

Selective Laser Melting (SLM[®]) 3D Metal Printer

New perspectives for high productive batch production
for Aerospace Industry.



A presentation by:

Dipl.-Ing. Hendrik Schonefeld

Area Sales Manager North Europe

mobil +49.170.5649474

Fon +49.451.16082-274

Fax +49.451.16082-250

E-Mail hendrik.schonefeld@slm-solutions.com

SLM Solutions GmbH
Roggenhorster Str. 9c
D-23556 Lübeck

Germany
www.slm-solutions.com

Leading industrial companies see the potential of metal based 3D printing

GE quotes:

- “By 2020 GE Aviation will manufacture more than 100,000 additive parts for the leap in GE9X engines.”
- “In the next 5 years we will invest more than 3.5 billion US\$ in new equipment to produce advanced components.”
- “Complexity comes for free”
- “Additive manufacturing is just a great game changer!”



Note: Statements by General Electric, <https://www.ge.com/stories/additive-manufacturing>

○ Agenda

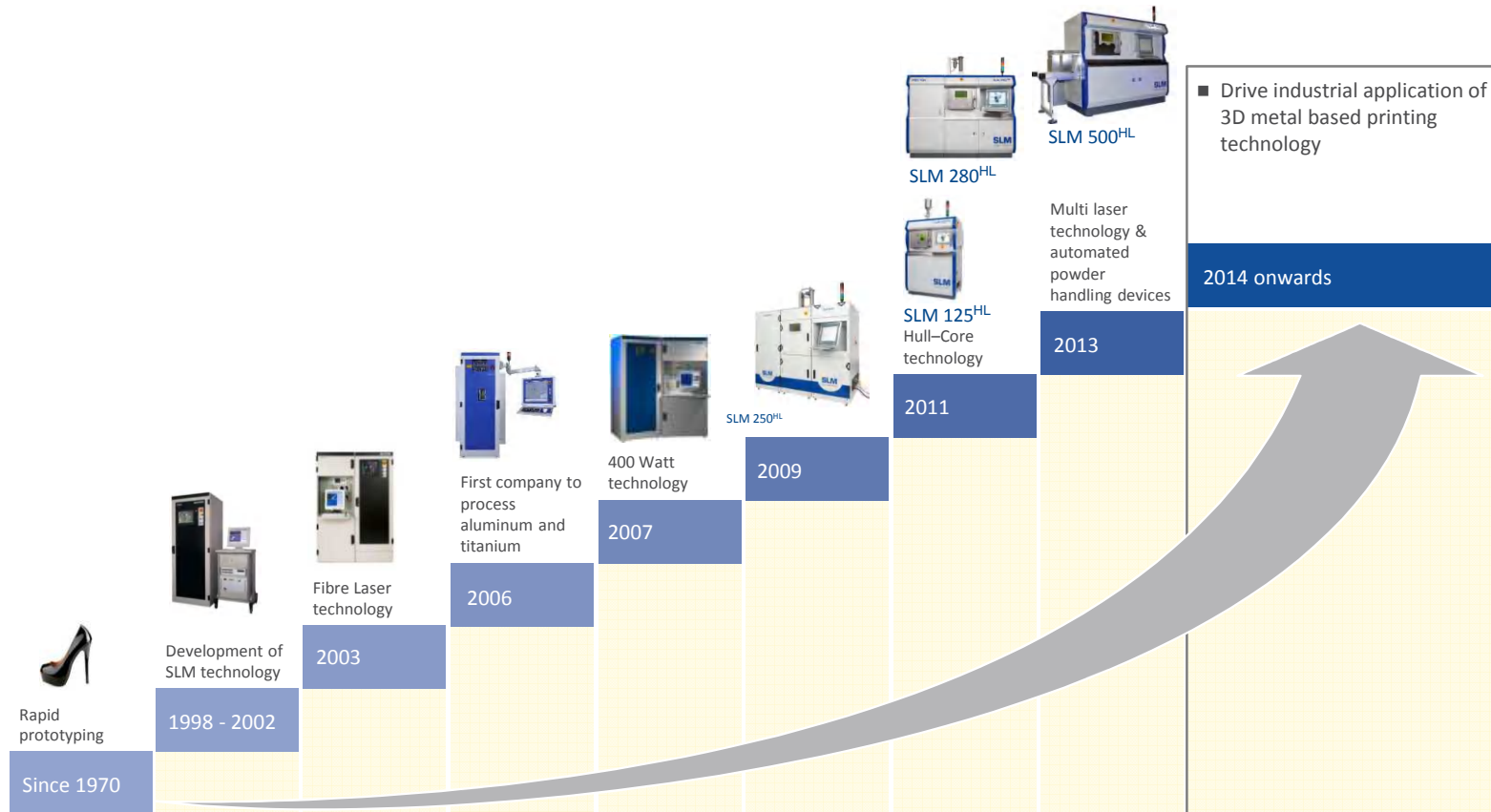


1. SLM-Solutions Group
2. Initial Situation for Part Production
3. High-Batch Repair by means of SLM
4. Increase Manufacturing Productivity

○ Welcome to the North! **53°52'N, 10°42'O, MEZ**



○ SLM Solutions Group – a deep rooted 3D printing heritage



○ SLM Solutions – German engineering with a global reach

Key products



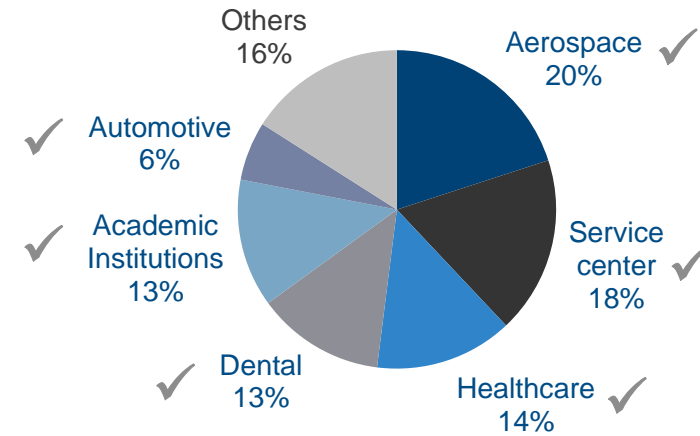
SLM[®]125^{HL}

SLM[®]280^{HL}



SLM[®]500^{HL}

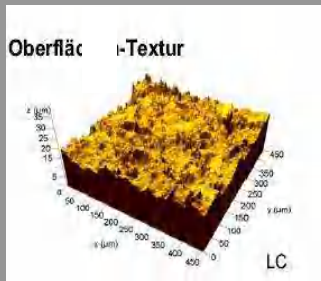
SLM Solutions covers all relevant end markets



✓ = SLM Solutions end market

Important Material and Part Properties

Surface



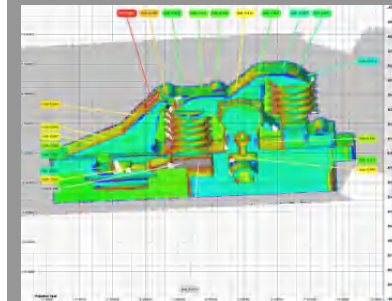
$R_z \approx 30 \mu\text{m}$

Strength



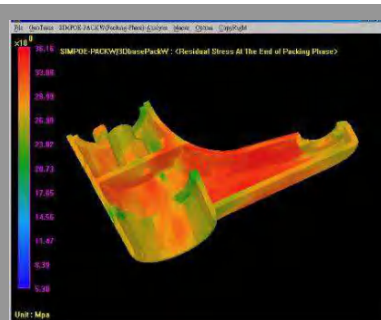
up to 1730 MPa

Accuracy



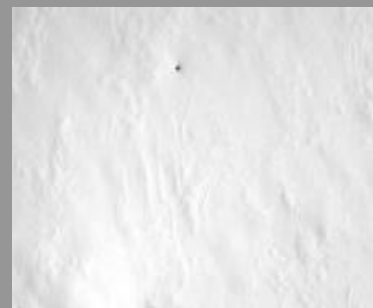
$\pm 25 \mu\text{m} / 100 \text{mm}$

Stress



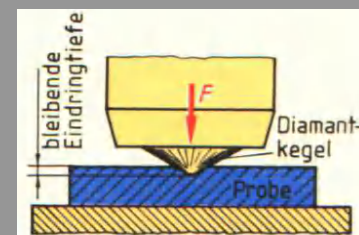
Influences

Density



$\sim 99.X \%$

Hardness



Rockwell-Prüfung

up to 54 HRC

○ Main SLM Process Variables

L: laser power
v: scan velocity
 Δy : hatch distance
 Δz : layer thickness

$$\text{Energy Density } E = L / (v \times \Delta y \times \Delta z)$$

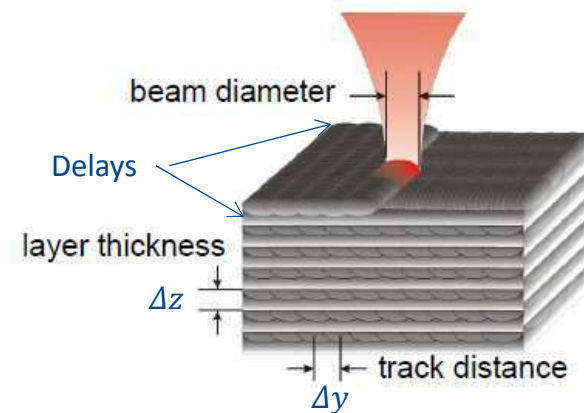
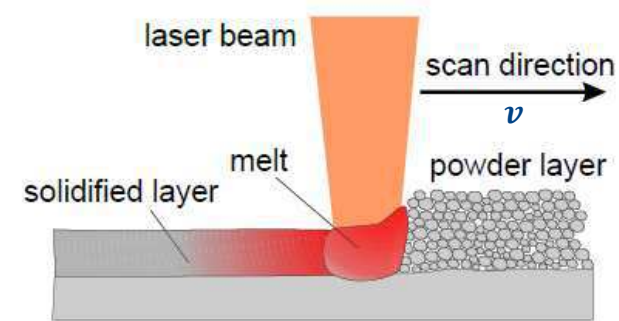
$$\text{Build Rate: } V = v \times \Delta y \times \Delta z$$

Example for aluminium with one laser:

$v \approx 1000 \text{ mm/s}$, $\Delta y \approx 0,2 \text{ mm}$, $\Delta z = 0,05 \text{ mm}$
→ $V = \text{theoretical build rate} \approx 35 \text{ cm}^3/\text{h}$

without delays and recoating time
good accordance with reality for parts with large volume

Conclusion: The four main variables are strong levers for productivity increase



Picture Source: FhG ILT Aachen

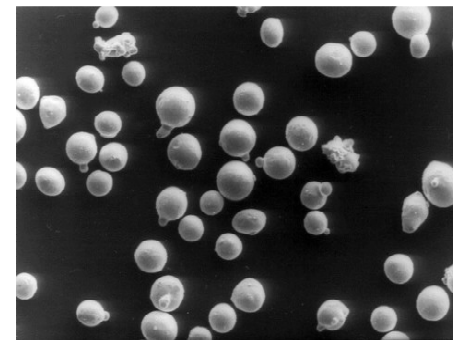
available Material parameters

- **Stainless Steel** 1.4404, 1.4410, 1.4542
- **Tool Steel** 1.2344, 1.2709
- **Co- Cr Alloys** 2.4723 / ASTM F75
- **Super Alloys** Inconel 625, 718, 939 or HX
- **Titanium** Grade 1 - 2
- **Titan Alloys** TiAl6Nb7, TiAl6V4
- **Aluminium Alloys** AlSi12, AlSi10Mg, AlSi7MgCu
- **Bronze** CuSn10



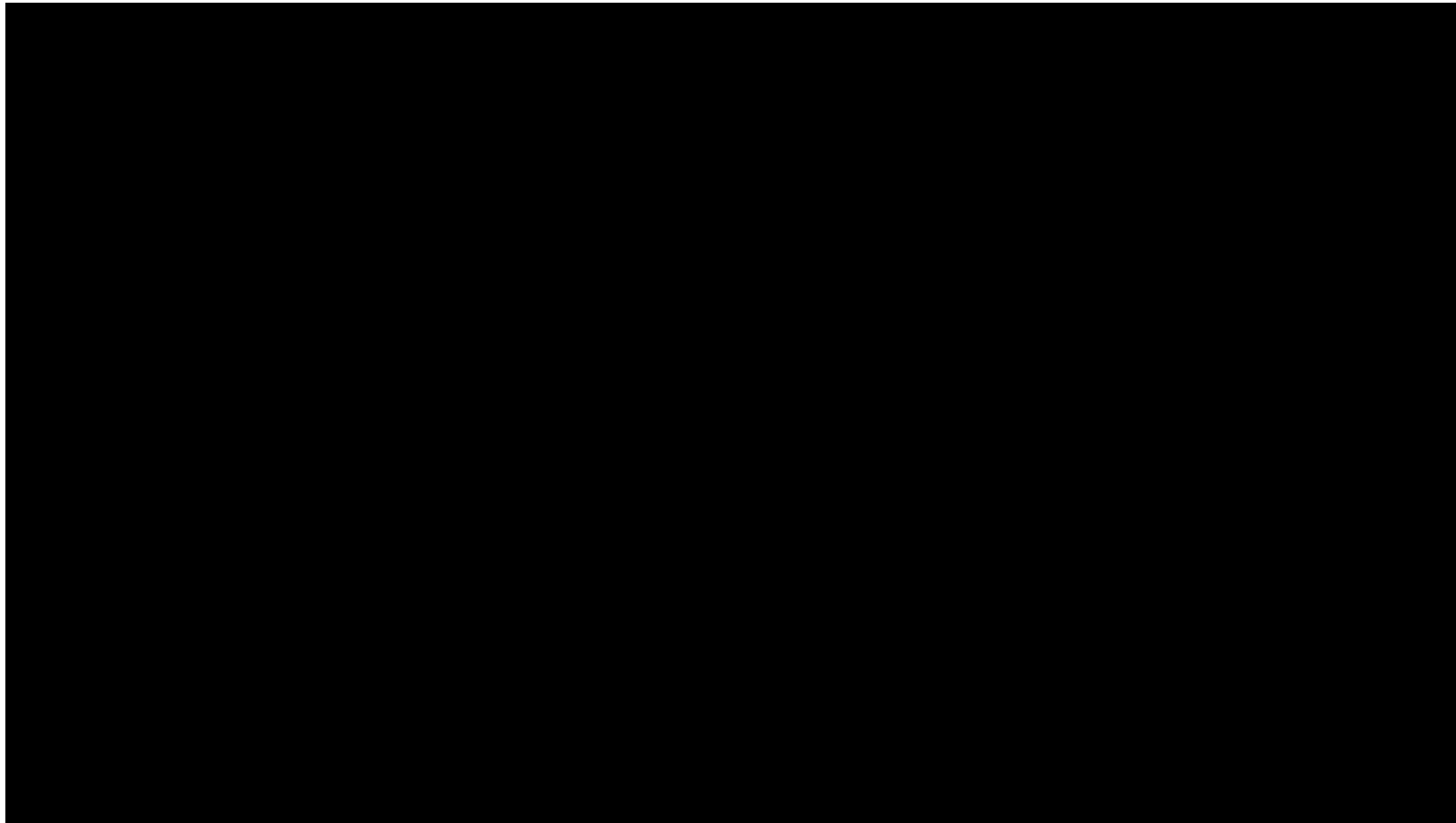
Specifications:

- spherical particles
- $10 \mu\text{m} < \phi < 45 - 63 \mu\text{m}$
- good flowability
- dryness
- pureness (chemistry)



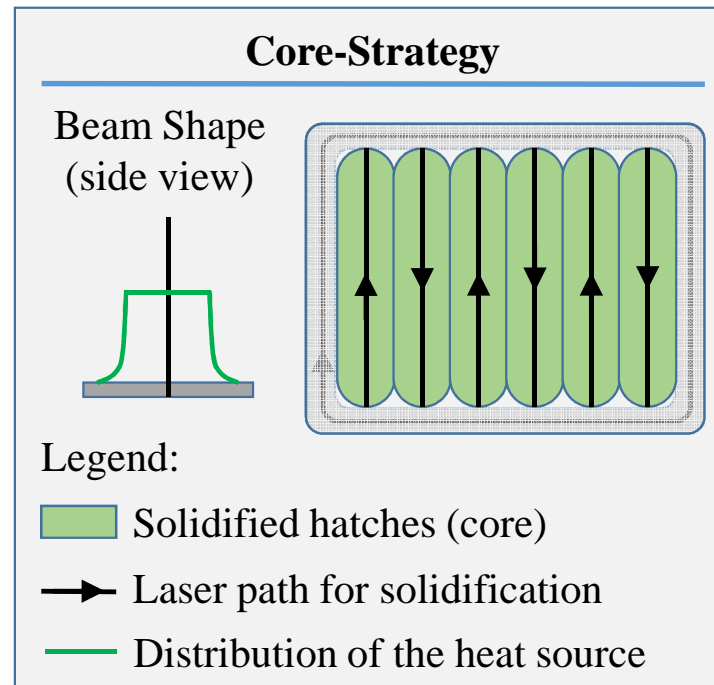
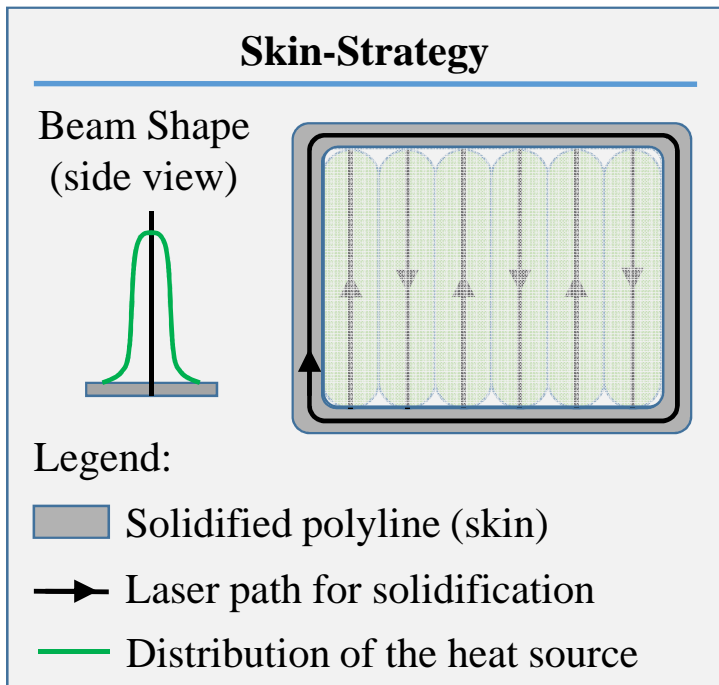
- Technology project:
RepAIR (Funding: EU FP7)

High-Batch Repair by means of SLM



○ Double-Beam Technology

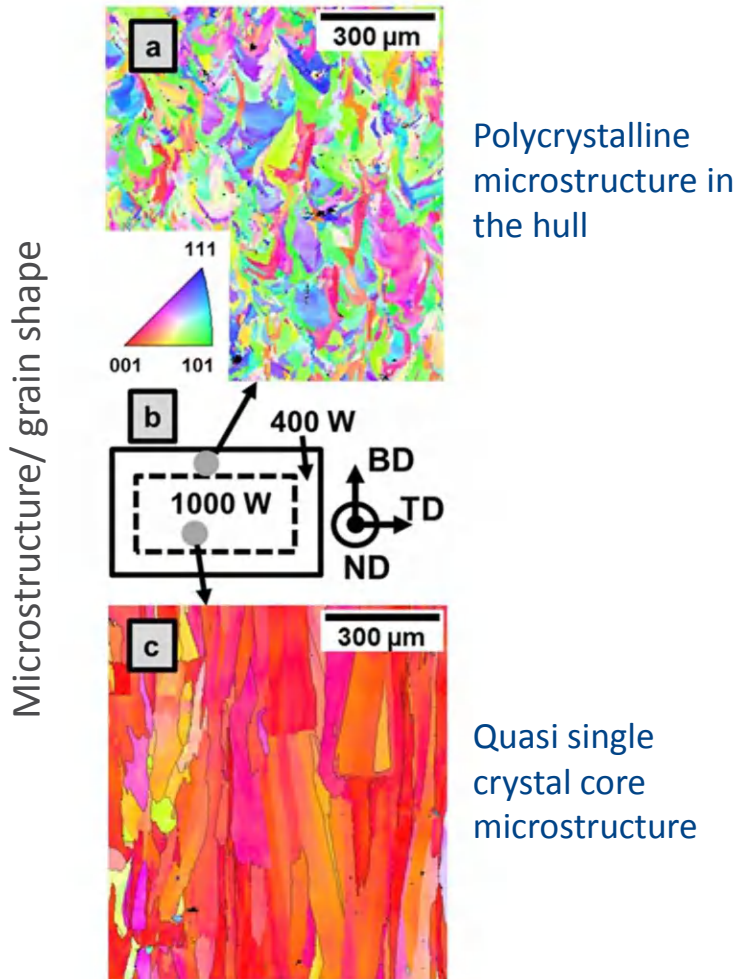
Skin and Core Strategy



➔ **build rate increase possible without loss of surface quality**

T. Niendorf, S. Leuders, A. Riemer, H.A. Richard, T. Tröster, D. Schwarze: *Highly anisotropic steel processed by selective laser melting*, Metall. Mater. Trans. B, 2013, DOI:10.1007/s11663-013-9875-z

○ Core Microstructure Design



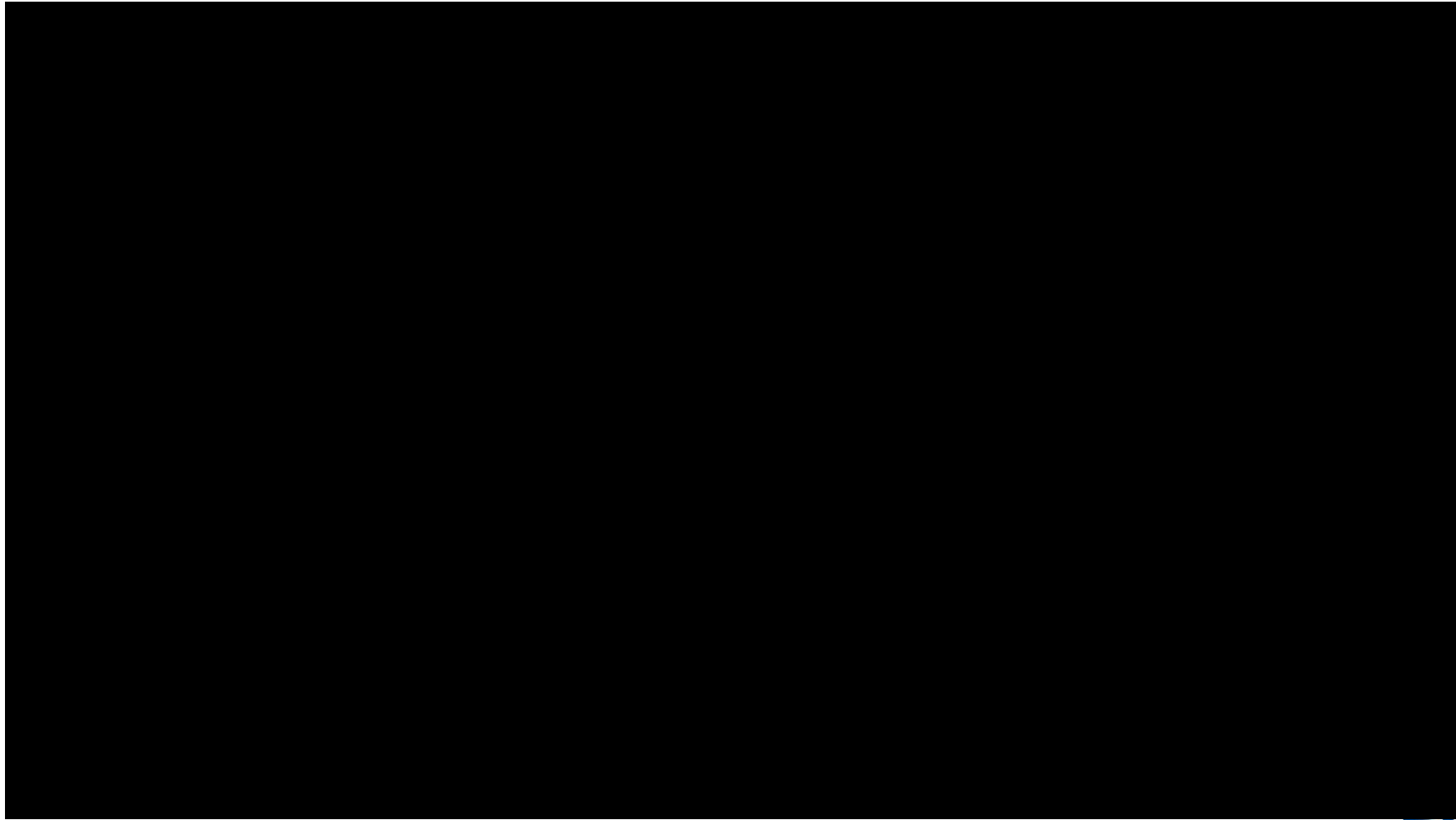
The unique double-beam technology of SLM Solutions is perfectly suited to create a microstructure that can be very beneficial e.g. for high temperature applications.

The quasi single crystal microstructure was found in stainless steel as well as in Inconel, Hastelloy X and CoCr.

T. Niendorf, S. Leuders, A. Riemer, H.A. Richard, T. Tröster, D. Schwarze: *Highly anisotropic steel processed by selective laser melting*, Metall. Mater. Trans. B, 2013, DOI:10.1007/s11663-013-9875-z



○ Productivity Increase with 4 Scanners and 4 Lasers in the SLM 500 HL



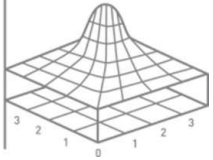
○ Productivity



+68%

+235%

Build rate (cm³/h)



Thank you for your attention!



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