ADDITIVE MANUFACTURING

The process

Additive Manufacturing (AM) technology fundamentally differs from traditional material removal process like milling, turning and spark erosion, since this technology family creates metal components by incremental addition of material instead of removal of chips. *Starting* from a three-dimensional CAD representation of an object, the object is virtually 'sliced' into a set of two-dimensional layers. These layers are then successively fused and consolidated on top of each other, to recreate the three-dimensional object.

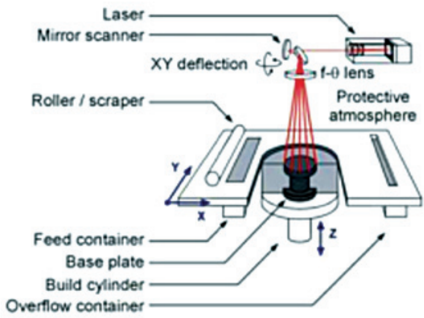

FIGURE 1: **Schematic illustration of the Selective Laser Melting process (left), SLM production of a dental implant suprastructure in Ti6Al4V (right)**

AM technologies exist since a few decades already and were originally developed as plastic prototyping technologies. Over the last decade, metal AM technologies were developed, in order to benefit from the AM advantages also for manufacturing of metallic components. Selective Laser Melting (SLM) is the best established AM technology for high-quality metal manufacturing. In the SLM process, thin layers of metal powder (typically 20 to 40 microns) are spread by a powder deposition system. Next, a focused laser beam is used to scan a 2D layer of the 3D component. This process repeats until the whole 3D object has been 'printed'.

Advantages and limits

Like all AM technologies, SLM technology offers the advantage of complete geometric freedom in the design and manufacturing of medical components, thanks to the layer-wise build-up of the components. This facilitates manufacturing patient-specific implants, but also designed porous structures with full control over the porosity degree and pore interconnection.

Since SLM technology is a fully digital technology, requiring no tooling, it is capable of producing parts with very short lead times. By using conventional metal and alloys as base material, the resulting components have mechanical and physical properties that are equivalent to the respective bulk material properties. As an illustration, the following medical SLM materials are available at LayerWise[1]; stainless steel (e.g. 316L alloy), titanium and its alloys (Ti CP grade 1 and grade 2 and Ti6Al4V / Ti6Al4V ELI), and CoCrMo alloys (ASTM F75). Finally, SLM technology is fully compatible with all existing manufacturing or finishing technologies (machining, spark erosion, grinding and polishing, etc.).

Current SLM technology faces a few drawbacks, compared to traditional machining technologies. First, today's

1. Non-exhaustive list, contact us for further information.

SLM technology – as most AM techniques – can only produce components with limited dimensions; a typical SLM machine has a working area of 250 by 250 by 250 mm.[2] Next, SLM technology has a relatively low build rate, the order of magnitude being a few cubic centimeters per hour. While SLM can be a cost efficient solution for components with limited material volume, voluminous implants or instruments may be expensive to manufacture.

Applications in the medical field

Due to the unlimited geometric freedom, patient specific implants are perfectly suited to be produced with SLM technology. Figure 2 shows a custom mandible implant produced with SLM technology. The implant custom designed based on CT scan data.[3]

Besides custom implants, SLM technology also introduces new possibilities for manufacturing standard implants and instrumentation. Orthopedic implants for example, can be designed with integrated porosity regions for improved osseointegration. As an illustration Figure 3 shows a titanium femur incorporating four different scaffolds designs and various degrees of surface finish.

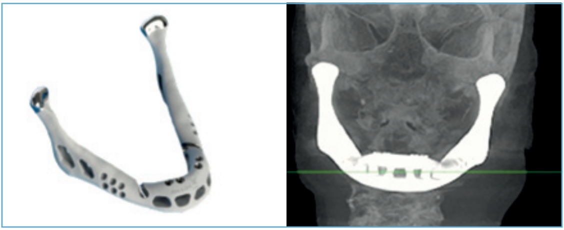

FIGURE 2: Custom mandible implant produced with SLM (material: Ti6Al4V ELI)

2. LayerWise currently supports maximal product dimensions of 250 x 250 x 400 mm.
3. Collaboration with Prof. Dr. Jules Poukens and Xilloc BV.

FIGURE 3: Demonstrator femur illustrating different porous scaffold designs

Due to its nature, the SLM technology is well suited for manufacturing complex shaped implants, with limited material volume. Examples are spinal implants, acetabulum cups, small joint prostheses, complex shaped CMF and trauma plates, bone fillers, etc. Typical lot sizes start from unique components up to series of 10.000 pieces.

Quality aspects

Since SLM technology uses a focused laser beam resulting in extremely high power intensities, the powder particles used can be fully molten and all successive layers can be perfectly interconnected by partially re-melting underlying previously solidified layers. Accurate control of all influential process parameters (scanning velocity, laser power, layer thickness, powder morphology, atmosphere purity, etc.) ensures a highly repeatable production process. As an illustration Figure 3 shows the combined alpha-beta microstructure of LayerWise' medical grade Ti6Al4V material; a relative densities of nearly 100% is obtained and mechanical properties are comparable to the bulk material properties (see Table 1).

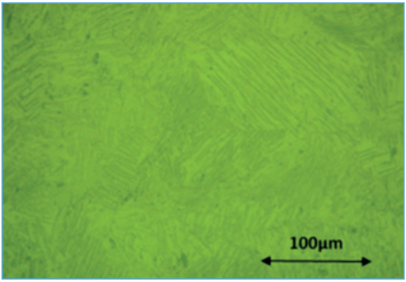

FIGURE 4: Microstructure of medical grade Ti6Al4V (source: LayerWise NV).

MECHANICAL PROPERTY	VALUE
Density	4.41 g/cm³
Young's modulus	110 GPa
Yield strength (0.2%)	915 MPa
Ultimate Tensile Strength	1000 MPa
Break elongation	14 %
Fatigue strength @ 10^7 cycles	550 MPa

TABLE 1: mechanical properties of Ti6Al4V ELI (source: LayerWise NV)

Partner

LayerWise is one of the top players in metal Additive Manufacturing technology. As an AM technology innovator, LayerWise stretches the limits of metal part performance and manufacturing economics. After gaining recognition across industrial sectors, AM is increasingly being adopted in different medical fields such as dentistry, orthopedics, maxillofacial and spinal surgery. Based in Leuven, Belgium, LayerWise intensively collaborates with academic partners, and heavily invests in research and development to push the boundaries of AM technology.

www.layerwise.com

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