SLM® Medical and Dental Applications

Metal Additive Manufacturing Solutions for Healthcare

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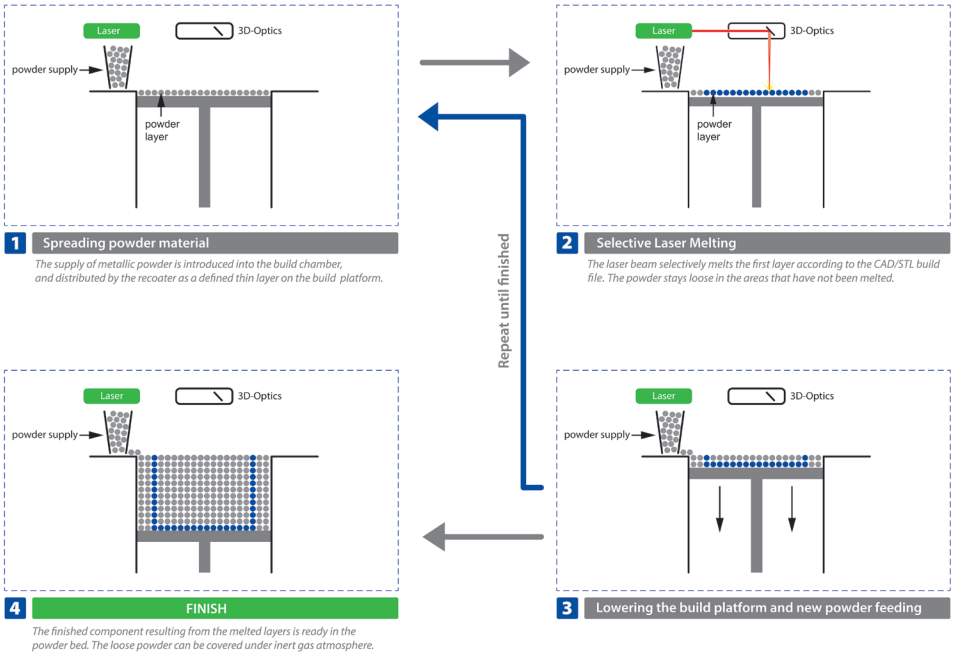
Medical device manufacturers are increasingly adopting metal additive manufacturing technology to produce a wide range of medical and dental parts. Selective laser melting is a metal powder bed fusion technology used to manufacture functional prototypes, for the serial production of surgical implants, to manufacture new designs of instruments and equipment and utilized for mass customization, i.e. the production of patient-matched implants and prostheses on a large scale. Dental prosthetic components, orthopaedic, spine and cranio-maxillofacial implants are all common applications of the SLM® technology.

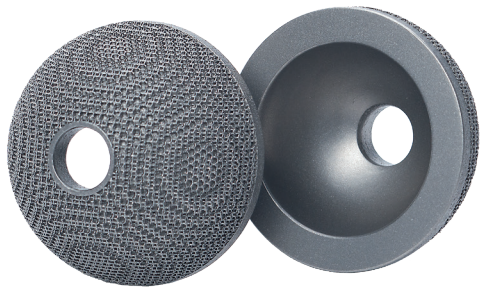
Selective laser melting is the ideal production technique to integrate function into medical device components, such as printing surgical implants with lattice structures for enhanced osseointegration and reduced stress shielding. Designs optimized for SLM® process, and those custom to patients' anatomy, often create complex, bionic geometries only able to be manufactured with selective laser melting. The technology also provides productivity and cost advantages to users, and the following pages feature examples of SLM® healthcare solutions.

SLM® Technology

Selective laser melting technology produces a part layer by layer with the selective accumulation of material. The powder bed fusion technology starts with a CAD or STL file and scans a precise laser beam across thin layers of metal powder to selectively melt complex geometries. Parts built with SLM® technology demonstrate high density often exceeding 99.9%, and high mechanical properties that exceed the properties of cast parts and that, following thermal treatment, can be equivalent to the properties of machined parts.



Orthopaedic Hip Implant



Build Data

- SLM®280 Twin
- Ti6Al4V Gd. 23 (ASTM F136)
- 60 µm layer thickness

Benefits of Utilizing the SLM® Process

- Integration of function as the lattice can be printed in-process
- Complex geometry build with control over strut size, shape, orientation and overall porosity
- Productivity and cost advantages over conventional manufacturing techniques

This acetabular cup is a standard sized hip implant built layer by layer with selective laser melting. The porous structure on the exterior surface facilitates osseointegration. SLM® systems are able to achieve the fine details needed across the porous geometry for optimal connection between the implant and the bone to encourage long-term stability of the implant through bone ingrowth. Selective Laser Melting enables the user to control the design and manufacture of the lattice struts in terms of shape, size, orientation and spacing. This level of control cannot be matched by traditional plasma spray coating processes.

Orthopaedic Knee Implant

Build Data

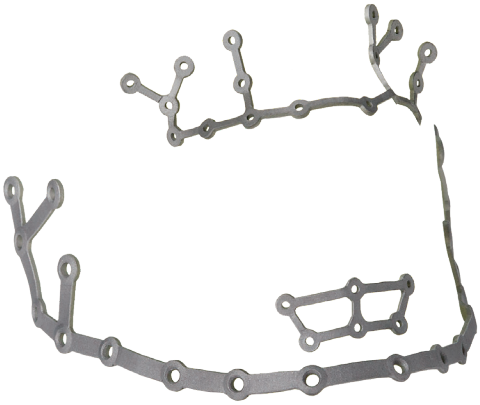
- SLM®280 Twin
- CoCr28Mo6 (ASTM F75)
- 30 µm layer thickness

Benefits of Utilizing the SLM® Process

- Integration of functional lattice structure for implant retention
- Complex geometries of personalized implants produced efficiently
- Productivity and cost advantages for patient-matched components

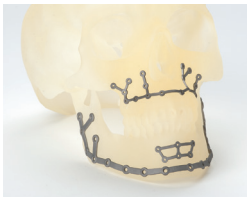
This femoral knee implant is a standard sized knee implant featuring an inlay lattice. The ability to control the shape, size and orientation of the lattice leads to increased implant retention. Selective Laser Melting aligns with the trend toward customization where traditional casting methods may require too much set-up for the production of patient-matched implants. Unicondylar knee implants, for example, create a new option for minimally invasive knee surgery when possible. Requiring much more personalization, such solutions are enabled by metal additive manufacturing.

CMF Implants



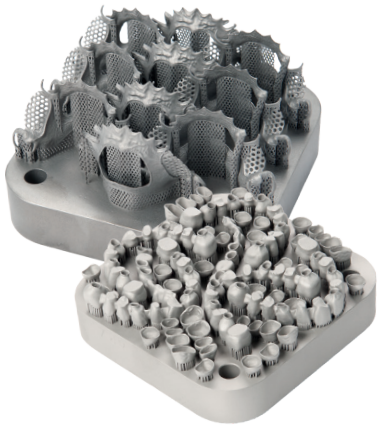
Build Data
- SLM®125
- Ti6Al4V Gd. 23 (ASTM F136)
- Ti Gd. II (ASTM F67)
- 30 µm layer thickness

Benefits of Utilizing the SLM® Process
- Efficient production of implants designed for fit and function
- Complex geometries produced more efficiently and economically
- Functional integration of lattice structures where needed
- Enabling mass customization



These maxillofacial implants are designed and produced specific to the patient's anatomy, on the basis of the patient's CT-scan images. They enable a more efficient surgical procedure, achieving functional and cosmetic restoration. The production of patient-matched and custom CMF implants by Selective Laser Melting is more efficient and more economical compared to traditional CNC-milling techniques.

Dental Prosthetic Components



Build Data
- SLM®125
- CoCr SLM® MediDent (ISO 22674)
- 20 µm / 30 µm layer thickness

Benefits of Utilizing the SLM® Process
- Precision manufacturing with minimal material waste
- Productivity and cost advantages compared to casting and milling
- RPD frames for upper and lower jaw with high precision, high fatigue resistance and integrated malleability

Dental crowns and bridges for PFM prostheses, as well as removable partial denture frameworks for acrylic prostheses are common dental applications of selective laser melting. These dental protheses are printed to patient-specific designs, however multiple patients' customized geometries can be printed simultaneously during one SLM® build. By printing the required design directly, production creates much less material waste and is more economical compared to traditional casting and milling techniques. Implant abutments, implant bars and frameworks are also produced with a hybrid production technique, i.e. Selective Laser Melting followed by CNC-milling. The hybrid production technique is more economical compared to traditional milling, and also enables the integration of lattice structures for improved prosthesis retention where needed.

Surgical Instruments

Build Data

- SLM®280 Twin
- 17-4PH Stainless Steel
- 30 µm layer thickness
- Produced by Forecast3D: forecast3d.com

Benefits of Utilizing the SLM® Process

- Efficient manufacturing reducing production time by weeks
- Complex design construction with minimal material waste

Service bureau Forecast3D produced this surgical instrument used for orthopaedic shoulder replacement surgery with Selective Laser Melting overnight, whereas traditional machining of the same part would have taken weeks. The implemented design for additive manufacturing (DfAM) strategy shifted traditional manufacturing methods to parts designed specifically for additive manufacturing technology, developing more efficient production at lower costs with little to no material waste.

Consultation and Qualification

SLM Solutions understands the importance of quality assurance and process documentation to qualify the production of biomedical components and shares knowledge and best practices to ensure success with selective laser melting. Contact us to discuss your projects with our industry experts and learn more about the consultation services we offer to help ramp customers up to qualified serial production, effectively implement mass customization strategies or to be connected with contract manufacturing services within the selective laser melting network.

Selective Laser Melting Machines

SLM®125

The compact SLM®125 Selective Laser Melting metal 3D printer offers a build envelope of 125 x 125 x 125 mm with a single 400W fiber laser. Includes substrate plate pre-heating to 200°C.

With a larger build plate and higher-powered laser than other similar-sized machines, the SLM®125 is a flexible manufacturing system to fit users' specific needs. The compact footprint and efficient use of metal powder and inert gas resources optimize cost of ownership. Closed-loop powder handling with chamber gloves and sealed transport bottles ensure operator safety and all selective laser melting powders, including reactive materials, can be processed on the SLM®125.

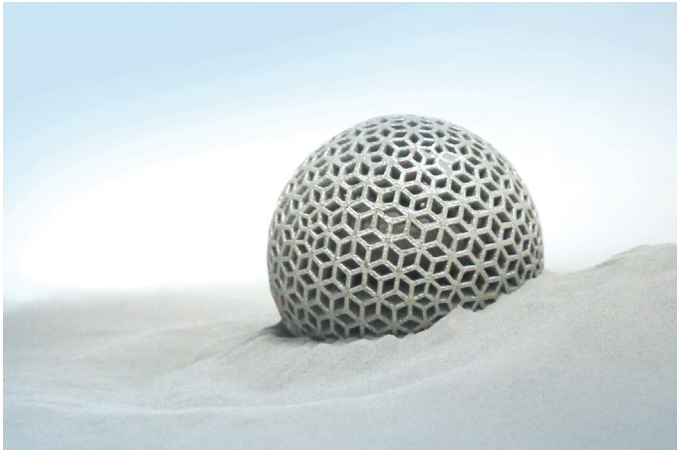
SLM®280

The robust SLM®280 Selective Laser Melting machine provides a 280 x 280 x 365 mm build envelope and patented multi-laser technology optimized for production.

With a build plate 25% larger than standard mid-sized machines to fit more parts per build and configuration options of one or two 400W or 700W lasers, the twin-laser SLM®280 can achieve build rates 80% faster than single laser machines to promote production-oriented additive manufacturing. The SLM®280 offers a multi-laser scan strategy and industry-leading gas flow to minimize soot interference and deliver parts with the same mechanical properties across the entire build plate.

Technical Specifications	SLM®125	SLM®280
Build Envelope (L x W x H)	125 x 125 x 125 mm reduced by substrate plate thickness	280 x 280 x 365 mm reduced by substrate plate thickness
3D Optics Configuration	Single 1x 400W IPG fiber laser	Single (1x 400W or 1x 700W), Twin (2x 400 W or 2x 700W) IPG fiber laser
Real Build Rate	up to 25 cm^3/h*	up to 113 cm^3/h*
Variable Layer Thickness	20 µm - 75 µm, more available on request	20 µm - 90 µm, more available on request
Minimum Feature Size	140 µm	150 µm
Beam Focus Diameter	70 - 100 µm	80 - 115 µm
Maximum Scan Speed	10 m/s	10 m/s
Average Inert Gas Consumption in Process	0.6 l/min (Argon or Nitrogen)	5 l/min (Argon or Nitrogen)
Average Inert Gas Consumption in Purging	70 l/min (Argon or Nitrogen)	110 l/min (Argon or Nitrogen)
E-Connection / Power Input	400 Volt 3NPE, 32 A, 50/60 Hz, 3 kW	400 Volt 3NPE, 63 A, 50/60 Hz, 3.5-5.5 kW
Compressed Air Requirement	ISO 8573-1:2010 [1:4:1] 7 bar	ISO 8573-1:2010 [1:4:1] 7 bar
Machine Dimensions (L x W x H)	1400 mm x 900 mm x 2460 mm	Dependent on machine configuration

*depending on material and build part geometry



Metal Powder

SLM Solutions offers a wide range of qualified metal powders for use on our selective laser melting systems and commonly utilized in the healthcare industry. All materials provided by SLM Solutions are qualified for their chemistry, spherical structure, grain size distribution and dryness to ensure optimal flowability.

Safe Powder Handling

SLM Solutions offers safe and closed-loop powder handling on all its SLM® machines to maximize both operator safety and material quality. Material delivery, overflow and sieving take place in an inert atmosphere to safeguard the quality of the powder against contamination and oxidation. Manual powder sieves enable powder tracing for batch management while automated powder systems feature valves to sample for continuous material quality and RFID tracing can be added to build data.

Quality Assurance

Comprehensive monitoring and quality assurance enable a high degree of process documentation and verification. Chamber temperature, oxygen, gas flow and other variables are constantly monitored and logged to ensure consistent, high quality builds. Layer Control System (LCS), Melt Pool Monitoring (MPM) and Laser Power Monitoring (LPM) monitor various systems to detect possible irregularities.

Build Envelope Sizes

SLM Solutions - Technology Pioneers, Innovation Leaders

SLM Solutions helped invent the laser powder bed fusion process, was the first to offer multi-laser systems and all selective laser melting machines offer patented quality, safety and productivity features. Taking a vested interest in customers' long-term success in metal additive manufacturing, SLM Solutions' experts work with customers at each stage of the process to provide support and knowledge-sharing that elevate use of the technology and ensure customers' return on investment is maximized. Optimal paired with SLM Solutions' software, powder and quality assurance products, the SLM® technology opens new geometric freedoms that can enable lightweight construction, integrate internal cooling channels or decrease time to market.

A publicly traded company, SLM Solutions Group AG focuses exclusively on metal additive manufacturing and is headquartered in Germany with offices in Canada, China, France, India, Italy, Russia, Singapore and the United States and a network of global sales partners.






SLM Solutions Group AG | Estlandring 4 | 23560 Lübeck | Germany
+49 451 4060 - 3000 | info@slm-solutions.com | slm-solutions.com