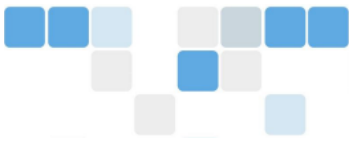


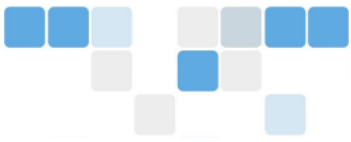
AFX Beam Control Technology – Lasers built for AM series-production





Agenda

- **Introduction Optoprim / nLIGHT**
- **AFX Introduction & Motivation**
- **Technology**
- **Application examples**



Facts

Application

Service

- **Distributor for industrial and scientific state of the art laser / photonic products**
- **Founded in 1994**
- **65 employees**
- **Locations in Paris / Munich / Monza / Rome**
- **Strong focus in industrial laser applications & material processing**
- **Offering of sales, application, training and service support**
- **Member of EPIC network**

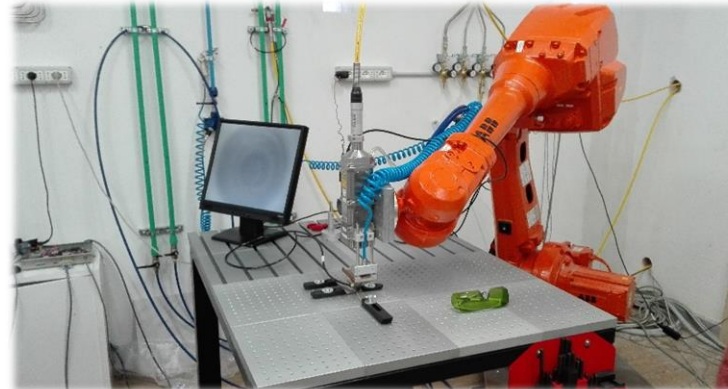




Facts



Application



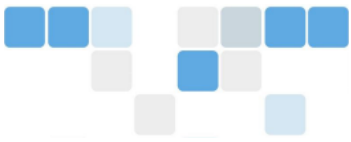
Service



Offering of various application processes – MACRO, MICRO & MARKING



Different laser technologies, consumables & analyses equipment

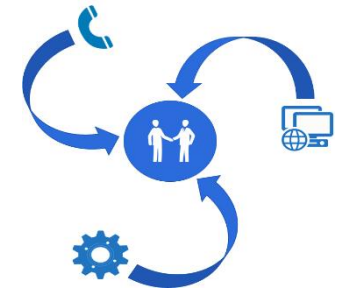


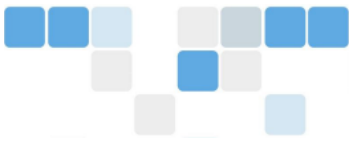
Facts

Application

Service

- **Installation Support and Training**
- **Application Support in our Lab or at Customer Side**
- **Field Service at Customer Side, Repairs in the Lab or Remote service**
- **Spare Parts and Safety Stock**
- **Consulting**

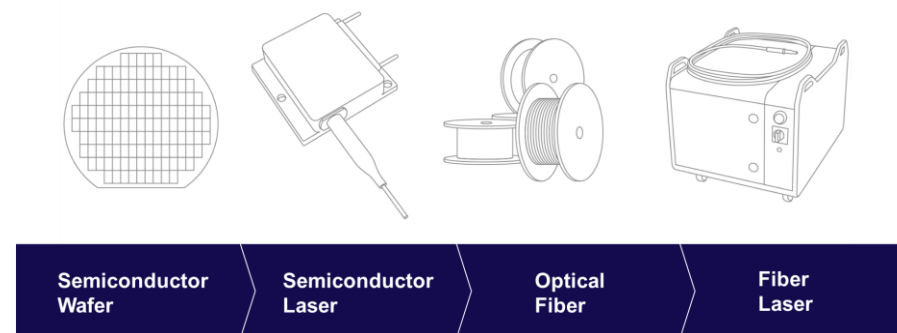


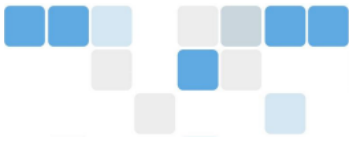


nLIGHT: High-power semiconductor and fiber lasers

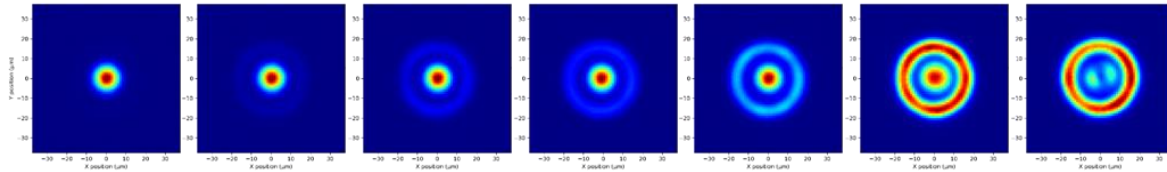


- **Technology Focus:** Vertically-integrated leading supplier of high-power semiconductor and fiber lasers
- **Applications:** Industrial, microfabrication, aerospace & defense
- **Founded:** 2000
- **Headquarters:** Camas, WA USA
- **Sales:** 2020 revenues of >\$200 million (growing >20%/Yr.)
- **People:** >1,200 employees
- **Patents:** >320



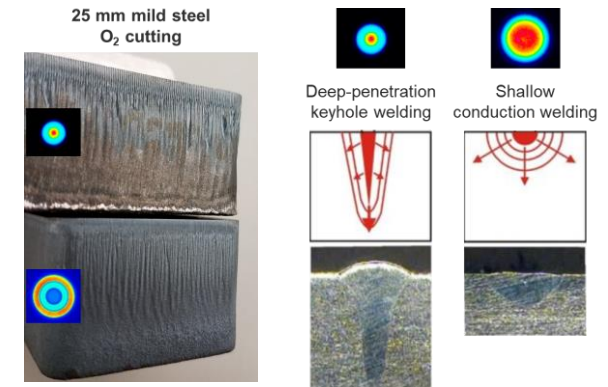


Industrial fiber laser with a rapidly tuneable beam profile optimized for additive manufacturing



Motivation

- **Materials processing performance depends on the laser beam characteristics**
 - size
 - shape
 - divergence
- **Precise heat deposition is critical for**
 - controlling the feature size
 - maximizing the production rate
 - maximizing part quality
 - minimizing heat-affected zone, spatter, porosity, and other deleterious effects
 - versatility in material composition and thickness



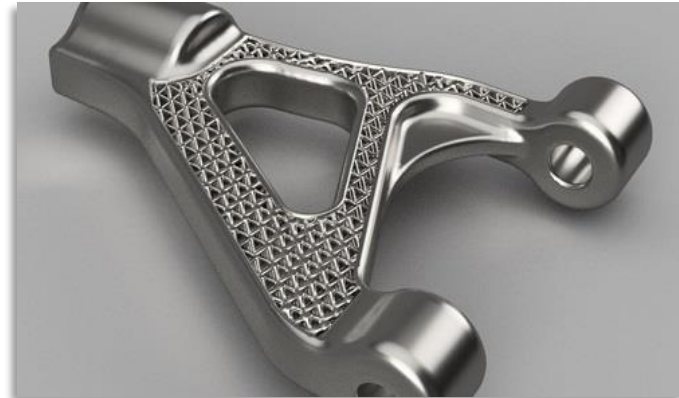
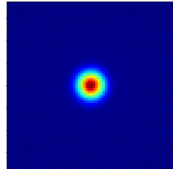
Proven technology for multi-kW applications since 2018
(currently available up to 15 kW)



The need for beam spatial control in AM tools



Single-mode laser -
analogous to a
fine point paint brush

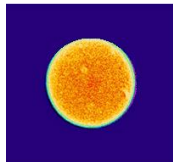


credit: <https://www.autodesk.com/products/netfabb/overview>

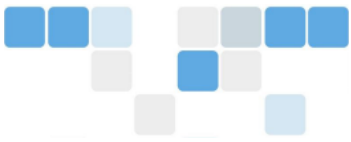
Imagine you have the full palette of
spot sizes + different beam profiles on top



Multi-mode laser -
analogous to a
thick paint brush

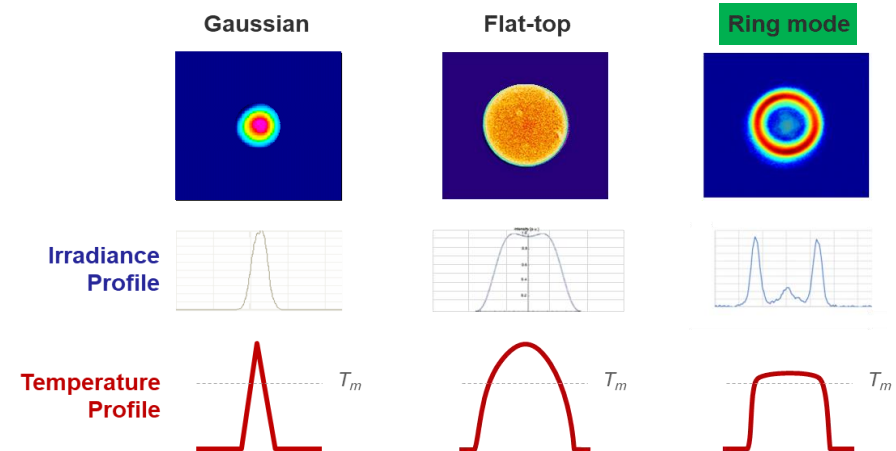


- parts typically have both fine detail and large-scale features
- L-PBF tools use single-mode lasers to achieve fine-scale resolution
- small spot size limits the productivity
- switching between single mode and larger spot sizes could greatly increase build rates



What about beam shape?

- For larger spot sizes, non-Gaussian beams are preferred

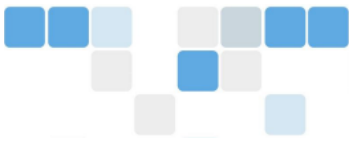


Most lasers have fixed beam characteristics

- downstream methods to tune the beam have proven impractical
 - increase cost and complexity
 - decrease tool performance or reliability

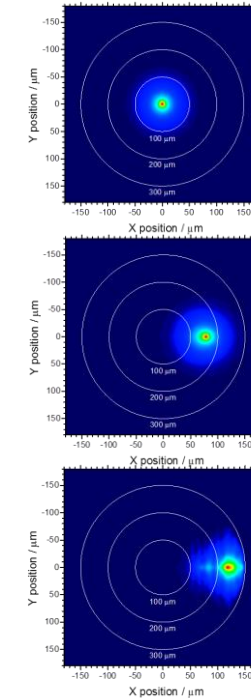
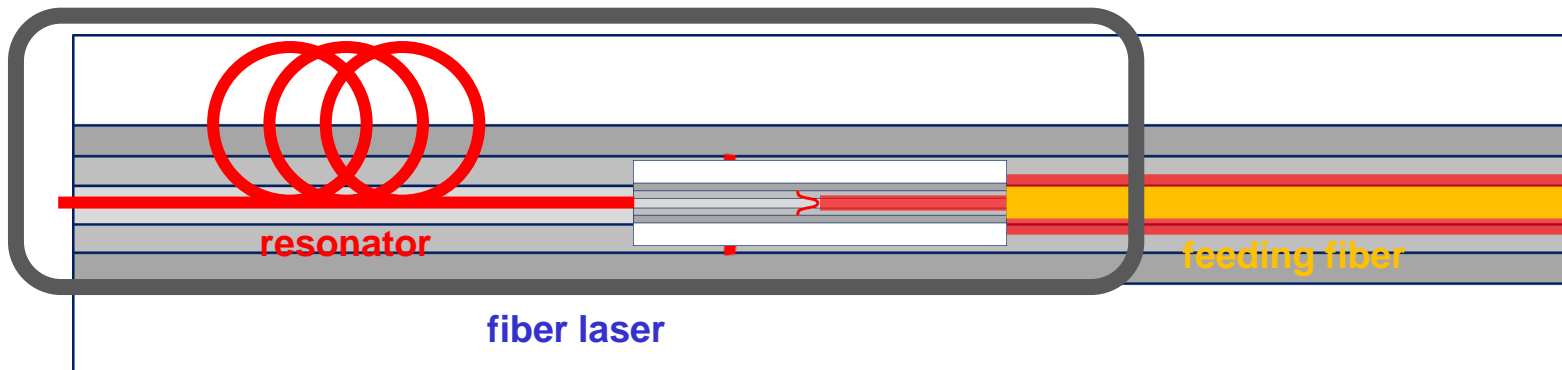


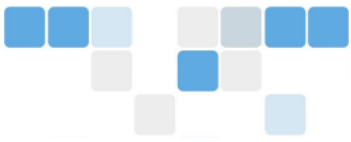
Inconel 718



Three basic components:

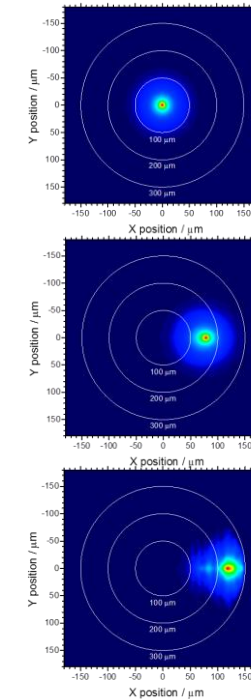
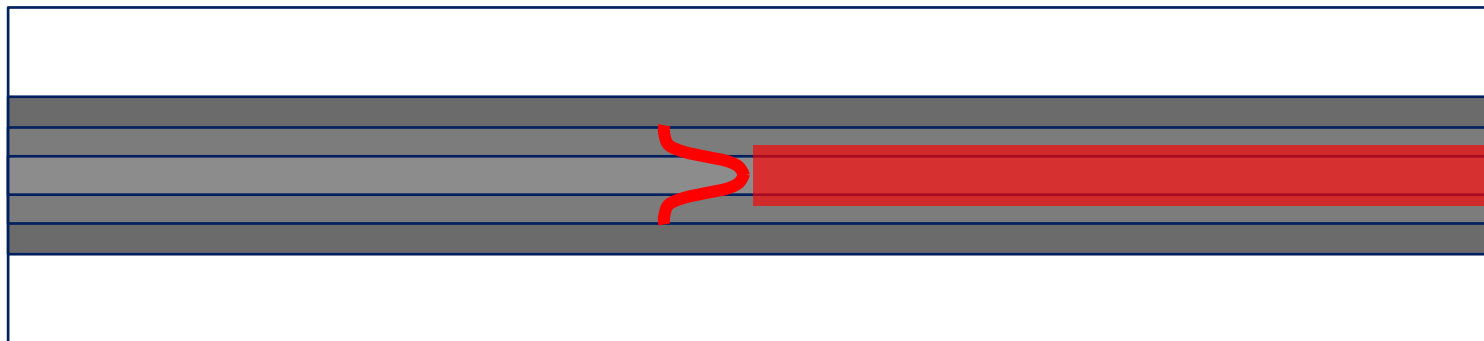
1. A feeding fiber that has multiple guiding regions
2. A fiber that enables the beam to be shifted radially via application of a perturbation
3. A mechanism to adjust the beam





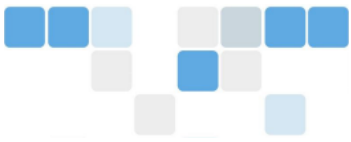
AFX is integrated (spliced) into the fiber laser

- maintains all of the fiber laser performance and reliability benefits
- no free-space optics
- fast switching (< 30 ms)
- optimization of each process step on-the-fly
- highly reliable
- >20 million beam changes with no change in performance
- large depth of field (process window)





Christian Schröter – OptoPrim – AFX Beam Control Technology - Lasers built for AM series-production



Precision

Optimization

Productivity

Lattice



credit: Aconity3D GmbH

Mixed geometries



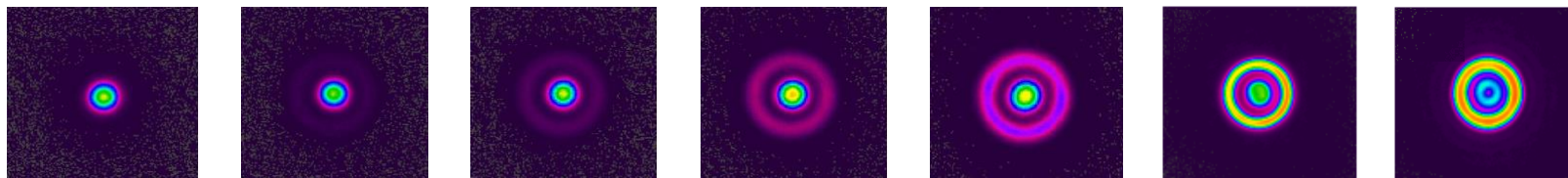
credit: Aconity3D GmbH

Bulk



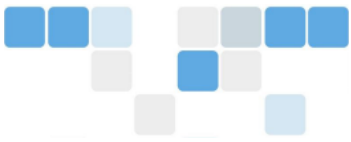
credit: Aconity3D GmbH

Single-mode
spot size, d_0



Ring-mode
spot size, $3d_0$

Switch beam profiles,
on-the-fly, in millisecond timescales



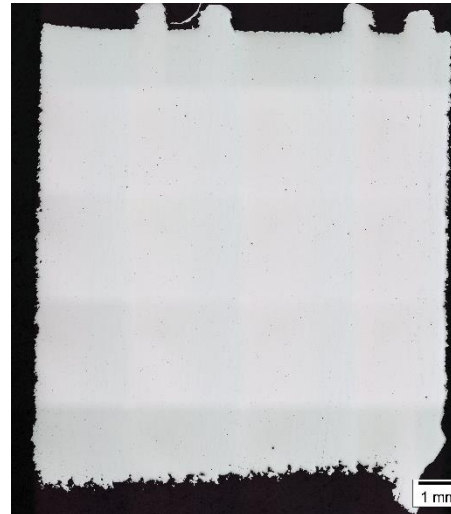
Content credit:
Tim Lantzsch



Processing of IN625

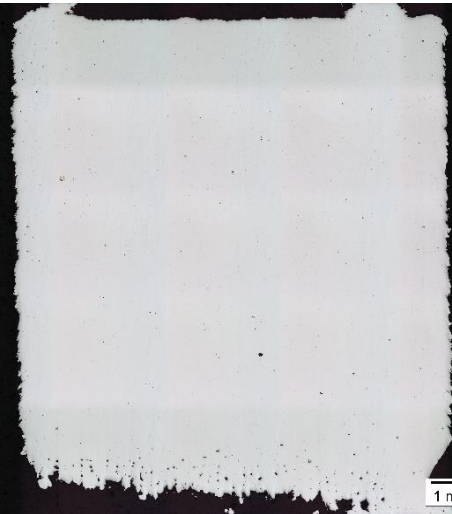
- Three main parameter sets for LPBF-processing:
 - Reference
 - Maximum scan speed
 - Maximum build-up rate
- Relative density > 99,8% can be achieved for all parameter sets

Reference



$P_L = 350 \text{ W}$, $v_s = 1000 \text{ mm/s}$, $D_s = 50 \text{ }\mu\text{m}$, $V_{th} = 6 \text{ mm}^3/\text{s}$

Max. scan speed

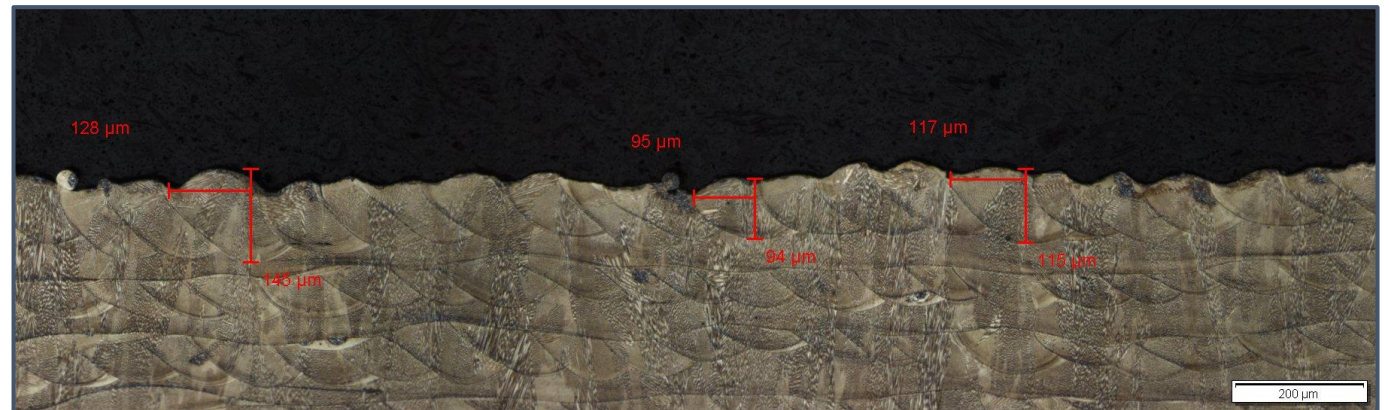


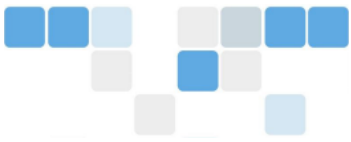
$P_L = 650 \text{ W}$, $v_s = 2200 \text{ mm/s}$, $D_s = 50 \text{ }\mu\text{m}$, $V_{th} = 11 \text{ mm}^3/\text{s}$

Max. productivity



$P_L = 675 \text{ W}$, $v_s = 1700 \text{ mm/s}$, $D_s = 100 \text{ }\mu\text{m}$, $V_{th} = 17 \text{ mm}^3/\text{s}$





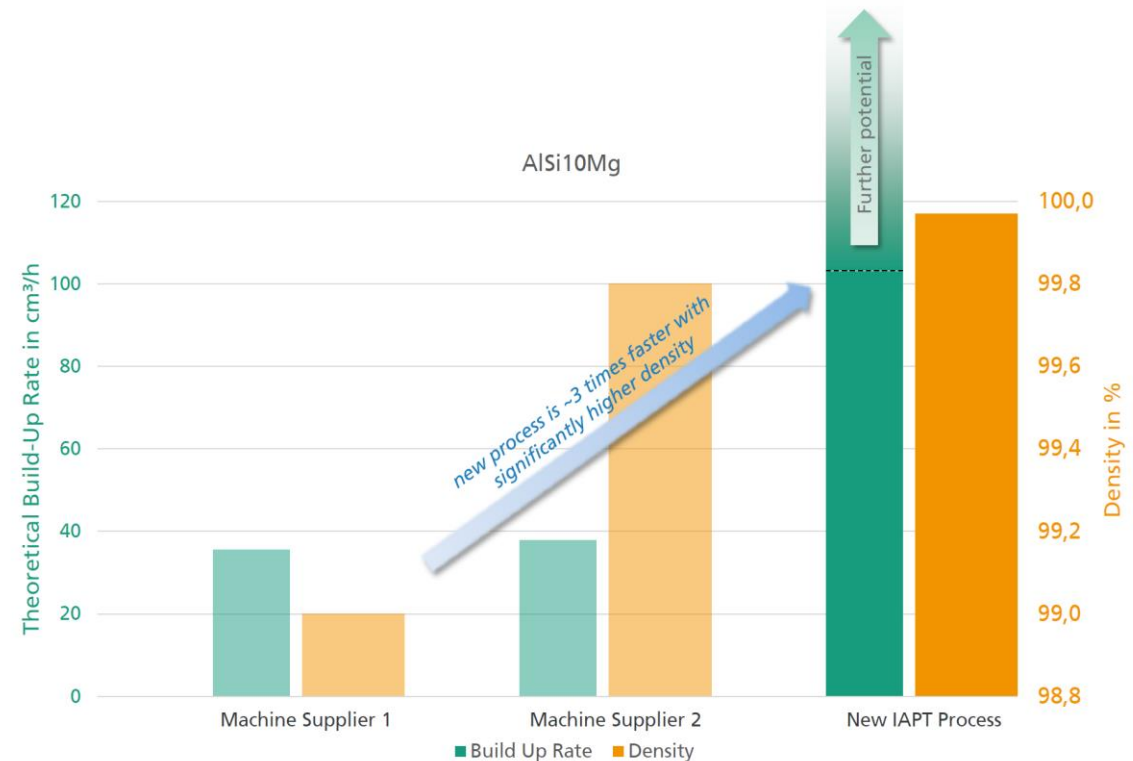
Content credit:
Philipp Kohlwes



Processing of AlSi10Mg

- donut profile enables higher energy input, as a gaussian profile in the peak would lead to much too high laser intensities
- theoretical build-up rate could be reproducibly increased to 103 cm³/h at a density of 99.97 %

further potentials could be identified (reduction of target density, higher layer thicknesses,...)

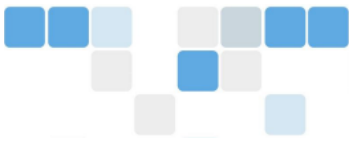


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© Fraunhofer

public

values of the official datasheets
same layer thickness for all three suppliers



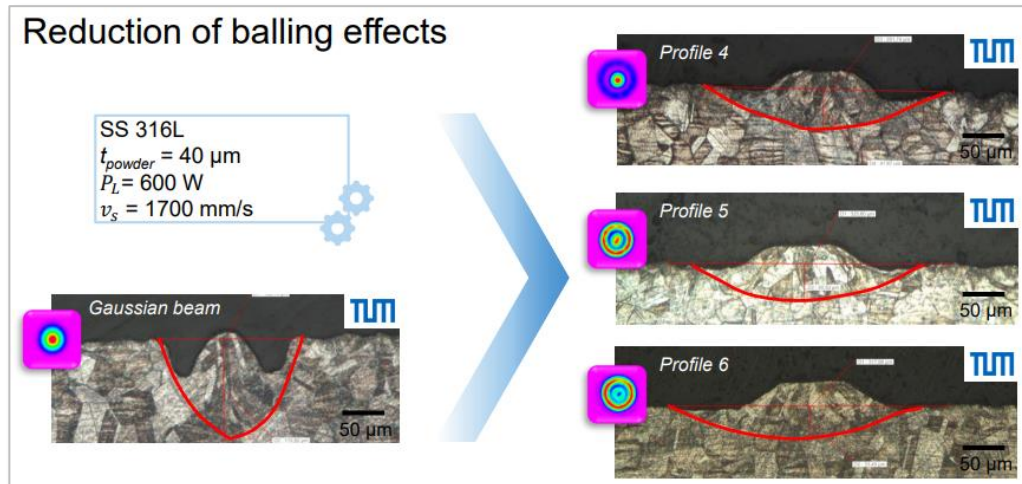
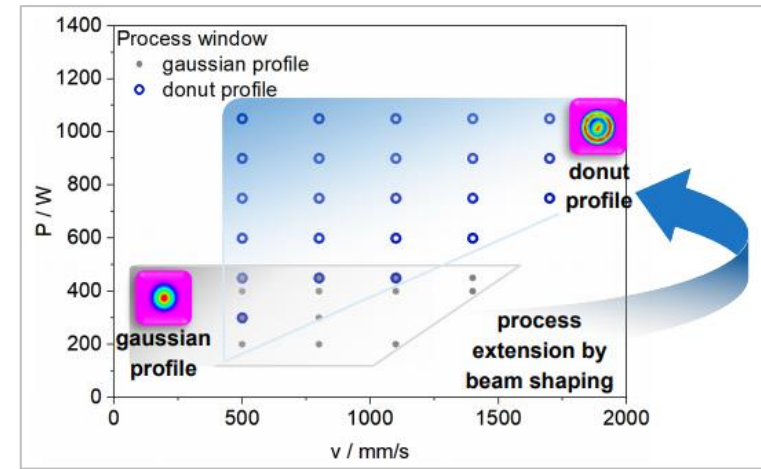


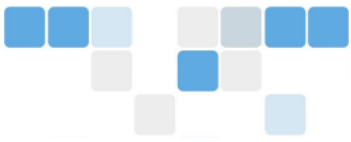
Content credit:
Katrin Wudy &
Jonas Grünewald



Processing of 316L

- Extension of process window
- Potential to increase productivity
- Reduction of balling effects
- Tailoring microstructure



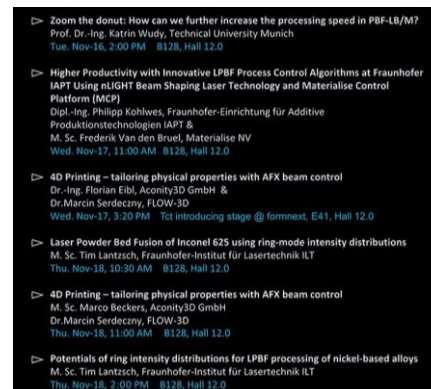


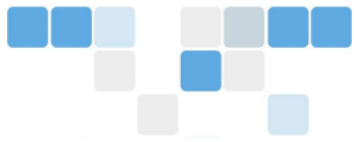
AFX Beam Control Technology – Lasers built for AM series-production



Conclusion

- **AFX is a breakthrough for L-PBF tools**
 - unmatched productivity and part quality
 - enables a new generation of AM tools for series production
- **Novel technology provides industry-leading performance**
 - optimized beam shapes
 - beam tuning on-the-fly for optimization of each process step
 - all-fiber design overcomes limitations of previous technologies
- **For more information**
 - Formnext AFX 360 presentations
 - www.optoprim.de
 - www.nlight.net

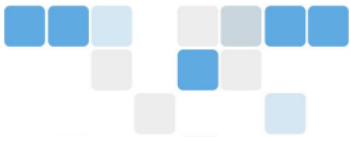




Next level of tailoring microstructure:

4D Printing?





AFX Beam Control Technology – Lasers built for AM series-production



Thank you – Danke – Merci – Grazie

FOR YOUR ATTENTION

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[Link to our industrial brochure](#)

AMEXCI

Top 5 Metal Technology Highlights
from Formnext 2020

