3D-Printing of functional optimized Al-Components

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3D-Printing / Additive Manufacturing – Different Technologies

STL/SLA – Stereolithography
DLP – Digital Light Processing
PJM – Poly-Jet Modeling

FDM – Fused Deposition Modeling
3DP – 3D-Printing
SLS/SLM – Selective Laser Sintering
Selective Laser Melting

Laser Additive Manufacturing

LMD – Laser Metal Deposition

SLM – Selective Laser Melting
Selective Laser Melting SLM – Basic Principle

Digital data – 3D-CAD model

Material – metal powder

Energy – laser beam

Application of powder layer

Melting of the powder

Lowering the platform

Metal part made of serial material
Selective Laser Melting SLM – Basic Principle
Selective Laser Melting SLM – From Rapid Prototyping to Rapid Manufacturing

- use of serial material
- complete melting of the powder particles
- part density of 100%
- available technologies enables processing of a wide range of materials:
  - Titanium alloys
  - Aluminum alloys
  - Steel
  - CoCr alloys
  - Nickel alloys
State of the Art SLM Machines

EOS M290
- 250 mm x 250 mm x 325 mm
- 400 W fiberlaser
- 100 µm spotsize

SLM Solutions SLM280HL
- 280 mm x 280 mm x 350 mm
- 400 W / 1000 W fiberlaser
- 100 µm / 700 µm spotsize

Source: EOS, SLM Solutions
Selective Laser Melting SLM – Series Production

- dentistry
- hearing aid
- individualised mass production
- design for optimised functionality
- improvement of part efficiency during life cycle
- example: turbo machinery
- light weight design
- example: hinges for aerospace applications

Source: Bego, General Electric, EADS
Selective Laser Melting SLM – Interesting Al-Applications

- fast availability of functional prototypes for product development
  - example: automotive
- tool less production for small series
- flexible production of special parts
  - example: Al-die casting
- tooling
- conformal cooling
- shorter cycle times

- Selective Laser Melting (SLM)

- Al-die casting example
Additive Manufacturing – A new Industrial Revolution?!

![Cost vs Lot size graph for Conventional Production](chart1)

![Cost vs Product complexity graph for Conventional Production](chart2)
Additive Manufacturing – A new Industrial Revolution?!

- Product complexity
  - Conventional Production
  - Additive Manufacturing

- Cost
  - Conventional Production
  - Additive Manufacturing

- Lot size

- Cost
  - Conventional Production
  - Additive Manufacturing

- Product complexity
Additive Manufacturing – A new Industrial Revolution?!

Conventional Production

Lot size

Product complexity

Cost

Additive Manufacturing

Cost

Additive Manufacturing

Conventional Production

SLM 1-3 cm³ / min

LMD 10-30 cm³ / min

Ablation 0,2-0,5 cm³ / min

Laserstrahl

umgeschmolzene Schicht

Bewegungsrichtung des Laserstrahls

Pulverschicht

Schmelzbad

Strahldurchmesser d, Spurabstand δy

Schichtdicke D.
Additive Manufacturing – A new Industrial Revolution?!

Individualisation for free

Cost

Lot size

Conventional Production

Additive Manufacturing
Additive Manufacturing – A new Industrial Revolution?!

Individualisation for free

Lot size

Cost

Conventional Production

Additive Manufacturing

Innovative Business Models
Individualisation for free – Services like Shapeways

Made in the Future. Made for You.
Shapeways is a 3D Printing marketplace and community. Learn more.

Source: Shapeways
Individualisation for free – Services like Shapeways

- 1,000,000 3D printed products in 2012
- over 10,000 uploads per week
- 8000+ Shapeways Shops
- shop owners earned $500,000 in 2012
- 230,000+ Community Members in over 130 countries
- new factory opened in New York to 3D print 3 to 5 million unique products per year

Source: Shapeways
Additive Manufacturing – A new Industrial Revolution?!
Additive Manufacturing – A new Industrial Revolution?!

- Complexity for free

Cost

Additive Manufacturing

Conventional Production

Product complexity
Additive Manufacturing – A new Industrial Revolution?!

- Individualisation for free
- Complexity for free

Innovative Products
Complexity for free – Monolithic design
Complexity for free – Lattice structure automotive part
Complexity for free – Bionic automotive part
Mechanical properties of AlSi10Mg

- SLM of AlSi10Mg with $P_L=250\text{W}$
- High Power SLM of AlSi10Mg with $P_L=1\text{kW}$

Increasing the laser power shows no significant differences to conventional SLM process
Complexity for free – Functional optimized upright

First AlMgSc (Scalmalloy®) part manufactured by HP-SLM
Increase strength of AlMgSc (Scalmalloy®)

- Hypereutectic amount of scandium (larger 0.5 w-%)
- Rapid solidification (SLM ca. $7 \times 10^6$ K/s)
- Formation of supersaturated solid solution (scandium maintains in solution)
- Precipitation hardening: Increase strength due to nano-sized precipitates of the form $\text{Al}_3\text{Sc} (+\text{Zr})$

Source: Aeromat, Hypereutectic high strength AlMgSc profile materials, F. Palm, EADS GmbH

Fig. 1 — Al-Sc phase diagram as determined by Willey.$^{[14]}$
Additive Manufacturing – A new Industrial Revolution!

**Individualisation for free**

- Cost vs. Lot size
- Conventional Production vs. Additive Manufacturing

**Complexity for free**

- Cost vs. Product complexity
- Conventional Production vs. Additive Manufacturing

**Innovative Business Models**

**Innovative Products**
Thank you for your attention!