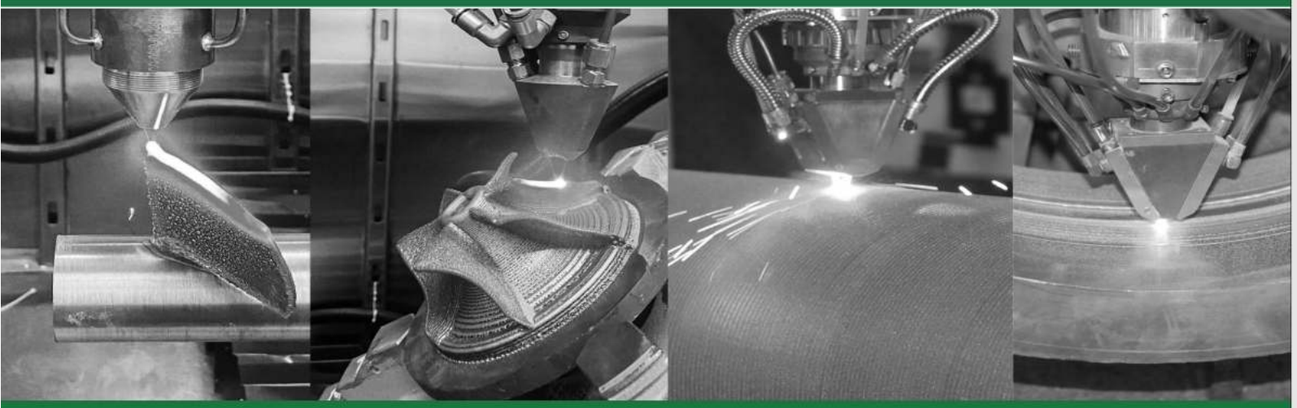
GREENSTONE®



Complete Solutions for High-Performance Metal Additive Manufacturing

Equipment • Engineering • Services • Industrial Applications

GREENSTONE®

Leading the Future of High-Performance Metal Additive Manufacturing.

Advanced Equipment • Engineering Expertise • Industrial Solutions

CONTENTS

01. Why GREENSTONE----------3
Technology Advantages & Core Competencies

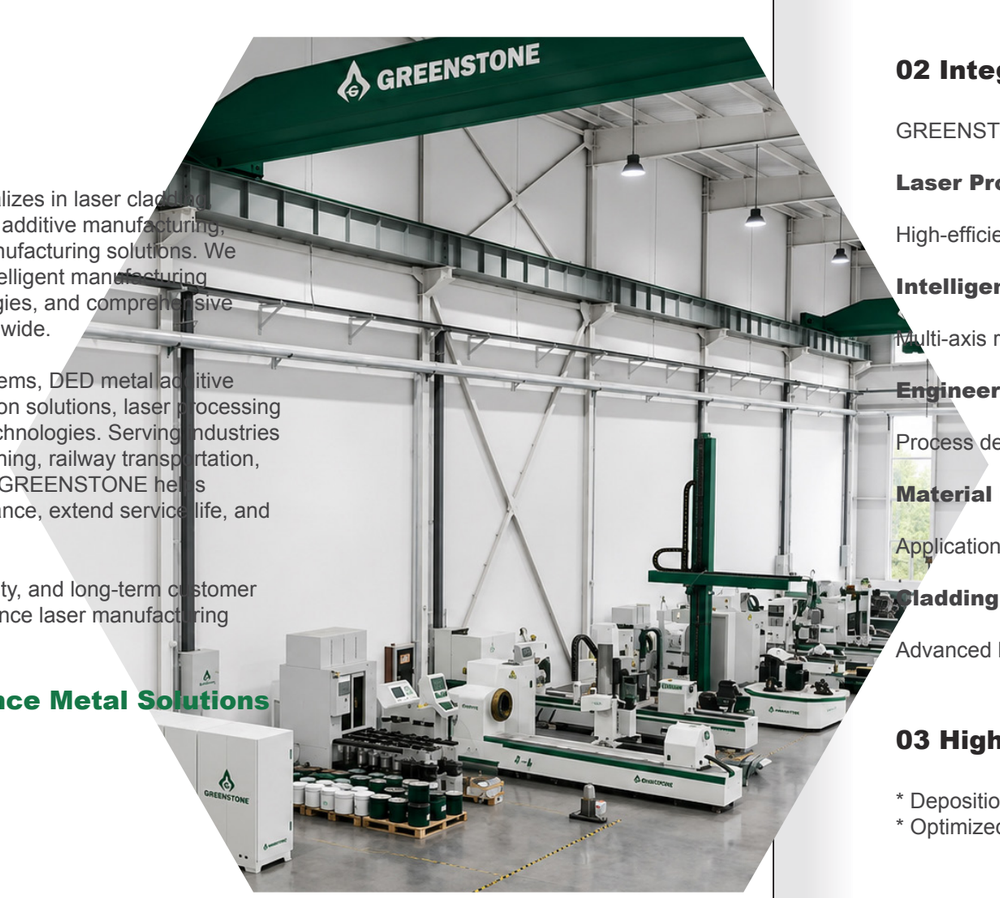
02. Equipment & Intelligent Manufacturing Systems----------5
Laser Cladding and Metal Additive Manufacturing Solutions

03. Laser Processing Services----------50
Engineering, Manufacturing and Remanufacturing Services

04. Core Technologies----------64
Innovative Processes and Key Components

05. Applications & Success Stories----------71
Industry Solutions and Customer Case Studies

06. Material Solutions----------76
Materials for Laser Cladding and DED Manufacturing



Founded in 2012, GREENSTONE specializes in laser cladding, Directed Energy Deposition (DED) metal additive manufacturing, surface engineering, and industrial remanufacturing solutions. We provide high-performance equipment, intelligent manufacturing systems, core laser processing technologies, and comprehensive engineering services for customers worldwide.

Our portfolio includes laser cladding systems, DED metal additive manufacturing systems, robotic automation solutions, laser processing heads, and advanced powder feeding technologies. Serving industries such as aerospace, energy, oil & gas, mining, railway transportation, marine engineering, and heavy industry, GREENSTONE helps customers enhance component performance, extend service life, and improve manufacturing efficiency.

With a commitment to innovation, reliability, and long-term customer value, GREENSTONE continues to advance laser manufacturing technologies for the future of industry.

Engineering High-Performance Metal Solutions for the Future.

01. Why GREENSTONE

Technology Advantages & Core Competencies

Advanced Technology. Proven Performance. Reliable Solutions.

GREENSTONE combines advanced laser processing technologies, intelligent automation, material engineering, and application expertise to deliver high-performance solutions for laser cladding, metal additive manufacturing, and industrial remanufacturing.

01 Multi-Process Laser Manufacturing Platform

Supporting a wide range of laser processing technologies including:

* Coaxial Ring Laser Cladding
* Coaxial Broadband Laser Cladding
* Off-Axis Broadband Laser Cladding
* Internal Bore Laser Cladding
* Wire-Fed Laser Cladding
* Directed Energy Deposition (DED)

This flexible process portfolio enables optimal solutions for different component geometries, materials, and industrial applications.

02 Integrated Core Technologies

GREENSTONE systems are built upon the integration of five key technologies:

Laser Processing Technology

High-efficiency laser-material interaction and process control.

Intelligent Automation

Multi-axis robotic systems and automated manufacturing solutions.

Engineering Design & Simulation

Process development, CAD/CAM integration, and manufacturing optimization.

Material Engineering

Application-specific material development and qualification.

Cladding Head & Powder Delivery Technology

Advanced laser optics, powder feeding, and deposition control technologies.

03 High Deposition Efficiency

* Deposition rates up to 50+ kg/h*
* Optimized process productivity

* Reduced manufacturing cost
* Improved operational efficiency

*Depending on material and process configuration.

04 Superior Coating Quality

* Metallurgical bonding
* Dense microstructure
* Low dilution rate
* Minimal heat affected zone
* Excellent wear and corrosion resistance

05 Broad Material Compatibility

Qualified for a wide range of materials including:

* Iron-based alloys
* Nickel-based alloys
* Cobalt-based alloys
* Copper alloys
* Titanium alwloys
* Composite materials
* Specialized engineering materials

06 Industry-Proven Reliability

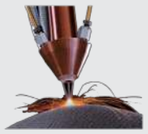
Serving customers across:

* Aerospace
* Energy & Power Generation
* Oil & Gas
* Mining
* Railway Transportation
* Marine Engineering
* Heavy Industry
* Agricultural Machinery

Laser Processing Technology

Multi-Axis Motion Control Technology

Computer-Aided Design and Manufacturing (CAD/CAM)



Metal Thermal Processing Technology

Optical Sensing and Closed-Loop Control Technology

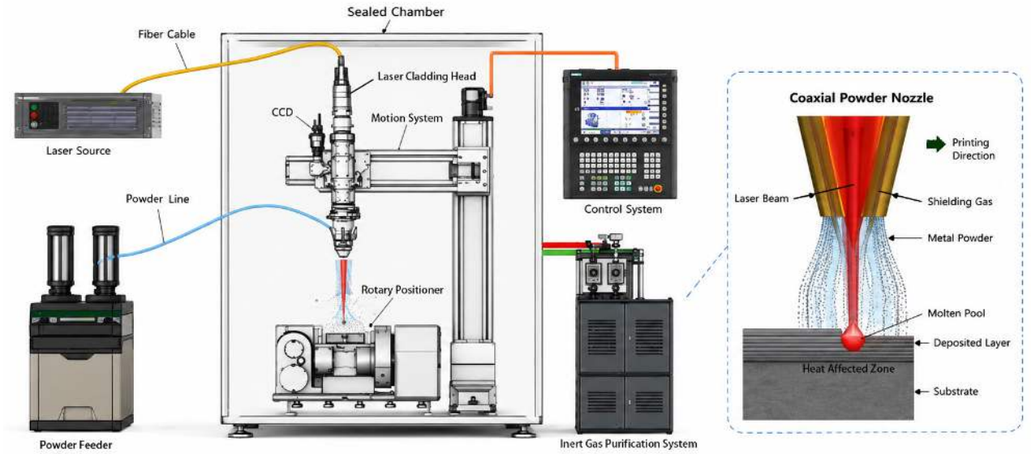
02. Equipment & Intelligent Manufacturing Systems

Laser Cladding and Metal Additive Manufacturing Solutions

Greenstone series coaxial powder laser 3D printing equipment utilizes metal powders delivered synchronously with the laser through a coaxial nozzle, following a preplanned toolpath to deposit and manufacture metal parts layer by layer. The system features an inert gas, hermetic sealing environment, dust removal and purification system, motion system, laser source, optical fiber, processing head, mechanical motion system, powder feeder, and chiller, all integrated with path planning, fault diagnosis, closed-loop control, process database, and process simulation software. It is suitable for rapid mold manufacturing of large and complex metal structures, as well as precision repair and remanufacturing of components.

Coaxial Powder Feed Laser Metal 3D Printing Technology

Working Principle



The laser beam and metal powder are coaxially delivered to the same focal point.
The metal powder is melted by the laser to form a molten pool, which solidifies rapidly to build layers and form the part.

Product Advantages

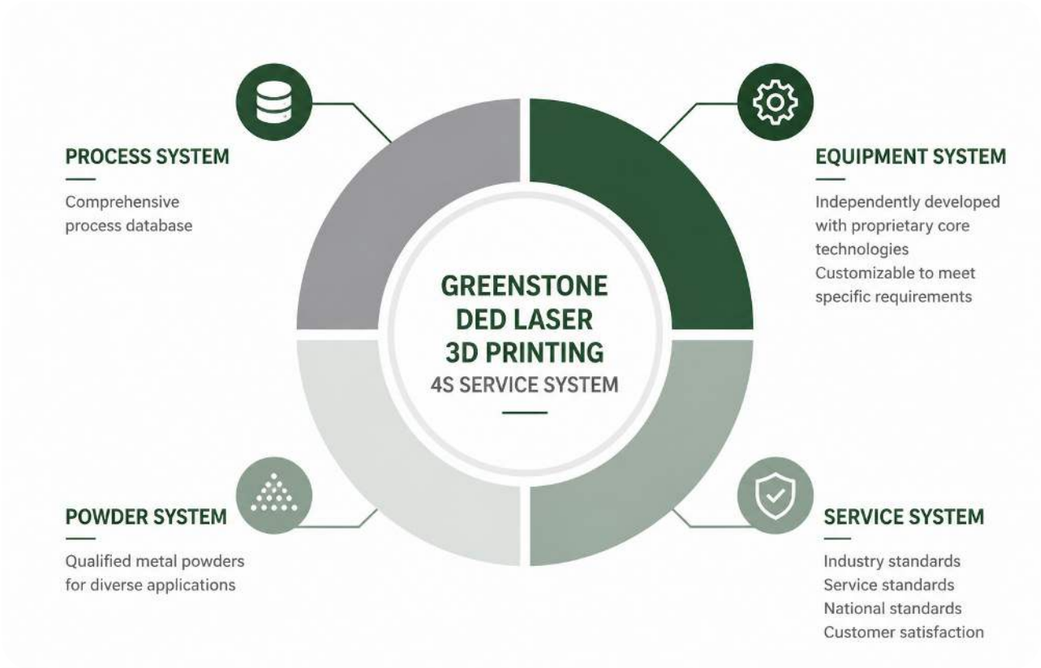
- Produce complex metal parts without tooling, reducing development time.
- Compatible with a wide range of engineering metal alloys.
- Deliver high-density parts with excellent mechanical properties.
- Reduce material waste and post-processing through near-net-shape manufacturing.
- Rapidly manufacture large and complex metal components.
- Enable additive manufacturing, precision repair, and remanufacturing on one platform.

Compatible Materials

- Titanium Alloys
- Aluminum Alloys
- Nickel-Based Superalloys
- Stainless Steels
- High-Strength Steels
- Tool Steels
- Copper Alloys
- Other Engineering Metal Powders

Typical Industries

- Aerospace
- Aviation
- Defense
- Marine & Shipbuilding
- Industrial Machinery
- Tool & Die
- Research Institutes
- Education
- Electronics



GSLAM Series Smart Robotic Laser Metal Additive Manufacturing Systems

Sealed-Chamber 8-AxisIntelligent Additive Manufacturing System

This system is designed for net-shape forming and remanufacturing of high-value components that require strict control of moisture and oxygen levels, and also supports direct metal fabrication of new parts.

It has been widely applied in direct metal additive manufacturing, repair, and 3D printing of materials including nickel-based superalloys, titanium alloys, aluminum alloys, cobalt-based alloys, high-strength steels, and more.

High Motion Accuracy/8-Axis Synchronized Motion/ Superior Metal Forming

Equipment Series	GSLAM Series 8-Axis Robotic Intelligent Additive Manufacturing System		
Model	GSLAM-500E	Positioning Accuracy (Repeatability)	±0.05mm
Laser Power	<8KW	Laser Head	Straight / Bent Laser Head
Laser Source	Fiber / Semiconductor Laser	Applicable Wavelength	900-1100nm
Moisture & Oxygen Content	<50PPM	Powder Feeder	1-6 Hoppers (Optional)
Chiller	Dual Temperature Control	Cladding Nozzle	Three-Point / Annular Type
Control System	Closed-Loop Motion Control	Robot Type	6-Axis Industrial Robot
Spot Size	0.4-6mm	Operator Display	Dual Screens: 21.5-inch, 15-inch
Overall Size	2.6 × 1.7 x 2.2 m	Forming Size	500 x 500 x 500 mm
Equipment Floor Space Requirement	Rotary Axis Vision, Melt Pool Monitoring, Platform Heater, Cross Slide, Positioner, etc.		
Software	Path Planning Software, Online Monitoring Software, Temperature Closed-Loop Control Software		

Workstation Smart Robotic Laser DED System

The system takes a high-flexibility robot as the core, integrates the core technologies of laser cladding and metal 3D printing, and can realize near-net shaping of complex curved surfaces, non-standard special-shaped parts, integrated printing, and high-performance repair of precision parts such as turbine engines. It combines the capabilities of surface modification, additive manufacturing, repair and remanufacturing, meets customized processing requirements, and provides flexible additive manufacturing solutions.

Flexible Configuration/Wide Application Range/ Complex Part Repair

Sliding-Table Surface Enhancement & Remanufacturing System

The Greenstone Sliding-Table Surface Enhancement & Remanufacturing System is an intelligent ultra-high-speed laser cladding solution developed in-house, integrating a 6-axis industrial robot with a precision linear slide. Equipped with a laser processing rotary table, it enables ultra-high-speed laser cladding for both flat and complex curved surfaces, as well as high-efficiency cladding of shaft components. Designed for large industrial workpieces, the system delivers reliable repair, remanufacturing, and surface enhancement with exceptional flexibility, precision, and productivity.

Ultra-High-Speed Laser Cladding / Flexible & User-Friendly Operation / Large Component Repair

Equipment Name	Robot Rail Sliding Laser Cladding System		
Laser Source	Fiber / Semiconductor Laser	Spindle Speed	≤1000rpm
Max Power	10000W	Cladding Width	0.5-30mm
Rail Travel (Stroke)	≤10m	Cladding Thickness	0.6-0.9mm

G-Motion S Series High-Throughput DED Metal 3D Printing Systems

Compact Environmental Chamber Wire-DED Metal 3D Printing System

The Greenstone Compact Environmental Chamber Wire-DED Metal 3D Printing System is designed for high-precision, high-quality metal additive manufacturing. Featuring an advanced laser closed-loop control system with center wire feeding, it delivers positioning accuracy of up to 0.02 mm. Equipped with a vacuum and inert gas protection system, the chamber rapidly reduces oxygen levels to ensure superior print quality and process stability. The system supports both Wire-DED metal additive manufacturing and laser wire welding, providing a flexible solution for precision manufacturing, repair, and advanced metal fabrication.

High-Precision Wire Feeding / Vacuum & Inert Gas Protection / Tailored Energy Field Control

Equipment Name	Environmental Chambers Wire Feeding 3D Printing System		
Display	Dual Screen: Operation Screen / Visual Monitoring Screen	Applicable Wire Diameter	0.2-1.2 mm
Control System	Closed-loop Motion Control	Water Chiller	Dual Temperature, Dual Control
Max Part Size	Within 200 × 200 × 400 mm	Oxygen Content	<50 PPM
Laser Source	Fiber / Semiconductor Laser	Overall Dimensions (L*W×H)	1.2 × 1.2 × 2.5 m
Wire Feeding System	Push-Pull Wire Feeding	3-Axis Travel (XYZ)	200 × 200 × 400 mm
Laser Power	2 kW	Laser Head	Dual Version
Positioning Accuracy	±0.02 mm	Power Requirement	<5 kW
Spot Size	0.2-3 mm	—	—
Expandable Modules	Platform Heater, Transfer Chamber, Positioner, etc.		
Configuration Software	Path Planning Software, Online Monitoring Software		

Mid-Size Environmental Chamber DED Metal 3D Printing System

The Greenstone Mid-Size Environmental Chamber DED Metal 3D Printing System is a high-performance solution designed for advanced metal additive manufacturing. It enables the fabrication of functionally graded and multi-material metal components through continuous composition control. The system can be customized to meet specific application requirements and is ideal for high-efficiency production, metal 3D printing, component repair, laser cladding, surface enhancement, and materials research. With its stable process control and flexible configuration, it provides a reliable platform for industrial manufacturing and R&D applications.

Expandable Motion System / Stable Dynamic Performance / Real-Time Multi-Powder Blending

Equipment Name	High-Throughput Metal Material 3D Printing System		
Control System	3-Axis Linkage Control	Travel Range (XYZ)	500 x 400 x 300 mm
Laser Source	Fiber / Semiconductor Laser	Powder Feeder	Optional: 4 / 5 / 6 Hopers
Laser Water Chiller	Dual Temperature Control	Cladding Nozzle	Coaxial Ring Nozzle
Substrate Preheating	Preheating Temperature ≥ 300 °C	Environmental Oxygen Content	As Low As 1 ppm
Overall Dimensions	2374 × 1815 × 2530 mm	Laser Head	Direct Fiber Laser Head
Weight	≤ 1200 kg	Forming Area	300 × 300 × 300 mm
Current	50 A ± 10%	Positioning Accuracy	< 0.05 mm
Power Requirement	≤6KW	Spot Diameter	0.4 - 6 mm
Configuration Software	Process Monitoring Software, Slicing Software, Electrical Control System		

Large Environmental Chamber DED Metal 3D Printing System

The Greenstone Large Environmental Chamber DED Metal 3D Printing System utilizes advanced coaxial laser powder deposition technology to build high-performance metal components layer by layer along predefined toolpaths, enabling rapid, mold-free manufacturing. The system integrates a sealed environmental chamber, dust extraction unit, laser processing system, motion control system, and precision powder feeding mechanism into a highly integrated manufacturing platform. Equipped with intelligent path planning, process database, fault diagnosis, and simulation software, it is ideally suited for the agile production and precision repair of large, complex metal structures and high-value industrial components.

Highly Integrated System / Visualized Process Monitoring / Dedicated Process Software

Equipment Name	Extra-Large High-Throughput Metal Material 3D Printing System		
Model	G-Motion S2000E	Build Size	Within 2 x 2 x 1 m
Control System	Closed-loop Motion Control	Powder Feeder	Optional: 2-6 Hopers
Overall Dimensions	4.1 × 3.3 × 2.6 m	Cladding Nozzle	3-Point / Ring-Type Nozzle
Laser Source	Fiber / Semiconductor Laser	Oxygen Content	<50 ppm
Laser Power	2-10 kW	3-Axis Travel (XYZ)	2 x 2 x 1m
Water Chiller	Dual Temperature Control	Positioning Accuracy	±0.02 mm
Laser Head	Straight / Angle Fiber Laser Head	Spot Size	0.4-6 mm
Power Requirement	<10 kW	—	—
Expandable Modules	Platform Heater, Transfer Chamber, Gloves, Positioner, etc.		
Configuration Software	Path Planning Software, Online Monitoring Software		

G-Motion X Series Multi-Axis DED Metal 3D Printing Systems

Multi-Axis Controlled Energy Field Metal Additive Manufacturing System

The Greenstone Multi-Axis Controlled Energy Field Metal Additive Manufacturing System is specifically developed for research institutions and powder metallurgy manufacturers, combining high efficiency with exceptional process flexibility. Equipped with a multi-channel powder feeding system, it enables real-time mixing of multiple metal powders with precisely controllable composition ratios. Integrated with a high-throughput experimental software platform, the system supports single-run batch fabrication of samples with varying material compositions, significantly improving research efficiency.

The system offers high powder utilization, flexible compositional control, and a wide material compatibility range. It is suitable for steels, aluminum alloys, titanium alloys, nickel-based superalloys, high-temperature alloys, and ceramic powders, making it an ideal platform for material screening, performance evaluation, and gradient material research in scientific laboratories.

Multi-Powder Real-Time Mixing / High-Throughput Material Research / Flexible Composition Control

Model	G-Motion X400E	Positioning Accuracy	±0.02 mm
Display	23.8-inch / Touch Screen	Laser Head	Straight / Angle Laser Head
Control System	Multi-Axis Motion Control Board	Power Requirement	<10 kW
Laser Source	Fiber / Semiconductor Laser	Powder Feeder	1-4 Hopers (Optional)
Laser Power	1-6 kW	Cladding Nozzle	Coaxial Three-Point / Ring-Type Nozzle
Water Chiller	Dual Temperature Control	Oxygen Content	<50 ppm
Overall Dimensions	1.6 × 1.6 × 2.2 m	Travel Range (XYZ)	400 × 400 × 400 mm
Enclosure Volume	≤0.8 m3	Spot Size	0.4-5 mm
Expandable Modules	Preheating Platform, Two-Axis Positioner, Wire Feeding System, etc.		
Configuration Software	Path Planning Software, Melt Pool Monitoring Software, Coaxial Vision System, etc.		

Medium-to-Large Multi-Axis High-Throughput DED Metal 3D Printing System

The Greenstone Medium-to-Large Multi-Axis High-Throughput DED Metal 3D Printing System is designed for metal additive manufacturing, precision repair, and new material development. Optimized through years of engineering, it features advanced thermal management, fume extraction, and powder containment for stable, reliable operation. Multi-channel powder feeding and interchangeable coaxial nozzles deliver high deposition efficiency, excellent accuracy, and clog-free performance. Intelligent control software supports real-time monitoring, fault diagnostics, and optional melt pool monitoring and process simulation for consistent, high-quality production.

Multi-Feeder Powder Delivery / High-Throughput Material Development / Intelligent Process Monitoring

Equipment Name	Industrial Multi-Axis High-Throughput DED Metal 3D Printing System		
Model	G-Motion X800M/ G-Motion X1500M	Build Volume	800 × 600 × 900 mm/ 1500 x 1000 x 1000 mm
X/Y/Z Axis Positioning Accuracy	0.08 mm	X/Y/Z Axis Repeatability	0.05 mm
X/Y/Z Axis Max. Speed	5 m/min	Oxygen Content	≤50 ppm
Dual-Axis Rotary Table (Optional)	Ø400 mm Table Diameter	Swing Range	±90°
Rotary Range	n × 360°	Load Capacity	Horizontal 200 kg / Vertical 100 kg
Fume Filtration Level	H11	Shielding Gas	Ar
Working Voltage	AC380V ±10% / 3P+N+PE	Rated Power	55 kW/70 kW
Laser Power	2-6 kW	Control System	GST-S-L
Machine Dimensions (L × W × H)	3200 × 2500 × 2600 mm / 4000×3200×3200 mm	Machine Weight	6 T/12T
Applicable Materials	Titanium Alloys, Aluminum Alloys, Nickel-Based Alloys, Steel Alloys, Tool Steel, Stainless Steel, Copper Alloys, Low-Alloy Steels, etc.		

Extra-Large Multi-Axis High-Throughput DED Metal 3D Printing System

The Greenstone Extra-Large Multi-Axis High-Throughput DED Metal 3D Printing System integrates large-format metal additive manufacturing, precision repair, gradient material fabrication, and surface enhancement into a single platform. A movable worktable enables convenient loading and unloading of large workpieces, while the high-dust-proof motion system ensures reliable operation in demanding metal powder environments. Equipped with a fourth-generation independent explosion-proof dust collection system and high-power powder delivery technology, it delivers stable powder flow, precise deposition, and exceptional processing efficiency for large-scale industrial applications.

Large-Format Multi-Process Manufacturing / Heavy-Duty Powder Handling / Explosion-Proof Dust Collection

Equipment Name	Industrial Multi-Axis High-Throughput DED Metal 3D Printing System		
Model	G-Motion X2500	Build Volume	2500 × 2500 × 1500 mm
X/Y/Z Axis Positioning Accuracy	0.10 mm	X/Y/Z Axis Repeatability	0.08 mm
X/Y/Z Axis Max. Speed	5 m/min	Oxygen Content	≤50 ppm
Dual-Axis Rotary Table (Optional)	Ø650 mm Table Diameter	Swing Range	±90°
Rotary Range	n × 360°	Load Capacity	Horizontal 500 kg / Vertical 400 kg
Fume Filtration Level	H11	Shielding Gas	Ar
Working Voltage	AC380V ±10% / 3P+N+PE	Rated Power	85 kW
Laser Power	8kW / 10 kW	Control System	GST-S-L
Machine Dimensions (L × W × H)	5100 × 4700 × 4300 mm	Machine Weight	38 T
Applicable Materials	Titanium Alloys, Aluminum Alloys, Nickel-Based Alloys, Iron-Based Alloys, Tool Steel, Stainless Steel, Copper Alloys, Low-Alloy Steels, etc.		

GPLAM Series Portal Laser Metal Additive Manufacturing Systems

Ultra-Large Gantry Laser DED Metal Remanufacturing System

The Greenstone Ultra-Large Gantry Laser Direct Energy Deposition (DED) System is designed for heavy-duty industrial remanufacturing, large component repair, and surface enhancement. Featuring a high-rigidity gantry structure and ultra-large working envelope, it enables stable, high-precision laser processing of oversized and complex geometries, including flat, curved, and irregular surfaces.

Built on an open and modular platform architecture, the system integrates laser source, cooling unit, deposition head, gantry motion system, rotary table, powder feeding system, and electrical control system according to application requirements. It supports multi-process capabilities including laser cladding, surface strengthening, and dimensional restoration, significantly extending component service life while reducing maintenance cost.

Equipped with high-power laser compatibility (6–20 kW), advanced motion control, and intelligent system integration, it delivers high deposition efficiency, excellent consistency, and reliable performance for large-scale industrial manufacturing environments.

Ultra-Large Format Manufacturing / Heavy-Duty Gantry System / Multi-Process Laser Remanufacturing

Laser Power	1 - 20 kW	Working Envelope (X/Y/Z)	200 × 200 × 400 mm - 12000 × 6000 x 1500 mm
Max Load Capacity	0.2 - 30 T	Rotary Table Diameter	Ø400 - Ø2000 mm
Applicable Laser Type	Fiber / Semiconductor	Shielding Gas	Ar
Control System	Industrial CNC	Fume Filtration Level	H11
Application	Laser Cladding / Hardfacing / Alloying / Melting / Remanufacturing of Large Components		

GMLAM Series Mobile Laser Cladding & Additive Remanufacturing Systems

On-Site Laser Remanufacturing Mobile Workstation

Mobile Field Repair / Dual-Cabin Human-Centered Design / Integrated Monitoring System

The Greenstone On-Site Laser Remanufacturing Mobile Workstation is designed for field repair and refurbishment of large industrial components. Featuring a robot lifting platform, suspended robotic arm system, and integrated multi-cabin layout, it enables flexible on-site laser processing for oversized parts.

The system adopts an ergonomic and human-centered design with separate equipment and operation cabins connected by an internal passageway, allowing efficient operation, maintenance, and inspection. Built-in air conditioning, lighting, and environmental control systems ensure stable working conditions, while a full-coverage monitoring system guarantees safe and reliable operation throughout the laser processing workflow.

Mobile Laser Additive & Subtractive Manufacturing System

- Compact Version (Left)
- Standard Version (Right)

The Greenstone Mobile Laser Additive & Subtractive Manufacturing System is engineered for rapid on-site remanufacturing and repair of large industrial components. Its modular design integrates all key laser processing units into transportable modules that can be quickly delivered, assembled, and commissioned at the customer's site. After the operation is completed, the system can be rapidly dismantled and transported, significantly reducing response time, labor requirements, and installation costs while maximizing maintenance efficiency and equipment uptime.

Rapid On-Site Response / Fast Assembly & Disassembly / Large Component Field Repair

Adaptive Profile Laser Cladding Technology

Greenstone's Adaptive Profile Laser Cladding Technology combines 3D surface scanning, intelligent path generation, and robotic trajectory planning to automate the entire repair process. Designed for large curved and complex components, it significantly reduces manual programming time while improving repair accuracy, efficiency, and process consistency through automatic defect compensation and digital reconstruction.

Intelligent Repair Workflow

3D Scanning → Point Cloud Generation → Robotic Path Planning → Defect Compensation → Adaptive Laser Cladding → 3D Reconstruction → Digital Verification

GPoLAM Series Portable Intelligent Laser Additive & Subtractive Repair Systems

Portable Robotic Laser Repair System

The GPoLAM Series Portable Intelligent Laser Additive & Subtractive Repair System is engineered for rapid on-site maintenance and remanufacturing of high-value industrial components. Combining collaborative robotics, intelligent laser processing, and modular architecture, the system provides an efficient solution for field repair where conventional stationary equipment cannot be deployed.

Compared with traditional fixed laser systems, GPoLAM offers outstanding portability, flexible deployment, and integrated additive & subtractive capabilities, making it ideal for large components, confined spaces, and complex maintenance environments.

System Features

1. Adaptive Vision-Guided Repair
Supports Teach-by-Demonstration, Vision-Guided Programming, and 3D Scanning-Based Programming. Intelligent path planning automatically identifies damaged areas and generates optimized repair trajectories with positioning accuracy up to 0.1 mm, significantly reducing programming time.

2. Modular Portable Architecture
The modular design allows each functional unit to be transported independently and rapidly assembled on-site. Modules can be freely configured according to different maintenance scenarios, improving deployment efficiency and operational flexibility.

3. Force-Controlled Grinding
Integrated force-controlled grinding technology enables precise contact force regulation and automatic grinding path planning, providing stable pre-processing and post-processing for repair operations.

4. Magnetic Attachment System
The magnetic mounting mechanism enables fast installation on ferromagnetic structures, allowing secure operation on vertical, curved, and confined surfaces while significantly improving field accessibility and repair efficiency.

Typical Applications

- On-Site Component Repair
- Surface Restoration & Remanufacturing
- Laser Cladding Repair
- Laser Grinding & Finishing
- Maintenance of Large Industrial Equipment
- Repair in Confined or Hard-to-Reach Areas

Key Advantages

- Portable Modular Platform
- Collaborative Robot Integration
- Intelligent Vision-Guided Repair
- Magnetic Attachment Technology
- Rapid Field Deployment
- Additive & Subtractive Processing

Equipment Name	GPoLAM Series Portable Intelligent Laser Additive & Subtractive Repair System		
Model	GPoLAM 300R	Laser Power	3000 W
Laser Type	Fiber Laser / 200 μm / 20 m	Motion System	Robot Arm
Motion Mode	Manual Push / Portable Operation	Repeatability	±0.03–0.04 mm
Payload (Robot)	10–12 kg	Vehicle Load Capacity	200 kg
Powder Feeder	5 L Single Hopper	Powder Feeding Rate	1–400 g/min
Feeding Accuracy	±1%	Cooling System	CWFL-3000AN
Cladding Head	D52 Coaxial Type	Beam Diameter	0.6–4 mm
Machine Dimensions	1140 × 685 × 1385 mm		
Remark	Specifications can be customized to meet specific application requirements.		

Application Cases

1. Wind Power Industry
On-site repair of gearboxes, shafts, and large rotating components. The system enables efficient restoration of worn or damaged surfaces in harsh field conditions, extending service life and reducing downtime.

2. Hydropower Industry
Laser repair and surface strengthening of turbine runners and large hydraulic components. Suitable for erosion, cavitation, and corrosion damage restoration in complex geometries.

3. Mining & Heavy Machinery
Remanufacturing of hydraulic cylinders, rollers, crusher components, and large structural parts. Provides high-strength surface rebuilding for severe wear and impact conditions.

4. Energy & Industrial Pipelines
On-site repair of large pipelines, elbows, and metal structures. Ideal for confined or difficult-access environments requiring fast deployment and reliable repair quality.

UHS-GCoat Series Ultra-High-Speed Laser Cladding Hybrid Additive Manufacturing System

Ultra-High-Speed Laser Cladding Hybrid Manufacturing System

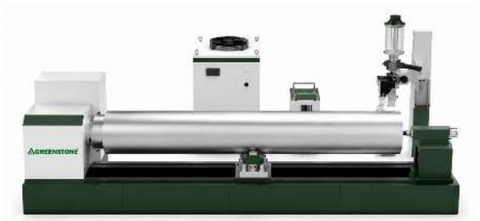
The Greenstone UHS-GCoat C1025B is an ultra-high-speed laser cladding hybrid manufacturing system engineered for high-efficiency surface engineering, precision remanufacturing, and large-scale industrial production. By integrating high-speed laser cladding with precision turning in a single setup, the system completes additive and subtractive processing without repeated workpiece repositioning, significantly improving machining efficiency, dimensional accuracy, and production consistency.

Developed through extensive process validation and continuous optimization, the UHS-GCoat C1025B delivers stable, repeatable coating quality suitable for long-term industrial operation. The optimized EHLA process minimizes heat input while producing dense metallurgical bonds, low dilution rates, and high-quality coatings with excellent wear, corrosion, and fatigue resistance.

Designed for shafts, rollers, hydraulic cylinders, and other rotational components, the system supports continuous, high-throughput production while reducing material consumption, machining time, and overall manufacturing cost. It is an ideal solution for industrial remanufacturing, surface enhancement, and advanced coating applications requiring high productivity and reliable process stability.

Model	UHS-GCoat C1025B	Control System	CNC
Laser Type	Fiber Laser / Semiconductor Laser	Laser Power	10 kW
Laser Head	Straight / Bent-Type Cladding Head	Positioning Accuracy	±0.05 mm
Nozzle Type	Coaxial / Annular Laser Nozzle	Scanning / Beam Spot	0.4–6 mm
Powder Feeder	1–4 Hoppers (Optional)	Powder Feed Rate	1–400 g/min
Feeding Accuracy	±1%	Cooling System	Dual-Temperature Water Chiller
Forming Size	≤500 × 400 × 300 mm	Machine Power	<45 kW
Rotary Table Load	3000 kg (Customizable)	Workpiece Length	1500 mm (Customizable)
Workpiece Diameter	600 mm (Customizable)	Software	Online Monitoring & Data Acquisition

Compact High-Speed Rotary Laser Coating System



The Greenstone GCoat S is a compact rotary laser coating system designed for precision surface engineering of shafts, rollers, and other cylindrical components. Its adaptive spindle drive and intelligent hydraulic tailstock ensure stable rotation, accurate clamping, and consistent coating quality across different workpiece sizes. Delivering excellent metallurgical bonding, high repeatability, and reliable process stability, the GCoat S is an ideal solution for industrial remanufacturing, surface enhancement, and high-efficiency rotary laser coating applications.

Model	GCoat S	Max Load Capacity	1.5 T
Power Supply	3-phase 380VAC, 50/60Hz, TN-S	Laser Power	6000 W
Spindle Speed	0.1–10.0 rpm	Beam Spot Size	20 × 2 mm
Effective Workpiece Length	3000 mm	Repeat Positioning Accuracy	±0.1 mm
Effective Clamping Diameter	Ø500 mm	Deposition Efficiency	8 cm³/min
Max Rotation Diameter	Ø500 mm	Base Dilution Rate	≤10%
Coating Thickness	2 mm	Powder Utilization Rate	≥85%

Application Case

Sliding Bearing Surface Restoration

A sliding bearing was restored using the Greenstone GCoat Series laser cladding system. After cladding, the coating surface was finish-machined and evaluated according to ISO 4386-3:2018, achieving Grade A surface quality with no defects detected during non-destructive inspection.

A metallurgical bond strength evaluation was performed using a tin-bronze alloy deposited on AISI 1045 steel. In accordance with ISO 4386-2, the coating exhibited a stable bond strength exceeding 300 MPa, demonstrating excellent adhesion and long-term reliability.

Metallographic analysis confirmed a dense and uniform coating structure with a heat-affected zone (HAZ) typically below 200 μm, minimizing thermal impact on the substrate while ensuring outstanding coating integrity and dimensional stability.

Key Results

* ISO 4386 compliant coating quality
* Bond strength >300 MPa
* Heat-affected zone <200 μm
* Dense metallurgical bonding
* High coating integrity and dimensional stability
* Suitable for high-performance bearing remanufacturing and surface enhancement

GInLAM Series Internal Diameter Laser Cladding & Additive Repair Systems

- Concentrated laser energy with low heat input and a minimal heat-affected zone (HAZ), preserving substrate properties.
- Smooth, high-quality coating surface requiring minimal post-machining.
- Shallow penetration and low dilution rate for superior corrosion and wear resistance.
- Compatible with a wide range of coating materials, delivering cost-effective processing.
- Highly integrated, high-precision, and adaptable design for reliable processing of complex internal geometries.

The Greenstone Internal Diameter Laser Cladding System is engineered for high-efficiency, high-precision laser cladding of internal surfaces across a wide range of cylindrical components. Featuring a highly integrated, compact design with exceptional positioning accuracy and adaptability, the system provides superior accessibility in confined bores that conventional laser processing heads cannot achieve. Combined with Greenstone's Ultra-High-Speed Laser Cladding (UHS) technology, it enables rapid, high-quality cladding of hydraulic cylinders, guide columns, and other deep-bore components while significantly improving productivity and coating performance.

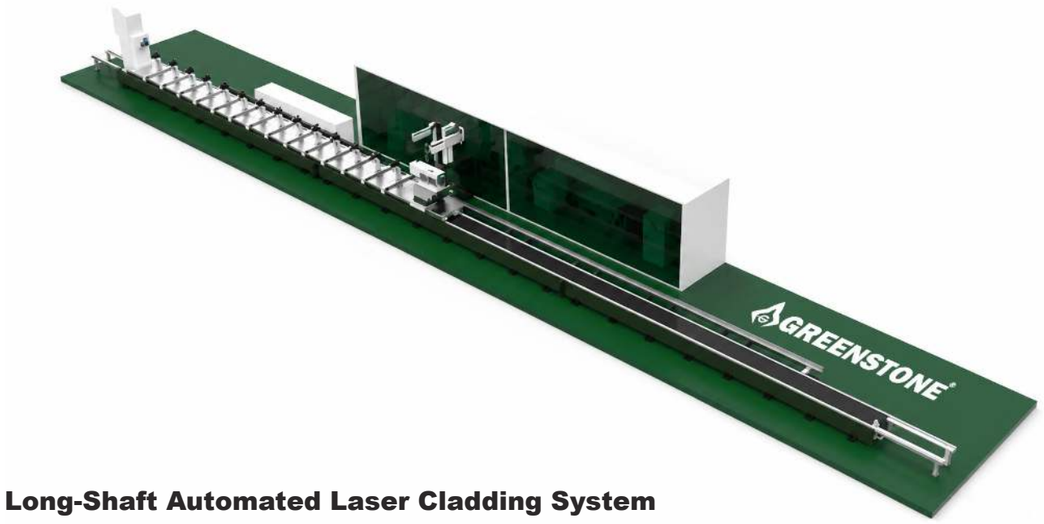
Laser Type	Fiber Laser / Semiconductor Laser	Chuck Diameter	500 mm
Laser Power	6 kW	Max Rotation Diameter	600 mm
Spindle Speed	1–50 rpm	Base Material Dilution Rate	<1%
Motion System	3+1 Axes	Processing Length	≥2 m
Repeat Positioning Accuracy	0.02 mm	Max Workpiece Length	2 m
Max Load Capacity	3 T	Software	Online Monitoring & Data Acquisition

Application Case

Hydraulic Cylinder Bore Restoration

The Greenstone GInLAM Series was used for internal bore restoration of hydraulic cylinder sleeves. A uniform cladding thickness of 0.3–0.6 mm was achieved with continuous, defect-free coatings free of cracks, porosity, and lack of fusion. Metallographic analysis confirmed a dense metallurgical bond, low dilution, and an average coating thickness of ~0.3 mm. After finish machining, the remaining coating thickness was ~0.15 mm with a surface roughness of Ra 0.8. A 100-hour neutral salt spray test in accordance with GB/T 10125-1997 showed no visible corrosion, demonstrating excellent wear resistance, corrosion protection, and long-term reliability for hydraulic cylinders, compressor housings, and other internal-diameter components.

Customized Automated Laser Cladding Systems -Tailored High-Performance Solutions for Intelligent Batch Manufacturing



Long-Shaft Automated Laser Cladding System

The Greenstone Long-Shaft Automated Laser Cladding System is engineered for intelligent, high-efficiency remanufacturing of long cylindrical components. Featuring a high-rigidity multi-axis motion platform and fully automated workpiece handling, the system delivers continuous, high-precision laser cladding with excellent process stability and production efficiency. Designed for shafts, rollers, drill pipes, hydraulic cylinders, and other elongated components, it supports flexible customization for various workpiece sizes while ensuring consistent coating quality and reliable batch production.

Compact Automated Laser Cladding System

The Greenstone Compact Automated Laser Cladding System is designed for precision laser cladding of small and medium-sized components with complex geometries. Its highly integrated modular architecture provides excellent flexibility, positioning accuracy, and automation, making it suitable for valves, molds, drill bits, turbine components, sealing surfaces, and other high-value precision parts. Supporting multi-station processing and intelligent control, the system enables stable, repeatable, and cost-effective batch manufacturing for industrial surface enhancement and remanufacturing applications.

GWAAM Series Wire Arc Additive Manufacturing Hybrid Systems

The Greenstone GWAAM Series integrates Wire Arc Additive Manufacturing (WAAM), Laser Powder DED, and subtractive machining into a single intelligent hybrid manufacturing platform. Designed for large-scale metal component fabrication, repair, and functionally graded material development, the system enables additive manufacturing, finish machining, and remanufacturing within one setup, significantly improving production efficiency while reducing material waste and processing time.

Featuring a high-rigidity robotic platform, heavy-duty rotary positioner, and intelligent process planning software, the system supports high-deposition arc printing, precision laser deposition, and integrated milling operations. It is ideal for manufacturing large structural components, repairing high-value parts, developing new materials, and producing complex metal components for aerospace, energy, marine, heavy equipment, and industrial manufacturing.

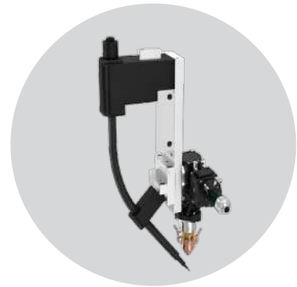
Equipment Type	Flexible Additive & Subtractive Manufacturing System	Maximum Build Size	Ø2000 × 1000 mm
Maximum Payload	2000 kg	Machine Dimensions	4700 × 5000 × 4000 mm
Machine Weight	12 t	Software	Proprietary Additive & Subtractive Path Planning Software
Wire Arc Additive Manufacturing System			
Maximum Deposition Rate	Up to 900 cm³/h	Welding Current Range	MIG/MAG: 3–400 APlasma Arc: 10–400 A
Laser Powder DED System			
Deposition Rate	120–350 cm³/h	Laser Power	4–10 kW
Powder Utilization	70–80%	-	-
Subtractive Machining System			
Milling Spindle Speed	12,000 rpm	Rated Spindle Power (S1/S6)	8.5 / 10 kW
Rated Spindle Torque (S1/S6)	6.7 / 8 N·m	Tool Magazine Capacity	6 Tools
Motion System			
Robot Payload	500 kg	Maximum Robot Reach	2830 mm
Positioner Travel	Rotation: 360° × NTilting: ±120°	Positioner Table Diameter	Ø2000 mm
Robot Position Repeatability	±0.08 mm		

GLW Series Laser-Arc Hybrid Welding System

The Greenstone GLW Series Laser-Arc Hybrid Welding System integrates advanced laser and MIG arc hybrid welding technology into a single intelligent platform. By combining the high energy density of laser welding with the excellent gap-bridging capability of arc welding, the system significantly improves welding efficiency, penetration depth, weld quality, and process stability while reducing overall manufacturing costs.

Compared with conventional laser or arc welding, the hybrid process delivers higher energy utilization, deeper penetration, and faster welding speeds. Laser stabilization of the welding arc also improves tolerance to joint gaps and fit-up variations, resulting in more stable welding performance and higher production efficiency. The system is ideal for heavy fabrication, shipbuilding, energy equipment, pressure vessels, engineering machinery, and other large metal structure applications.

Hybrid Welding Head



Laser Source	Fiber Laser	Hybrid Welding Process	Laser + DC MIG Hybrid
Laser Source Capacity	20 kW	Laser Power (Process)	5 kW
Fiber Core Diameter	200 μm	Welding Current	144 A
Collimation / Focal Length	100 / 200 mm	Welding Voltage	16.7 V
Welding Power Source	CMT Welding System	Welding Speed	10 mm/s
Motion System	KUKA KR210 Robot	Weld Width	6.7 mm
Maximum Penetration Depth	9 mm	-	-

GLH Series Automated Laser Hardening System

The Greenstone GLH Series Automated Laser Hardening System is specifically designed for the high-efficiency laser surface hardening of slender shaft-type and precision metal components. By integrating automatic loading, machine vision positioning, robotic motion control, laser hardening, and automatic unloading, the system delivers a fully automated production workflow that significantly improves manufacturing efficiency while ensuring stable and repeatable processing quality.

The production line automatically transports workpieces to the laser processing station through an intelligent loading system. A high-speed vision system accurately identifies the required hardening position, records the coordinate information, and transmits it to the robotic motion controller. The robot automatically follows the calculated path to perform precise laser hardening. After processing, the finished workpiece is automatically pushed onto the receiving rack by a pneumatic unloading mechanism, enabling continuous unmanned production.

Optional machine vision positioning and automatic clamping modules further enhance positioning accuracy and production flexibility. The system is suitable for large-scale automated manufacturing in the automotive, engineering machinery, energy equipment, heavy industry, and precision component industries.

Robot	6-Axis Industrial Robot	Laser Type	Semiconductor Laser
Laser Power	3 kW	Adjustable Beam Size	5 × 5 mm – 32 × 32 mm (Customizable)
Temperature Monitoring	Dual Infrared Pyrometers	Control System	Closed-Loop Temperature Control System
Positioning Method	Machine Vision Guidance	Automation	Automatic Loading, Positioning & Unloading

Process Validation

40Cr Steel

The laser hardening process achieves a hardened layer depth of 3.0–5.0 mm while meeting hardness requirements throughout the hardened zone. The localized laser heat treatment produces virtually no distortion, maintaining the dimensional accuracy and geometric integrity of the workpiece.

QT700 Ductile Iron

Laser hardening produces a smooth and bright surface with a uniform internal microstructure. The effective hardened depth reaches 0.65 mm, providing stable hardening performance and excellent surface quality.

Validation Results

Process parameters can be optimized according to different workpiece materials and application requirements to maximize mechanical performance. The laser hardening process enables rapid localized heat treatment with high thermal efficiency, excellent dimensional accuracy, simple operation, and minimal heat input, making it highly suitable for continuous automated industrial production while ensuring consistent hardening quality and production reliability.

GClean Series Intelligent Laser Cleaning Systems

Portable Laser Cleaning Machine

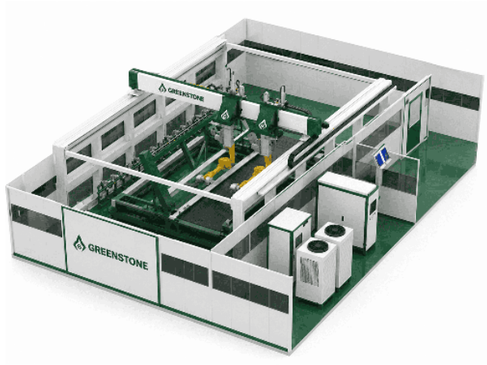
The Greenstone Portable Laser Cleaning Machine is a compact, easy-to-operate solution featuring a medium-to-low power pulsed fiber laser and high-speed galvanometer scanning technology. It is suitable for precision cleaning, rust removal, paint stripping, oxide removal, and surface preparation across a wide range of industrial applications, offering low operating and maintenance costs with excellent portability.

Portable Operation · Non-Contact Cleaning · Low Operating Cost

Mobile Laser Cleaning System

The Greenstone Mobile Laser Cleaning System is a high-power robotic solution developed for on-site industrial cleaning applications. It efficiently removes oil, grease, rust, oxide layers, paint coatings, and other surface contaminants without damaging the base material. Designed for field service and large workpieces, the system has been widely adopted in industrial production and equipment maintenance.

On-Site Cleaning · Non-Contact Process · Base Material Protection



Automated Laser Cleaning Production Line

The Greenstone Automated Laser Cleaning Production Line is designed for high-volume industrial cleaning with outstanding efficiency, stability, and environmental performance. The system supports fully automated processing for medium and large shaft components, integrating rust removal, paint stripping, oxide scale removal, and surface preparation into one production line. For thick oxide removal after hot rolling, the cleaning efficiency can reach up to 10 m²/h, making it ideal for continuous industrial manufacturing.

Fully Automated Production · Eco-Friendly Process · Surface Oxide Removal

Laser Processing Components
GHead Series Laser Cladding Heads

The Greenstone GHead Series Laser Cladding Heads are engineered for a wide range of high-performance laser cladding and Directed Energy Deposition (DED) applications. Featuring a modular optical architecture and multiple interface configurations, the system is compatible with a broad range of industrial fiber and semiconductor lasers, providing exceptional flexibility, optical stability, and long-term reliability for continuous industrial operation.

The modular optical design enables rapid configuration between straight and right-angle optical paths to meet different installation requirements. Supporting laser power up to 12 kW, the system can be equipped with interchangeable optical lenses and beam-shaping modules to produce optimized spot sizes for various deposition processes. A fully enclosed dust-proof structure combined with an integrated water-cooling circuit maintains stable optical temperatures, prevents lens contamination and condensation, and ensures consistent processing performance under demanding production environments.

Optional vision modules, beam alignment modules, industrial CCD/CMOS cameras, illumination systems, and beam-shaping optics further enhance process monitoring, alignment accuracy, and application flexibility. The GHead Series is suitable for laser cladding, laser hardening, laser alloying, repair, remanufacturing, and metal additive manufacturing across aerospace, energy, mining, heavy industry, oil & gas, marine, and advanced manufacturing sectors.

Item	LH-ZSR-1020	LH-ZVR-1020	LH-WSR-1020	LH-WVR-1020
Optical Path Configuration	Straight		Right-Angle	
Operating Wavelength	No	Yes	No	Yes
Operating Wavelength	900–1100 nm			
Maximum Laser Power	12 kW			
Laser Transmission Efficiency	>99.5% @ 900–1100 nm			

Item	LH-ZSR-1020	LH-ZVR-1020	LH-WSR-1020	LH-WVR-1020
Fiber Interface	QBH, LLK-B/D, LOE			
Optical Axis Adjustment	Precision X/Y Adjustment			
Collimation Focal Length	100 / 150 mm			
Focusing Focal Length	200 / 300 mm			
Circular Spot Diameter	0.5–5.0 mm			
Focus Adjustment	Manual			
Focus Adjustment Range	±5 mm			
Imaging Module	No	Yes	No	Yes
Industrial Camera	No	CCD / CMOS	No	CCD / CMOS
Line Beam Shaping Module	Optional			
Illumination Module	Optional			
Line Beam Dimensions	8×2 mm, 10×2 mm, 12×2 mm, 16×2.5 mm, 20×2 mm, 30×2 mm			
Dimensions (L × W × H)	122 × 102 × 364 mm	200 × 102 × 364 mm	309 × 102 × 258 mm	309 × 102 × 258 mm
Weight	4.5 kg	5.0 kg	6.0 kg	6.5 kg

Coaxial Wide-Beam Laser Cladding Head
Model: D52WL
* Optical Path Configuration: Single Right-Angle
* Lens Configuration: Collimation Lens + Copper Mirror
* Operating Wavelength: 900–1100 nm
* Maximum Laser Power: ≤8 kW
* Optical Axis Adjustment: Precision X/Y Adjustment
* Collimation Focal Length: 100 mm, 150 mm
* Focusing Focal Length: 300 mm, 400 mm
* Rectangular Beam Size: 10 × 2 mm, 16 × 2.5 mm, 20 × 2 mm

Off-Axis Wide-Beam Laser Cladding Head
Model: D52WL
* Optical Path Configuration: Single Right-Angle
* Lens Configuration: Collimation Lens + Copper Mirror
* Operating Wavelength: 900–1100 nm
* Maximum Laser Power: ≤8 kW
* Optical Axis Adjustment: Precision X/Y/Z Adjustment
* Collimation Focal Length: 100 mm, 150 mm
* Focusing Focal Length: 300 mm, 400 mm
* Rectangular Beam Size: 10 × 2 mm, 16 × 2.5 mm, 20 × 2 mm

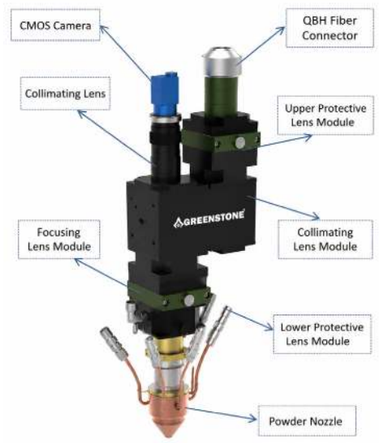
Off-Axis Wide-Beam Laser Cladding Head
Model: D52ZL
* Optical Path Configuration: Dual Right-Angle
* Lens Configuration: Dual Copper Mirrors
* Operating Wavelength: 900–1100 nm
* Maximum Laser Power: ≤12 kW
* Optical Axis Adjustment: Precision X/Y/Z Adjustment
* Collimation Focal Length: 100 mm, 150 mm
* Focusing Focal Length: 300 mm, 400 mm
* Rectangular Beam Size: 10 × 2 mm, 16 × 2.5 mm, 20 × 2 mm, 30 × 2 mm

Internal Bore Laser Cladding Head
Model: D40
* Maximum Laser Power: 2 kW
* Operating Wavelength: 900–1100 nm
* Fiber Interface: QBH
* Minimum Bore Diameter: 40 mm
* Maximum Processing Depth: 500 mm
* Alignment Adjustment: ±2 mm
* Spot Size: 2–3 mm
* Powder Feeding Method: Dual-Point Powder Feeding

Internal Bore Laser Cladding Head
Model: D100
* Maximum Laser Power: 6 kW
* Operating Wavelength: 900–1100 nm
* Fiber Interface: QBH, LOE, LLK-D
* Minimum Bore Diameter: 100 mm
* Maximum Processing Depth: 1200 mm
* Alignment Adjustment: ±2 mm
* Spot Size: 3–4 mm
* Powder Feeding Method: Annular Powder Feeding

Internal Bore Laser Cladding Head
Model: D180
* Maximum Laser Power: 6 kW
* Operating Wavelength: 900–1100 nm
* Fiber Interface: QBH, LOE, LLK-D
* Minimum Bore Diameter: 180 mm
* Maximum Processing Depth: 1200 mm
* Alignment Adjustment: ±2 mm
* Spot Size: 3–5 mm
* Powder Feeding Method: Independent Nozzle (Multi-Point or Annular Configuration)

Laser Processing Components
Intelligent Monitoring Laser Cladding Head



The Intelligent Monitoring Laser Cladding Head integrates high-precision laser cladding optics with a coaxial real-time monitoring system, enabling in-situ observation and control of the molten pool during laser processing. The system combines CMOS imaging, thermal monitoring, and process feedback functions to significantly improve process stability, forming quality, and defect detection capability.

With high-resolution visual acquisition and multi-sensor data fusion, the cladding head can dynamically capture molten pool morphology, temperature distribution, and energy coupling behavior in real time. This allows adaptive adjustment of process parameters to ensure consistent coating quality and improved metallurgical bonding performance.

The system is designed for high-end laser cladding and additive manufacturing applications, supporting complex industrial environments and enabling precise, stable, and repeatable surface engineering operations.

Laser Power Compatibility	≤ 10 kW	Operating Wavelength	900 – 1100 nm
Fiber Interface	QBH / LLK / Custom Interfaces	Monitoring System	Coaxial CMOS real-time imaging system
Imaging Resolution	High-resolution monitoring (approx. 25–28 px/mm class)	Monitoring Functions	Molten pool imaging, temperature observation, process tracking
Process Control	Real-time feedback for adaptive parameter adjustment	Optical Configuration	Modular cladding head with integrated vision channel
Cooling Method	Water-cooled structure	Application Mode	Laser cladding / surface remanufacturing / additive repair

Laser Processing Components
Blind-Hole Laser Cladding Head Series

* Adjustable processing depth for different blind-hole applications
* Fully enclosed four-channel integrated optical protection design
* 45° angled blind-hole laser processing technology
* Replaceable protective window for convenient maintenance

The Greenstone Blind-Hole Laser Cladding Head Series is specifically engineered for laser cladding and additive repair inside blind holes and deep internal cavities where conventional laser processing heads cannot operate effectively. It is ideal for the repair and remanufacturing of hydraulic cylinders, valve bodies, bearing housings, molds, heavy equipment components, and critical parts used in mining, marine, petrochemical, power generation, and engineering machinery industries.

Designed with a compact optical structure and high-rigidity mechanical architecture, the cladding head delivers exceptional accessibility for complex internal geometries while maintaining stable powder delivery and high coating consistency. Compatible with fiber and semiconductor lasers up to 6 kW, the system enables precise restoration of worn, corroded, or damaged internal surfaces with excellent metallurgical bonding and minimal heat input.

Its modular design supports multiple bore diameters and processing depths, allowing users to select the most suitable model for different internal repair requirements while ensuring reliable performance in demanding industrial environments.

Item	D60M	D80M	D85M	D180M
Compatible Laser Power	4 kW	4 kW	4 kW	6 kW
Fiber Interface	QBH	QBH	LLK-D	QBH
Minimum Bore Diameter	60 mm	80 mm	85 mm	180 mm
Maximum Processing Depth	1000 mm	1000 mm	1200 mm	1000 mm
Protective Windows	1	2	2	3

Standard Processing Depth	500 mm	Temperature Monitoring Module	Optional
Operating Wavelength	900–1100 nm	Powder Extraction Module	Optional
Beam Alignment Adjustment	±2 mm	Cooling Method	Internal Water Cooling / Powder Cooling
Powder Flow Adjustment	Yes	Shielding Gas	Supported
Laser Spot Size	3–4 mm	Powder Feeding Method	Two-Point Powder Feeding

Laser Processing Components
Wire Feeding Laser Cladding Head

Center Wire Feeding Laser Cladding Head

The GWF-CR6 Center Wire Feeding Laser Cladding Head is a high-efficiency directed energy deposition (DED) solution developed for precision surface strengthening, remanufacturing, and metal additive manufacturing. Featuring a coaxial center wire feeding architecture, it delivers stable wire transfer, uniform heat distribution, and consistent metallurgical bonding, making it ideal for both large-area deposition and precision repair applications.

GAX Wire Feed Laser Cladding Side-Feed Module

Designed for seamless integration with any compatible Greenstone powder-fed laser cladding head of the corresponding size, enabling rapid conversion into a high-performance wire-fed laser cladding head.

Supporting laser power up to 6 kW, the GWF-CR6 provides excellent deposition efficiency while maintaining a dilution rate below 5% and minimizing thermal distortion. The optimized optical system generates a highly uniform circular laser spot to ensure stable melt pool formation and superior cladding quality. Compatible with Ø1.2–1.6 mm metal wire, the system achieves 100% material utilization, significantly reducing material waste and operating costs compared with conventional powder-based processes.

Designed with a modular optical architecture, the GWF-CR6 enables fast maintenance and simplified servicing. An integrated optical temperature monitoring and alarm system protects critical optical components during abnormal operating conditions, improving operational reliability and extending service life. The standard QBH fiber interface ensures compatibility with most industrial fiber laser sources, making integration into robotic or CNC laser processing systems straightforward.

Model	GWF-CR6	Maximum Laser Power	≤ 6000 W
Fiber Interface	QBH	Working Wavelength	1080 nm
Laser Spot Shape	Circular	Spot Diameter	~Ø5 mm
Working Distance	~20 mm	Wire Feeding Method	Center Wire Feeding
Applicable Wire Diameter	Ø1.2–1.6 mm	Material Utilization	100%
Cladding Dilution	<5%	Thermal Deformation	≤5 μm
Groove Overlap Angle	≤15°	Cooling Method	Water Cooling
Overall Dimensions (L × W × H)	425 × 270 × 270 mm	Weight	~15 kg
Cooling Water Requirement	Purified Water	-	-

Internal Wall Wire-Feeding Laser Cladding Head

The GIWF-CR series internal wall wire-feeding laser cladding head is a high-performance solution designed for internal bore surface strengthening and repair applications. It enables stable and efficient laser cladding inside large-diameter cylindrical components with excellent process repeatability and low thermal deformation.

The system supports two power configurations: 12 kW (GIWF-CR12) and 6 kW (GIWF-CR6), meeting different industrial productivity requirements. It is specifically optimized for internal diameter processing applications (≥180 mm), making it suitable for hydraulic cylinders, pipeline systems, sleeves, and large hollow structural components.

With a circular laser spot design and modular optical architecture, the system ensures uniform energy distribution, high cladding consistency, and stable melt pool behavior. The wire-feeding process achieves 100% material utilization, significantly reducing operational cost while maintaining high deposition efficiency.

Integrated temperature monitoring and alarm protection ensure safe operation of optical components. The head is compatible with mainstream laser interfaces (QBH / LOE), enabling flexible system integration and upgrade.

Model	GIWF-CR12	GIWF-CR6
Max Laser Power	12,000 W	6,000 W
Fiber Interface	QBH / LOE	
Applicable Wavelength	1080 nm	
Optical Spot Diameter	~Φ6.5 mm	
Spot Shape	Circular	
Minimum Internal Diameter	≥ Φ180 mm	
Working Distance	~20 mm	
Wire Feeding Material	Metal wire (e.g., stainless steel wire)	
Wire Diameter	Φ1.2 – Φ1.6 mm	
Material Utilization Rate	100%	
Dilution Rate	≤ 3%	
Thermal Deformation Control	≤ 0.2 mm	
Cooling Method	Water cooling	
Cooling Water Requirement	Deionized water	
Weight & Size	Weight: ~3 kg ; Size (L × W × H): 340 × 150 × 75 mm	

GREENSTONE

Laser Processing Components
High-power Reflective Laser Cladding Head

Reflective Laser Cladding Heads

Greenstone reflective laser cladding heads adopt a proprietary Z-type reflective optical path, supporting coaxial ring, coaxial wide-band, and off-axis wide-band beam delivery configurations. Compatible with precision coaxial powder feeding, dual wide-band powder feeding, and gravity powder feeding systems, these heads deliver highly uniform laser energy distribution, excellent metallurgical bonding, and powder utilization of over 93%, 85%, and 97%, respectively. Designed for high-power continuous industrial operation, the modular architecture supports laser cladding, laser additive manufacturing, laser hardening, welding, and surface engineering by simply changing the front-end processing module.

Specification	Reflective Coaxial Ring Laser Cladding Head	Reflective Coaxial Wide-Band Laser Cladding Head	Reflective Off-Axis Wide-Band Laser Cladding Head
Appearance			
Reflective Optics	Off-Axis Parabolic Collimating Mirror + Off-Axis Parabolic Focusing Mirror + Beam Homogenizer	Off-Axis Parabolic Collimating Mirror + Beam Homogenizer	Off-Axis Parabolic Collimating Mirror + Beam Homogenizer
Laser Spot Size	Top-Hat: 3×3 mm, 4×4 mm; Circular: Ø2–5 mm	20×4 mm, 12×3 mm (Customizable)	20×4 mm, 25×4 mm, 40×3 mm (Customizable)
Optical Alignment Module	Standard		X/Y/Z Fine Adjustment: ±15 mm; Angular Adjustment: ±40°
Powder Feeding Configuration	Split Coaxial Ring Powder Feeding	Coaxial Dual Wide-Band Powder Feeding	Gravity Powder Feeding
Powder Utilization	>93%	>85%	>97%
Weight	7.5 kg		11.5 kg
Fiber Interface	QBH, QD, LLK-D, LOE	Optical Path	Z-Type Reflective Optical Path
Protective Lens	3 Layers	Cooling Method	Water Cooling
Maximum Laser Power	≤20 kW	Collimation Focal Length	150 mm
Focusing Focal Length	300 mm	Laser Wavelength	900–1080 nm
Optical Efficiency	>99.25%	Temperature Monitoring	Protective Lens Temperature Monitoring
Optional Functions	Closed-Loop Temperature Control, CCD Vision		

GREENSTONE

Internal Reflective Laser Cladding Heads

Greenstone Internal Reflective Laser Cladding Heads are specially engineered for internal bore laser cladding using a proprietary reflective optical path. Available in coaxial ring, off-axis wide-band, and off-axis needle configurations, the series features an anti-back-reflection optical structure that effectively prevents spatter and dust contamination of the protective optics. Fully integrated internal cooling, shielding gas, and powder delivery channels enable reliable 24/7 continuous operation. Compact, thermally stable, and highly efficient, these heads deliver excellent beam uniformity, high powder utilization, and outstanding process stability, making them ideal for deep-bore repair, remanufacturing, and internal surface enhancement.

Specification	Internal Reflective Coaxial Ring Laser Cladding Head	Internal Reflective Off-Axis Wide-Band Laser Cladding Head	Internal Reflective Off-Axis Needle Laser Cladding Head
Appearance			
Fiber Interface	QBH, QD, LLK-D, LOE		QBH, LLK-D
Reflective Optics	Off-Axis Parabolic Collimating Mirror + Off-Axis Parabolic Focusing Mirror + Beam Homogenizer	Off-Axis Parabolic Collimating Mirror + Beam Homogenizer	Off-Axis Parabolic Collimating Mirror + Off-Axis Focusing Mirror
Maximum Laser Power	≤12 kW		≤6 kW
Focusing Focal Length	135 mm	160 mm	55 mm
Laser Spot Size	Top-Hat: 3×3 mm, 4×4 mm; Circular: Ø2–5 mm	20×4 mm	Adjustable Circular Spot Ø2–5 mm
Structural Configuration	110° / 120° Inclined Head (Continuous Straight Bore Processing)	110° / 120° Inclined Head (Continuous Straight Bore Processing)	130° Inclined Head (Continuous Straight Bore Processing)
Powder Feeding Configuration	Coaxial Ring Powder Feeding	Off-Axis Wide-Band Powder Feeding	Off-Axis Needle Powder Feeding
Powder Utilization	>85%	>97%	>80%
Minimum Bore Diameter	≥180 mm	≥180 mm	≥45 mm
Maximum Processing Depth	3000 mm (Extendable)		2000 mm (Extendable)
Weight	30 kg (Longer Extension Arms Increase Weight)	35 kg (Longer Extension Arms Increase Weight)	10 kg (Longer Extension Arms Increase Weight)
Optical Path	Reflective Optical Path	Protective Lens	Single Layer
Cooling Method	Water Cooling	Collimation Focal Length	100 mm
Laser Wavelength	900–1080 nm	Optical Efficiency	>99.25%
Optical Alignment Module	Standard	Temperature Monitoring	Protective Lens Temperature Monitoring
Optional Functions	CCD Vision System		

Laser Processing Components
Ultra-Wide Beam Laser Hardening Head

The Greenstone Ultra-Wide Beam Laser Hardening Head is developed to address the increasing demand for high-efficiency laser surface hardening of large industrial components. Conventional laser hardening typically requires multiple overlapping scanning passes, which can reduce productivity and introduce inconsistencies in overlap regions. Greenstone's innovative ultra-wide beam optical design significantly expands the effective hardening width, minimizes overlap defects, and improves overall process efficiency.

Capable of producing rectangular beam widths up to 60 × 2 mm, the system greatly reduces processing time while maintaining uniform energy distribution and consistent hardening quality. Featuring a modular optical architecture, precision beam alignment, and compatibility with high-power fiber and semiconductor lasers, the hardening head provides exceptional flexibility for a wide range of industrial heat-treatment applications.

Ultra-Wide Beam Hardening · Up to 60 × 2 mm Beam Width · Reduced Overlap Zones · High-Efficiency Surface Hardening · Modular Optical Design · High-Power Laser Compatible

Model	D52WL / D52ZL	Optical Structure	Single-Bend / Double-Bend
Optical Lens Configuration	Dual Lens	Operating Wavelength	900–1100 nm
Fiber Interface	QBH / LLK-D / LOE	Beam Alignment Adjustment	Precision X-Y-Z Adjustment
Working Distance	100 mm / 150 mm	Focal Length	300 mm / 400 mm
Rectangular Beam Size	10×2 mm, 16×2.5 mm, 20×2 mm, 30×2 mm, 60×2 mm	-	-

Key Features

Modular Optical Architecture

Supports interchangeable single-bend and double-bend optical configurations for different laser processing requirements.

High-Power Compatibility

Compatible with fiber and semiconductor lasers up to 12 kW, providing stable performance for demanding industrial hardening applications.

Flexible Beam Configuration

Multiple interchangeable beam modules allow rapid selection of beam sizes from 10 × 2 mm up to 60 × 2 mm, improving productivity while reducing scanning passes.

Fully Enclosed Cooling Design

A sealed optical structure with an integrated water-cooling circuit ensures stable operating temperature, minimizes contamination, and extends component lifetime.

Quick-Replace Protective Window

Replaceable protective optics simplify routine maintenance, reduce downtime, and lower operating costs.

Application Case

Workpiece
Gear Surface Hardening (40Cr Steel)

Processing Results
The ultra-wide beam laser hardening process provides highly uniform energy distribution across the treatment area without overlap irregularities during processing. The hardened surface exhibits excellent finish quality with no visible hardening defects or discontinuities. Testing demonstrates stable process performance, consistent hardening results, and reliable metallurgical quality, making the system ideal for high-efficiency heat treatment of 40Cr gears and other wear-resistant components requiring large-area laser hardening.

Laser Processing Components
Laser Cladding Head Nozzle

Modular Annular Powder Nozzle

The Greenstone Modular Annular Powder Nozzle is a next-generation coaxial powder delivery solution developed to improve laser cladding efficiency, flexibility, and process stability. Designed to overcome the limitations of conventional one-piece nozzles, it adopts a fully modular architecture in which the inner and outer nozzle components can be independently replaced, allowing rapid configuration for different laser cladding applications.

The system supports multiple powder focal diameters and powder focal heights through interchangeable nozzle modules, enabling precise control of powder convergence and deposition characteristics for various materials, laser powers, and coating requirements. This innovative powder flow management concept provides greater process adaptability while reducing maintenance costs and consumable replacement time.

Engineered for high-performance laser cladding, additive manufacturing, and surface engineering applications, the FTCC Series delivers excellent powder utilization, stable coaxial powder feeding, and highly consistent coating quality. Its modular design helps manufacturers optimize productivity, improve process repeatability, and minimize operating costs across a wide range of industrial applications.

Key Advantages

* Modular Replaceable Design for fast maintenance and lower operating costs.
* Independent Inner & Outer Nozzle Modules for flexible process configuration.
* Multiple Powder Focus Options to match different deposition widths and cladding geometries.
* Optimized Powder Flow Control for stable powder convergence and high deposition consistency.
* High Powder Utilization Efficiency with excellent

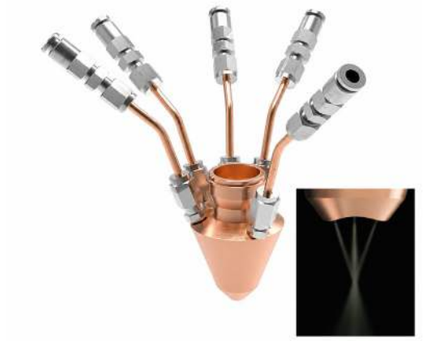
Model	FTCC Series	Compatible Laser Power	≤ 6 kW
Through Hole Diameter	Ø4–8 mm	Powder Particle Size	50–150 μm
Powder Focal Height	8–20 mm (Optional)	Powder Feed Rate	1–45 g/min
Powder Spot Diameter	1–3 mm	Powder Distributor	1-to-3 Powder Splitter
Nozzle Design	Modular Annular Coaxial Nozzle	Replaceable Components	Independent Inner & Outer Nozzle Modules
Applications	Laser Cladding, DED Additive Manufacturing, Surface Repair, Surface Strengthening		

Coaxial Multi-Point Nozzle Series

The Greenstone Coaxial Multi-Point Nozzle Series is engineered to satisfy the demanding requirements of modern laser cladding applications in terms of coating quality, deposition precision, and production efficiency. Designed with standardized mechanical interfaces, each nozzle can be rapidly interchanged and seamlessly integrated with Greenstone laser cladding heads through a unified nozzle coupling module, providing maximum flexibility across different processing scenarios.

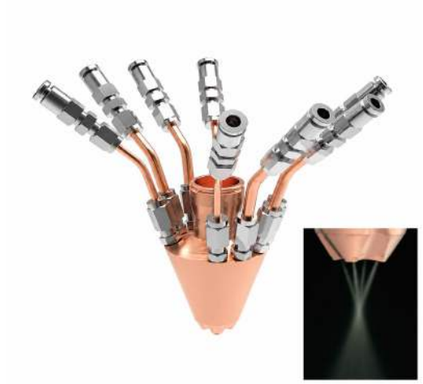
The series includes multiple coaxial powder delivery configurations optimized for various deposition widths, laser powers, and material systems. Combined with Greenstone's beam-shaping optics, strip-beam nozzle configurations produce uniform rectangular energy distribution, making them particularly suitable for high-power laser cladding applications (≥4 kW) requiring continuous, high-efficiency deposition over large surface areas.

Through optimized powder flow control and precise coaxial focusing, the Coaxial Multi-Point Nozzle Series delivers excellent powder concentration, stable material feeding, and consistent coating geometry. The result is higher powder utilization, improved deposition repeatability, adaptive layer thickness control, and superior coating quality, making the system ideal for industrial remanufacturing, additive manufacturing (DED), surface strengthening, and high-productivity laser cladding operations.



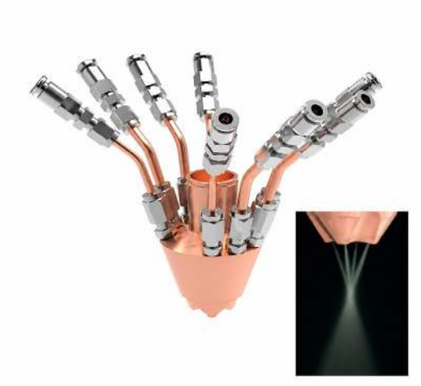
Coaxial Three-Point Nozzle

Model: CT-1317-01
Material: Copper
Compatible Laser Power: ≤ 4 kW
Weight: 0.73 kg
Powder Feed Ports: 3
Powder Focal Height: 16–18 mm
Powder Spot Diameter: 2–3.5 mm
Through Hole Diameter: Ø6.5 mm
Compatible Powder Size: 50–200 μm
Powder Feed Rate: 3–25 g/min
Cooling Water Flow Rate: ≥ 2 L/min
Powder Outlet Diameter: Ø1.2 mm / Ø1.5 mm
Connection Type: Standard Interface (Greenstone Compatible)
Powder Distributor: 1-to-3 Splitter



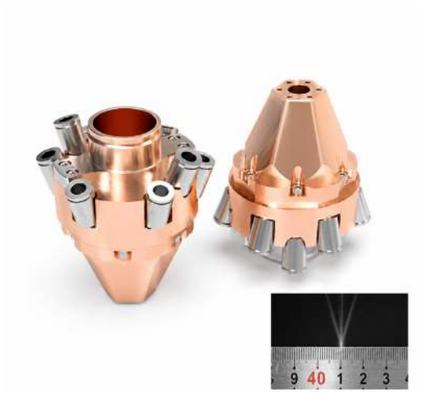
Coaxial Four-Point Nozzle

Model: CF-1317-01
Material: Copper
Compatible Laser Power: ≤ 6 kW
Weight: 1.25 kg
Powder Feed Ports: 4
Powder Focal Height: 16–18 mm
Powder Spot Diameter: 2.5–4 mm
Through Hole Diameter: Ø7.5 mm
Compatible Powder Size: 50–200 μm
Powder Feed Rate: 10–100 g/min
Cooling Water Flow Rate: ≥ 2 L/min
Powder Outlet Diameter: Ø1.2 mm / Ø1.5 mm
Connection Type: Standard Interface (Greenstone Compatible)
Powder Distributor: 1-to-4 Splitter



Coaxial Four-Point Nozzle

Model: CF-1330-01
Through Hole Diameter: Ø7.5 mm
Material: Copper
Compatible Powder Size: 50-200 um
Compatible Laser Power: ≤ 6 kW
Powder Feed Rate: 10-100 g/min
Weight: 1.25 kg
Cooling Water Flow Rate: > 2 L/min
Powder Feed Ports: 4
Powder Outlet Diameter: Ø1.2 mm / Ø1.5 mm
Powder Focal Height: 30-32 mm
Connection Type: Standard Interface
Powder Spot Diameter: 3.5-5.5 mm
(Greenstone Compatible)
Powder Distributor: 1-to-4 Splitter



High-Power Coaxial Multi-Point Nozzle

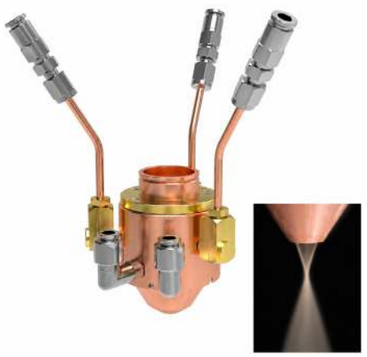
Model: CS-1025-01
Compatible Laser Power: ≤20 kW
Powder Focal Height: 25 mm
Powder Spot Diameter: 3–4 mm
Through Hole Diameter: Ø8 mm
Compatible Powder Size: 50–200 μm
Nozzle Insert Diameter: Ø0.75 mm, Ø1.0 mm, Ø1.3 mm, Ø1.5 mm

Coaxial Annular Nozzle Series

The Greenstone Coaxial Annular Nozzle Series features a fully coaxial annular powder delivery design for stable powder flow, uniform deposition, and high powder utilization. Optimized for precision laser cladding, it delivers consistent coating quality, low dilution, and excellent metallurgical bonding. Multiple nozzle sizes are available to match different laser powers and processing requirements, making the series ideal for precision repair, surface enhancement, additive manufacturing, and industrial remanufacturing applications.

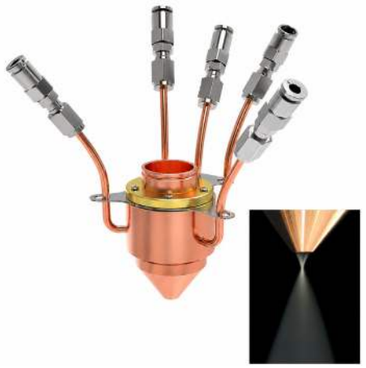
High-Speed Coaxial Annular Nozzle

Model: CC-0610-02
Material: Brass
Compatible Laser Power: ≤5 kW
Weight: 0.62 kg
Powder Flow Pattern: Annular
Powder Focal Height: 9–13 mm
Powder Spot Diameter: 0.8–1.5 mm
Through Hole Diameter: Ø6 mm
Compatible Powder Size: 25–150 μm
Powder Feed Rate: 1–45 g/min
Cooling Water Flow Rate: ≥1.5 L/min
Connection Type: Standard Interface (Greenstone)
Powder Splitter: 1-to-3 Divider



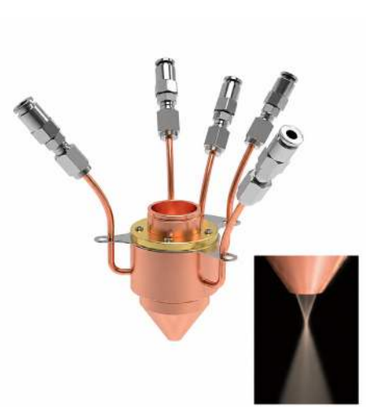
Water-Cooled Enhanced Coaxial Annular Nozzle

Model: CC-0715-01
Material: Brass
Compatible Laser Power: ≤6 kW
Weight: 1.02 kg
Powder Flow Pattern: Annular
Powder Focal Height: 15–17 mm
Powder Spot Diameter: 2.0–3.5 mm
Through Hole Diameter: Ø7 mm
Compatible Powder Size: 50–150 μm
Powder Feed Rate: 1–45 g/min
Cooling Water Flow Rate: ≥2.5 L/min
Connection Type: Standard Interface (Greenstone)
Powder Splitter: 1-to-3 Divider



Standard Ultra-High-Speed Coaxial Annular Nozzle

Model: CC-0406-01
Material: Brass
Compatible Laser Power: ≤3 kW
Weight: 0.62 kg
Powder Flow Pattern: Annular
Powder Focal Height: 6–7 mm
Powder Spot Diameter: 0.6–1.0 mm
Through Hole Diameter: Ø4.3 mm
Compatible Powder Size: 50–150 μm
Powder Feed Rate: 1–45 g/min
Cooling Water Flow Rate: ≥1.5 L/min
Connection Type: Standard Interface (Greenstone)
Powder Splitter: 1-to-3 Divider

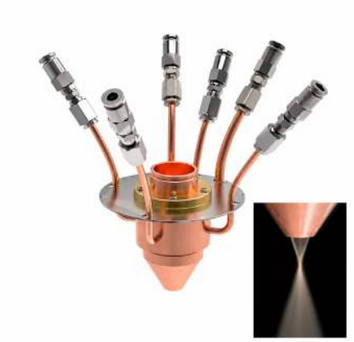


Ultra-High-Speed Coaxial Annular Nozzle

Model: CC-0408-01
Material: Brass
Compatible Laser Power: ≤3 kW
Weight: 0.62 kg
Powder Flow Pattern: Annular
Powder Focal Height: 7–9 mm
Powder Spot Diameter: 0.8–1.5 mm
Through Hole Diameter: Ø4.2 mm
Compatible Powder Size: 25–150 μm
Powder Feed Rate: 1–45 g/min
Cooling Water Flow Rate: ≥1.5 L/min
Connection Type: Standard Interface (Greenstone)
Powder Splitter: 1-to-3 Divider

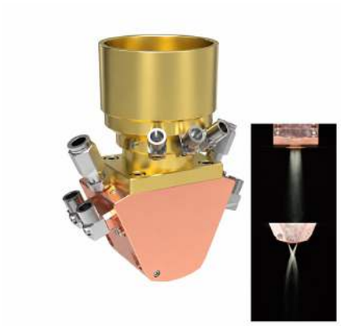
Other Specialty Nozzle Series

The Greenstone Other Specialty Nozzle Series includes coaxial and off-axis nozzle solutions designed for specialized laser cladding applications. Covering linear powder flow, ultra-fine deposition, and wide-beam processing, these nozzles provide flexible options for different component geometries, deposition widths, and laser power ranges. Engineered for stable powder delivery, high deposition efficiency, and reliable coating quality, they are ideal for precision repair, surface engineering, additive manufacturing, and industrial remanufacturing across a wide range of materials and applications.



Long Focal Length Coaxial Annular Nozzle

Model: CC-7520-02
Type: Coaxial
Number of Powder Ports: 2
Powder Flow Pattern: Annular
Dimensions: 100 × 114.5 × 49 mm
Cooling Method: Water Cooling
Powder Spot Diameter: 1.5–2.5 mm
Working Distance: 19–23 mm
Compatible Powder Size: 53–150 μm
Powder Feed Rate: 1–45 g/min
Weight: 0.62 kg
Recommended Laser Power: ≤8 kW

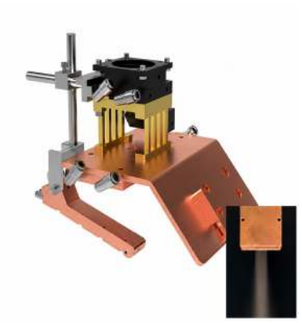


Coaxial Linear Nozzle

Model: CC-1012 (10–15)-01
Type: Coaxial
Number of Powder Ports: 2
Powder Flow Pattern: Linear
Linear Powder Stream Length: 6–24 mm
Linear Powder Stream Width: 2–4 mm
Cooling Method: Water Cooling
Working Distance: 12.2 mm
Compatible Powder Size: 50–200 μm
Powder Feed Rate: 30–200 g/min
Weight: 0.95 kg
Recommended Laser Power: 3–10 kW

Off-Axis Nozzle (Circular Spot)

Model: SO Series
Type: Off-Axis
Minimum Powder Feed Diameter: 1.5–2.0 mm
Recommended Laser Power: ≤6 kW
Cooling Method: Water Cooling
Working Distance: 10–15 mm
Compatible Powder Size: 50–200 μm



Off-Axis Nozzle (Linear Spot)

Model: SL Series
Type: Off-Axis
Powder Stream Length: 5–22 mm
Recommended Laser Power: 3–10 kW
Cooling Method: Water Cooling
Working Distance: 10–15 mm
Compatible Powder Size: 50–200 μm

Laser Processing Components
Powder Feeder

The Greenstone Intelligent Powder Feeder Series is engineered for high-precision laser material processing, delivering stable long-distance powder transport for laser cladding, Directed Energy Deposition (DED), laser metal additive manufacturing, and thermal spraying applications. Featuring high feeding accuracy, synchronized control, and flexible multi-hopper configurations, the system ensures consistent powder delivery with minimal fluctuation, even over conveying distances of up to 20 meters.

Multiple carrier gas flow rates, adjustable motor speeds, and optional heating, stirring, and dynamic weighing functions enable reliable processing of a wide range of metal powders. The system supports both carrier-gas powder feeding and gravity-assisted feeding modes, providing excellent process stability, repeatability, and production efficiency for demanding industrial applications.

Powder Outlet Block | Powder Inlet Block | Powder Distribution Disc

Item	Single Hopper Powder Feeder	Dual Hopper Powder Feeder	Multi-Hopper Powder Feeder	Gravity Powder Feeder
Configuration	Single Hopper	Dual Hopper	4 / 5 / 6 Hoppers	Single Hopper (Carrier Gas Optional)
Powder Feed Rate	0.4–300 g/min	0.4–300 g/min	0.4–300 g/min	20–50 / 20–400 / 20–300 / 0.1–100 g/min
Feed Rate Accuracy	≤±1%	≤±1%	≤±1%	≤±2%
Operating Pressure	0.2–0.6 MPa	0–0.6 MPa	0–0.6 MPa	0–0.6 MPa
Carrier Gas Flow Rate	1–15 L/min	1–15 L/min	1–15 L/min	-
Heating Temperature	N/A / 0–65°C	0–65°C	0–65°C	-
Hopper Capacity	1.5 L / 5 L	1.5 L / 5 L	1.5 L / 5 L	1.5 L / 5 L
Compatible Powder Size	20–300 μm	20–300 μm	20–300 μm	20–300 μm
Drive Motor	Stepper Motor	Servo Motor	Servo Motor	DC Motor
Optional Functions	Stirring & Heating	Stirring, Heating & Dynamic Weighing	Stirring, Heating & Dynamic Weighing	Roller / Electromagnetic / Screw / Linear Feeding
Communication Interface	I/O	I/O, AI, Profinet, Modbus	AI, Profinet, Modbus	-

Advanced Powder Feeding Technologies

Greenstone continuously advances powder feeding technology to improve precision, flexibility, and production efficiency for laser material processing. The system supports closed-loop dynamic weighing control with an accuracy of ±0.5 g, enabling highly stable powder delivery. Modular multi-channel powder feeding allows quick hopper switching without interrupting production, while the continuous refill system enables uninterrupted operation during long processing cycles. Optimized for ultra-fine powders, the feeder accurately delivers metallic and non-metallic powders down to 2 μm. For low feed-rate applications, it provides a closed-loop feeding range of 1–30 g/min, a 2 kg load capacity, and supports multi-hopper integrated configurations for demanding industrial and additive manufacturing processes.

Ultra-Fine Powder Feeder Series

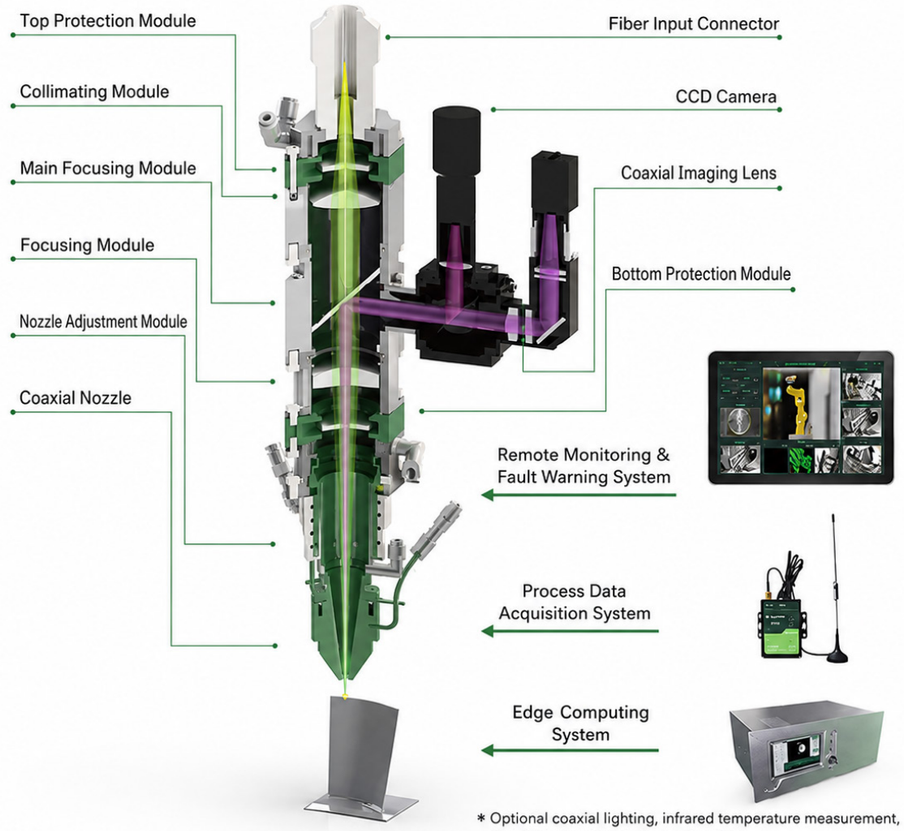
The Greenstone Ultra-Fine Powder Feeder Series is specifically developed for high-precision processing of ultra-fine powders, non-metallic powders, alloy powders, crystalline powders, and continuous high-volume powder feeding applications. To overcome the challenges of stable micro-powder delivery, the series includes Ultra-Fine Powder Feeders, Electromagnetic Powder Feeders, and Inert Gas-Protected Powder Feeders, delivering exceptional feeding stability, repeatability, and process accuracy. These systems have been successfully validated across multiple industries and are ideally suited for precision laser cladding, DED metal additive manufacturing, thermal spraying, and advanced materials research.

Ultra-Fine Powder Feeder

Electromagnetic Disc Powder Feeder

Reactive Powder Feeder (Inert Gas Protected)

Laser Processing Systems
Intelligent Monitoring System & Softwares



Greenstone Intelligent Laser Cladding Software Suite

The Greenstone CAAM (Computer-Aided Additive Manufacturing) software suite provides a complete digital workflow for laser cladding, Directed Energy Deposition (DED), and metal additive manufacturing. It integrates intelligent process planning, real-time sensing, adaptive control, and quality management into a unified platform, enabling higher process reliability, automation, and production efficiency.

The software combines multiple intelligent modules—including ImageSense process monitoring, SmartVision visual positioning, DynamiHeat thermal control, and ScanPath slicing and toolpath planning—to support every stage from part preparation to final quality verification. Through closed-loop process control and digital manufacturing technologies, Greenstone ensures stable deposition quality, optimized process consistency, and simplified production management.

Integrated Digital Manufacturing Workflow

Design
* Expert Process Database & AI-Assisted Parameter Recommendation
* 3D CAD Model Import
* Repair Region Definition
* Process Configuration

Preparation
* Automatic Slicing & Toolpath Planning (ScanPath)
* Smart Vision Positioning (SmartVision)
* Adaptive Repair Planning
* Process Simulation

Pre-Processing
* Intelligent Temperature Control (DynamiHeat)
* CNC System User Interface
* Process Parameter Verification
* Equipment Initialization

Printing
* Real-Time Melt Pool Monitoring (ImageSense)
* Closed-Loop Process Control
* Thermal Field Monitoring
* Automatic Process Adjustment

Post-Processing
* Equipment Status Monitoring
* Process Data Analysis
* Manufacturing Report Generation

Quality Control
* Process Data Storage
* Digital Twin Traceability
* Production Quality Evaluation

Delivery
* Manufacturing Execution System (MES) Integration
* Complete Production Records
* Process Traceability & Quality Documentation

Core Intelligent Software Modules

ImageSense™

Real-time melt pool monitoring and closed-loop process control. The system continuously captures melt pool geometry and process behavior to automatically optimize deposition quality and process stability.

SmartVision™

Machine vision-based positioning and alignment system for accurate workpiece localization, automatic feature recognition, and adaptive laser processing.

DynamiHeat™

Intelligent thermal monitoring module that continuously measures temperature distribution during processing, preventing overheating while maintaining consistent metallurgical quality.

ScanPath™

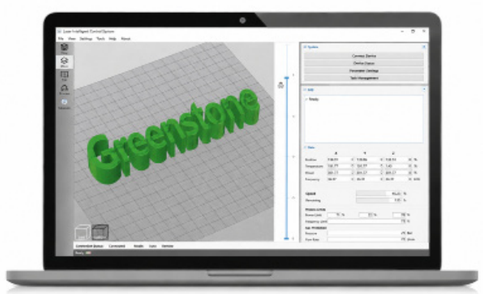
Automatic slicing and toolpath generation software supporting complex 3D geometries, repair paths, and optimized deposition strategies for additive manufacturing applications.

Key Features

* Fully integrated digital workflow from design to production
* AI-assisted process database and parameter optimization
* Automatic slicing and intelligent toolpath planning
* Machine vision positioning and adaptive repair technology
* Real-time melt pool monitoring with closed-loop control
* Intelligent thermal monitoring and temperature feedback
* Equipment status monitoring and predictive maintenance
* CNC-based user interface for intuitive operation
* Complete process data recording and digital twin traceability
* Manufacturing Execution System (MES) compatibility

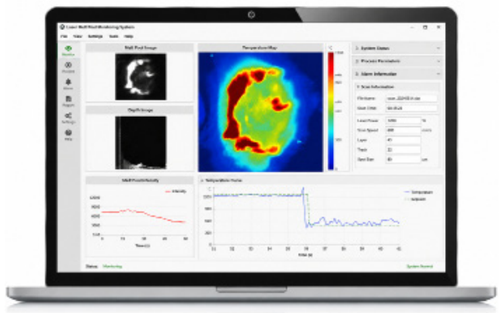
Advantages

* Higher process consistency and repeatability
* Reduced operator dependency
* Improved deposition quality and dimensional accuracy
* Intelligent adaptive control for complex geometries
* Enhanced production efficiency through automation
* Complete digital traceability for industrial manufacturing
* Scalable architecture supporting laser cladding, DED, repair, and hybrid manufacturing applications



ScanPath™ Slicing & Toolpath Planning System

The ScanPath™ software provides intelligent model slicing and toolpath generation for laser additive manufacturing. Supporting multiple 3D file formats, it automatically optimizes deposition paths, process parameters, and material usage based on part geometry and manufacturing requirements, delivering high-precision, high-efficiency production with reduced material waste.



ImageSense™ Melt Pool Closed-Loop Control System

ImageSense™ captures real-time infrared images of the melt pool and continuously monitors thermal behavior during deposition. With intelligent threshold analysis, multi-point temperature measurement, process trend visualization, and historical data management, the system enables adaptive process control, improves deposition consistency, and provides reliable quality traceability.

DynamiHeat™ Thermal Closed-Loop Control System

DynamiHeat™ intelligently controls heating, heat preservation, and cooling throughout the manufacturing process. Working together with the melt pool monitoring system, it automatically adjusts thermal cycles according to material characteristics and process conditions, ensuring stable metallurgical quality, minimizing residual stress, and improving overall process reliability.

Multi-Source Data Acquisition & Analytics System

The Greenstone multi-source data platform synchronously collects temperature, flow, image, and process data from edge devices, remote gateways, and cloud services. Through real-time analytics and digital twin technologies, it supports predictive maintenance, process optimization, full production traceability, and intelligent manufacturing management.

Multi-Sensor Data Acquisition & Analysis Platform

The multi-sensor platform integrates thermal, vision, spectral, and process sensors into a unified monitoring system. By continuously analyzing key manufacturing parameters in real time, it generates visual process reports, supports intelligent decision-making, and ensures stable, repeatable, and high-quality laser additive manufacturing throughout the entire production cycle.

03. Laser Processing Services

Engineering, Manufacturing and Remanufacturing Services

Surface Additive Manufacturing
Conventional Laser Cladding

Technology Overview

Conventional laser cladding is a mature surface engineering technology that deposits high-performance metallic materials onto component surfaces using a focused high-energy laser beam. The coating material and substrate are simultaneously melted to form a dense metallurgical bond with low dilution and minimal thermal distortion.

The process significantly improves wear resistance, corrosion resistance, oxidation resistance, and high-temperature performance while restoring worn or damaged components to their original dimensions. It is widely applied in the repair, remanufacturing, and surface enhancement of high-value industrial components across aerospace, gas turbines, steel and metallurgy, rail transportation, energy, mining, and defense industries.

Service Advantages

High Dimensional Accuracy
Powered by the Greenstone ImageSense™ intelligent monitoring system, cladding geometry is precisely controlled with dimensional accuracy up to ±0.25 mm and coating thickness accuracy up to ±0.10 mm.

Extended Component Service Life
The metallurgical bond between the coating and substrate provides significantly higher bonding strength than conventional surface coatings, greatly extending component service life.

Enhanced Fatigue Resistance
Combined with DynamiHeat™ intelligent thermal control and advanced alloy materials, the process minimizes residual stress and thermal deformation while maximizing fatigue performance.

Complete Engineering Solutions
Greenstone provides complete turnkey solutions covering process development, equipment integration, material selection, repair services, and surface enhancement for critical industrial components.

100% In-House Core Technology
All core laser cladding equipment, software, process technologies, and control systems are independently developed by Greenstone, ensuring excellent reliability, flexibility, and long-term service support.

Industry-Leading Technology
With extensive engineering experience and proprietary laser processing technologies, Greenstone delivers high-performance laser cladding solutions trusted for demanding repair and remanufacturing applications worldwide.

Application Case

Forging Die Repair

Workpiece Material: 5CrNiMo Tool Steel

Process Requirements

* Cladding thickness: 10 mm
* Minimum machining allowance: ≥3 mm
* Hardness after tempering: ≥45 HRC
* Excellent impact, high-temperature, and wear resistance

Service Result

The damaged forging die was successfully restored using Greenstone conventional laser cladding technology. The repaired surface achieved excellent metallurgical bonding, uniform coating quality, and outstanding mechanical performance, significantly extending component service life while reducing maintenance costs and production downtime.

Surface Additive Manufacturing
Ultra-High-Speed Laser Cladding

Technology Overview

Greenstone Ultra-High-Speed Laser Cladding (EHLA) technology is designed for the rapid surface enhancement and remanufacturing of cylindrical components with various diameters and lengths. Unlike conventional laser cladding, the coating material is melted before reaching the substrate, enabling ultra-high deposition speeds while producing dense metallurgically bonded coatings with extremely low dilution, minimal heat input, and negligible substrate deformation.

The process delivers outstanding coating quality, high dimensional accuracy, and excellent surface finish with virtually no thermal damage to the base material. It is particularly suitable for large-area surface restoration and functional coating applications, significantly reducing production costs, shortening maintenance cycles, and extending component service life. Greenstone EHLA technology also enables the manufacture of innovative wear-resistant components with minimal lifetime degradation.

Technical Advantages

One-Step Near-Net-Shape Manufacturing
Combines ultra-high-speed cladding with precision machining to maximize production efficiency and minimize post-processing requirements.

Longer Coating Service Life
Dense metallurgical coatings with ≥99% density provide outstanding wear resistance, corrosion protection, and significantly longer component lifetime.

Laser Direct Energy Deposition Technology
Supports coating thicknesses from 100 μm up to 1,000 μm, providing flexible solutions for precision surface engineering.

Minimal Thermal Distortion

Extremely low heat input greatly reduces the heat-affected zone, minimizing residual stress, deformation, and crack formation compared with conventional cladding.

Lower Manufacturing Cost

High material utilization and exceptional deposition efficiency reduce processing costs to levels comparable with hard chrome plating while delivering superior performance.

Ultra-High Processing Speed

Deposition efficiency is up to two orders of magnitude faster than conventional laser cladding, making EHLA ideal for high-volume industrial production.

Application Case

Hydraulic Cylinder Rod Surface Remanufacturing

Process Requirements

* Dense metallurgical bonding between coating and substrate with no cracks, pores, or unmelted defects
* Coating thickness greater than 0.6 mm
* Deposition speed of ≥4 m²/h
* Excellent wear resistance, corrosion resistance, and fatigue performance for demanding industrial applications

Service Result

Using Greenstone Ultra-High-Speed Laser Cladding technology, the hydraulic cylinder rod achieved a uniform, high-density coating with exceptional metallurgical quality and dimensional consistency. The repaired surface fully met industrial service requirements while significantly reducing repair time, manufacturing cost, and equipment downtime.

Surface Additive Manufacturing Laser Wire Cladding

Technology Overview

Laser Wire Cladding is an advanced Directed Energy Deposition (DED) process that feeds metallic wire directly into the laser-generated molten pool to produce dense metallurgically bonded coatings with virtually 100% material utilization. Compared with powder-based cladding and conventional arc welding, the process offers lower dilution, finer microstructures, minimal thermal distortion, and superior bonding strength while significantly reducing post-machining requirements.

Greenstone Laser Wire Cladding is ideal for large-area surface restoration, wear-resistant coatings, corrosion protection, and precision remanufacturing. The clean, environmentally friendly process minimizes material waste and delivers consistent coating quality, making it suitable for demanding industrial applications requiring high efficiency, long service life, and sustainable manufacturing.

Equipment Advantages

Optimized for Large Components
Designed for large-area and long-seam applications with robotic automation, multi-axis coordination, and flexible positioning for complex geometries.

High-Efficiency Robotic Integration
Supports automated welding stations with quick setup, improving production efficiency while reducing manual intervention and tooling time.

Precision Laser Energy Control
High-power laser technology delivers stable heat input, accurate deposition, and excellent dimensional consistency for demanding industrial applications.

Superior Surface Finish
Produces smoother, cleaner coatings than conventional arc welding, minimizing post-processing and improving final component appearance.

Cost-Effective and Sustainable
100% wire utilization, repeatable processing, low operating costs, minimal spatter, and environmentally friendly manufacturing without powder contamination.

Process Performance

Cu-Based Alloy Wire Cladding
Greenstone utilizes copper-based alloy wire to achieve highly stable cladding performance with excellent metallurgical quality.

Typical Results
* Coating thickness: Approximately 2.8 mm
* Deposition efficiency: Approximately 0.17 m²/h, comparable to conventional arc welding productivity
* Dense metallurgical bonding with no unfused defects or porosity
* Uniform diffusion layer between coating and substrate
* Bonding strength exceeding 90 MPa, verified through tensile testing

Application Case

Automotive Rear Axle Laser Wire Cladding

Greenstone Laser Wire Cladding technology has been successfully applied to automotive rear axle remanufacturing, producing dense metallurgically bonded coatings with excellent wear resistance, fatigue performance, and dimensional accuracy. The process significantly extends component service life while reducing manufacturing costs and improving production efficiency for high-volume industrial applications.

Surface Additive Manufacturing On-Site Repair

Rapid On-Site Repair Solution

For large, heavy, or difficult-to-transport components requiring urgent maintenance, Greenstone provides integrated mobile laser cladding systems specifically designed for on-site repair. The solution combines laser processing equipment, robotic automation, and portable positioning platforms to perform high-quality repairs directly at customer facilities, eliminating costly transportation and lengthy equipment downtime.

The mobile platform features heavy-duty omnidirectional wheels, precision lifting mechanisms, segmented transport modules, and a stable support structure. It can be quickly deployed on uneven industrial surfaces, delivering reliable laser cladding with high dimensional accuracy, excellent metallurgical bonding, and consistent restoration quality.

Cost & Downtime Comparison
Using a cement support roller repair as an example:

Repair Method	Direct Cost	Repair Time	Spare Inventory Required	Potential Risks
Component Replacement	USD 40,000–70,000	Approximately 15 Days	Yes	Long procurement cycle, transportation risk, installation alignment issues
Greenstone Laser Repair	Approximately USD 14,000	Approximately 7 Days	No	Minimal heat input with controlled laser processing

Application Case

Greenstone mobile laser cladding technology has been successfully deployed across a wide range of heavy industries for emergency maintenance and large-component restoration, including:

*** Hydropower Turbine Runner Surface Reinforcement**
*** On-Site Repair of Ship Bottom Structures**
*** On-Site Repair of Metallurgical Guide Rolls**
*** Laser Cladding Repair for Rolling Mill Components**

The solution significantly reduces maintenance costs, shortens downtime, minimizes logistics requirements, and extends the service life of critical industrial equipment while ensuring stable, high-quality repair performance in demanding field environments.

Surface Enhancement & Modification Laser Functional Coatings & Laser Alloying

Technology Overview

Greenstone has extensive expertise in laser surface engineering and remanufacturing technologies. Building on years of industrial experience, we have developed a comprehensive portfolio of advanced surface enhancement solutions, including Laser Alloying, Laser Particle-Reinforced Alloying, and Laser Carbide Composite Coatings.

These technologies create dense metallurgically bonded functional surfaces with significantly improved hardness, wear resistance, corrosion resistance, and fatigue performance. They are widely applied to metallurgical rolls, heavy industrial components, energy equipment, and other critical parts requiring extended service life and enhanced operating reliability.

Typical Applications

Laser Alloying for Roughing Rolls

Material: 150CrNiMo & 220CrNiMo Steel
Process: Laser Alloying
Performance: Surface hardness increased by 70–120%, significantly improving wear resistance and roll service life.

Laser Alloying for Descaling Rolls

Material: Medium & Low Alloy Cast Iron
Process: Laser Alloying
Performance: Surface hardness increased by approximately 100%, providing excellent resistance to abrasion and thermal fatigue.

Laser Alloying for Core Bars

Material: 40CrNiMo Alloy Steel
Process: Laser Alloying
Performance: Surface hardness increased by approximately 50%, enhancing durability under continuous high-load operation.

Wear-Resistant Laser Coating

Material: Q235 Carbon Steel
Process: Laser Cladding
Performance: 65% WC composite coating with hardness exceeding HRC 60, dramatically improving wear resistance and extending component service life.

Laser Reinforcement for Sealing Rings

Material: 45# Steel
Process: Laser Cladding
Performance: 30% WC composite coating significantly improves surface hardness, wear resistance, and long-term sealing performance.

Laser Reinforcement for Critical Compressor Components

Material: Cast Iron Components
Process: Laser Cladding with WC Composite Alloy
Performance: High-hardness WC-reinforced coatings greatly enhance abrasion resistance, surface hardness, and operational reliability under severe working conditions.

Surface Enhancement & Modification
Laser Hardening

Technology Overview

Greenstone Laser Hardening is an advanced surface heat treatment process that utilizes a high-energy laser beam to rapidly heat the workpiece surface, followed by self-quenching through the base material without the need for water, oil, or other external cooling media. Compared with induction hardening, flame hardening, and carburizing, laser hardening provides significantly higher surface hardness, minimal heat-affected zones, excellent dimensional stability, and precise control of hardening depth.

The process is particularly suitable for high-precision components where distortion must be minimized while achieving superior wear resistance, fatigue strength, and service life. With intelligent closed-loop process control and real-time temperature monitoring, Greenstone delivers highly consistent hardening quality for demanding industrial applications.

Technical Advantages

Environmentally Friendly Process
A clean, pollution-free heat treatment technology requiring no quenching oil, water, or chemical cooling media.

Localized Precision Hardening
Highly focused laser energy enables selective hardening of specific functional areas without affecting surrounding material.

Improved Surface Performance
Significantly enhances surface hardness, wear resistance, fatigue strength, and component durability while maintaining core toughness.

Stable Temperature Control
Real-time infrared temperature monitoring and closed-loop process control ensure uniform heating and consistent hardening quality.

Intelligent Closed-Loop Control
Integrated intelligent control system continuously optimizes laser parameters to ensure stable, repeatable processing.

Minimal Component Distortion
Low heat input and a narrow heat-affected zone greatly reduce thermal deformation, making the process ideal for precision molds and critical mechanical components.

Surface Enhancement & Modification
Laser Cleaning

Technology Overview

Greenstone Laser Cleaning is an advanced non-contact surface treatment technology that utilizes high-energy laser beams to precisely remove rust, oxides, paint, grease, coatings, and other contaminants from metal surfaces. Through rapid laser-material interaction, unwanted surface layers are instantly vaporized or detached without damaging the base material, delivering an efficient, environmentally friendly, and highly controllable cleaning process.

Compared with traditional mechanical, chemical, or abrasive cleaning methods, laser cleaning requires no consumables or chemical agents, generates minimal waste, and offers exceptional precision for industrial manufacturing, maintenance, remanufacturing, and surface preparation applications.

Technical Advantages

Eco-Friendly Process
No chemicals, solvents, abrasive media, or secondary cleaning agents are required, enabling a clean and sustainable manufacturing process.

Easy Waste Recovery
Cleaning residues consist primarily of dry particulate matter that can be efficiently collected through industrial dust extraction systems.

No Secondary Contamination
Completely non-contact processing eliminates abrasive residues, chemical pollution, and cross-contamination.

Safe & Operator Friendly
Low-noise operation with no hazardous chemical exposure provides a safer and healthier working environment.

No Damage to the Base Material
Laser parameters can be precisely adjusted to selectively remove contaminants while preserving the substrate and maintaining dimensional accuracy.

Low Maintenance Cost
Highly automated operation with minimal consumables significantly reduces operating and maintenance expenses.

Application Case

Greenstone Laser Cleaning technology is widely used for precision surface preparation and industrial maintenance, including:

*** Mold Surface Cleaning**
*** Pipe Coating Removal**
*** Large Precision Machinery Rust Removal**
*** Metal Surface Degreasing & Oil Removal**

The technology provides fast, repeatable, and environmentally responsible cleaning solutions that improve production efficiency while preserving the integrity of high-value components.

Metal Additive Manufacturing
Powder-Fed 3D Printing

Technology Overview

Greenstone Powder-Fed Metal 3D Printing is an advanced Directed Energy Deposition (DED) technology that delivers high deposition efficiency, virtually unlimited build size, and exceptional material flexibility. By synchronously feeding metal powder into a laser-generated molten pool, the process forms fully dense, metallurgically bonded components with mechanical properties comparable to forged materials.

Compared with conventional metal additive manufacturing technologies, powder-fed DED enables multi-material deposition, functionally graded structures, component repair, feature addition, and large-scale manufacturing within a single platform. It is particularly suitable for aerospace, energy, heavy industry, mold manufacturing, and high-value component remanufacturing.

Experimental Verification

Material Validation
Material: AISI 10Mg Aluminum Alloy
Greenstone successfully manufactured dense aluminum alloy specimens using powder-fed DED technology, demonstrating excellent material compatibility, stable deposition quality, and reliable metallurgical bonding.

Hardness Evaluation
Hardness testing confirms highly consistent mechanical properties throughout the deposited material. The results demonstrate stable process control and uniform microstructural characteristics suitable for demanding industrial applications.

Metallographic Analysis
Metallographic inspection verifies complete metallurgical bonding between the deposited material and substrate. The coating exhibits a dense microstructure with no visible cracks, porosity, or lack-of-fusion defects, ensuring outstanding mechanical integrity and long-term reliability.

Representative Printed Components

Greenstone Powder-Fed Metal 3D Printing has been successfully applied to the manufacture and repair of a wide range of complex metal components, including:

* **CAD Model to Finished Part Manufacturing**
* **Complex Metal 3D Printed Components**
* **Precision Machined Functional Parts**
* **Closed-Loop Repair Additive Manufacturing**
* **Large-Scale Additive Structures**
* **Functional Deposition Test Samples**

The technology enables rapid production of complex geometries, high material utilization, and flexible manufacturing for both new part fabrication and high-value component remanufacturing, making it an ideal solution for advanced industrial production.

Metal Additive Manufacturing
Powder Bed Fusion (PBF) 3D Printing

Technology Overview

Since 2014, Greenstone has been providing professional metal Powder Bed Fusion (PBF) additive manufacturing services for customers worldwide. Leveraging years of expertise in aerospace, energy, advanced manufacturing, and metallic materials, we offer complete end-to-end solutions covering design optimization, process development, additive manufacturing, heat treatment, precision machining, and final inspection.

Our PBF capabilities support a wide range of engineering materials, including stainless steel, aluminum alloys, titanium alloys, nickel-based superalloys, cobalt-chromium alloys, copper alloys, and silicon carbide, enabling the production of high-precision, lightweight, and geometrically complex metal components for demanding industrial applications.

SLM Manufacturing Workflow

Greenstone provides a complete Powder Bed Fusion manufacturing process to ensure optimal part quality and production efficiency.

↓ 1. Design Analysis
Evaluate component geometry, optimize structures, and identify features suitable for additive manufacturing.
↓ 2. Build Preparation
Generate support structures, determine optimal build orientation, and perform slicing and process parameter optimization.
↓ 3. Additive Manufacturing
Produce high-density metal components using precision laser powder bed fusion technology with excellent dimensional accuracy.
↓ 4. Post-Processing
Perform support removal, heat treatment, surface finishing, CNC machining, and quality inspection according to application requirements.
↓ 5. Final Assembly & Delivery
Complete precision assembly, functional verification, and final quality assurance before product delivery.

Typical Applications

Greenstone Powder Bed Fusion technology is widely applied in the manufacture of high-value, high-performance metal components, including:

* **Precision Molds & Tooling**
* **Gears, Shafts & Transmission Components**
* **Aerospace Engine Components**
* **Oil & Gas Drilling Components**
* **Medical & Biomedical Implants**
* **Complex Lightweight Structural Parts**

With excellent dimensional accuracy, outstanding surface quality, and the ability to manufacture intricate geometries impossible with conventional methods, Greenstone delivers reliable metal additive manufacturing solutions for the most demanding industrial applications.

04. Core Technologies

Innovative Processes and Key Components

Greenstone Laser Cladding Core Technologies
Laser Cladding Optical Path Design

Laser cladding is governed by the precise interaction of four critical factors: laser energy, powder delivery, shielding gas flow, and the molten pool. Among these, laser beam energy distribution plays a decisive role in process stability, deposition quality, and manufacturing efficiency.

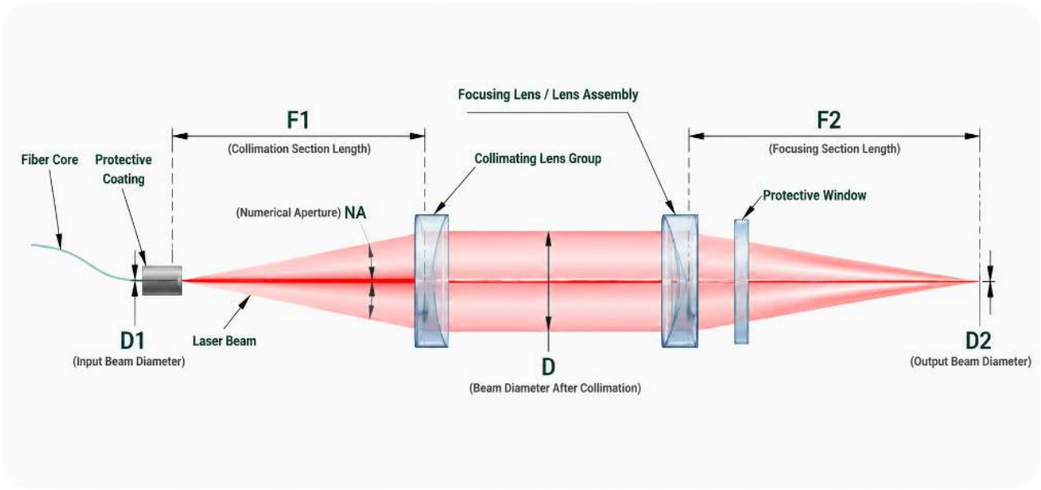
Greenstone has developed proprietary optical path technologies capable of precisely shaping laser energy from conventional Gaussian or quasi-Gaussian distributions into highly uniform Top-Hat profiles. By generating circular, ring-shaped, square, rectangular, or customized beam geometries, our optical systems optimize powder utilization, improve molten pool stability, and support applications ranging from ultra-high-speed laser cladding to precision additive manufacturing and wide-area surface treatment.

Transmissive Optical Path

Laser Sources
Compatible with fiber lasers, diode-pumped fiber-coupled lasers, and disk lasers.

Basic Optical Configuration
Dual-lens collimation combined with single- or dual-lens focusing modules and a protective window.
Additional protective lenses can be integrated according to operating conditions and process requirements.

Typical Applications
* Transmissive coaxial ring-shaped laser cladding
* Transmissive coaxial needle-type laser cladding
* Transmissive off-axis laser cladding

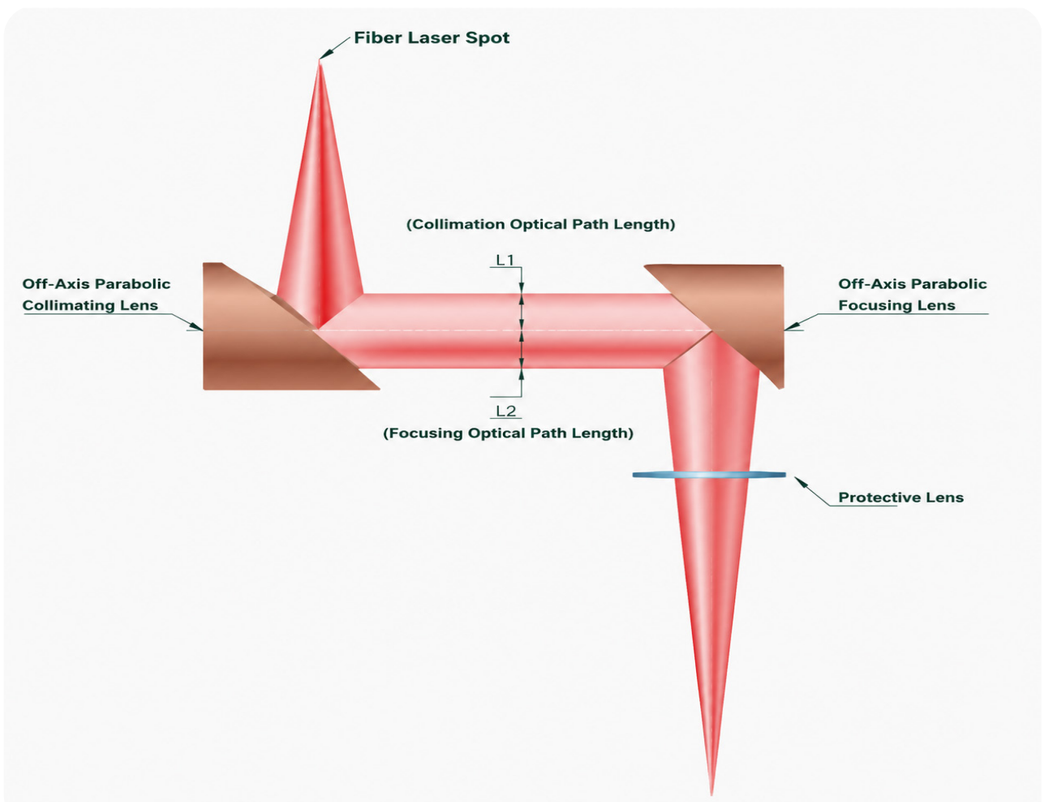


Reflective Optical Path

Laser Sources
Compatible with fiber lasers, diode-pumped fiber-coupled lasers, and disk lasers.

Basic Optical Configuration
Off-axis parabolic collimating mirror combined with an off-axis parabolic focusing mirror and protective window. The optical system can also be configured with a beam homogenizing integrator to generate a highly uniform Top-Hat laser spot for demanding processing applications.

Typical Applications
* Reflective coaxial ring-shaped laser cladding
* Reflective coaxial needle-type laser cladding
* Reflective coaxial wide-band laser cladding
* Reflective off-axis wide-band laser cladding

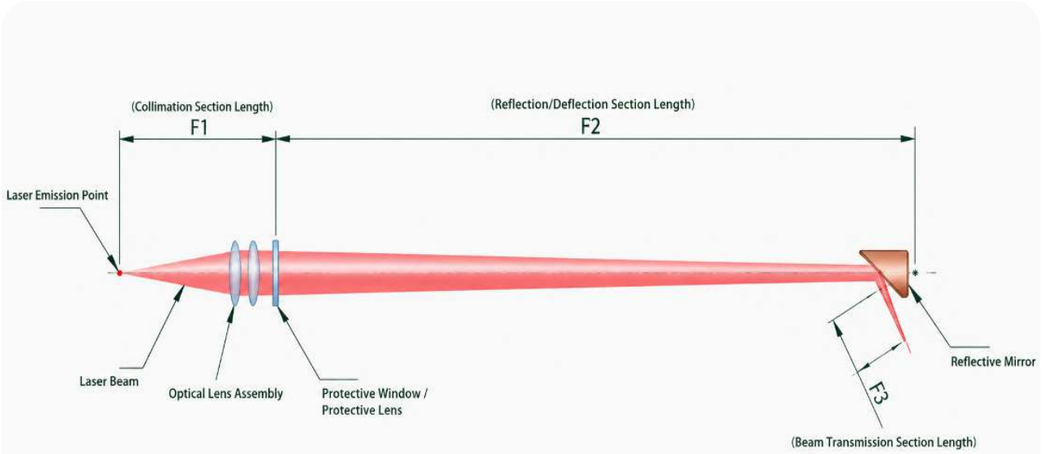


Internal Optical Path

Laser Sources
Compatible with fiber lasers, diode-pumped fiber-coupled lasers, and disk lasers.

Basic Optical Configuration
Collimating lens combined with an off-axis parabolic focusing mirror and protective window. A beam homogenizing integrator may be incorporated to achieve highly uniform energy distribution for internal surface processing.

Typical Applications
* Internal-wall reflective coaxial ring-shaped laser cladding
* Internal-wall reflective coaxial needle-type laser cladding
* Internal-wall reflective off-axis wide-band laser cladding



High-Quality Optical Components

Greenstone integrates premium optical components into every laser cladding system to maximize beam quality, energy efficiency, and long-term operational reliability. Our optical assemblies include precision focusing mirrors, roof mirrors, beam homogenizers, spherical mirrors, protective windows, and other critical beam delivery components manufactured to ultra-high precision standards.

Reflective optics and beam homogenizers are produced from oxygen-free high-conductivity copper (OFHC), providing excellent thermal conductivity, high reflectivity, low optical loss, and outstanding long-term thermal stability. Each component undergoes precision heat treatment to maintain dimensional accuracy during continuous high-power operation.

All reflective optical surfaces are ultra-precision machined on air-bearing diamond-turning equipment, achieving sub-micron form accuracy and nanometer-level surface roughness. Advanced vacuum-deposited optical coatings further enhance reflectivity, polarization performance, scratch resistance, oxidation resistance, and overall service life.

To ensure reliable operation under multi-kilowatt laser power, every reflective optical module incorporates an optimized internal water-cooling structure. Precision cooling channels efficiently dissipate thermal loads while hermetically sealed mirror assemblies provide excellent mechanical strength and long-term durability. Quick-connect water interfaces enable rapid maintenance and convenient replacement of optical modules.

Combining proprietary optical path design, advanced beam-shaping technology, premium optical materials, and precision manufacturing, Greenstone delivers industry-leading laser cladding optical systems with exceptional beam stability, high energy utilization, superior processing quality, and outstanding reliability for industrial laser cladding, laser hardening, laser additive manufacturing, and laser surface engineering applications.

Greenstone Laser Cladding Core Technologies
Laser Cladding Coating Development

Greenstone's Laser Cladding Coating Development Center combines advanced laser cladding equipment, comprehensive powder technology, and experienced process engineering to accelerate the development of high-performance coating solutions. From feasibility studies and process optimization to pilot production and technology transfer, we provide customers with complete technical support throughout the entire coating development cycle, helping shorten development time while improving coating performance, manufacturing efficiency, and product reliability.

Comprehensive Development Services

Our coating development capabilities include:
* Laser cladding coating design and development
* Powder selection, evaluation, and optimization
* Prototype development and pilot production
* Process database establishment
* Technical training and knowledge transfer
* Collaborative process development and validation for universities and research institutes

Laser Cladding Coating Development

Leveraging advanced processing equipment, optimized laser parameters, and extensive application experience, Greenstone develops customized laser cladding coatings tailored to specific materials and service conditions. Our engineering team determines the optimal process window to achieve superior metallurgical bonding, high deposition efficiency, and outstanding wear, corrosion, and heat resistance.

Powder Selection, Evaluation & Optimization

Material performance begins with the right powder. Greenstone evaluates alloy composition, particle size distribution, powder flowability, and application requirements to recommend the most suitable metal powders for each project. Customized powder optimization is also available to maximize coating quality, process stability, and deposition efficiency.

Prototype Development & Pilot Production

We support customers from concept verification through small-batch manufacturing. Prototype development includes process validation, parameter optimization, trial production, quality verification, and production readiness, enabling rapid transition from laboratory development to industrial manufacturing.

Process Database Development

Greenstone continuously builds and expands a comprehensive laser cladding process database covering different substrate materials, alloy powders, and application scenarios. Process parameters, monitoring data, and production records are systematically collected and analyzed to improve repeatability, reduce development time, and provide reliable references for future manufacturing projects.

Technical Training

Comprehensive training programs are available for equipment operation, laser cladding technology, powder handling, parameter optimization, maintenance, troubleshooting, and production management. Both theoretical instruction and practical hands-on training ensure customers achieve rapid deployment and long-term operational success.

Collaborative Research & Process Validation

Greenstone actively collaborates with universities, research institutes, and industrial partners on both fundamental and application-oriented research projects. Our engineering team provides process development, experimental validation, equipment integration, and technical consulting to accelerate innovation in laser cladding, additive manufacturing, and advanced surface engineering technologies.

Greenstone Laser Cladding Core Technologies
Laser Cladding Mechanical Design

Greenstone develops high-performance motion platforms specifically engineered for laser cladding, laser hardening, laser additive manufacturing, and other precision laser processing applications. Combining years of industrial experience with advanced mechanical engineering, our motion systems deliver outstanding positioning accuracy, structural rigidity, operational stability, and long-term reliability. Every platform is fully customized to match the customer's workpiece geometry, production requirements, and automation objectives.

Customization Capabilities

Each motion platform is engineered according to project-specific requirements, including:
* Machine dimensions and working envelope
* Positioning and repeatability accuracy
* Process parameters and production requirements
* Motion speed and acceleration
* Payload capacity
* CNC and automation control systems

Motion System Solutions

Machine-Type Motion Platforms
Greenstone offers a complete range of precision motion platforms, from compact three-axis workstations to multi-axis (6-axis/7-axis) robotic systems and large-scale industrial laser processing equipment, supporting applications from precision repair to heavy-duty manufacturing.

Motion Mechanism Configurations
Available motion architectures include:
* Single-axis horizontal motion
* Single-axis vertical motion
* Dual-axis synchronized motion
* Fixed-axis and variable-axis combinations
* Multi-axis coordinated motion
* Customized kinematic structures

Drive Systems

High-performance servo motors, precision gear transmissions, rack-and-pinion systems, ball screws, linear guideways, and direct-drive technologies are selected according to application requirements, ensuring smooth operation, high dynamic response, and long-term positioning accuracy.

Custom Motion Platforms

Greenstone provides fully customized mechanical solutions for specialized laser processing applications, including oversized workpieces, heavy-load systems, complex geometries, automated production lines, and integrated robotic manufacturing cells.

Core Advantages

High Precision

Rigid mechanical structures combined with precision transmission components deliver exceptional positioning accuracy and repeatability for demanding laser manufacturing applications.

High Load Capacity

Robust structural design supports heavy workpieces, high-power laser heads, multi-axis manipulators, and auxiliary process equipment while maintaining excellent dynamic performance.

Industrial Reliability

Premium mechanical components, optimized structural analysis, and strict manufacturing standards ensure long service life, stable operation, and low maintenance requirements in continuous industrial production.

Flexible Customization

Every motion system can be tailored to specific production processes, automation levels, workpiece dimensions, and future expansion requirements, providing customers with scalable and highly adaptable manufacturing solutions.

Greenstone Laser Cladding Core Technologies
Laser Cladding Intelligent Control

Greenstone's Laser Cladding Intelligent Control System is a fully integrated hardware and software platform designed specifically for laser cladding, laser hardening, laser additive manufacturing, and automated surface engineering. Built upon advanced CNC, PLC, robotics, and industrial communication technologies, the system provides intelligent process management, real-time parameter control, and seamless equipment integration, ensuring stable operation, high productivity, and consistent manufacturing quality.

Core Functions

Integrated Intelligent Control

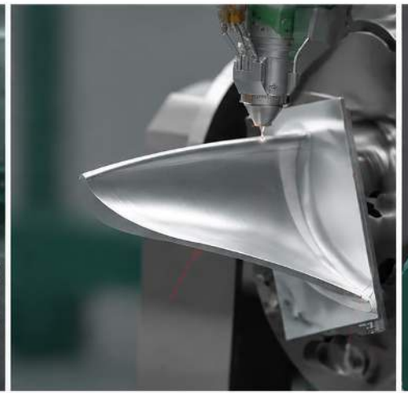
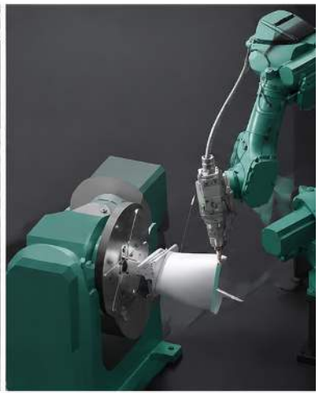
The system combines motion control, laser control, powder feeding, shielding gas management, process monitoring, and safety protection into a unified architecture, enabling synchronized control of the entire laser manufacturing process.

Advanced Process Automation

Automated process execution minimizes operator intervention while intelligently coordinating laser power, travel speed, powder feed rate, gas flow, and auxiliary equipment to maximize production efficiency and repeatability.

Flexible System Integration

Designed with an open architecture, the control platform is fully compatible with CNC systems, PLCs, industrial robots, machine vision, sensors, MES platforms, and external automation equipment for easy expansion and customized manufacturing solutions.

System Features

Human–Machine Interface
An intuitive graphical interface supports local and remote operation, recipe management, parameter adjustment, equipment diagnostics, and production monitoring, improving both usability and operational efficiency.

Advanced Path Planning
Supports 2D and 3D CAD/CAM data processing with intelligent toolpath generation for complex geometries, multi-axis motion, robotic trajectory planning, and additive manufacturing applications.

Real-Time Process Control
Continuously synchronizes laser power, powder delivery, gas flow, motion trajectory, and processing parameters to maintain a stable molten pool and ensure consistent deposition quality throughout production.

Intelligent Process Monitoring
Integrated monitoring functions collect and analyze real-time process data from multiple sensors, enabling automatic adjustment, abnormal condition detection, and continuous optimization during operation.

System Advantages

High Flexibility
Modular software architecture supports a wide range of laser processing applications, equipment configurations, and customized manufacturing processes.

High Precision
Closed-loop control algorithms and high-speed data acquisition ensure precise coordination between motion, laser energy, powder feeding, and auxiliary systems, delivering exceptional processing accuracy and repeatability.

Seamless Integration
The platform easily integrates with industrial robots, CNC controllers, machine vision systems, sensors, MES/ERP systems, and production automation networks, enabling efficient smart manufacturing.

Reliable Quality Assurance
Comprehensive diagnostic functions, multi-sensor data acquisition, real-time monitoring, fault detection, process recording, and automatic alarm mechanisms ensure stable equipment operation, consistent product quality, and full process traceability.

05. Applications & Success Stories

Industry Solutions and Customer Case Studies

—Aerospace—


Low-Pressure Turbine Blade Repair


Aero Engine Casing Repair


Compressor Blade Repair


Spline Shaft Repair


Compressor Blisk Blade Repair


High-Pressure Turbine Blade Repair


Blade Root Repair


Localized Cladding of Single Components

—Cutting Tools & Industrial Knives—


Wheat Harvester Blade Cladding


Corn Harvester Blade Cladding


Pulverizer Blade Cladding


Grass Cutter Blade Cladding


Packaging Paper Slitter Blade Cladding


Cutting Tool Repair


Batch Cutting Tool Cladding


Rotary Tiller Blade Cladding

—Energy & Power—


Thrust Pad Laser Repair


Gear Laser Cladding


Bearing Housing Repair


Runner Wear Plate Repair & Surface Reinforcement


Runner Blade Surface Reinforcement


Bottom Ring On-Site Repair


Power Connector Terminal On-Site Repair


Babbitt Alloy Laser Cladding for Shaft Components


Planet Carrier Laser Cladding Repair


Torque Arm Laser Cladding Repair

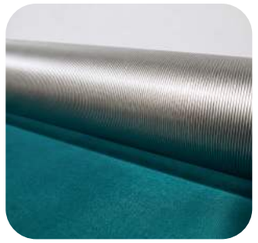

Intermediate Shaft Laser Cladding Repair


High-Speed Gear Laser Cladding Repair


Gas Turbine Blade Build-Up


Blade Repair


Fan Blade Laser Cladding


Boiler Tube Laser Cladding

—Mold Manufacturing—


Automotive Mold Repair


Glass Mold Plunger Laser Cladding


Bumper Stamping Die Repair


Glass Mold Repair

—Mining Equipment—


Hydraulic Support Column Repair


Hydraulic Cylinder Bore Laser Cladding


Sprocket Repair


Pick Cutter Laser Cladding

—Industrial & Construction Equipment—


Shield Machine Bearing Sleeve Repair


Transmission Shaft Laser Cladding


Gear Reducer Gear Repair


CNC Boring Machine Spindle Repair


Piston Rod Repair


Hydraulic Cylinder Bore Reinforcement


Motor Rotor Bore Repair


Compressor Screw Repair

—Shipbuilding Industry—


Piston Head Repair


Pump Shaft Repair


Turbocharger Rotor Repair


Stern Tube Repair


Stern Tube Bearing Sleeve Repair


Transmission Shaft Repair


Piston Rod Repair


Diesel Engine Cylinder Head Repair

—Metallurgical Industry—


Copper Mold Laser Cladding


Overhead Crane Drum Inner Journal Repair

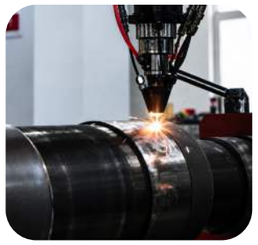

Fan Hub Sleeve Bore Repair


Valve Stem Repair


Hot Rolling Mill Bearing Chock Repair

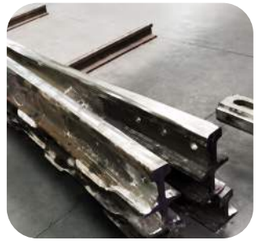

Rolling Mill Roller Repair


Heat Treatment Roller Reinforcement


Metallurgical Roller Repair

—Rail Transportation—


Rail Wheelset Axle Laser Cleaning


Railway Switch Frog Core Repair


Traction Motor End Cover Repair


High-Speed Rail Slide Plate Surface Treatment


Rail Vehicle Shaft Component Repair


Wheel Tread and Wheel Rim Repair


Laser Cleaning of Weld Oxides and Surface Contaminants


Brake Disc Laser Cladding

—Oil & Gas—


Long Shaft Wear Repair


Centralizer Wear Repair


Oilfield Drilling Tool Internal Bore Repair


Hastelloy Impeller Repair


Pressure Compensator Wear Repair


Main Spindle Wear Repair


Laser Cladding of Chemical Fiber Tubes


Ball Valve Laser Cladding

06. Material Solutions

Materials for Laser Cladding and DED Manufacturing

Material Family	Typical Materials	Typical Applications
Iron-Based Alloys	316L, 17-4PH, SS410, 420, 400	Stainless steel repair and component restoration
	H13 (SKD61), P20, P21, CPM	Die casting molds, injection molds
	40Cr, 45#, C160, 42CrMo, 40CrMnMo, 30CrMnSiA, 39CrMoAl	Shafts, gears, and wear-resistant components
	INVAR	Low thermal expansion components
Cobalt-Based Alloys	Stellite 6, 21, 31, Co50, 42	Wear-resistant and corrosion-resistant components
Nickel-Based Alloys	INCONEL 718 (GH4169), 625	Aero-engine components, oil & gas drilling equipment
	Waspaloy (GH738), GH4648, GH3030	Aero-engine components
	CMSX-4, Rene N5, DD6	Single-crystal turbine blades
	Rene 80, Rene 142	Aero-engine turbine disks and blades
	Ni60, Deloro 50, Deloro 60	Aero-engine wear-resistant components
Titanium-Based Alloys	Ti-6Al-4V	Biomedical implants, aero-engines, oil & gas industry
	TiAl	Turbine blades
	TiNi	Medical devices
	TA15, TC17, TC2, TC4	Aerospace components
Aluminum Alloys	AlSi, AlCu, AlMg, AlZn	Railway vehicles, aerospace
Metal Matrix Ceramics	WC, SiC	Wear-resistant applications
Copper-Based Alloys	CuSn12, SnSbCu4, QAl9-4	Plain bearings, hydraulic cylinders
Precious Metals & Refractory Metals	Au, Ag, Pt, W, Mo	Power generation and electrical equipment

GREENSTONE®

Built for Performance Engineered for the Future

Advancing Laser Cladding and Metal Additive Manufacturing for a Better Future