3D-Printing of functional optimized Al-Components

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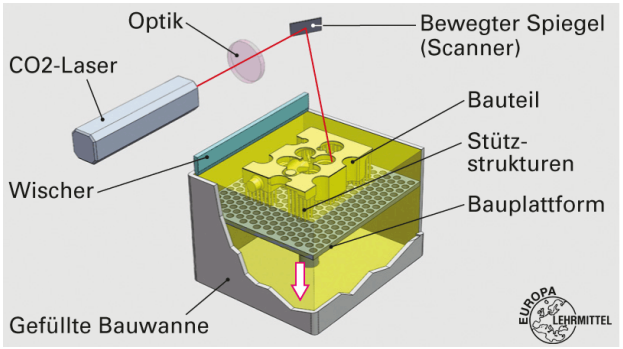
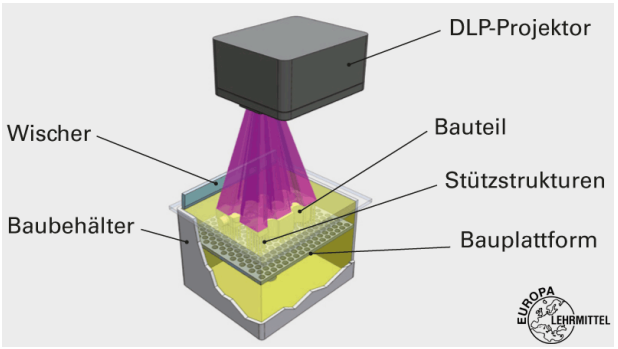
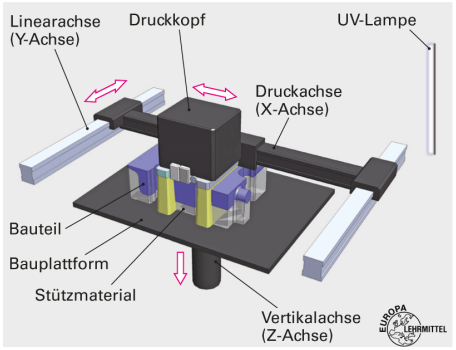
3D-Printing / Additive Manufacturing – Different Technologies



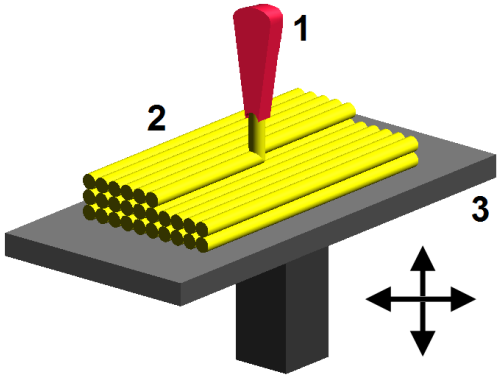
STL/SLA – Stereolithography



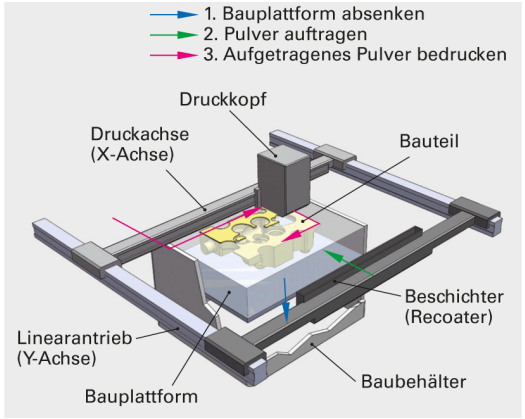
DLP – Digital Light Processing



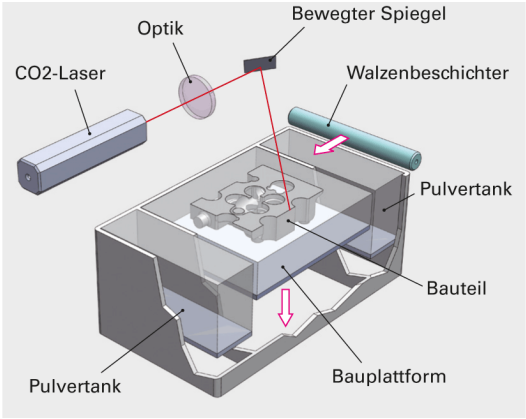
PJM – Poly-Jet Modeling



FDM – Fused Deposition Modeling



3DP – 3D-Printing

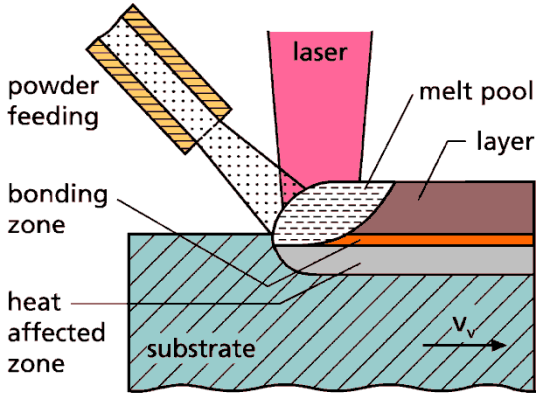


SLS/SLM – Selective Laser Sintering
Selective Laser Melting

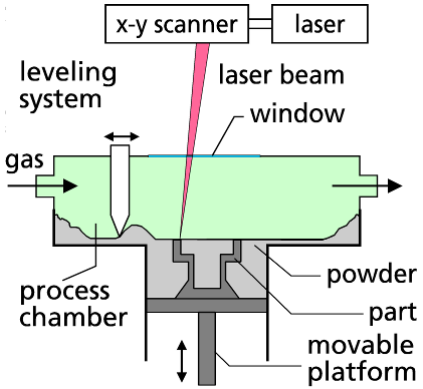
Source: Verlag Europa-Lehrmittel, Wikipedia

Laser Additive Manufacturing

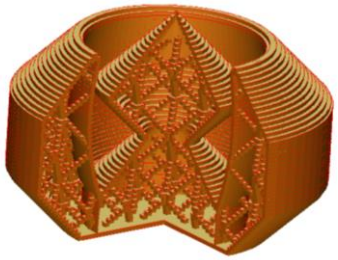
LMD – Laser Metal Deposition



SLM – Selective Laser Melting

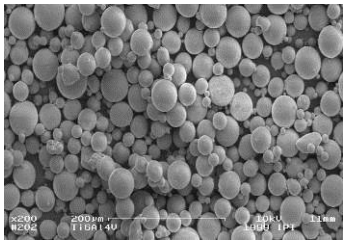


Selective Laser Melting SLM – Basic Principle



Digital data –
3D-CAD model

+



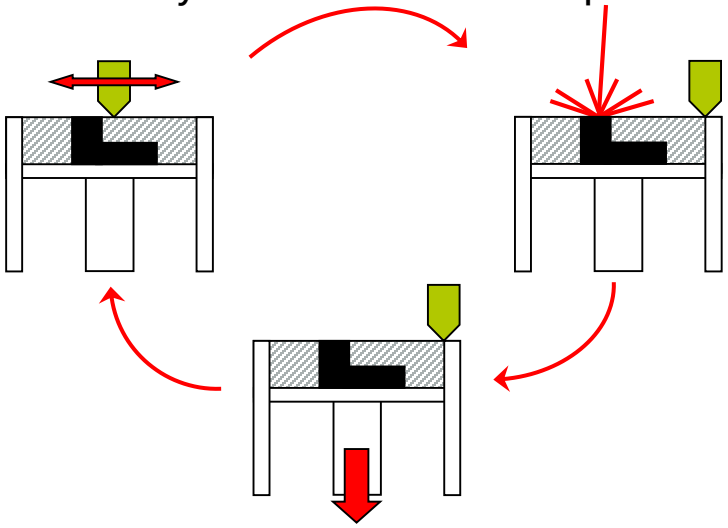
Material – metal powder

+

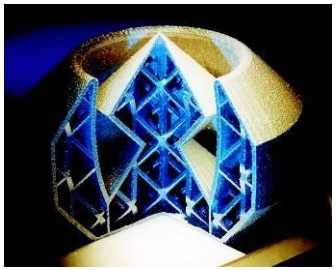
Energy – laser beam

application of
powder layer

melting of
the powder



lowering the platform

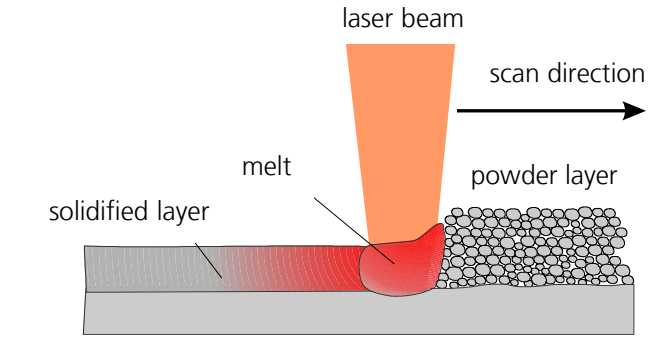


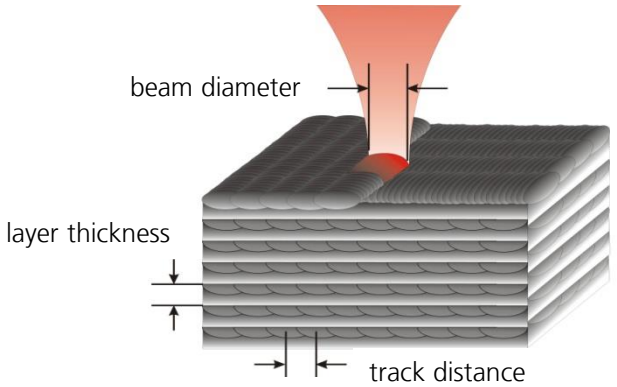
metal part made
of serial material

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

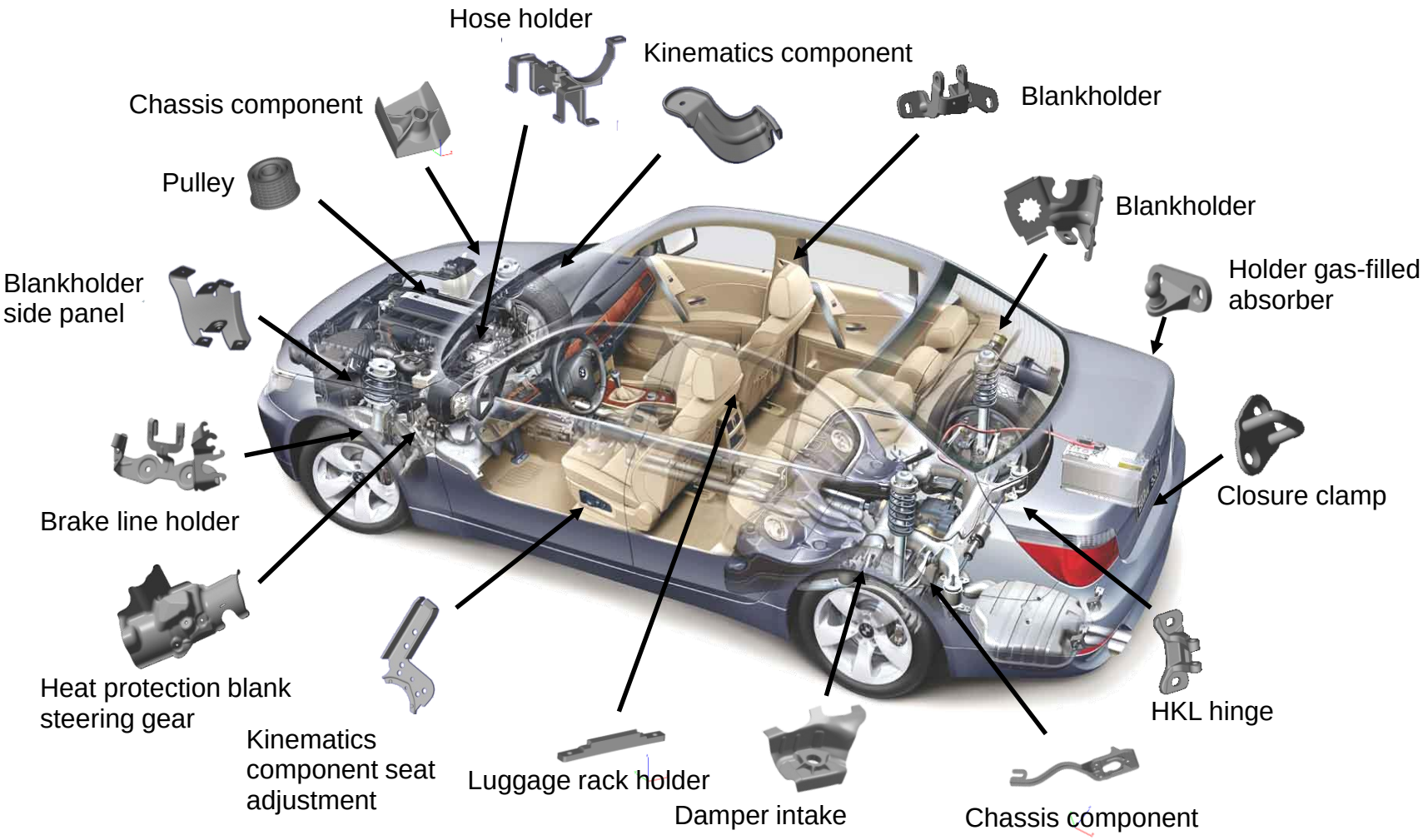
- 250 mm x 250 mm x 325 mm
- 400 W fiberlaser
- 100 µm spotsize

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 – Functional Prototypes



Source: N. Skrynecki, Kundenorientierte Optimierung des generativen Strahlschmelzprozesses, 2010

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

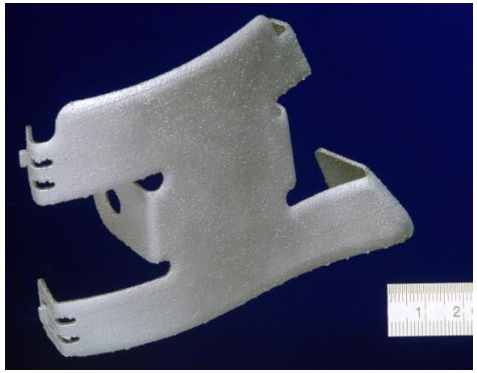
Source: Bego, General Electric, EADS

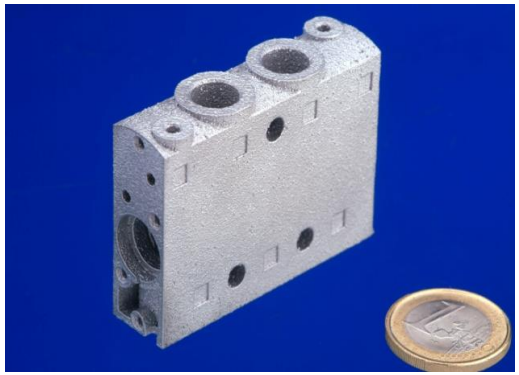
Selective Laser Melting SLM – Interesting Al-Applications

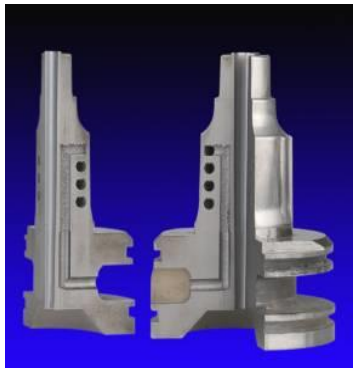
- fast availability of functional prototypes for product development
- example: automotive

- tool less production for small series
- flexible production of special parts
- example: Al-die casting

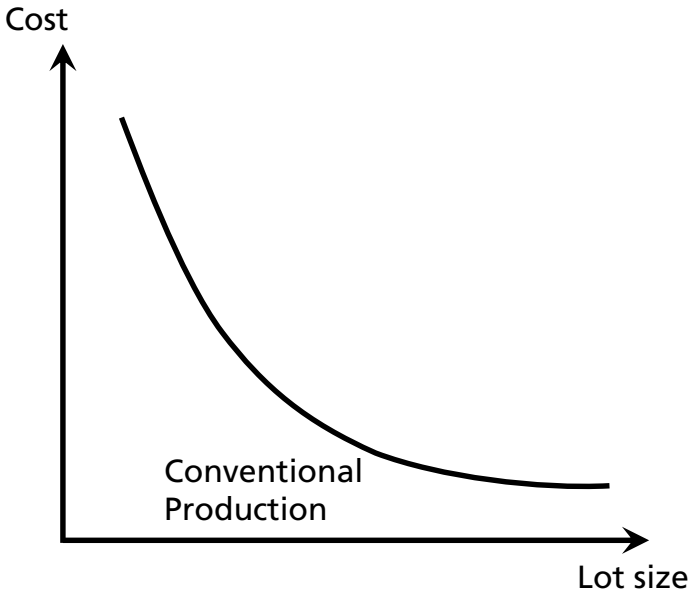
- tooling
- conformal cooling
- shorter cycle times

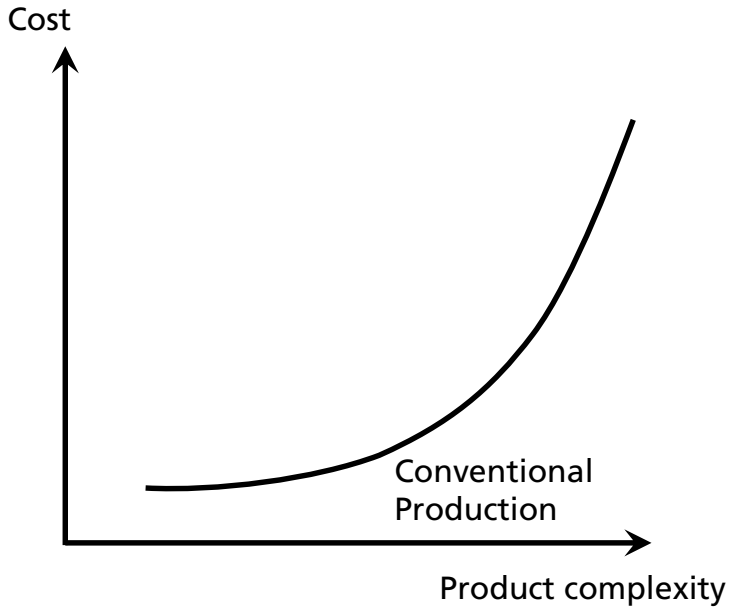






Additive Manufacturing – A new Industrial Revolution?!





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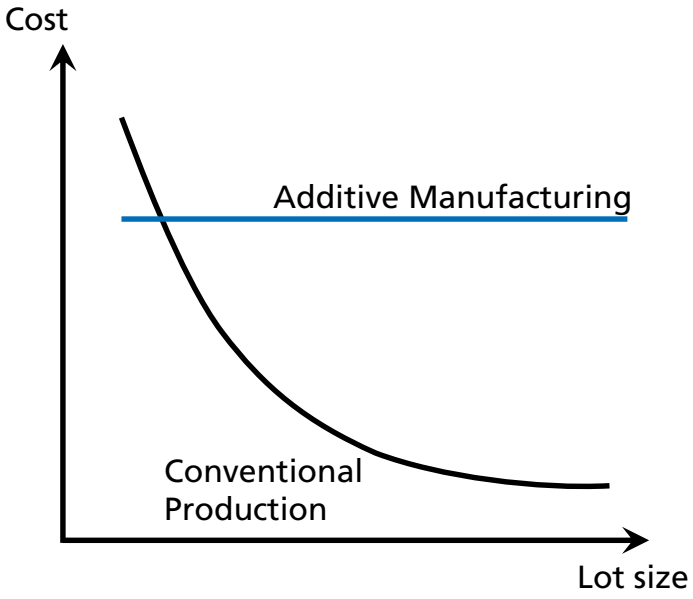

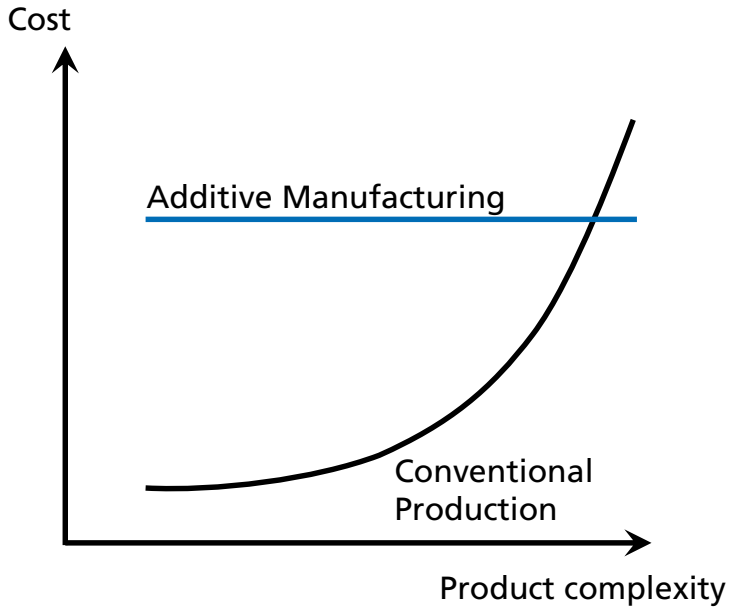

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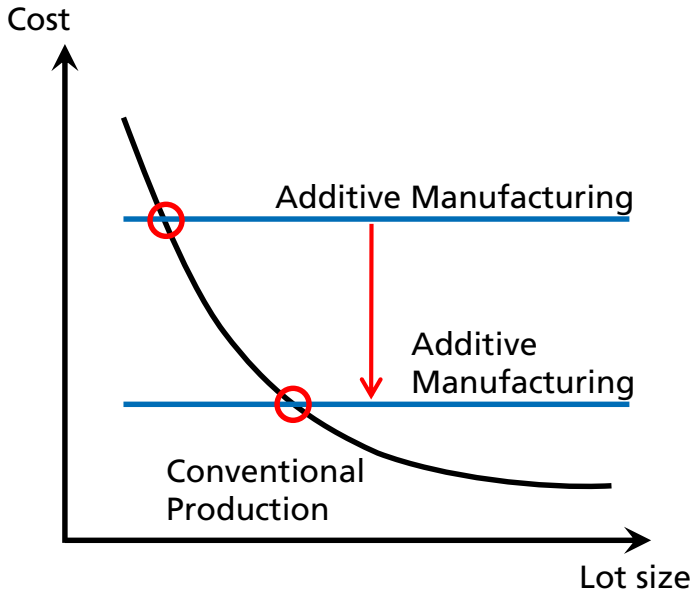
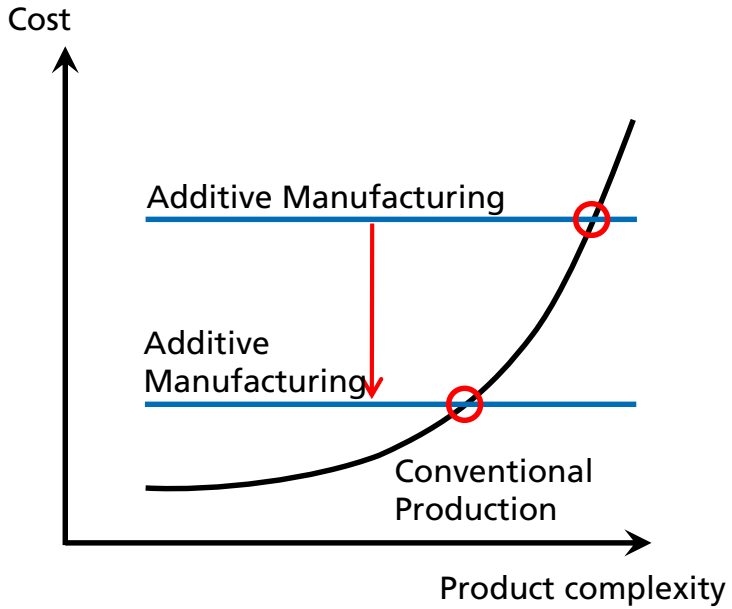
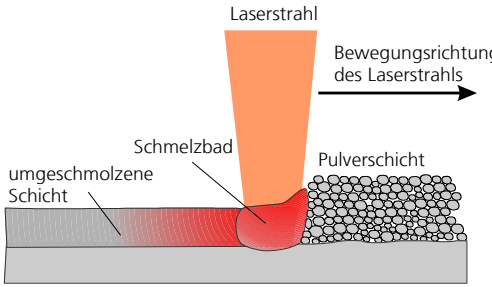
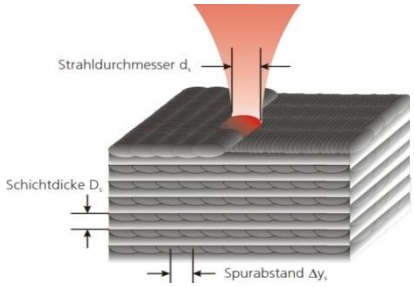


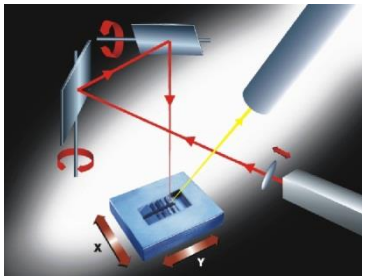




SLM 1-3 cm³ / min



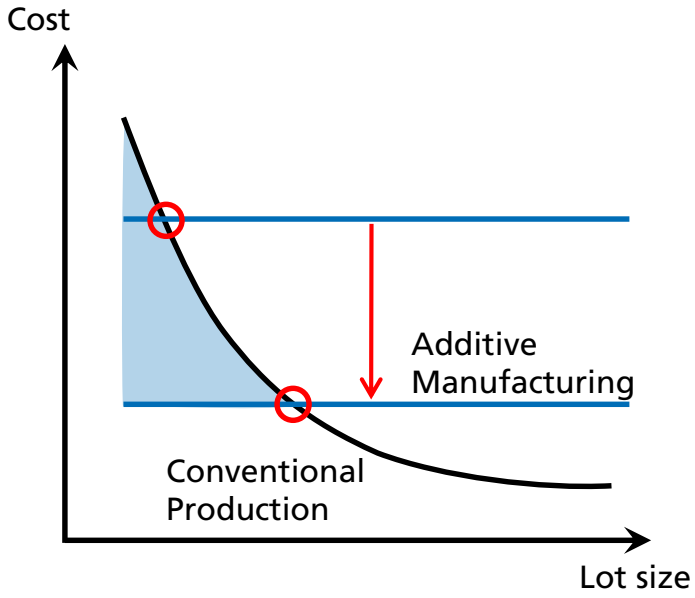
LMD 10-30 cm³ / min



Ablation 0,2-0,5 cm³ / min

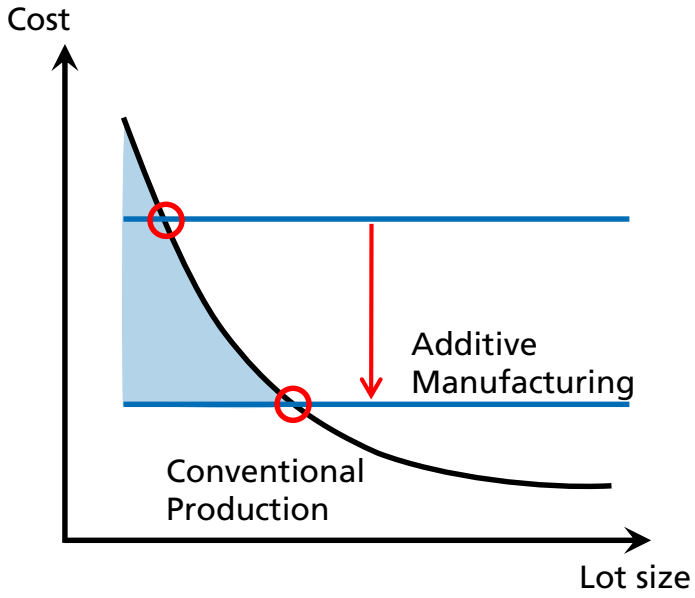
Additive Manufacturing – A new Industrial Revolution?!

Individualisation for free



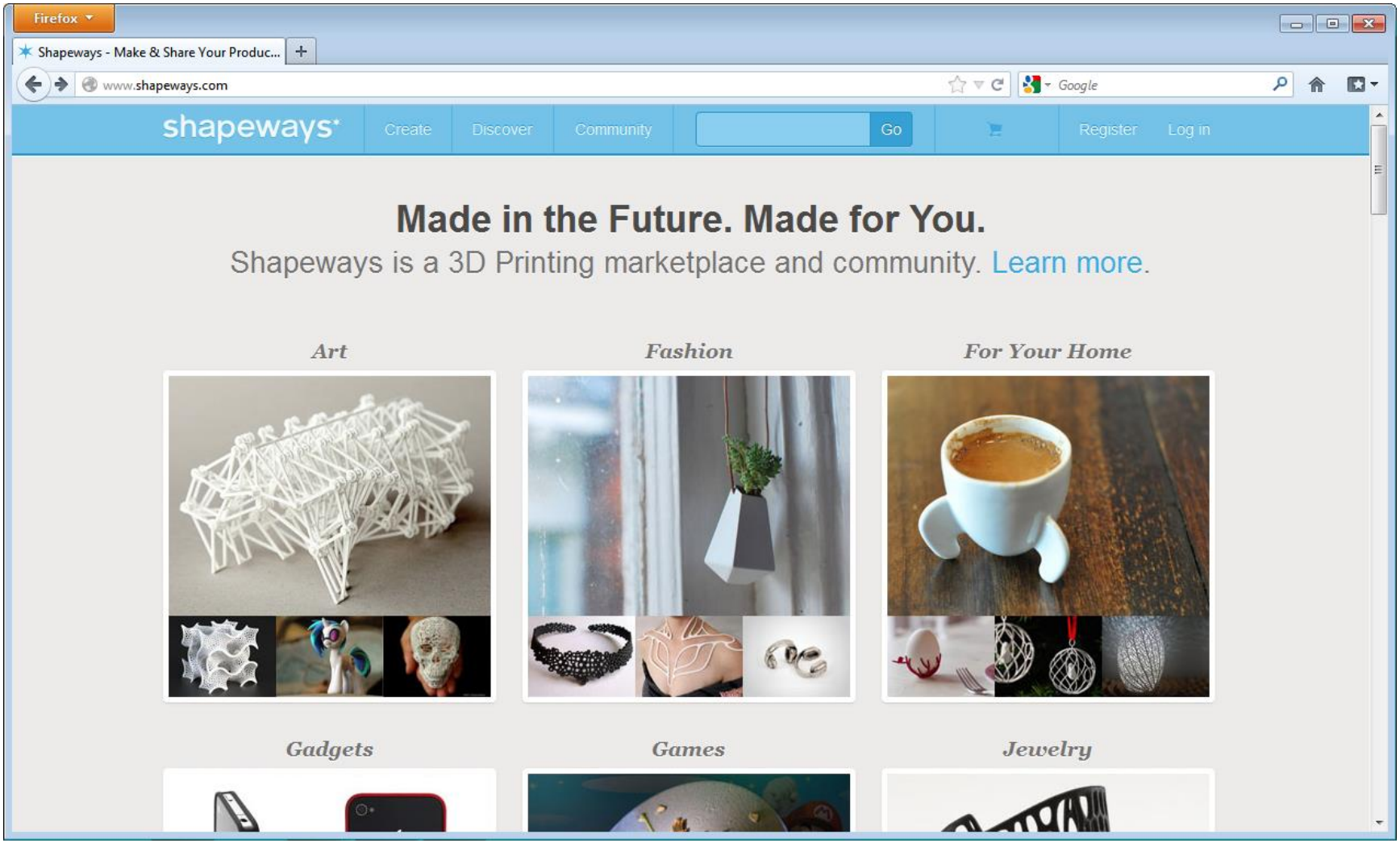
Additive Manufacturing – A new Industrial Revolution?!

Individualisation for free



Innovative Business Models

Individualisation for free – Services like Shapeways



Source: Shapeways

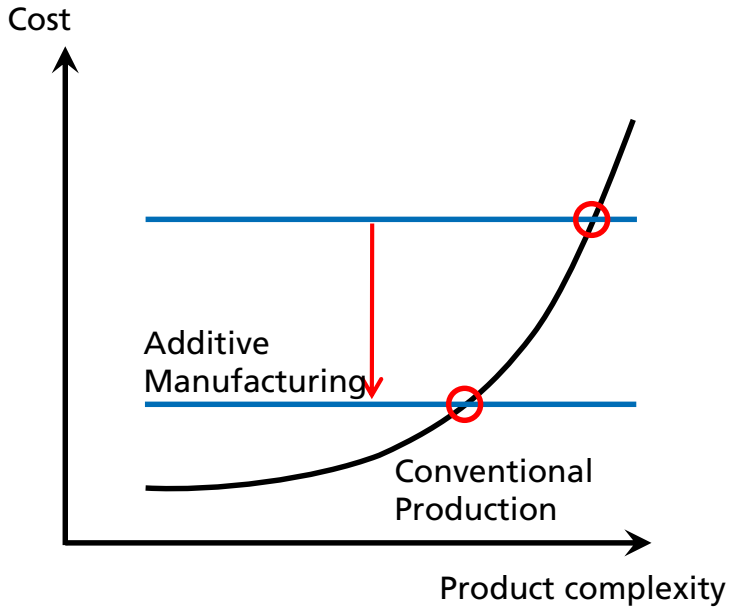
Individualisation for free – Services like Shapeways

- 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

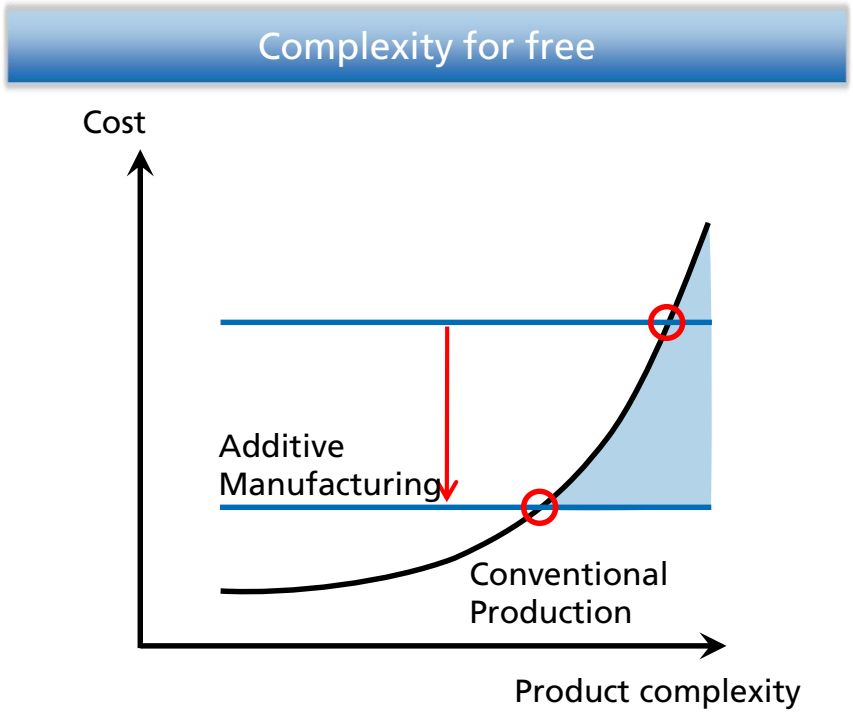
- new factory opened in New York
  to 3D print 3 to 5 million unique products per year

Source: Shapeways

Additive Manufacturing – A new Industrial Revolution?!

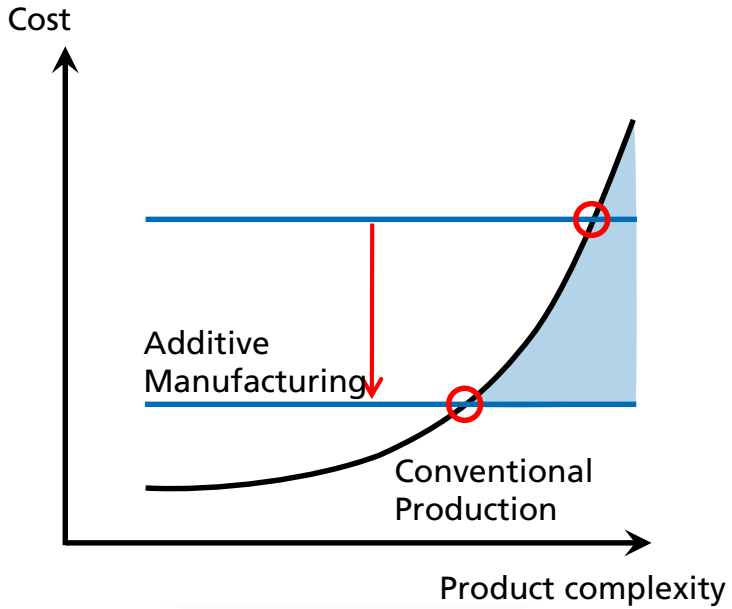


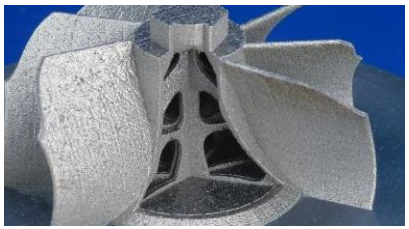
Additive Manufacturing – A new Industrial Revolution?!



Additive Manufacturing – A new Industrial Revolution?!

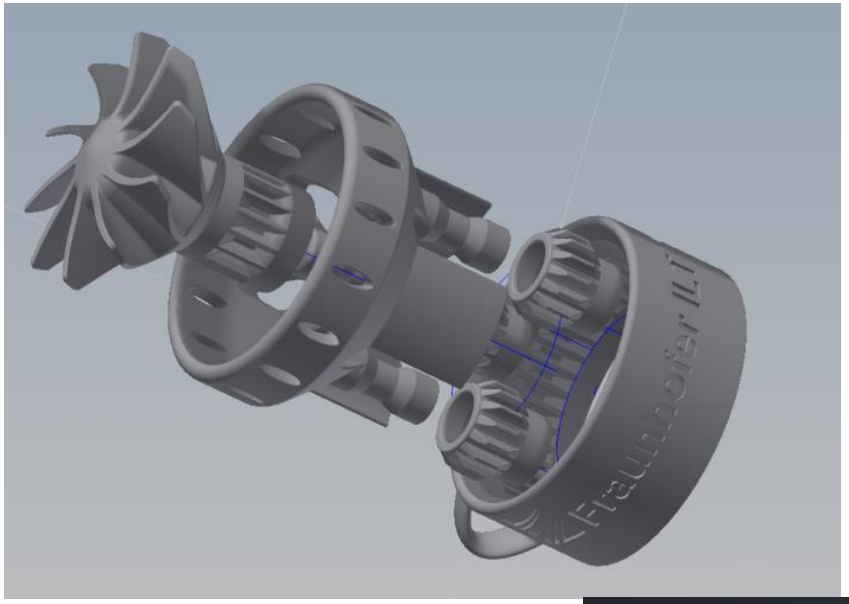
Complexity for free



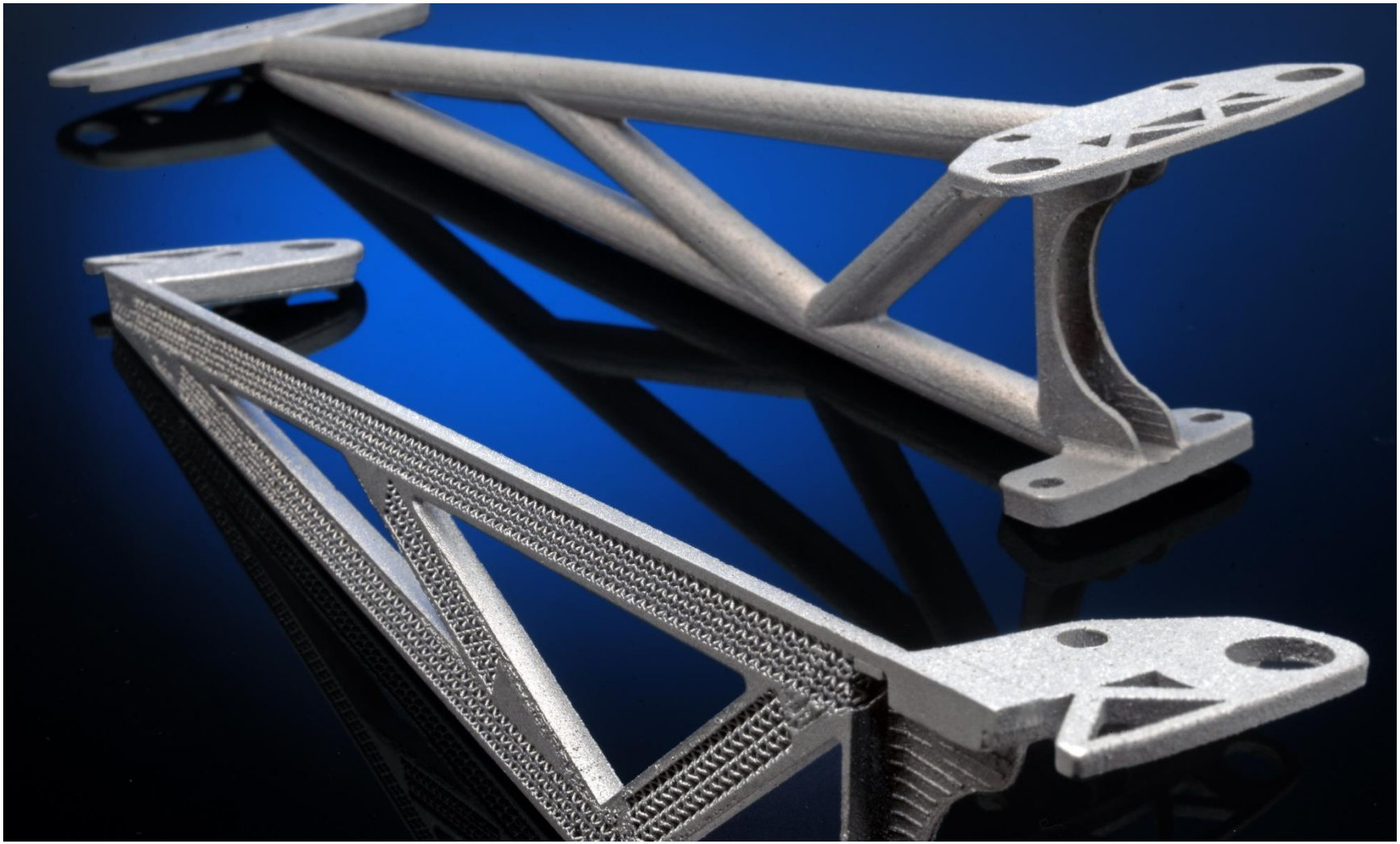


Innovative Products

Complexity for free – Monolithic design



Complexity for free – Lattice structure automotive part

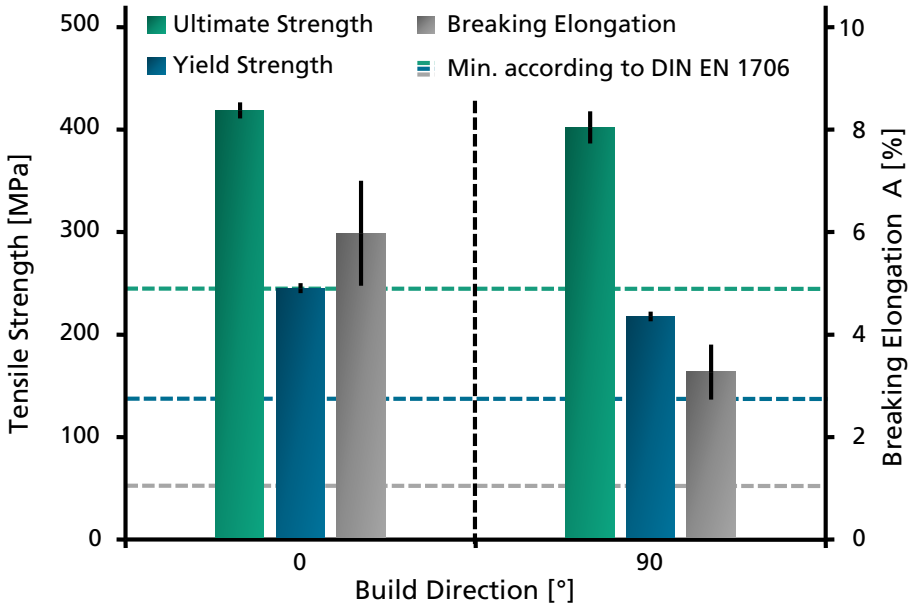


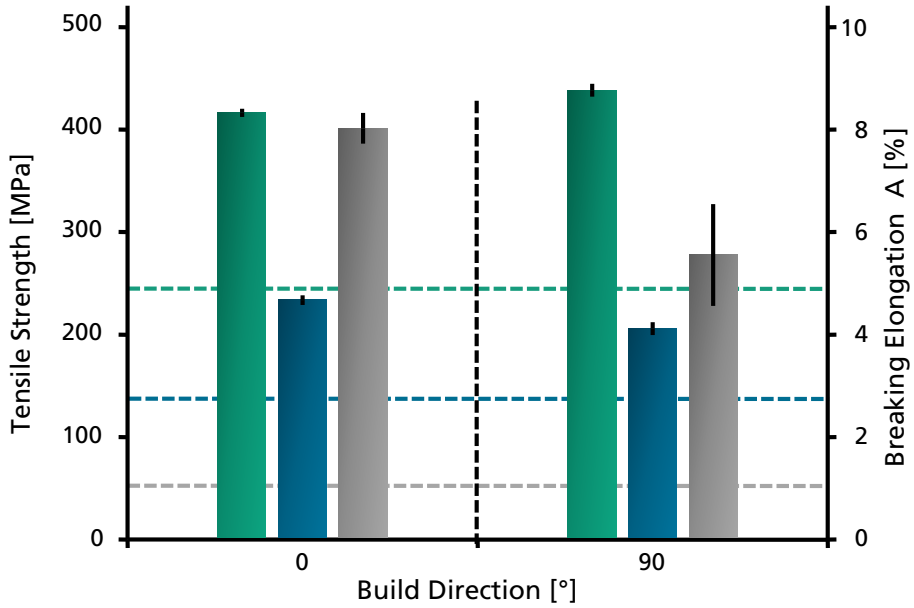
Complexity for free – Bionic automotive part

Mechanical properties of AlSi10Mg

SLM of AlSi10Mg with P_L=250W

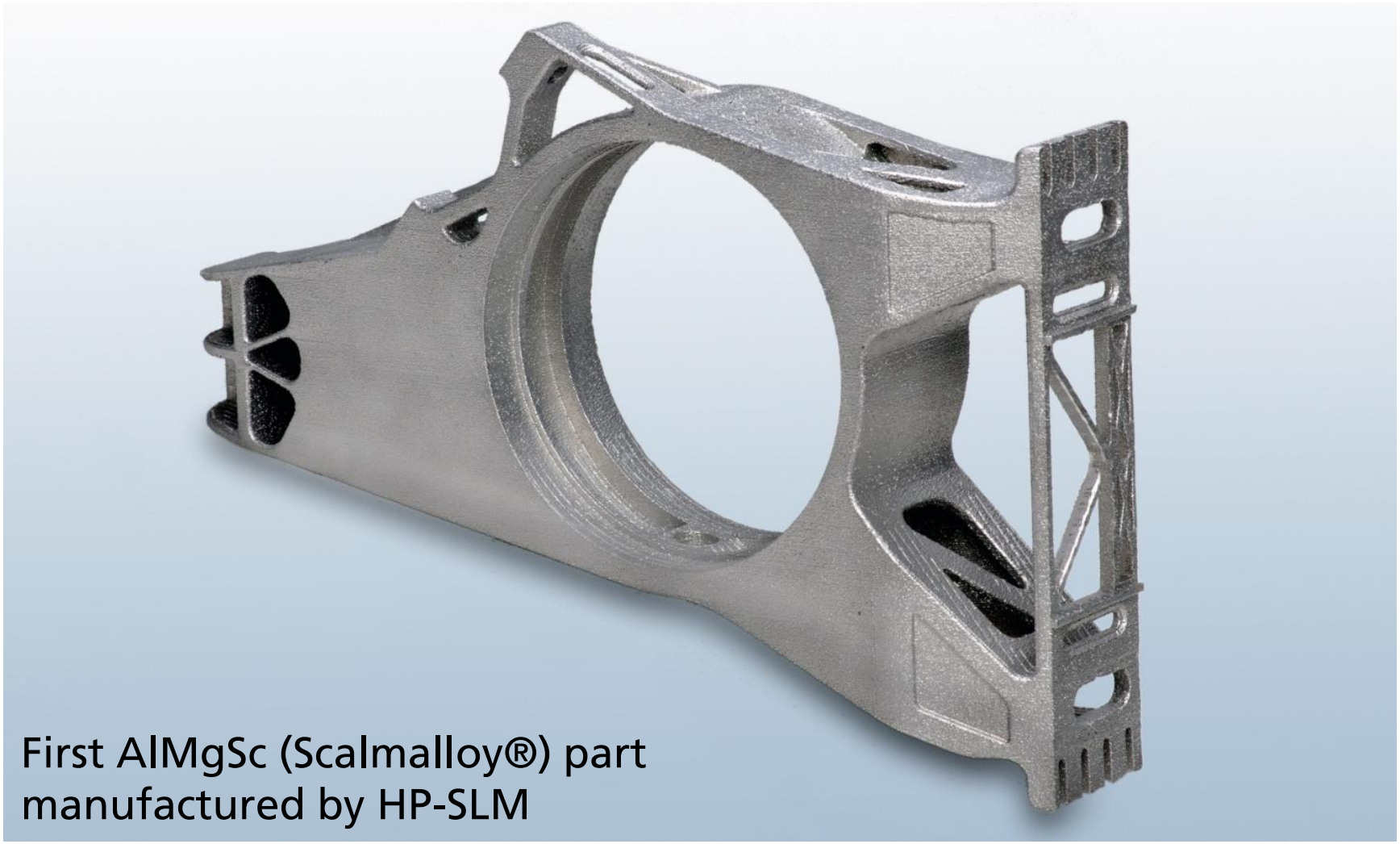
High Power SLM of AlSi10Mg with P_L=1kW





- 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

AlMgSc (Scalmalloy®) – SLM optimized Al-alloy

Increase strength of AlMgSc (Scalmalloy®)

- Hypereutectic amount of scandium (larger 0.5 w-%)
- Rapid solidification (SLM ca. $7x10^6$ K/s)
- Formation of supersaturated solid solution (scandium maintains in solution)
- Precipitation hardening: Increase strength due to nano-sized precipitates of the form Al_3Sc (+Zr)

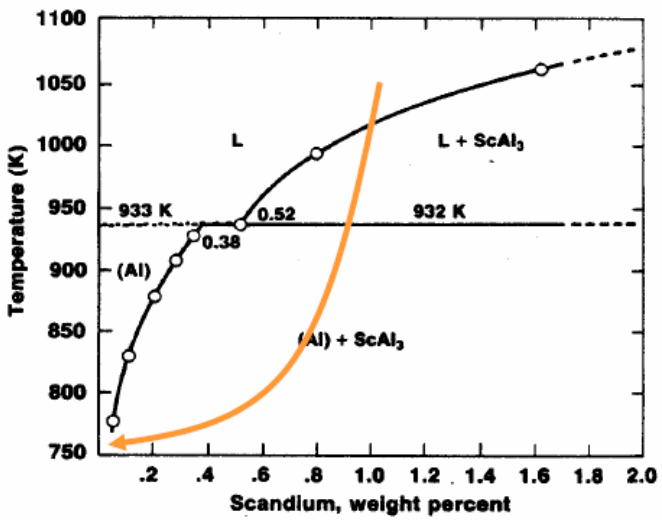
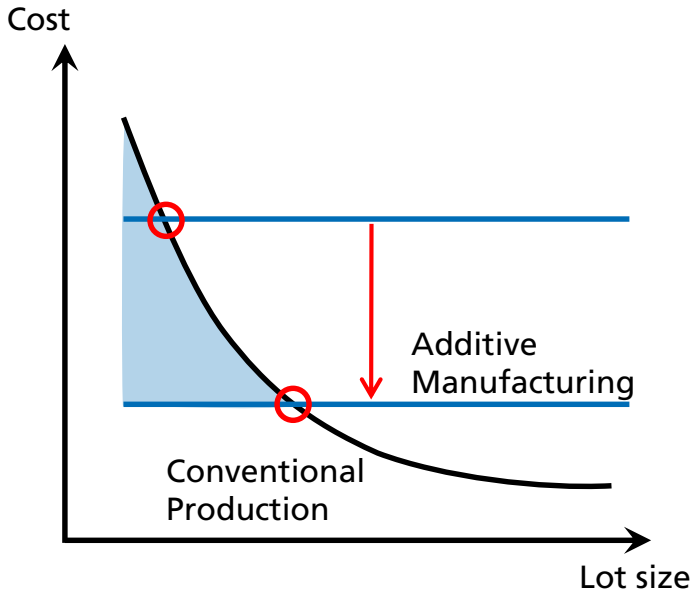


Fig. 1 — Al-Sc phase diagram as determined by Willey.[16]

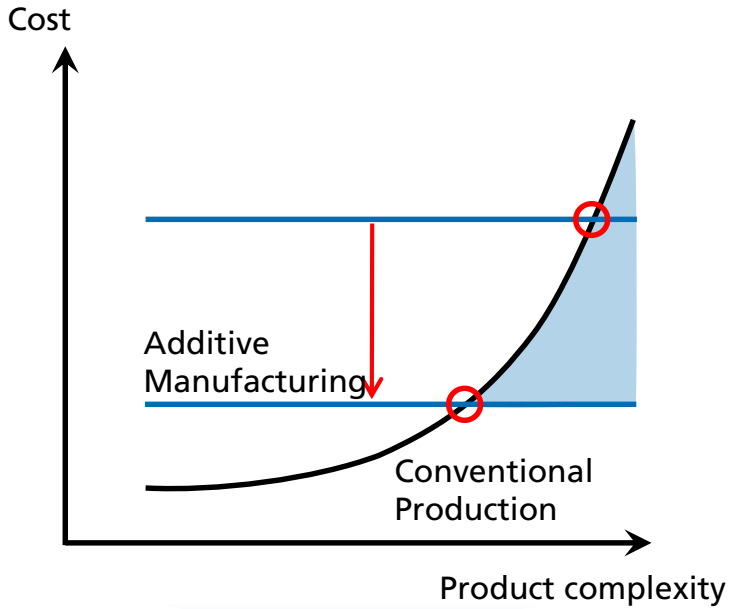
Source: Aeromat, Hypereutectic high strength AlMgSc profile materials, F. Palm, EADS GmbH

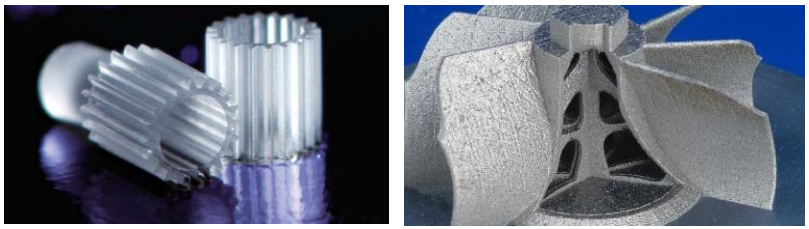
Additive Manufacturing – A new Industrial Revolution!

Individualisation for free



Complexity for free





Innovative Business Models

Innovative Products

Thank you for your attention!