TRUMPF

Overview of Laser Metal Deposition
Applications, Trends and Products

International Conference on Additive Manufacturing, EMO Hannover | 17. September 2019

Marco Göbel | Industry Management LMD

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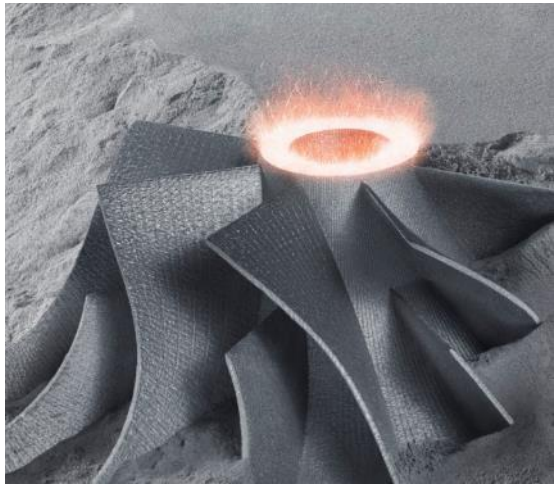
TRUMPF is…

Family business since 1923

Technology leader in two business divisions

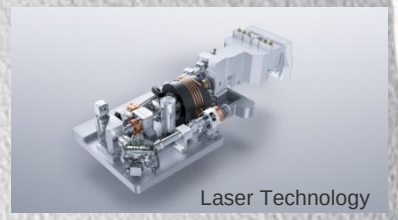
Close to its customers with 77 subsidiaries



Innovation promise – holistically and constantly

Facts and Figures TRUMPF

Company Figures FY 2018/19


Laser Technology


Machine Tools

R+D expenditures in Mio. €

337 +6 %

R+D Quota

9,5 %

Sales in Mio. €

3,800 +6 %

Employees on June 30,2019

~ 14,500

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Process – Differences LMD & LMF

Laser Metal Deposition (LMD)		Features	Laser Metal Fusion (LMF)	
Productive process for repair, surface functionalization and AM on free-form surfaces			Precise process for AM of complex workpieces in a powder bed	
-	★★★	Geometrical Complexity	★★★★★	(with preheating)
(free-form surface)	★★★★★	Build-Up on exisiting workpiece	★★★	(flat substrate)
-	★★★	Material Selection	★★★	-
(10 - 600 cm³ / h) [1]	★★★	Build-Up Rate	★★	(2 - 180 cm³ / h)[1]
(< 0.5 mm)	★★	Details / Precsion	★★★★	(< 0.1 mm)
(Ra 10-20 µm)	★	Surface Quality	★★★	(Ra 5-10 µm)

[1] depending on system configuration, parameters, strategy and material

Fields of Application

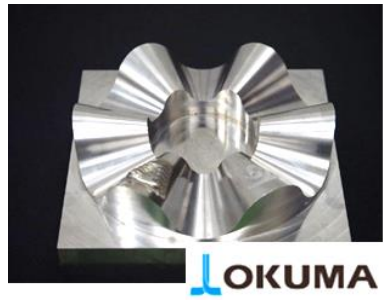
Surface Functionalization

Enhancement of wear- & corrosion protection

Repair

Repair of tools:

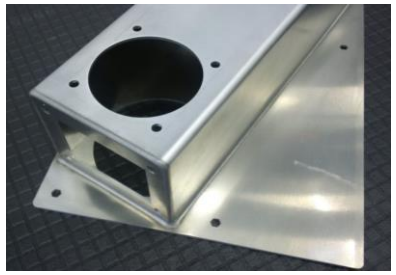
Hybrid method → OKUMA

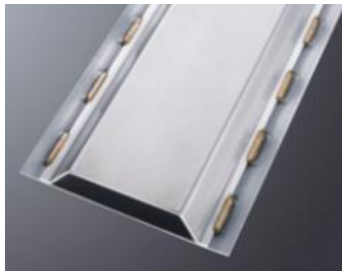


Joining Technology

Joining with powder additive:

- Gap bridging
- Joining of dissimilar materials
- 3D joining

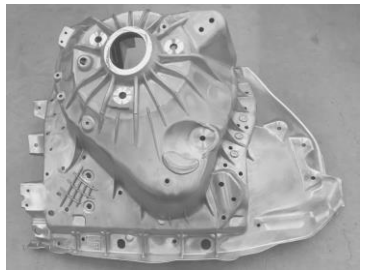


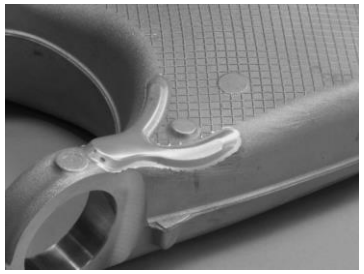


Additive Manufacturing

Modification of parts and AM on 3D structures:

- Build-up of complete volumes
- Local reinforcements





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Laser Metal Deposition

Equipment & Fields of Application

Fields of Application

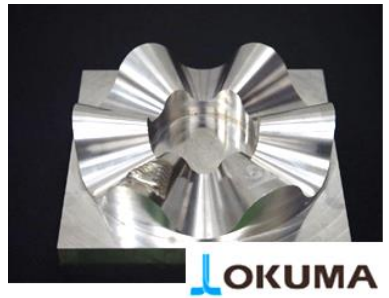
Surface Functionalization

Enhancement of wear- & corrosion protection

Repair

Repair of tools:

Hybrid method → OKUMA



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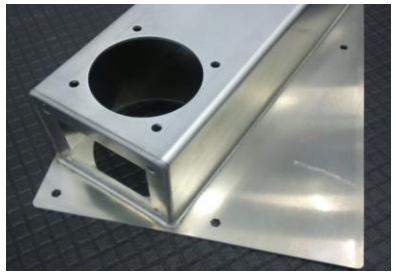

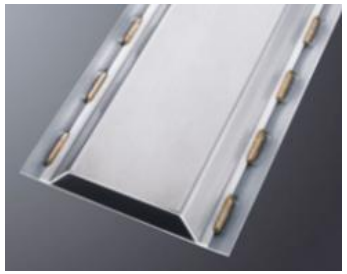

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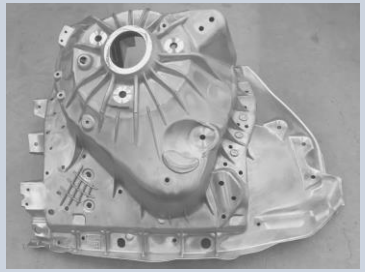

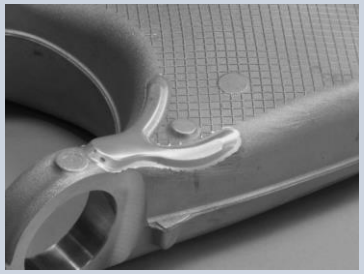

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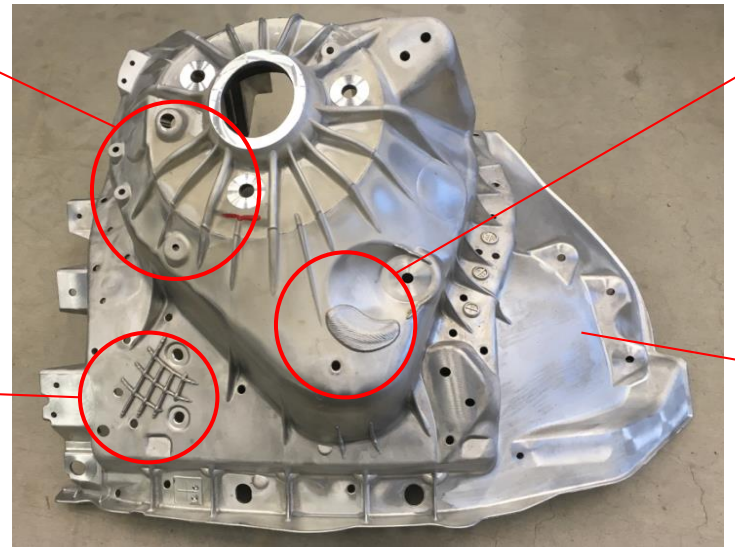
Part Customization by LMD – Modification of Automotive Parts

LMD on Conventionally Cast Preforms

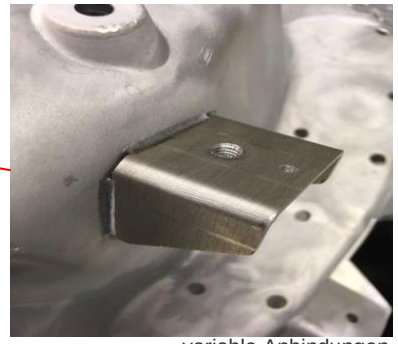
Rippenverstärkung

Verstärkungsgitter

Landesprojekt **„SerAddMeHa“**
Serienfähigkeit additiver Drucktechnologien
durch metallische Halbzeuge



Verstärkungsflächen



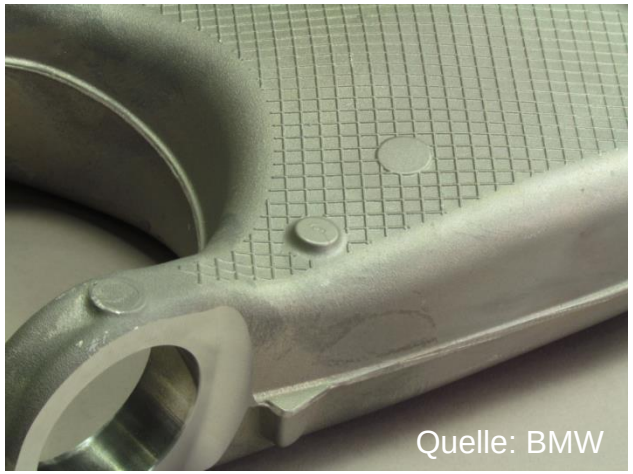
variable Anbindungen

- Application oriented modification of 3D-parts for small and big parts for small – medium size production
- Economical supplement by combination of conventional and additive manufacturing
- Combination of different materials, tailored to the requirements of a given application
- Reduction of different variants → „Mass customization“

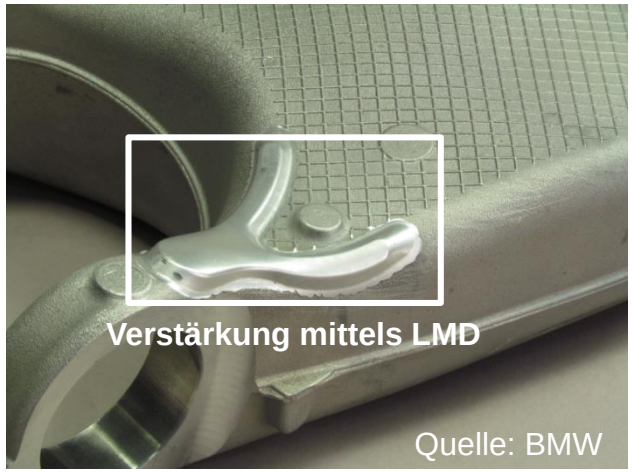
Part Customization by LMD – Modification of Automotive Parts

LMD on Conventionally Cast Preform

- Part: Suspension arm (part of a rear axle)
- Application: Local, stress optimized reinforcement of component
- Advantage: Reduction of various casting tools → reduction of costs



Preform



Reinforced and final machined part

Scope of Production: Reduction of process time and costs by approx. 67 %

Part Customization by LMD – Modification of Automotive Parts

LMD on conventionally cast preform – 5-Axis Application

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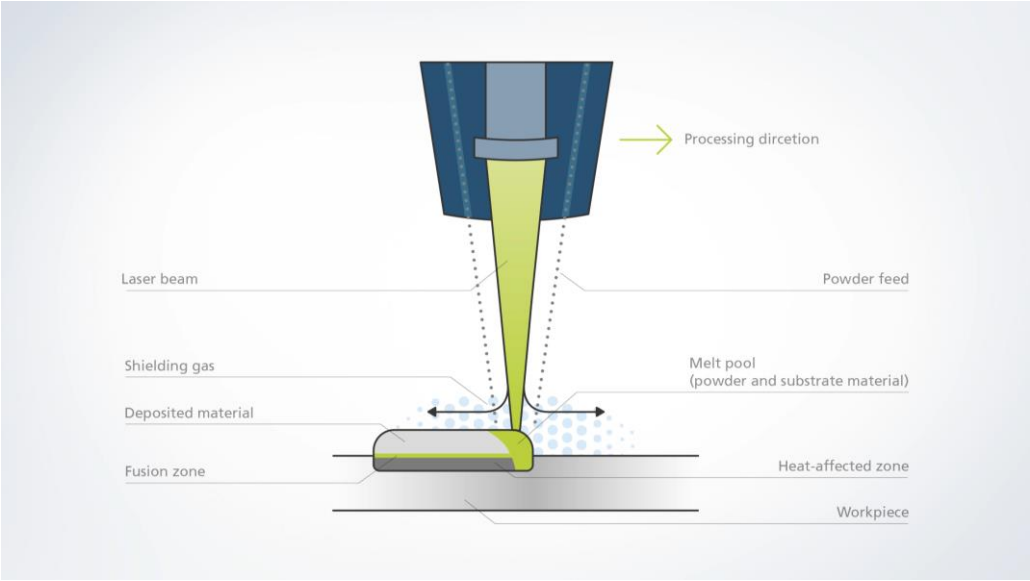
EHLA – „Hochgeschwindigkeits-Laserauftragsschweißen“

Comparision: Conventional LMD – EHLA

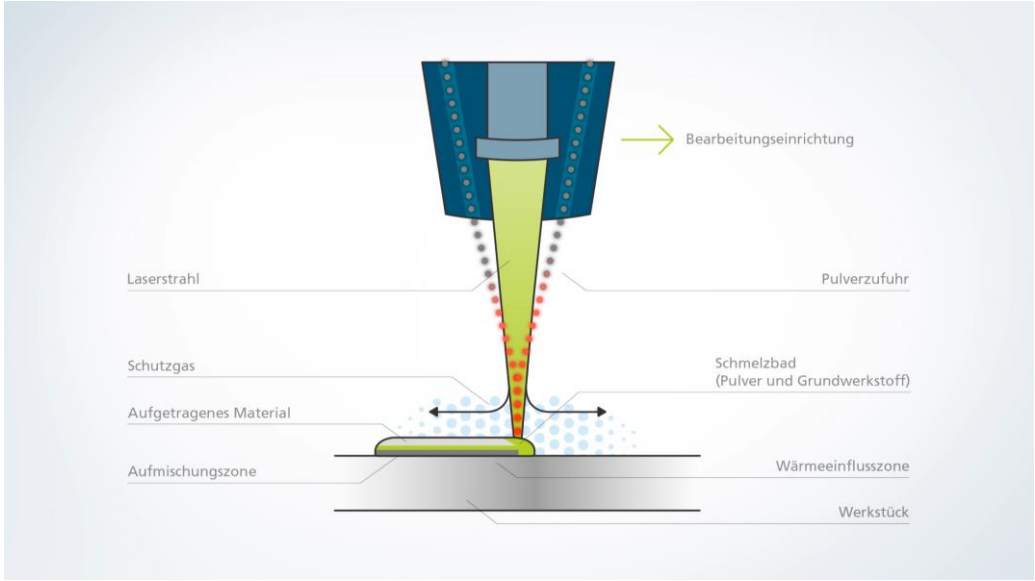
- EHLA is a very high speed variant of the LMD process, yielding very high surface rates
- Using the EHLA-process powder particles are heated up to melting temerpature before hitting the surface

Conventional LMD



→ Powder particles molten on surface
→ High build-up rates (volume)

EHLA



→ Powder particles molten above surface
→ Very high surface rates

Comparison LMD – EHLA

Feature	Conventional LMD	EHLA	Factor
Scanning speed	0.5 - 2 m/min	> 100 m/min	50
Surface rates	▪ 50 cm^2/min (local build-up) ▪ 100 cm^2/min (surface)	Up to 1000 cm^2/min	10 – 20
HAZ*	≥ 500 - 1000 µm	< 10 µm	100
Layer thickness	≥ 500 µm	≥ 50 - 250 µm	10
Surface roughness	R_z = 100 - 200 µm	R_z = 10 - 20 µm	10

* Typical values. Heat input can be reduced and adapted; enabling new material combinations and properties, which are considered to be not conventionally achievable (e.g. Ti on steel, defect free coatings on cast iron).

Significant increase in producitivity for coating of rotational symmetric parts.

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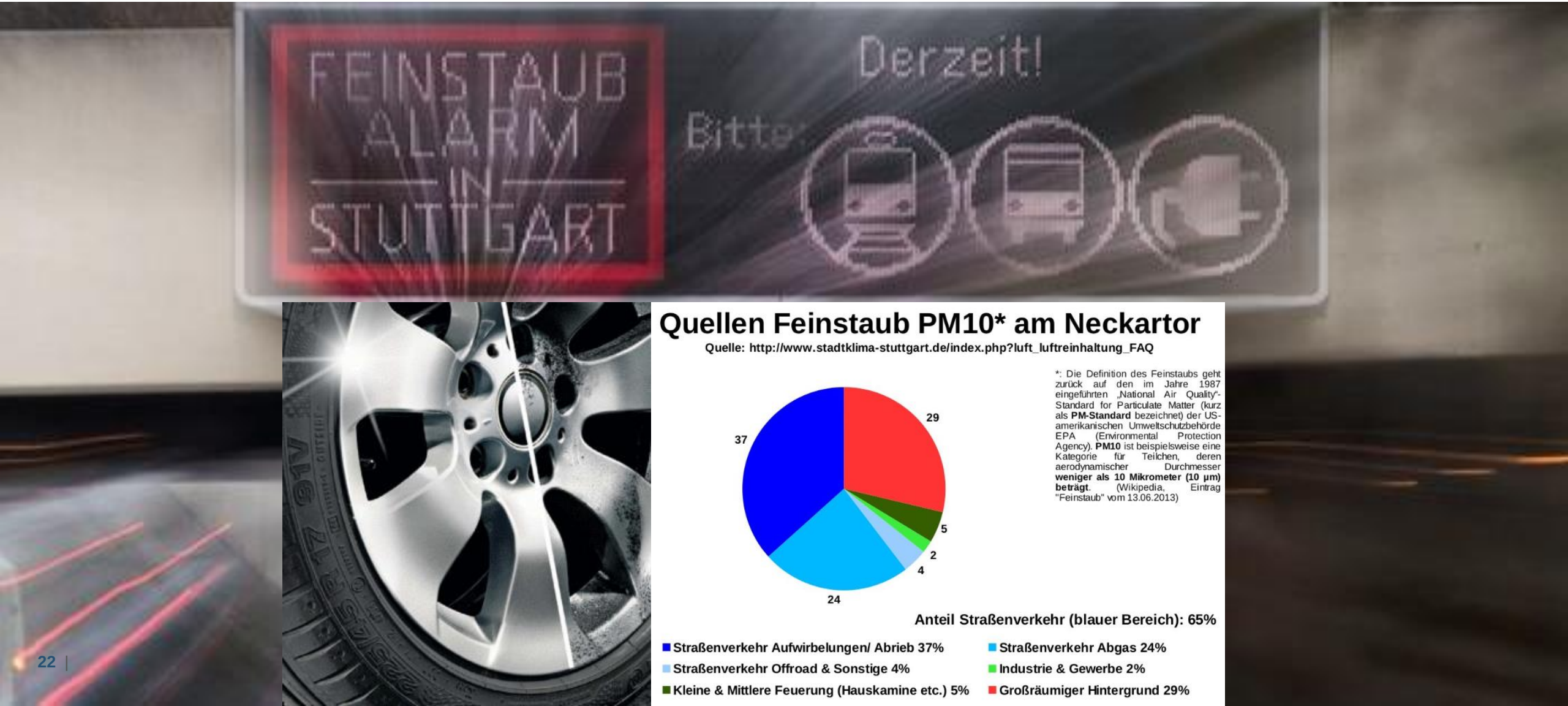
Fine Dust in Cities – A Very Acutal Problem in Stuttgart

37% Fine Dust Originates from Abrasion of e.g. Brake Discs



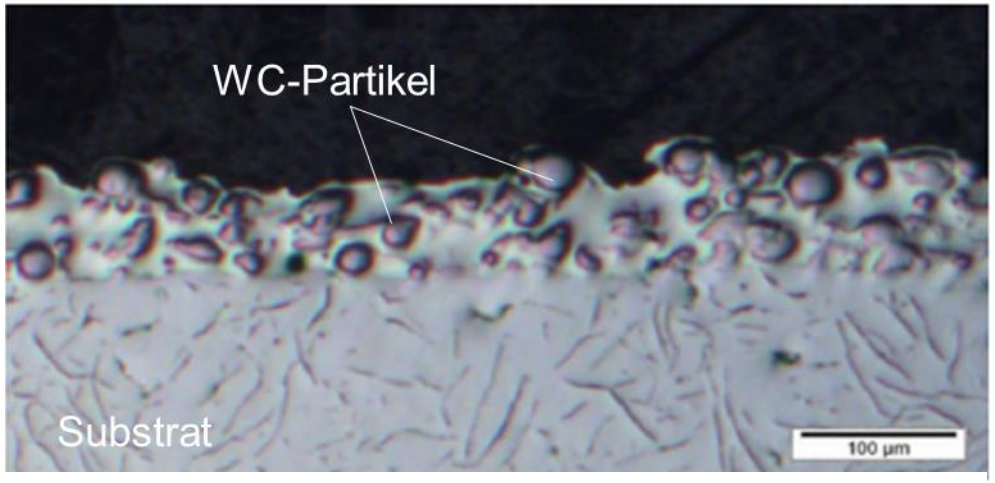
EHLA for Brake Discs

New Coatings with State of the Art Coating Technology

- Coating System (corrosion- and abrasion resistant) using Cermets
- Challenge for conventional welding and LMD: cast iron. Graphite in lamellas enhance brittle phases, which can cause cracking within coating and substrate.
- By use of EHLA a minimized thermal energy input and dillution into workpiece is feasible, therefore significant reduction of brittle phases and risk of cracking

Coated Brake Disc (felft).

Quelle: TRUMPF, Fraunhofer ILT

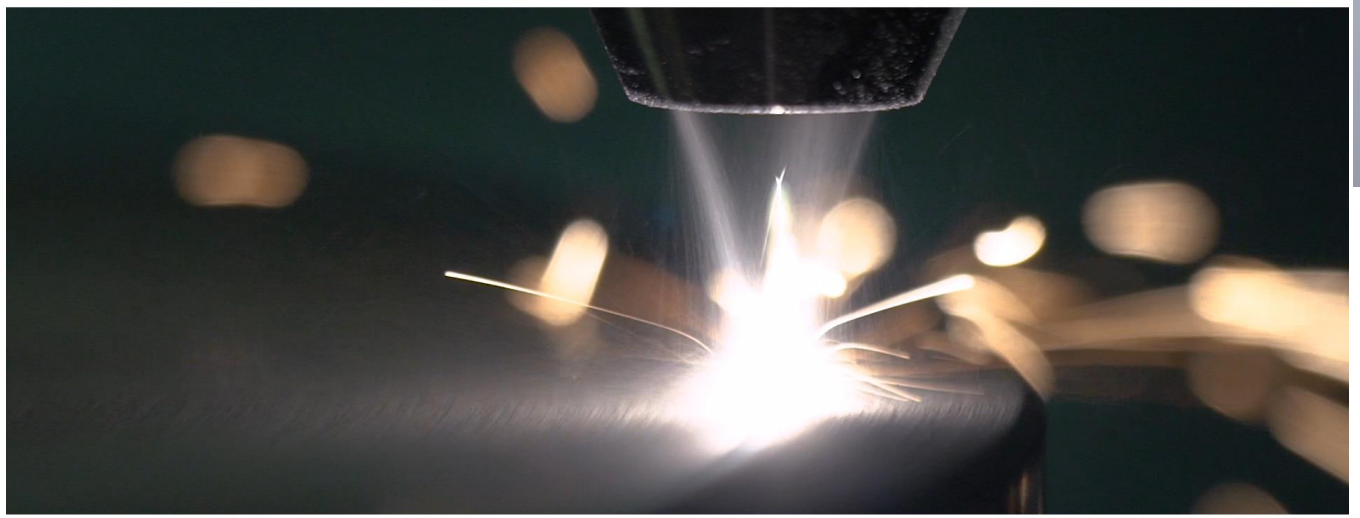


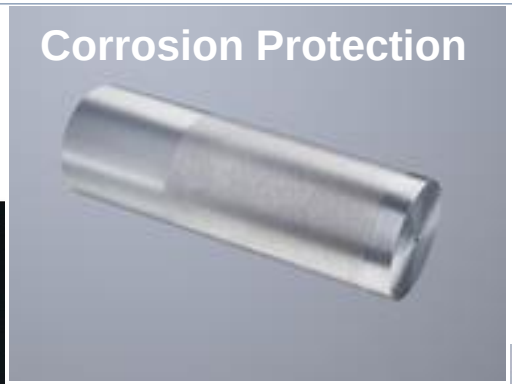
Cross section of Cermet: WC-Carbides in Ni-Matrix. Substrate is cast iron (right).

Further Applications for EHLA

Industry	Part
Printing industry	Feed-, print rolls, etc.
Machine- & Toolbuilder	Components of hydraulics; e.g. lifters, pistons, vibration dampers, etc.
Automotive	Brake disc, valves, piston rings, etc.

EHLA – Hochgeschwindigkeits-Auftragschweißen
Beschichten mit >100m/min





Shaft

Valve Seats

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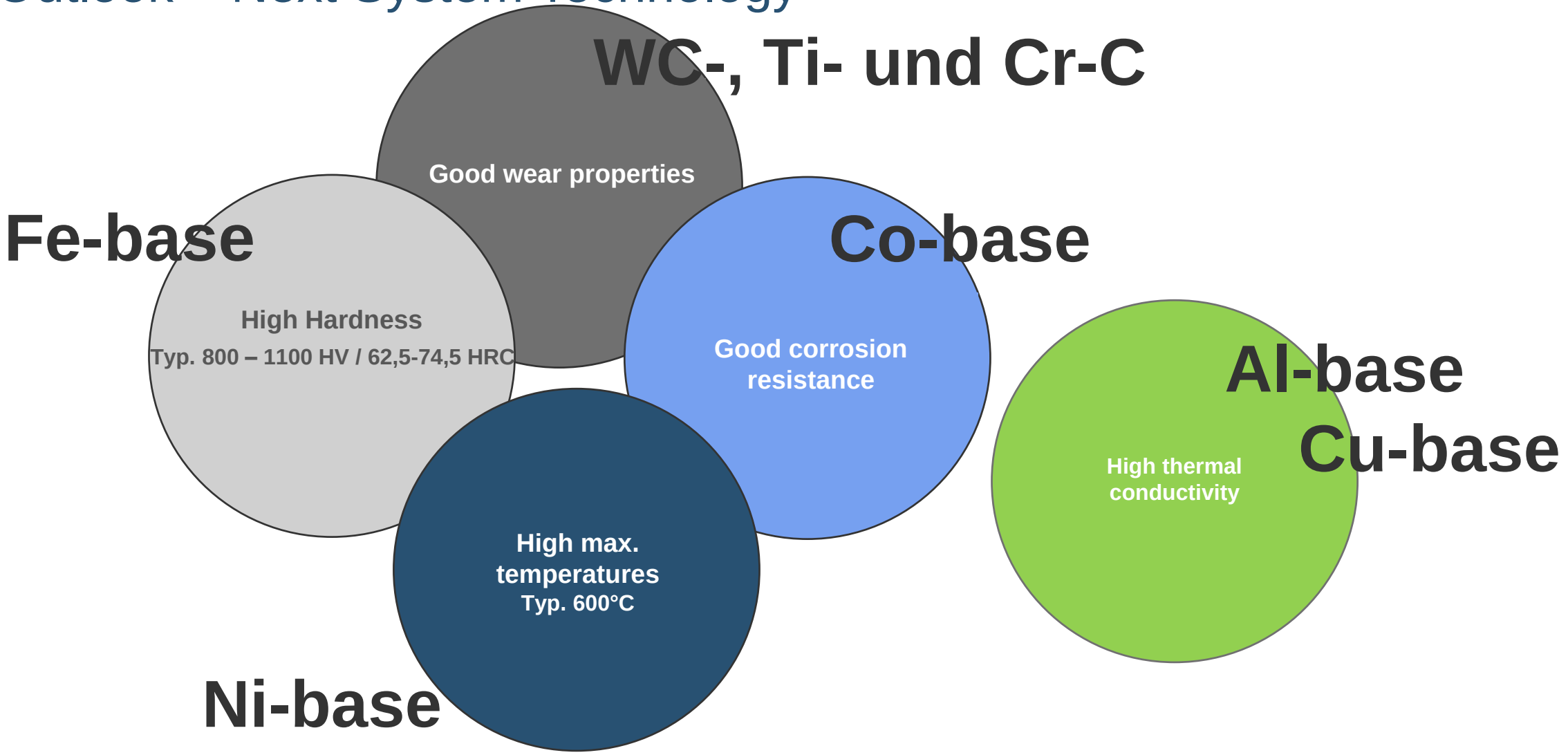
Typical Powder Additives for LMD

Outlook – Next System Technology



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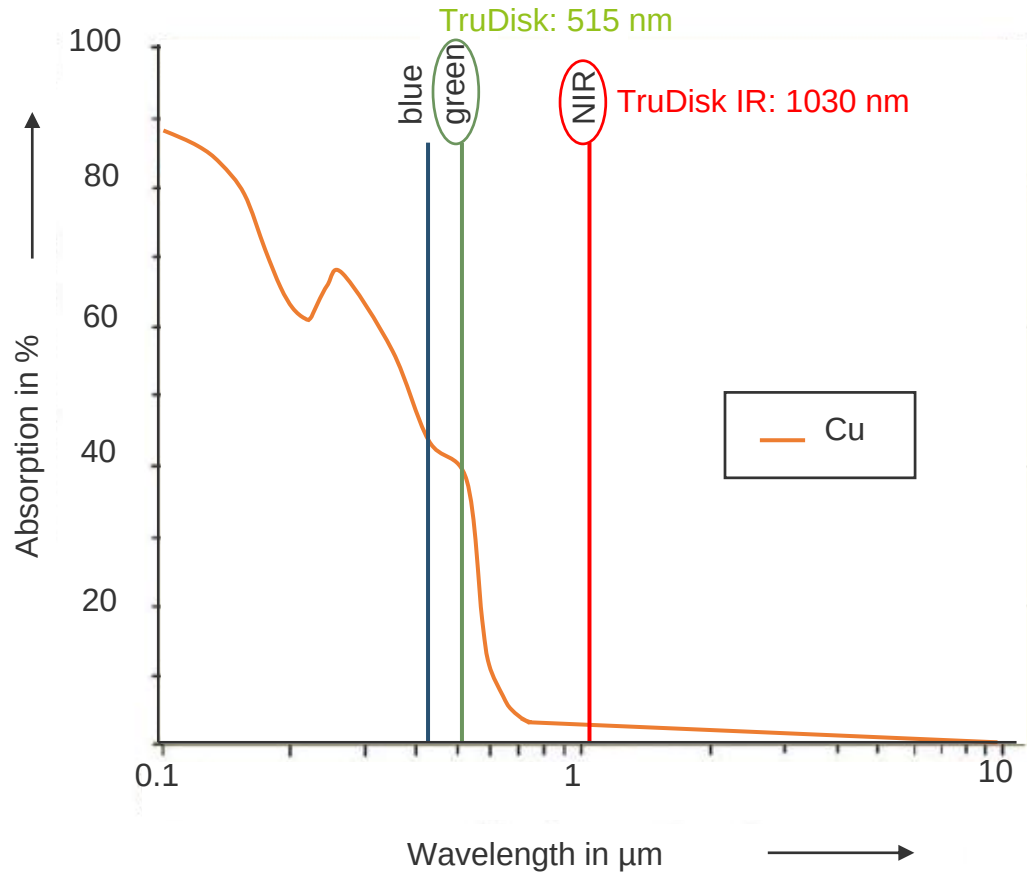
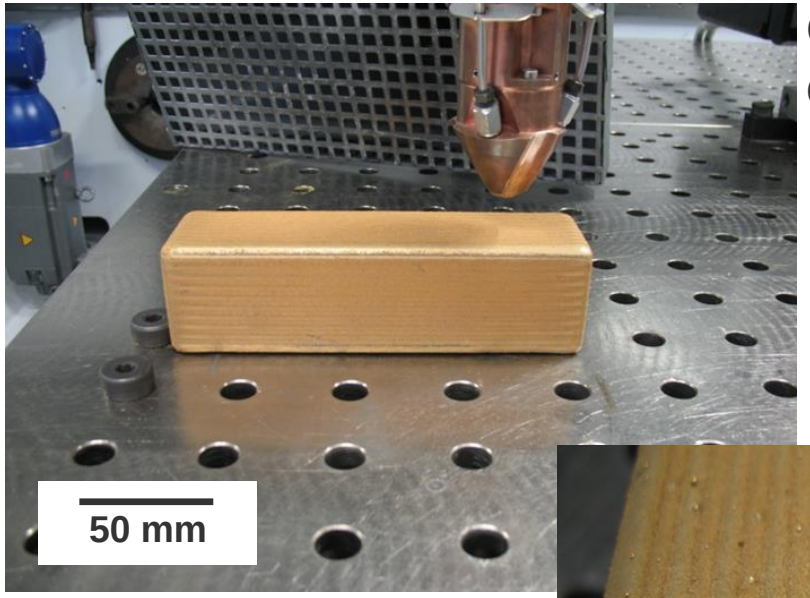
Outlook – LMD of Cu-Alloys

Absorption as Function of Laser Wavelength

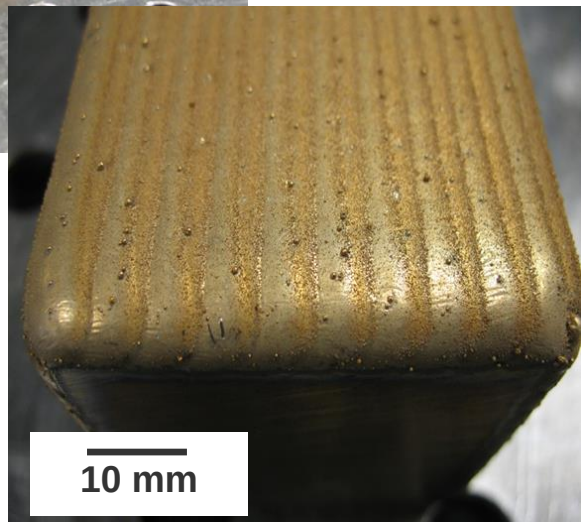
By use of green laser radiation an >30% increase of absorption feasible





Overview:
coating of cuboid

Detail



- Cu9.5Al (see above)
- Cu11Sn
- CuZn31Si1

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Green High-Power Lasers by TRUMPF

Current Laser Sources & Future Laser Soruces

	Pulsed	CW
Parameter	**TruDisk Pulse 421**	**TruDisk 1020**
Pulse peak power	4 kW	1 kW
Average power	400 W	1000 W
Wavelength	515 nm	515 nm
Pulse duration	0.3 … 50 ms	cw
Max. Pulse energy	40 J	---
Repetition rate	< 1000 Hz	---
LLK diameter	≥ 100 µm	≥ 50 µm
No. of outputs	max. 2	max. 2
BPP	4 mm·mrad	2 mm·mrad

Summary – Trends & Challenges for LMD

Productivity

Increase of laser power (also in “green“)

New optics and system technology

Automatization

Process Development

EHLA
Will become much stronger, but still new in market…

AM by LMD
Driven by CAD/CAM; predominantly for modification

Continuously: Repair & Coating
For molds, casts, aerospace and medical applications

Software

CAM-software and **simulation** tools for machine and part

Industry 4.0

Automatization and inter-machine networks

incl. a look into the overall process chain

Quality Assurance

Powder: mass, flow & focus	✓
Laser beam properties	✓
Process monitoring & -control	(✓)
In-situ check of quality	

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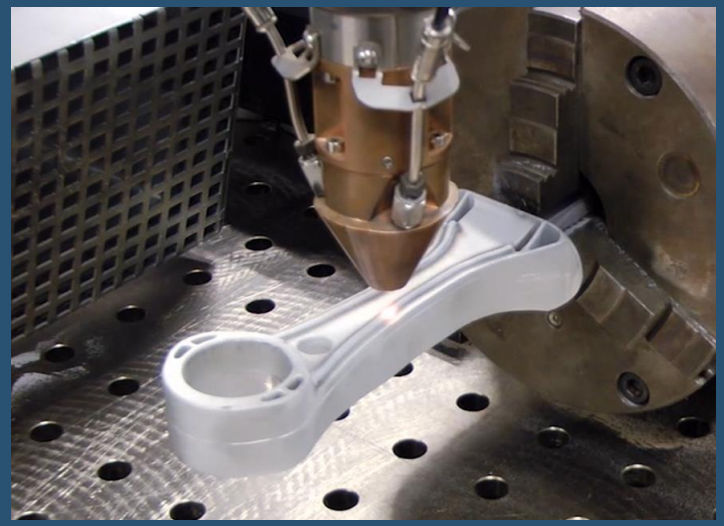

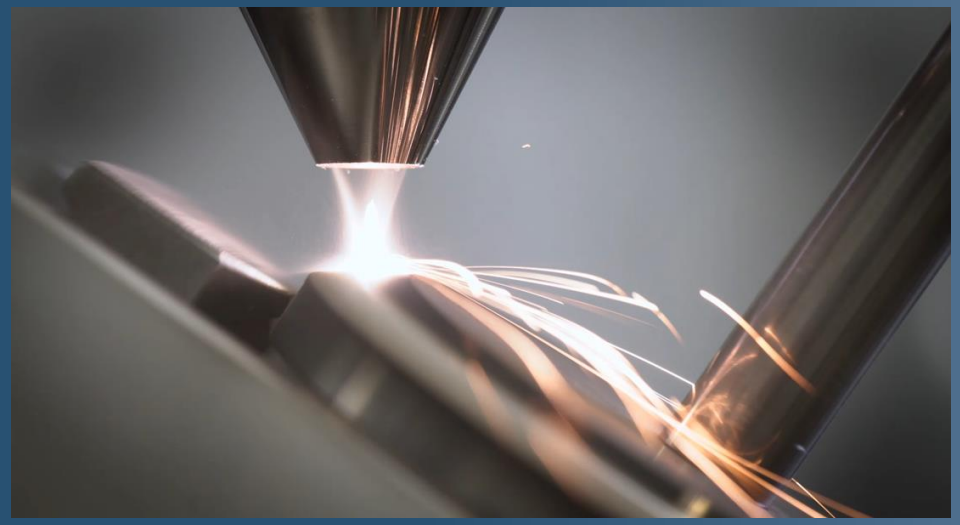

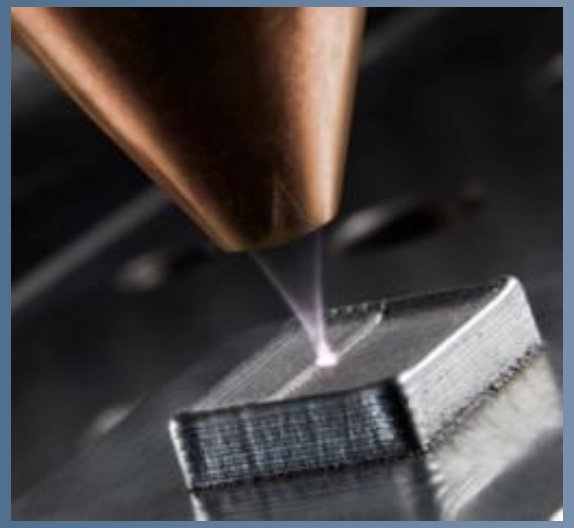

Thank You for your kind attention
Vielen Dank für Ihre Aufmerksamkeit

Marco Göbel
Branchenmanagement LMD

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