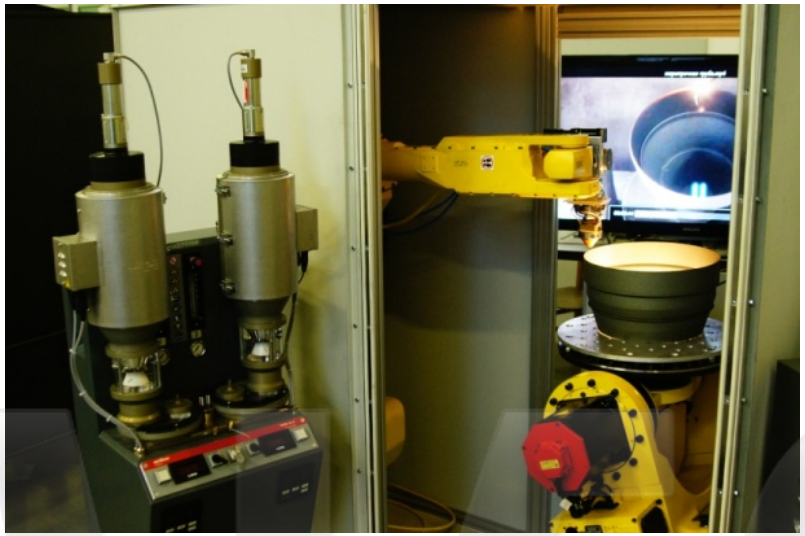
The versatility and modularity of systems allow to reduce terms production of equipment according the specifications and enhance the ability equipment due to simplicity of modernization, which provides cost-effectiveness of implemented technologies

Complex:

- The dual-axis rotator,
- Working chamber,
- Laser cladding head,
- The robot manipulator,
- preparation and supply gas system,
- gas cleaning and drying device,
- The laser fiber,
- Chiller,
- Cooling system,
- Control Stand,
- The powder feeder,
- Control system,
- Video surveillance system,
- Cladding nozzle



Working zone size 150x150x100

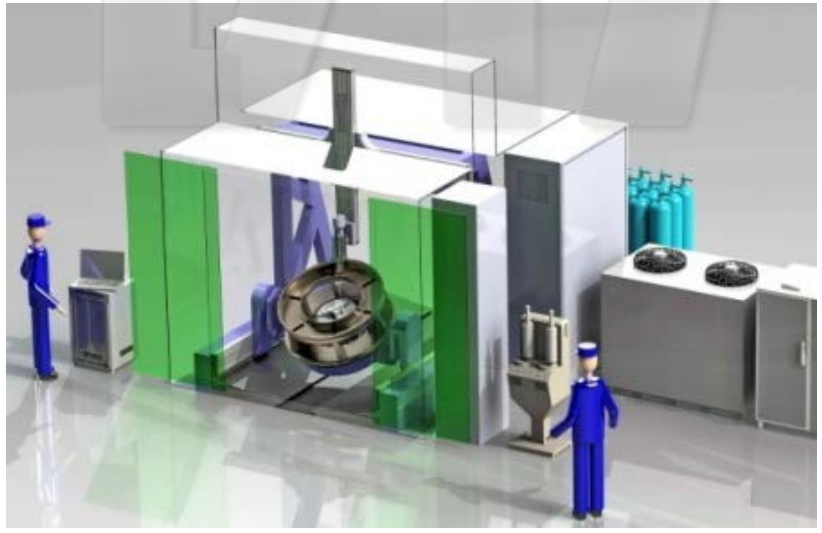


Working zone size 600x600x600

Technological complexes

The complete solution of industrial problems: design, development of technology and equipment, delivery, commissioning, training,

service maintenance

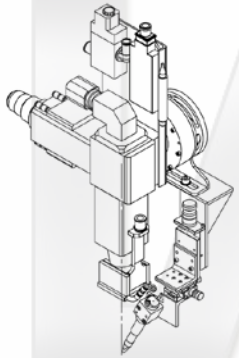


Working zone size 2500x2000x1000
** 2016*

Development of technological heads

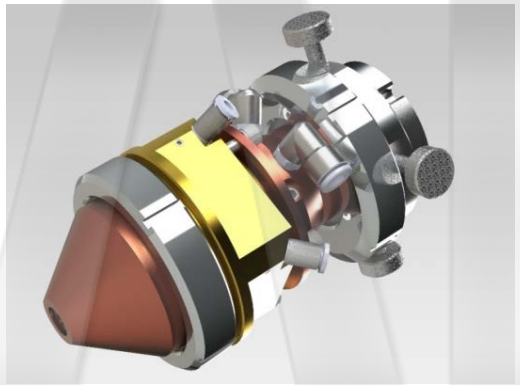
Lateral nozzle

High productivity



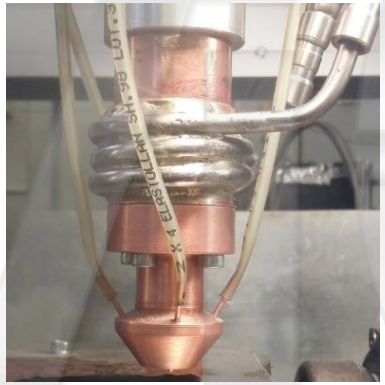
Coaxial nozzle

Products with complex form



4-jetting nozzle

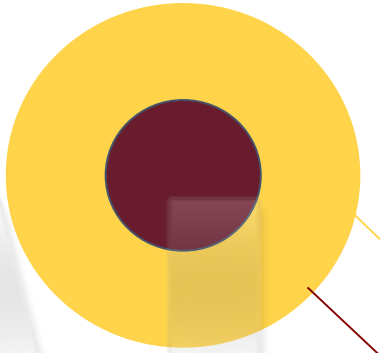
Products with gradient structure



- **Lateral feed with scanning – productivity of manufacturing part blanks above 18 kg/h (thin wall 3 - 20 мм).**
- **Lateral feed by focused gas-powder jet – productivity above 5 kg/h (wall 0.8 - 3 мм)**
- **Coaxial feed by focused jet – productivity above 1 kg/h (wall 0,6 – 2 мм)**

Samples of direct laser metal deposition

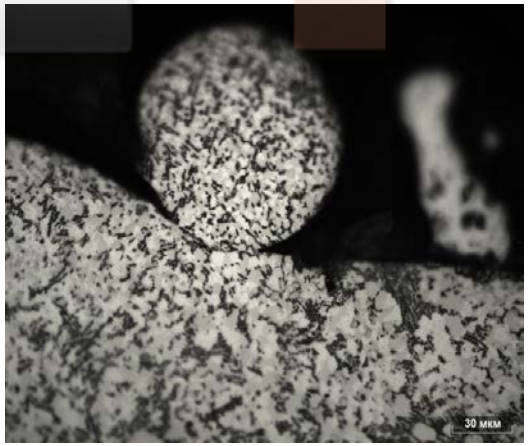
Melt powder nuclei become new centers of crystallization
The crystallization of the melt does not proceed from the surface, and from the volume - the key to obtaining a fine-grained structure of metal



DMD, DED, LENS

HLPM

Torch gas through a narrow powder slurry passes laser radiation.
We get the liquid shell and solid nucleus powder particles.
There is no complete melting of the powder.
The two-phase melt pool and the bulk crystallization.

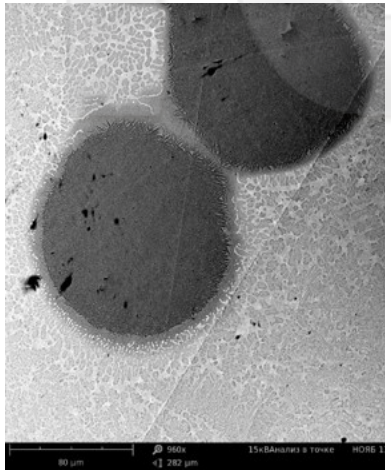


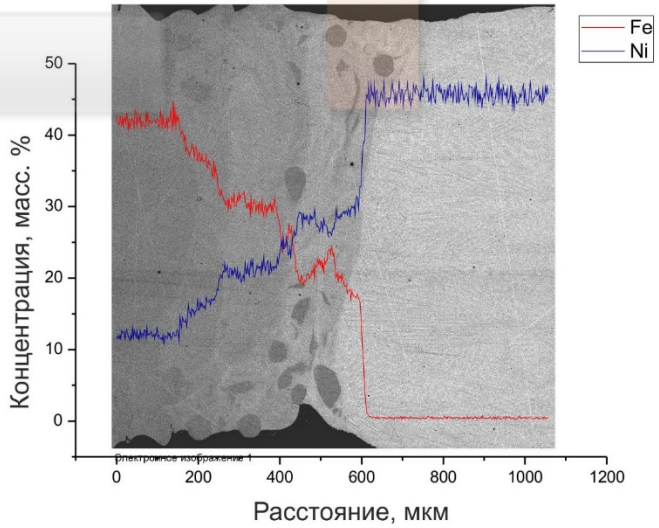
Characteristics

- Strength of details
- Impermeability
- Isotropism of properties
- Gradient properties
- Any configuration
- Limitlessness product sizes
- Facilitation detail - the possibility of topology optimization with weight decreasing
- The absence of post-processing
- High productivity

Implementing of high-speed direct laser deposition technology is most efficient for manufacture of product with large amount of assembly units, which have long production cycle. It is also suitable for large and thin wall products with complex configuration and a low materials utilization rate.

Maximum of service temperature of products
– at least 500 °C



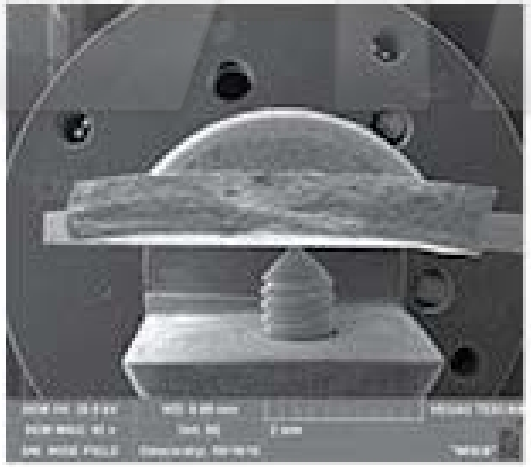


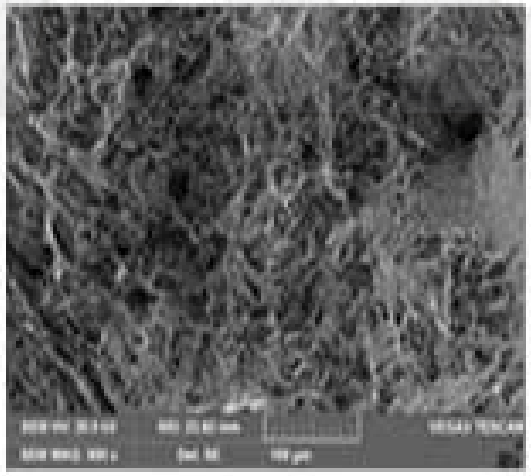
Results of metallographic researches and mechanical testing of produced samples confirmed their faultlessness and high operational characteristics.

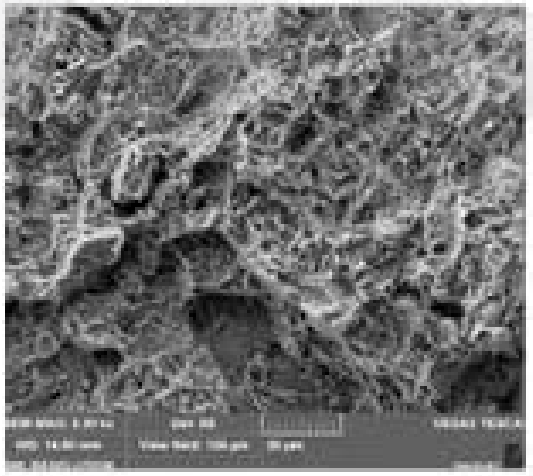
As compared with cast samples the products are manufactured by heterophasic powder laser metallurgy (HPLM) have ultrafine structure. It provides high level of mechanical characteristics. The strength characteristics HPLM samples is higher 20% in comparison with cast samples. Elongation of the material is increased to 3 times.

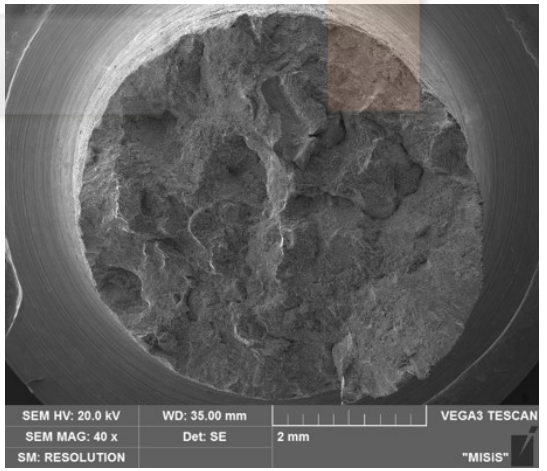
As opposed to cast samples, fracture of HPLM samples is characterized by ductile destruction.

Mechanical properties are on the rolled metal level

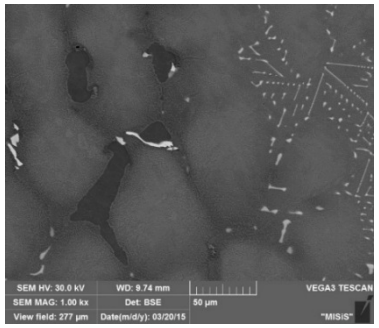




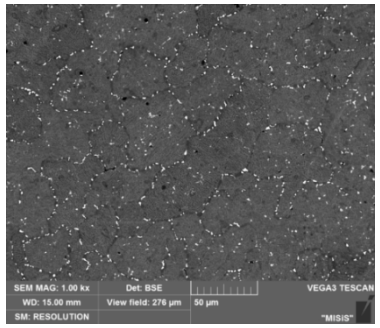




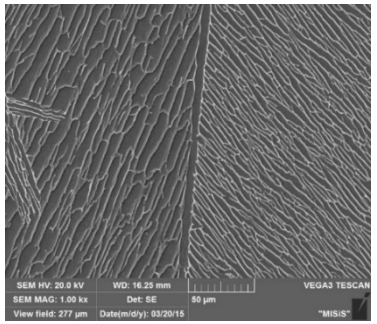
Materials	Properties
Inconel 625	Tensile strength $\sigma_{0,2}$ 489 MPa, $\sigma_в$ 865 MPa, δ 28,5 % (casting condition: $\sigma_{0,2}$ 310 MPa, $\sigma_в$ 800 MPa, δ 25 %, rolled metal $\sigma_{0,2}$ 414-758 MPa, $\sigma_в$ 827-1103 MPa, δ 30-60 %) Fatigue tests – samples were cracked at the 270 MPa, number of cycles $1,46x10^6$
ЖС6у	Tensile strength $\sigma_{0,2}$ 1046 MPa, $\sigma_в$ 1353 MPa, δ 11,5 % (casting condition: $\sigma_{0,2}$ 1075 MPa, $\sigma_в$ 1108 MPa, δ 2,9 %)
ВТ20	Tensile strength $\sigma_{0,2}$ 882 MPa, $\sigma_в$ 968 MPa, δ 6,6 % (cast: $\sigma_{0,2}$ 876 MPa, $\sigma_в$ 951 MPa, δ 6,4 %) Fatigue tests, not cracked during 50 ч at the 480 MPa, number of cycles $1,46x10^6$
316L	Tensile strength $\sigma_{0,2}$ 272,5 MPa, $\sigma_в$ 570 MPa, δ 41 % (heat-treated condition: $\sigma_{0,2}$ 182 MPa, $\sigma_в$ 485 MPa, δ 35 %)



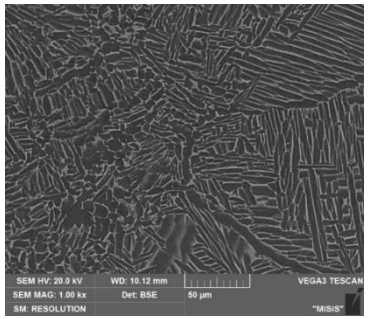
ЖС6у
Cast sample



ЖС6у
Deposited sample



ВТ20
Cast sample



ВТ20
Deposited sample

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Partners

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ
РОССИЙСКОЙ ФЕДЕРАЦИИ

ПОЛИТЕХ

ИННОВАЦИОННЫЕ
ЛАЗЕРНЫЕ
И СВАРОЧНЫЕ
ТЕХНОЛОГИИ