

**STATE SCIENTIFIC INSTITUTION «PHYSICAL-TECHNICAL INSTITUTE
OF THE NATIONAL ACADEMY OF SCIENCES OF BELARUS»**

**国家研究机构
“白俄罗斯国家科学院物理技术研究所”**



**ION THERMOCHEMICAL TREATMENT
TECHNOLOGY AND EQUIPMENT**

离子化学热处理技术和设备

**ENERGY-EFFICIENT INDUCTION HEATING
TECHNOLOGIES AND EQUIPMENT**

感应加热技术和设备

**MAGNETIC-PULSE
TECHNOLOGIES AND EQUIPMENT**

磁脉冲技术和设备

**COATINGS, TECHNOLOGIES AND EQUIPMENT
FOR THEIR DEPOSITION**

涂层应用技术和设备

**HIGH-STRENGTH AND HEAT-
RESISTANT CERAMIC PRODUCTS**

高强度耐热陶瓷制品

State Scientific Institution «Physical-Technical Institute of the National Academy of Sciences of Belarus» efficiently develops a wide range of scientific trends for more than 90 years holding leading positions in mechanical engineering and materials science in the Republic of Belarus.

The major directions for scientific, scientific and technical as well as innovative activities: fundamental and applied scientific researches and creation of scientific and technical developments in the field of surface engineering with an application of laser, ion and electron beams, plasma flows, flows of thermal energy and electromagnetic field; material working by methods of cross-wedge rolling, forging including magnetic-pulse and impact hydroforming methods; materials science (creation of new multifunctional and specialized materials with advanced characteristics); simulation of physical processes; design and production of high-technology equipment for depositing coatings of various purposes, ion thermochemical treatment, induction heating.

白俄罗斯国家科学院物理技术研究所作为大型国家研究机构，已有90年的历史，一直在广泛的科学领域取得有效的发展，并在白俄罗斯共和国处于领先地位。

主要科学、科技和创新方向包括以下内容：借助激光、离子束、电子束、等离子体流、热能流以及电磁场等技术，在表面工程领域开展基础和应用科学研究并创造科学技术发展；使用横向轧制、冲压的方法对材料进行压力加工，包括磁脉冲和液压冲击方法；探索材料科学领域，创造具有改进特性的新型多功能和专用材料；进行物理过程建模；设计和制造高科技设备，如各类涂层、离子化学热处理以及感应加热设备。

ION THERMOCHEMICAL TREATMENT TECHNOLOGIES AND EQUIPMENT (NITRIDING OF STEELS, CAST IRONS, TITANIUM ALLOYS, CARBURIZING AND NITROCARBURIZING OF STEELS)

离子化学热处理技术和设备 (钢、铸铁、钛合金渗氮 ; 钢渗碳和氮化陶瓷)

Diffusion coating of the surface of parts, cutting and stamping tools, casting tooling, etc. with nitrogen and carbon in an abnormal glow discharge at a pressure of 80–350 Pa (nitriding) and 300–1000 Pa (carburizing, nitrocarburizing).

在80-350 Pa (渗氮) 和300-1000 Pa (渗碳、氮碳共渗) 压力下 , 在异常辉光放电中用氮和碳对零件、切削和冲压工具、铸造设备等表面进行扩散饱和。



TECHNICAL CHARACTERISTICS:

After the nitriding of the steels, the surface microhardness is HV0.1 450-1200, the layer depth is 0.5–0.7 mm, the surface microhardness of titanium alloys is HV0.1 750–1100, the layer depth is up to 0.1mm.

After carburizing of the steels, the surface hardness (after quenching) is 58–63 HRC, the layer depth is up to 3.5–4 mm.

APPLICATION:

Machine-building, automobile, tractor, aircraft, shipbuilding and ship repair enterprises, plants for the production of agricultural machinery, pump and compressor equipment, electric power installations, etc.

ADVANTAGES:

In comparison with volumetric quenching, ion thermochemical treatment provides an increase in:

- durability;
- fatigue endurance;
- antiwelding properties;
- heat resistance;
- corrosion resistance.

Compared to gas quenching, ion thermochemical treatment provides:

- processing time reduction by 2–5 times;
- diminishing consumption of working gases by 20–50 times;
- reduction of electricity consumption by 1.5–3 times;
- simplicity of shielding nonhardenable surfaces;
- prevention of an increased brittleness of the layer;
- full compliance with all requirements for environment protection.

技术性能 :

钢氮化后 , 表面显微硬度为HV0.1 450-1200 , 层深为0.5-0.7mm , 钛合金为HV0.1 750-1100 , 层深可达0.1mm。

钢材渗碳后 , 表面硬度 (淬火后) 为58-63 HRC , 层深可达3.5-4mm。

应用领域 :

机械制造、汽车、拖拉机、航空、造船和修船企业、生产农业机械、泵和压缩机设备的工厂、发电厂等。

优点 :

相较于体积硬化 , 离子化学热处理提高以下性能 :

- 耐磨性;
- 疲劳寿命 ;
- 抗磨损性能 ;
- 耐热性;
- 耐腐蚀性能。

相较于气氛热处理 , 离子化学热处理具备以下优势 :

- 处理时间减少2-5倍 ;
- 工作气体消耗量降低20-50倍 ;
- 耗电量减少1.5-3倍 ;
- 简化非硬化表面的屏蔽 ;
- 降低层脆性风险 ;
- n完全符合环境保护要求。



INDUSTRIAL EQUIPMENT FOR ION THERMOCHEMICAL TREATMENT

离子化学热处理工业设备综合体

The ability to control the chemical activity of an abnormal glow discharge, depending on the type of treated material, hardening batch area, and an operating temperature. Pressure in the chamber and the consumption of each of the components of the gas mixture are controlled independently. The equipment is fully automated. The technologies are finishing, energy and resource-saving, environmentally safe.

根据正在处理的材料类型、强化装料的面积和处理温度来控制异常辉光放电的化学活性的能力。同时，独立控制室压力和气体混合物各成分的流量。该设备是完全自动化的。这种最终处理技术节约能源、资源、环境友好。

TECHNICAL CHARACTERISTICS:

Working space dimensions of door, bell or shaft type chambers:

◦ diameter, mm.....400-2500

◦ height, mm.....400-3200

Batch mass, kg.....up to 3000

Discharge power, kVA.....25-100

Working pressure is 80-350 Pa (nitriding) and 300-1000 Pa (carburizing, nitrocarburizing).

APPLICATION:

The equipment is used at the PTI NAS of Belarus, at the enterprises of Belarus and Russia.

ADVANTAGES:

The reliability of the technology — the reproducibility of the processing results, regardless of the loading efficiency of the chamber.

The ability to handle steels of different types: structural, tool, high-speed, stainless, cast iron of any type as well as titanium alloys.

Equipment for carburizing 渗碳设备



TECHNICAL CHARACTERISTICS:

There is an additional source of resistance heating and a system of fibrous thermal insulation in the chamber.

APPLICATION:

Hardening of gear wheels and large machine parts such as bearing rings.

ADVANTAGES:

The capability of carrying out ion carburizing and nitrocarburizing processes of steels, as well as nitriding of products from titanium alloys.

技术性能：

门式、罩式或竖井式室工作空间尺寸：

◦ 直径，mm.....400-2500

◦ 高度，mm.....400-3200

◦ 装料量，kg.....至3000

◦ 放电功率，kVA.....25-100

工作压力为80-350 Pa (渗氮) 和300-1000 Pa (渗碳、氮碳共渗)。

应用领域：

该设备已广泛用于白俄罗斯国家科学院物理技术研究所以及白俄罗斯和俄罗斯的各类企业。

优点：

确保技术连续稳定，不论处理负载如何，都能实现处理结果的可重复性。该技术可适用于各种等级的金属加工，包括结构钢、工具钢、高速钢、不锈钢，以及各种等级的铸铁和钛合金。

技术性能：

该室包含一个附加的电阻加热源和一个纤维绝缘系统。

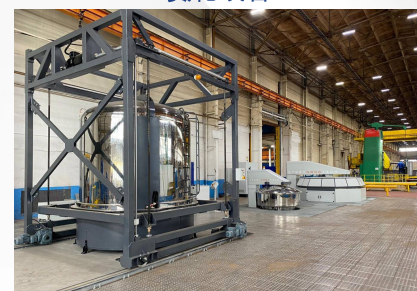
应用领域：

用于强化“白俄罗斯汽车制造厂”开放式股份公司生产的齿轮、轴承环等大型零件。

优点：

可对钢进行离子渗碳和氮碳共渗，对钛合金产品进行渗氮处理。

Equipment for nitriding 氮化设备



Declaration of conformity
of the Customs Union
№ RU Д-ВУ.АУ04.В.34463
关税同盟符合性声明
№ RU Д-ВУ.АУ04.В.34463

ЕВРАЗ
Сертификат соответствия
№ RU Д-ВУ.АУ04.В.34463
Государственный стандарт Российской Федерации
ГОСТ Р ИСО 9001-2015 (ISO 9001:2015)
Сертификат соответствия
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№ RU Д-ВУ.АУ04.В.34463
ISO 9001 Certificate
ISO 9001 合格证书

ENERGY-EFFICIENT INDUCTION HEATING TECHNOLOGIES AND EQUIPMENT

感应加热技术和设备

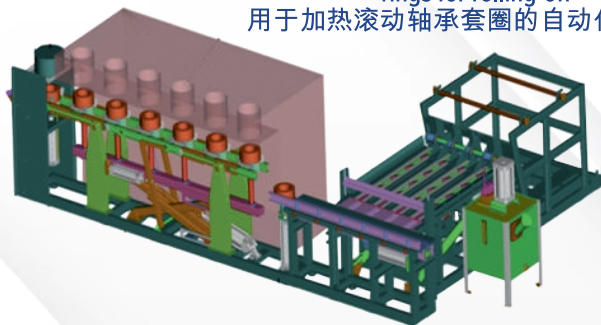
MAJOR FIELDS:

- simulation, design and development of energy efficient technologies of induction heating;
- development and production of automated complexes of induction heating;
- development and production of auxiliary induction heating equipment, tooling and control systems;
- modernization, repairing and adjustment of induction heating equipment.

主要活动领域：

- 节能感应加热技术的建模、计算和开发；
- 自动化感应加热综合体的开发和生产；
- 感应加热辅助设备、配件和控制系统的开发和生产；
- 感应加热设备的现代化、维修和调整。

An automated set for heating of bearing rings for rolling-off
用于加热滚动轴承套圈的自动化综合设施



Induction heating machine
感应加热装置



ALLOW TO MANUFACTURE:

- through heating of rods, tubes, rings and bands of various geometry for hot forging, upsetting, rolling;
- face hardening of various engineering parts: axles, pins, plugs, shafts gears, plates, machine stands;
- melting of metals before teeming;
- brazing of cutting tools.

可以生产：

- 通过加热各种几何尺寸的棒材、管材、棒材、环材、带材进行热冲压、锻造、轧制；
- 各种机械制造零件的表面硬化：轴、销、衬套、轴、齿轮、板、机床床身；
- 铸造前熔融金属；
- 切削工具的焊接。



ADVANTAGES:

- high productivity;
- technical simplicity;
- availability of full automation;
- low deformation of parts, absence of calx and decarbonization;
- high efficiency coefficient (no less than 95%);
- electricity saving (no less than 30%);
- return on investment just due to electricity saving (no more than 3 years);
- eco-friendliness;
- certificate of own production;
- declarations of compliance with the requirements of the Customs Union;
- technologies and equipment comply with the technological mode V;
- STB ISO 9001 certificates, SMK certificates.

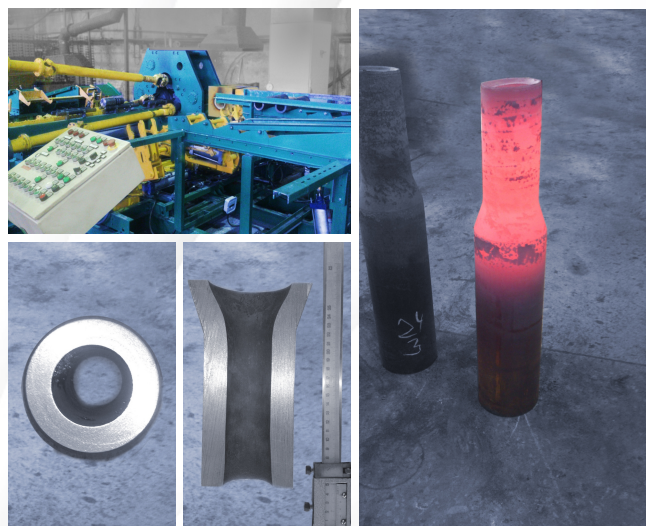
优点：

- 高性能；
- 完全自动化的可能性；
- 技术简单；
- 零件变形小，无氧化皮和脱碳；
- 加热效率高（至少95%）；
- 节约用电（至少30%）；
- 由于节能设备投资回收（不超过3年）；
- 绿色环保；
- 自产的证书；
- 符合关税同盟要求的声明；
- 技术和设备对应第五种技术结构；
- ISO 9001 白俄罗斯国家标准、质量管理体系合格证书。

Induction heating machine
for treating parts up to 4 meters in length
感应加热装置 FTI 3.148.2，用于加工长达 4 米的零件



Production of axis billets for agricultural machines
“BOBRUISKAGROMASH”股份公司以白俄罗斯国家
科学院物理技术研究所生产综合体为基础，
生产农业机械承重轴锻件



Heating equipment in forgings 锻造加热设备

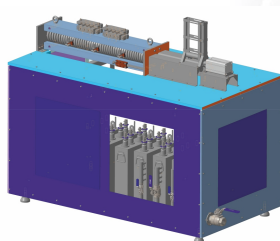


Thyristor and transistor converter of 5th generation with industrial internet function
第五代具有工业互联网功能的晶闸管-晶体管变流器

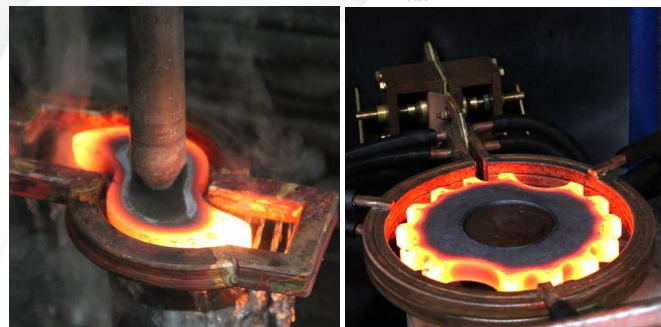


A mobile induction heating machine
移动式感应加热装置

A forging induction heater
锻造感应加热器



Inductors 电感器



TECHNOLOGIES AND EQUIPMENT OF MAGNETIC-PULSE HARDENING OF METAL PRODUCTS

金属制品磁脉冲强化技术及设备

High-speed magnetic-pulse surface treatment of finished metal products on the equipment developed at the Institute. Treated materials: steel, non-ferrous metals and alloys (titanium, bronze, duralumin), hard-alloy metals.

使用研究所开发的设备对金属成品进行高速磁脉冲表面处理。加工材料包括钢、有色金属和合金（钛、青铜、硬铝）、硬质合金。

TECHNICAL CHARACTERISTIC MIP-18

Maximum accumulated energy, kJ	15
Maximum operating voltage, kV	13,3
Storage capacity, μF	180
Power consumption under AC mains with a voltage of 220 V, a frequency of 50 Hz, no less than (VA)	3000
Supply mains voltage, V	220
Supply mains frequency, Hz	50
Depth of the installation, mm	620
Width of the installation, mm	1270
Height of the installation, mm	1760
Weight of the installation, kg	550
Capacity, impulses/min	up to 5

技术性能：

最大储存能量，kJ	15
最大工作电压，kV	13.3
存储容量，μF	180
安装消耗的交流电源电压为220 V，频率为 50 Hz，不超过 VA	3000
电源电压，V	220
电源频率，Hz	50
安装深度，mm	620
安装宽度，mm	1270
安装高度，mm	1760
安装重量，kg	550
生产率，脉冲/分钟高达	至 5



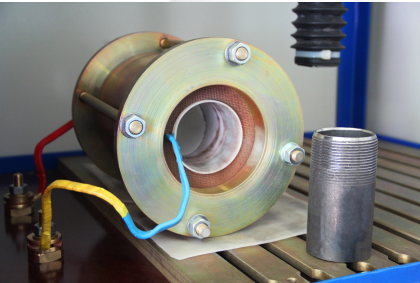
APPLICATION:

products and tool operating at high loads, including shock ones, and increased abrasive wear, applied in machine building, woodworking, forestry, agriculture, food and other industries.

应用领域：

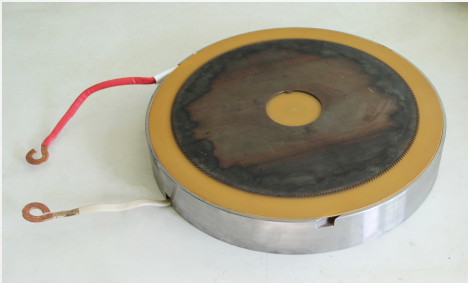
在高负载条件下运行的产品和工具，包括冲击和增加的磨料磨损，用于机械工程、木工、林业、农业、食品和其他行业。

INDUCTORS 电感器



Cylindrical inductor for hardening parts of a cylindrical shape: drills, rods, screws, complex parts

用于强化圆柱形零件的圆柱形感应器：
钻头、杆、螺钉、形状复杂的零件



For flat products (knives, mills, etc.) 用于扁平产品（刀具、铣刀等）



HARDENING OF CUTTING EDGES OF THE TOOL 强化工具的切削刃

FOR FOOD INDUSTRY: 食品行业：



Cutter knife

斩刀



Graphic knife
(for cutting film)

Two-time increase in a durability period

薄膜切割刀

使用寿命延长2倍



Curved knife

镰状刀



Cutting knife for sugar beet

1,8-time increase in a durability period

切割甜菜刀（德国）使用寿命延长1.8倍



Zigzag knives for cutting and packing candies

1,5-time increase in a durability period

切割糖果包装的锯齿形刀 使用寿命延长1.5倍

FOR METALWORKING INDUSTRY:

金属加工行业：



Drills made of steel P6M5

1,8-time increase in a durability period

R6M5 钢制钻头
使用寿命延长1.8倍

FOR AVIATION INDUSTRY: 航空业：



Treatment of titanium rods before a deposition of chromium coatings using electrodeposited method eliminates such defects as chips and coating delaminations.

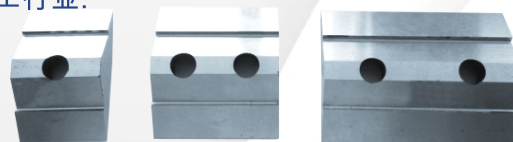
在涂覆电镀铬涂层之前对钛杆进行处理可以消除涂层碎片和剥落等缺陷

FOR WOODWORKING INDUSTRY: 木材加工行业：



Knives X-033.00.01 for Hombak chip flaker made of 60C2A steel
用于 Hombak 刨片机的刀具 X-033.00.01，材质为 60C2A 钢

1,3-time increase in a durability period



Chipper-canter knives made of tool steels 65Г, 60C2A
工具钢 65G、60C2A 铣削中心刀具

使用寿命延长1.3倍

TECHNOLOGIES AND EQUIPMENT OF THE MAGNETIC-PULSE TREATMENT

磁脉冲加工技术与装备

The technology and equipment of the magnetic-pulse treatment of materials is designed for obtaining products made of sheet metallic and non-metallic materials without using conventional die tooling.

TYPES OF TREATED MATERIALS: copper, aluminum, magnesium and their alloys, low-carbon steel.

TYPES OF TECHNOLOGICAL OPERATIONS:

- cutting, piercing, molding, embossing, grooving and shallow drawing of sheet blanks;
- swaging, bulging, cutting, hole punching, flanging, expansion, obtaining permanent and flexible joints on items made of tubular billets;
- crimping of cable lugs, wires and cables;
- electrodischarge forming and sintering of metallic powders;
- electrohydropulse forming of flares in grounds and boreholes for bored piles and anchors.

APPLICATION:

enterprises of automobile, aircraft and instrument industries, mechanical engineering and powder metallurgy, process lines for filling, packing and sealing in chemical, food and medical industries, construction of pile foundations; removal of foundry slags; dispersion of solid materials.

应用领域：

汽车、航空、仪器仪表制造、机械工程和粉末冶金企业，化工、食品和医疗行业的包装、包装和密封生产线，在桩基施工过程中施工；铸造炉渣的净化；分散固体材料。

通过利用磁脉冲材料加工技术和设备，实现了制造薄板金属和非金属材料的产品，无需传统冲压设备。

加工材料类型：

铜、铝、镁及其合金、低碳钢。

技术运营类型：

- 板坯的切割、冲孔、模压、冲制、定径和浅拉伸；
- 挤压、扩张、切割、冲孔、翻边、扩管，以及在管状原材料制品上制作不可拆卸和可移动的接头；
- 电缆接线头、电缆、绳索的压接；
- 金属粉末的放电成型及其烧结；
- 对土壤、钻孔桩和锚杆的加宽区域进行电液脉冲成形。

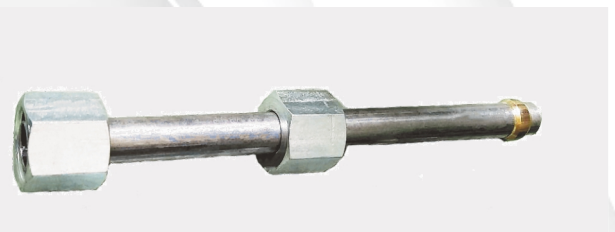


The magnetic-pulse press MIP-10 (MIP-20, MIP-30) with energy output of 10kJ (20 kJ, 30 kJ) and max. total capacity of 10 kW (15 kJ, 20 kJ)

磁力脉冲压力机 MIP-10 (MIP-20、MIP-30)，能量容量为 10 kJ (20 kJ、30 kJ)，最大装机功率为 10 kW (15 kW、20 kW)



Forging and cutting of various products 各类产品冲压、切割



A part of BELAZ fuel tube BELAZ 燃油管路的零件

WELDING OF DISSIMILAR METAL MATERIALS BY PULSED MAGNETIC FIELD

异种金属材料的脉冲磁场焊接

Magnetic-pulse welding is welding of metal details through impact. Acceleration and throwing of welded parts is provided by a pulsed electromagnetic field. It is possible to weld almost any metal in a short period of time, calculated in microseconds during which only setting processes take place but diffusion processes do not have time to develop.

APPLICATION:

relevant to enterprises of machine, instrument, aircraft industries, at electro-technical industry for obtaining parts from metal of various structural fulfilment (rod-tube, rod-sheet, sheet-sheet, compound of metal-ware with body parts and ect.)

ADVANTAGES:

- capability to smoothly manage processes;
- high stability of welded joint properties due to precise dosage of the discharge energy;

通过磁脉冲技术，可以在极短的微秒级时间内对几乎所有金属进行焊接，这个时间内只发生凝固，而扩散过程没有机会发展。

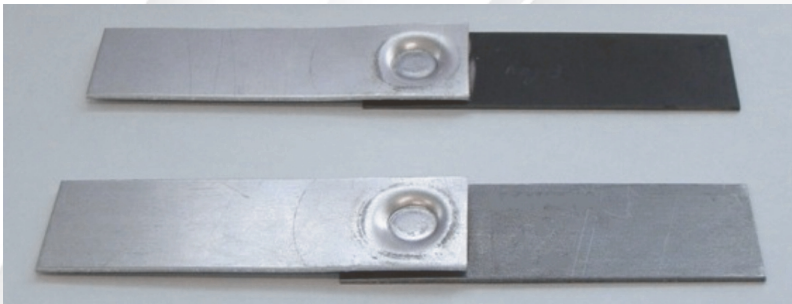
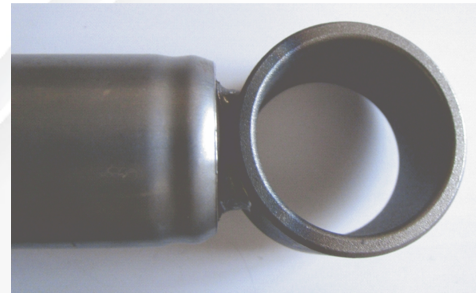
应用领域：

机械、仪器和飞机制造企业，在电气工业中用于生产各种设计的金属零件（棒-管、棒-板、板-板、硬件与车身零件的连接等）。

优点：

- 顺利管理流程的能力；
- 由于放电能量的精确计量，焊接接头性能高度稳定；
- 可以在保护气氛和真空中进行焊接。

Part samples 零件样品



Welding of dissimilar materials (steel – copper, steel – aluminum, copper – aluminum)
各种材料的焊接（钢-铜、钢-铝、铜-铝）



Welding and sealing of the exhaust system part of the vehicle
汽车排气系统部件的焊接和密封

TECHNOLOGY AND EQUIPMENT FOR DEPOSITION OF DIAMOND-LIKE CARBON COATINGS

类金刚石碳涂层应用技术和设备

Coating technologies and equipment for its deposition have been developed for plastic moulds, plungers, pistons, diesel engine piston rings, hologram embossing matrices, exteriors of the photodetectors of optical radiation for spacecrafts, lenses and germanium windows for infrared radiation, as well as medical implants and other products.



ADVANTAGES:

Advantages and innovations. The coating material is amorphous carbon with a short-range structure of diamond type, containing linear and cyclic inclusions of graphite form. The physical and chemical deposition technologies are used for coating applications in order to produce a wide range of diamond-like carbon materials.

开发的涂层技术和设备用于塑料模具、柱塞、活塞、柴油发动机活塞环、全息图压花矩阵、航天器光学光电探测器的外表面、红外辐射的透镜和锗窗以及医疗植入物和其他产品。

TECHNICAL CHARACTERISTICS:

- Thickness.....0.5-5 μm
- Density.....2.6-3.1 g/cm^3
- Hardness, HV.....3000-8000
- Heat resistance is.....up to 350 $^{\circ}\text{C}$
- Coatings are transparent in IR-range
- Elasticity modulus.....400-950 GPa
- Biocompatibility with body tissues

技术性能：

- 厚度.....0.5-5 μm
- 密度.....2.6-3.1 g/cm^3
- 硬度，HV.....3000-8000
- 耐热.....高达350 $^{\circ}\text{C}$
- 涂层在红外范围内是透明的
- 弹性模量.....00-950 GPa
- 与身体组织的生物相容性。

优点：

该涂层材料是一种具有短程金刚石型结构的无定形碳，含有石墨形式的线性和环状夹杂物。物理和化学沉积技术用于涂层生产各种类金刚石碳材料。

DESIGN AND PRODUCTION OF VACUUM MACHINES FOR SPECIFIC TASKS

特定技术真空装置的设计和制造



Specialized high-performance vacuum machine for obtaining diamond-like carbon coatings
用于生产类金刚石碳涂层的专用高性能真空装置



**COATINGS, TECHNOLOGIES AND EQUIPMENT
FOR THEIR DEPOSITION**
涂层应用技术和设备

WEAR-RESISTANT COATINGS FOR METAL- AND WOODWORKING TOOLS

金属和木工工具的耐磨涂层

A combination of nanostructured layers based on refractory metals (Ti, Zr, Mo, Cr, etc.), their nitrides, carbides, carbonitrides, oxycarbonitrides and diamond-like carbon.

TECHNICAL CHARACTERISTICS:

Number of coating layers.....2-12
Coating thickness, μm3-5
Microhardness, GPa.....30...85
Operating temperature, $^{\circ}\text{C}$400-780

APPLICATION:

Tool-making industry, metal- and woodworking, wear resistance improvement of drills, mills, cutting dies, threading rolls, broaches and other metal- and wood-working tools from alloy-treated steels and hard alloys.

ADVANTAGES:

Increase of tool durability by 2-5 times, improvement of the processing quality, increase of the performance characteristics of the tool under high temperatures and shock loads.

基于难熔金属 (Ti、Zr、Mo、Cr 等) 及其氮化物、碳化物、碳氮化物、氧碳氮化物和类金刚石碳的纳米结构层的组合。

技术性能：

▫ 涂层层数.....2-12
▫ 涂层厚度, μm3-5
▫ 显微硬度, GPa.....30...85

应用领域：

工具工业、金属和木工，增加合金钢和硬质合金制成的钻头、铣刀、冲裁模、滚花刀钢辊、拉刀和其他金属和木工工具的耐磨性。

优点：

将工具的使用寿命延长2-5倍，提高加工质量，增强工具在高温和冲击负荷下的性能特点。

TECHNOLOGY AND EQUIPMENT FOR DEPOSITION OF BIOCOMPATIBLE COATINGS ON IMPLANTS

在医疗植入物上应用生物相容性涂层的技术和设备

The technology is used to obtain biocompatible oxide coatings for medical implants and their color coding.

T该技术用于生产医疗植入物的生物相容性氧化物涂层，并对其进行颜色编码。

TECHNICAL CHARACTERISTICS:

·coating thickness is from 0.02 to 0.1 μm
·chemical inertness
·biocompatibility
·corrosion resistance
·decorative properties

技术性能：

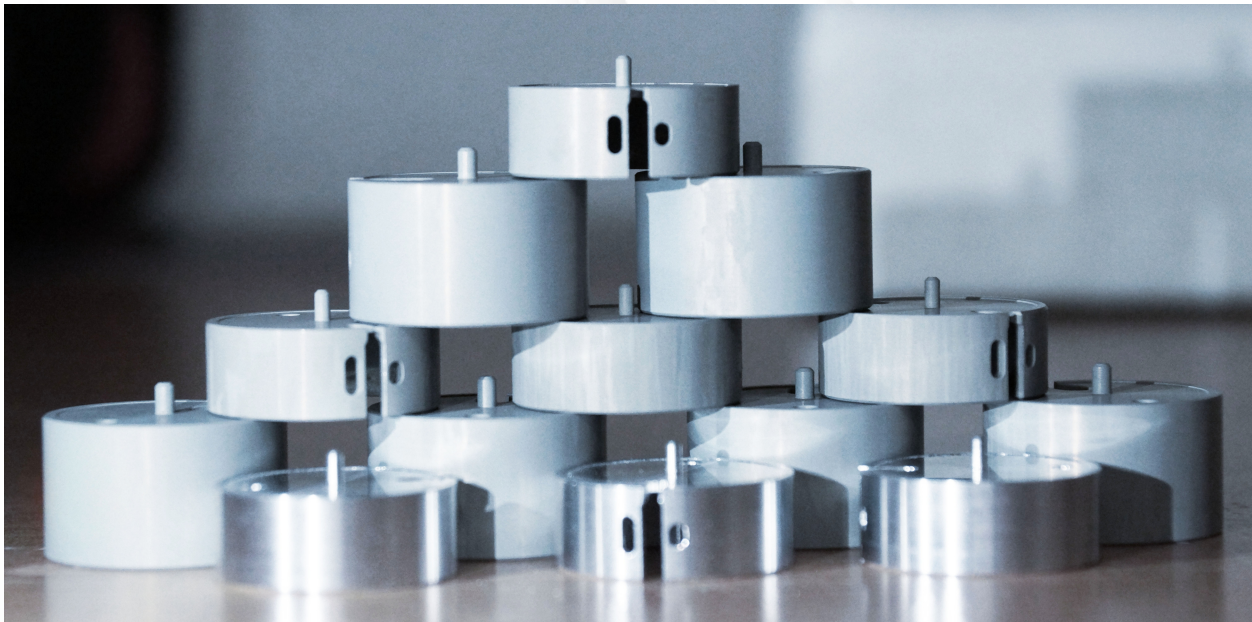
·涂层厚度为0.02至0.1 μm
·化学惰性
·生物相容性
·耐腐蚀性能
·装饰性



**COATINGS, TECHNOLOGIES AND EQUIPMENT
FOR THEIR DEPOSITION**
涂层应用技术和设备

WEAR-RESISTANT AND DECORATIVE ALUMINOXIDE CERAMIC COATINGS

耐磨装饰性氧化铝陶瓷涂层



Pulsed electrochemical process of a metal surface transformation into a decorative, strong and corrosion-resistant alumina ceramic coating.

TECHNICAL CHARACTERISTICS:

Breakdown voltage, V.....	over 2000
Wear resistance, mm ³ / N·m.....	1×10 ⁻⁸
Maximum thickness, μm.....	70
Thermal conductivity of the billet, W/m·K.....	120
Roughness, μm.....	0.05
Hardness, GPa.....	up to 8

ADVANTAGES:

Coatings are characterized by a considerable corrosion resistance, high hardness and wear resistance, show good electrical insulation properties and have high decorative qualities. It is possible to use the technology for the manufacturing of printed circuit boards, lighting equipment based on SMD LED elements. The subsequent decorative coloring of aluminum oxide is possible.

种脉冲电化学过程，可将金属表面转化为装饰性、耐用且耐腐蚀的氧化铝陶瓷涂层
技术性能：

▫ 击穿电压，V.....	超过 2000
▫ 耐磨性，mm ³ /N·m.....	1·10 ⁻⁸
▫ 最大厚度，μm.....	70
▫ 工件导热系数，W/m·K.....	120
▫ 粗糙度，μm.....	0.05
▫ 硬度，GPa.....	高达 8

优点：

该涂层展现出卓越的抗腐蚀、高硬度和耐磨特性，同时表现出卓越的电绝缘性和高装饰性。这项技术可用于制造基于SMD LED元件的印刷电路板毛坯和照明设备。能够随后进行氧化铝装饰涂层的应用。

HEAT RESISTANT CERAMICS

耐热陶瓷产品

Ceramic heat-resistant products based on mullite-cordierite and phosphate systems have good thermal and electrical properties, exceptionally high heat resistance and high thermal shock resistance (temperature variation rate > 2°C/s). They are used as electrically insulating products of different configurations in thermal generating units (furnaces, induction plants, etc.), as infrared emitters in heating plants, etc.

基于莫来石-堇青石和磷酸盐体系的耐热陶瓷产品在热性能和电性能方面表现出卓越，同时具备极高的耐热性和卓越的抗热冲击能力（温度变化率> 2°C/s）。它们广泛用于多种电绝缘产品配置，包括熔炉、感应装置等热设备，以及供暖装置中的红外发射器。

TECHNICAL CHARACTERISTICS:

Properties of heat-resistant ceramics that are based on mullite-cordierite and phosphate systems:

Porosity, %.....	15-35
Apparent density, kg/m ³	1820-2020
TCLE (at 300 °C), K ⁻¹	2.72-3.46×10 ⁻⁶
Bending strength, MPa.....	20-50

Volume resistivity:

For mullite-cordierite systems, Ohm-cm.....	(2.9-4.3)×10 ¹²
Heat resistance (1000 °C – water), thermal cyclings.....	no less than 50
Phase composition of the material is predominantly cordierite and mullite, as well as mullite and aluminum phosphates.	

APPLICATION:

Developed ceramic materials are recommended to be used as heat resistant electrically insulating products in thermal generating units (furnaces, induction plants, etc.).

ADVANTAGES:

- materials feature high physical and technical characteristics, simplicity of the manufacturing technology and availability of basic materials;
- an increase in service life of the plants is ensured.

技术性能：

莫来石-堇青石和磷酸盐体系耐热陶瓷的性能：

孔隙度，%.....	15-35
表观密度，kg/m ³	1820-2020
线热膨胀系数（300°C），K ⁻¹	2,72-3,46·10 ⁻⁶
弯曲强度，MPa.....	20-50

体积电阻系数：

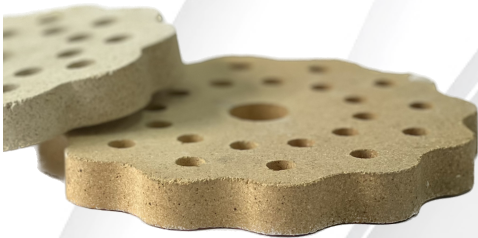
- 莫来石-堇青石系统，Ohm-cm.....(2,9-4,3)·10¹²
- T耐热性（1000°C，水）、热变化.....至少 50
- 该材料的相组成主要包括堇青石和莫来石，以及莫来石和磷酸铝。

应用领域：

所开发的陶瓷材料适用于热力设备（例如熔炉、感应设备等）中作为热稳定的电绝缘产品。

优点：

- 材料具有较高的物理和技术特性，制造工艺简单，原材料易得；
- 延长装置的使用寿命。



HIGH-STRENGTH AND HEAT-RESISTANT CERAMIC PRODUCTS
高强度耐热陶瓷制品

HIGH ENDURANCE WEAR- AND IMPACT-RESISTANT CERAMIC ALUMINUM OXIDE AND SILICON CARBIDE PRODUCTS

高强度耐磨抗冲击陶瓷氧化铝和碳化硅产品

Ceramics based on sintered Al_2O_3 and SiC for manufacturing special-purpose products (armor plates, friction pairs, etc.). Ceramics have high strength and hardness, which ensures the necessary wear resistance and impact toughness.

TECHNICAL CHARACTERISTICS:

Aluminium ceramics have
a density of, kg/m^3 3800–3900
Hardness, GPa.....14–17
Zero open porosity, bending strength, MPa.....350–500
SiC-based ceramics have a density of, kg/m^3 3100–3200
Hardness, GPa.....18–22
Zero open porosity, bending strength, MPa.....450–650

APPLICATION:

Manufacturing of impact-resistant barriers (armor), lining of heavily loaded grinding plants, friction pairs, etc.

ADVANTAGES:

The desired level of personal armor (6 and 6a class), high-wearing feature and high strength of products.

以烧结 Al、O₃ 和 SiC 为基础的陶瓷，用于制造特殊用途产品，例如装甲板和摩擦副。这些陶瓷具有高强度和硬度，能够提供所需的耐磨性和冲击强度。

技术性能：

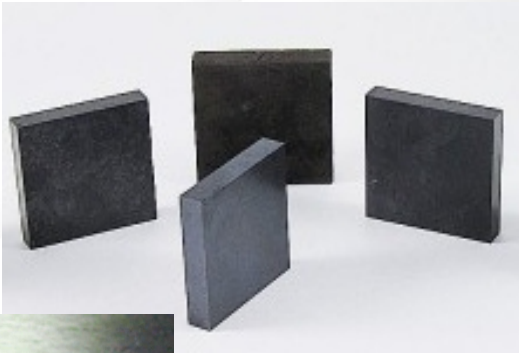
氧化铝陶瓷具有以下特点密度， kg/m^3 3800-3900
硬度，GPa.....14-17
零开型孔隙度弯曲强度，MPa.....350-500
碳化硅陶瓷密度具有以下特点密度， kg/m^3 3100-3200
硬度，GPa.....18-22
零开型孔隙度弯曲强度，MPa.....450-650

应用领域：

制造抗冲击屏障（装甲）、特殊负载磨削装置的衬里、摩擦副等。

优点：

确保个人装甲防护所需的特性水平（6级和6a级）、高耐磨性和高强度的产品。



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