Metal 3D printing for e-mobility

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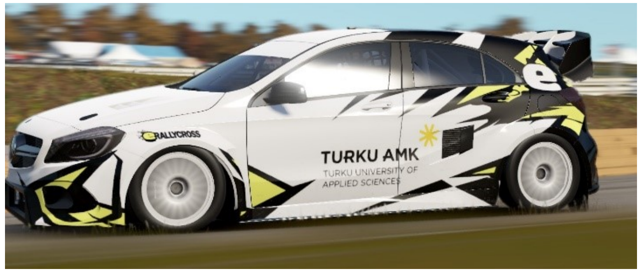
Research and production environment for EV parts at TUAS based on L-PBF and other laser processes

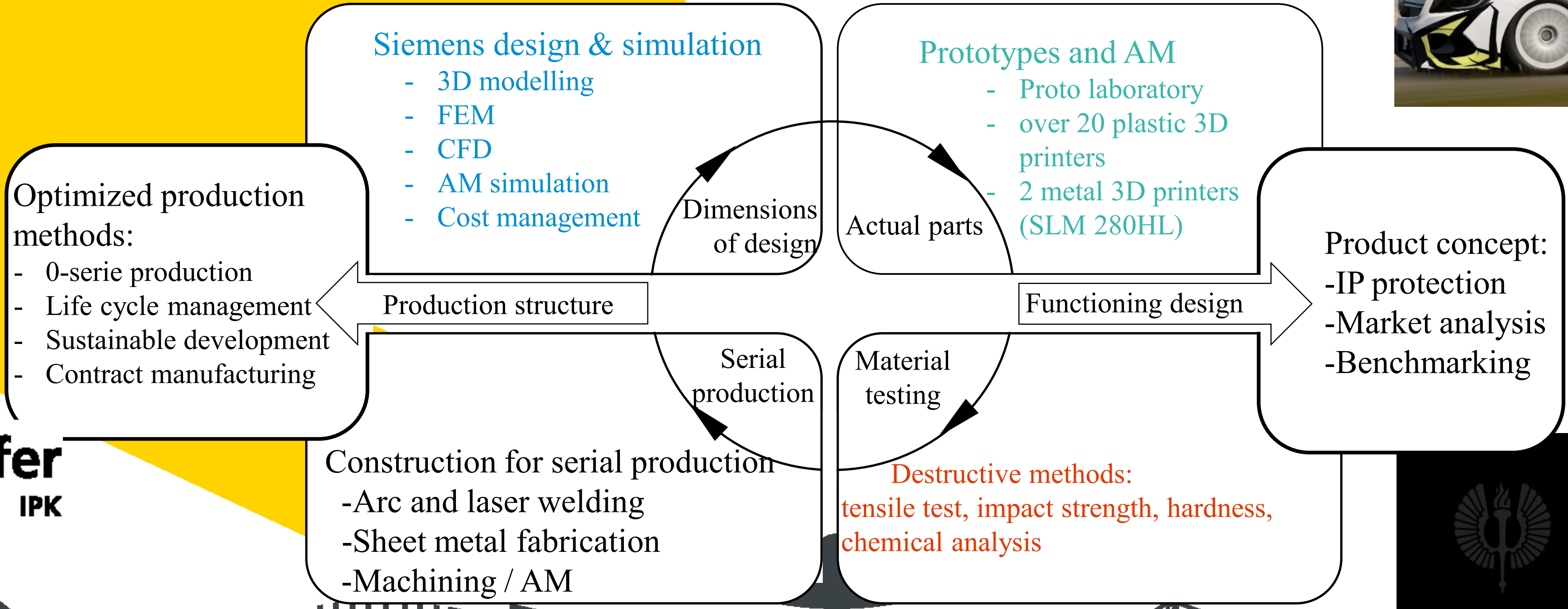
Webinar: The role of Additive Manufacturing (3D printing) in e-mobility and electrification

17.3.2021 eFlowHub

Heikki Saariluoma, TUAS

e-Mobility research's equipment and facilities at Turku region





SLM280HL – 2*400 W

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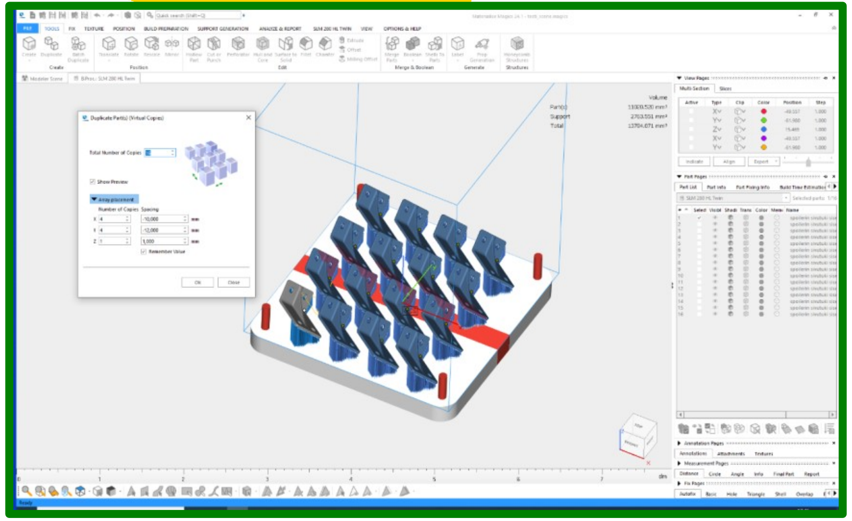
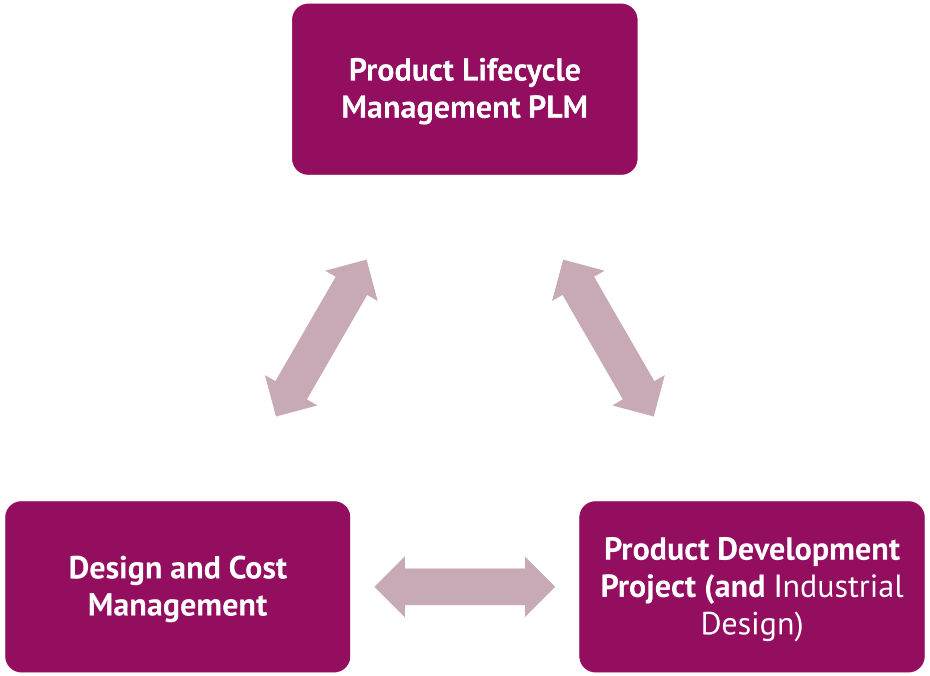
- Working area: 280*280*365-platform 20 mm
- Materials:
  - AlSi10Mg – Machine 1
  - Titanium – Machine 1
  - Stainless steels 316L – Machine 1
  - Co-Based Alloys (CoCr28Mo6) – Machine 2
- Materialise Magic - Data and Build Preparation Software



Two machines

Battery design and manufacturing software by Siemens NX

- **Siemens Development environment is available for:**
  - Research projects with Business Finland and companies
  - Thesis works for students
  - Several courses are suitable for smaller case studies



Siemens - Simcenter Amesim simulation environment for battery systems

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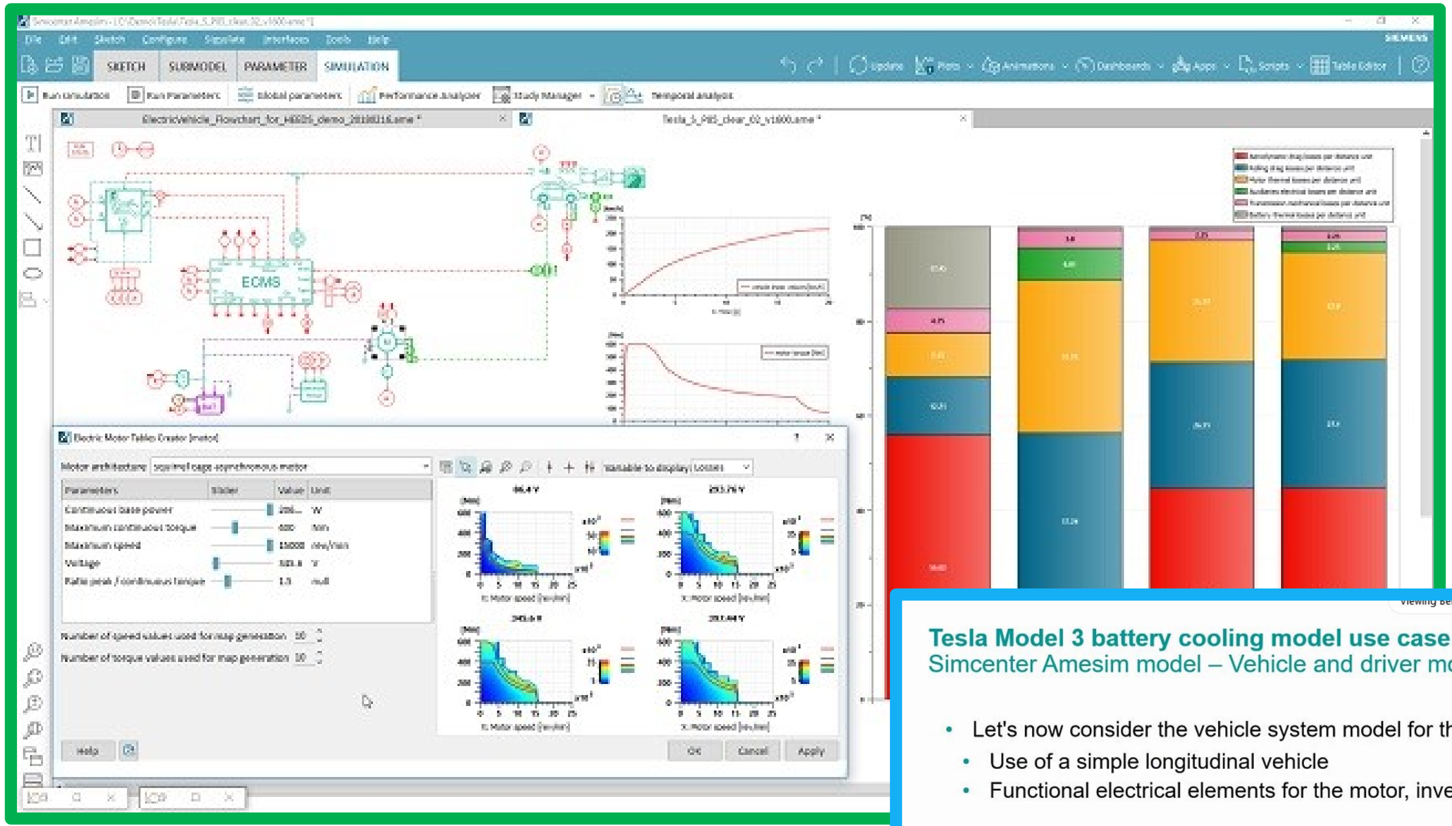
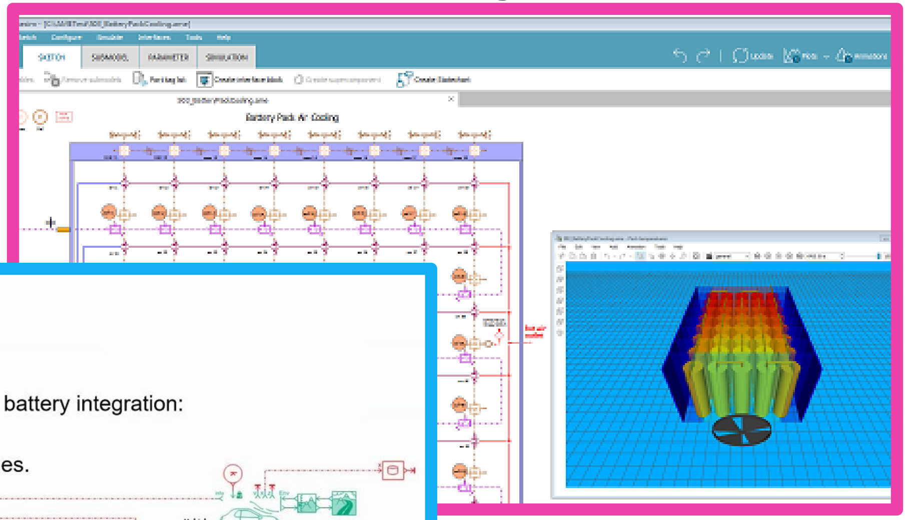
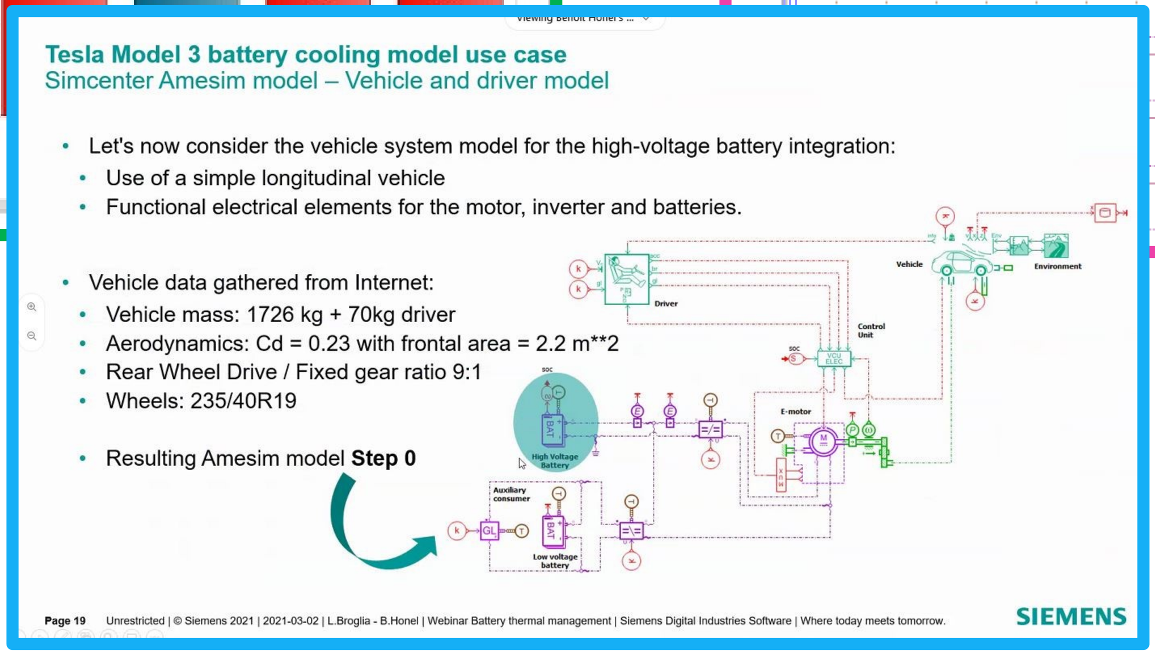


New study area in TUAS will be the battery systems with Simcenter Amesim which allows us to answer design questions that matter on vehicle, engine, transmission and thermal integration.





Electrified Vehicle Simulation

Meet strict emission regulations while ensuring a high-level of vehicle performance and comfort. Simcenter Amesim helps you win the electrification race by providing you the appropriate tools to embrace this technology evolution.
Simcenter Amesim allows you to answer design questions that matter on vehicle, engine, transmission and thermal integration. It also offers the required modeling level to simulate all critical electric subsystems. Whether you deal with battery sizing or electric machine design, you will benefit from efficient modeling workflows to support your engineering effort from architecture creation to integration, including detailed design.

Battery & Fuel Cell
Virtually assess the energy performance of electrochemical storage systems when integrated in hybrid or battery electric vehicles. Simcenter Amesim offers a scalable and flexible platform combined with a battery identification tool to characterize and simulate accurately the electro-thermal behavior of storage devices. You can easily size a pack, design a cooling subsystem, optimize a control strategy, reduce the fuel consumption or maximize the range.

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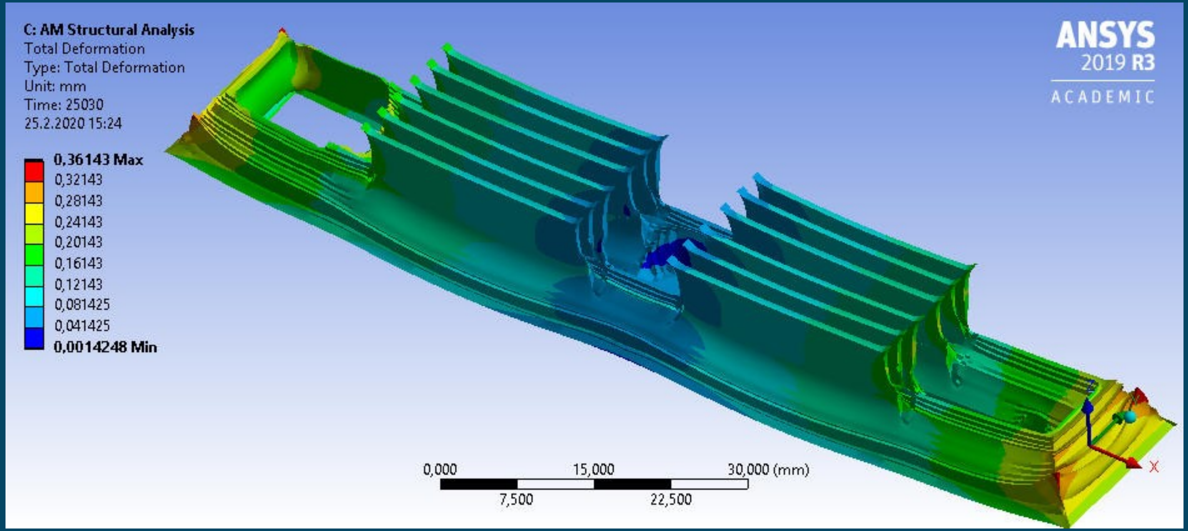
Mechanical Engineering / @ #factory & EduCity

Topology optimization and lattice structures

Searching optimal material distribution
Available tools
- ANSYS Topology optimization
- Siemens NX Nastran Topology Optimization
- Siemens NX Topology Optimization (Fustrum)



Metal AM-printing process simulation

Generate printing supports, deformations, residual stresses and simulate printing process
Available tools:
- ANSYS Additive Suite
- Siemens Simcenter 3D Additive manufacturing

NX CFD

Cooling channels for injection moulding tool

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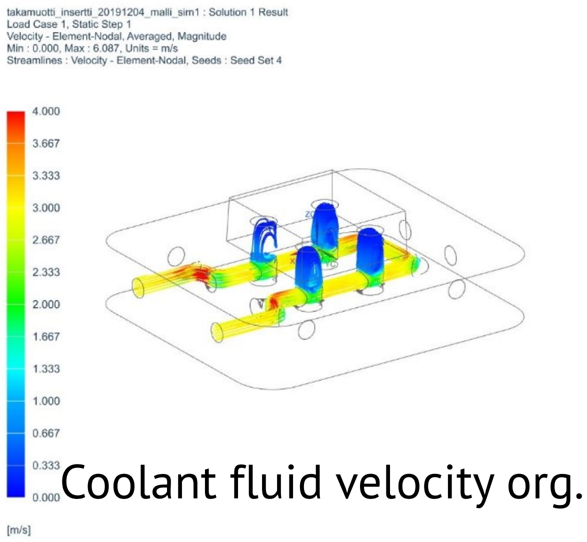
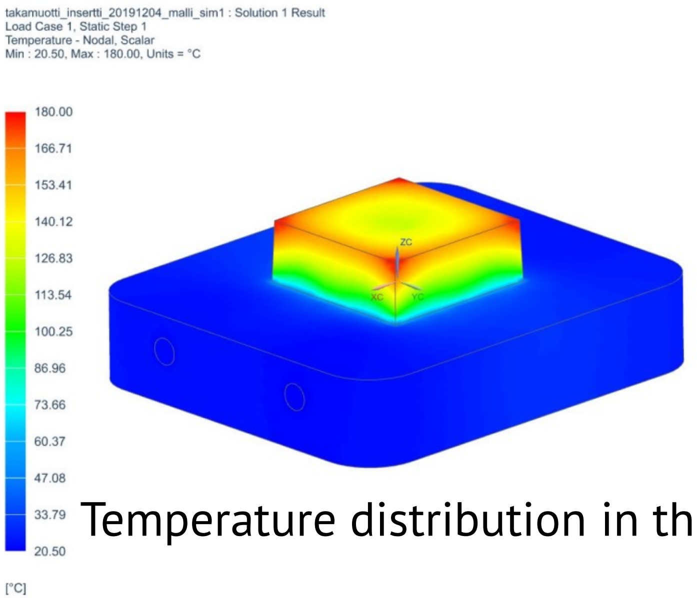
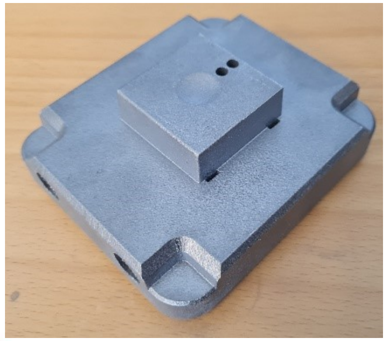
- Temperature and flow rate images were calculated with NX Advanced Flow CFD software
- Deformations and stresses caused by the resulting temperature distribution were calculated with Simcenter 3D Nastran FEM software (not shown)

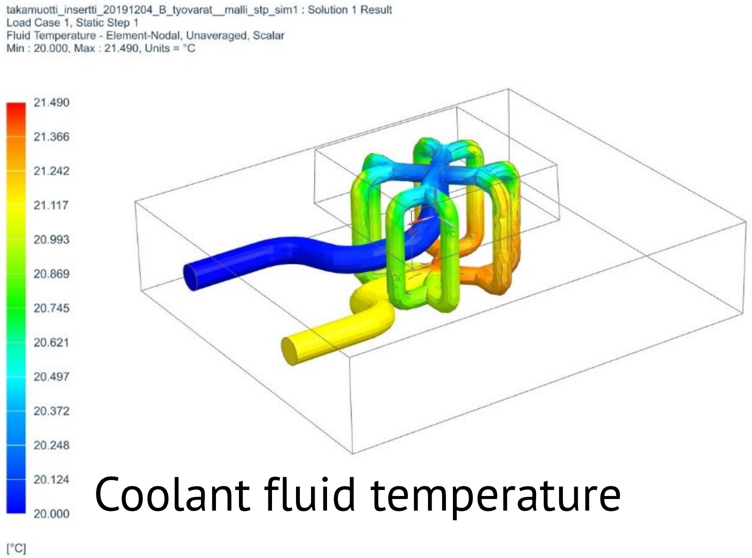


Coolant fluid velocity org.

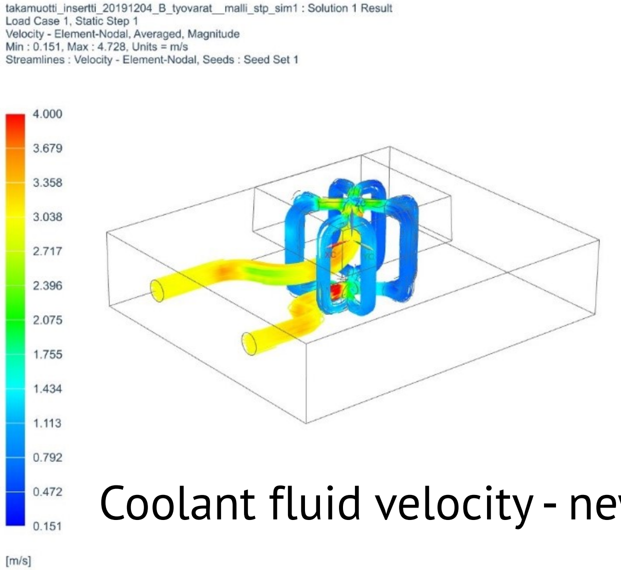


Temperature distribution in the part T max = 180 °C

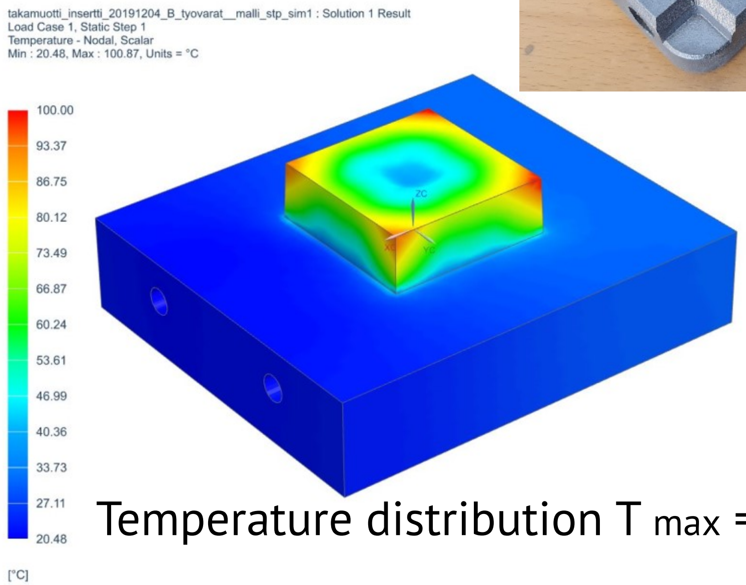




Coolant fluid temperature



Coolant fluid velocity - new



Temperature distribution T max = 100 °C

3D scanning and measuring

Dimension verifying - 3D scanner and CMM

System	Principle	Measuring volume/ area	Volumetric accuracy	Scanning area
Zeiss T-Scan 20	Laser scanning with external photogrammetric orientation	20 m^3	0.04 mm + 0.04 (L/1000) mm	125 mm line

Technical Data for ZEISS T-SCAN

	ZEISS T-SCAN
Measurement depth	+/- 50 mm
Line width	up to 125 mm
Mean working distance	150 mm
Line frequency	up to 330 Hz
Data rate	210.000 points/second
Weight	1100 g
Sensor dimensions	300 x 170 x 150 mm

- For verifying the actual part dimensions of the 3D printed parts based on 3D model

Error
Yellow= 0,1mm

Scale
____= 10mm

CMM
(Accredited)

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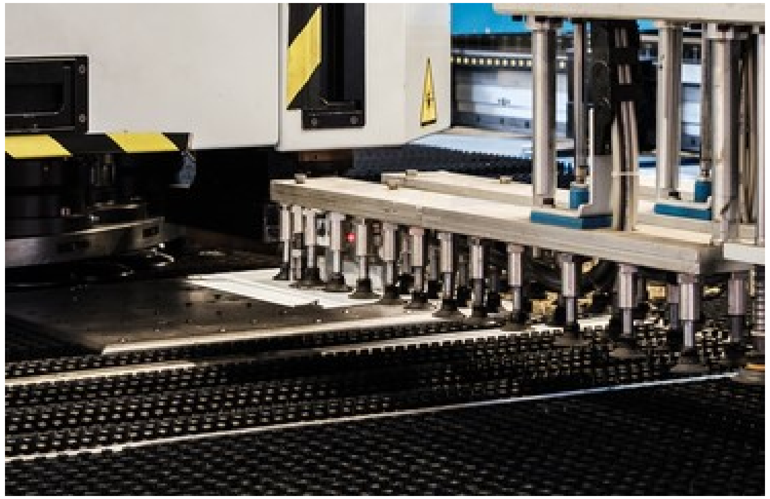
Material testing

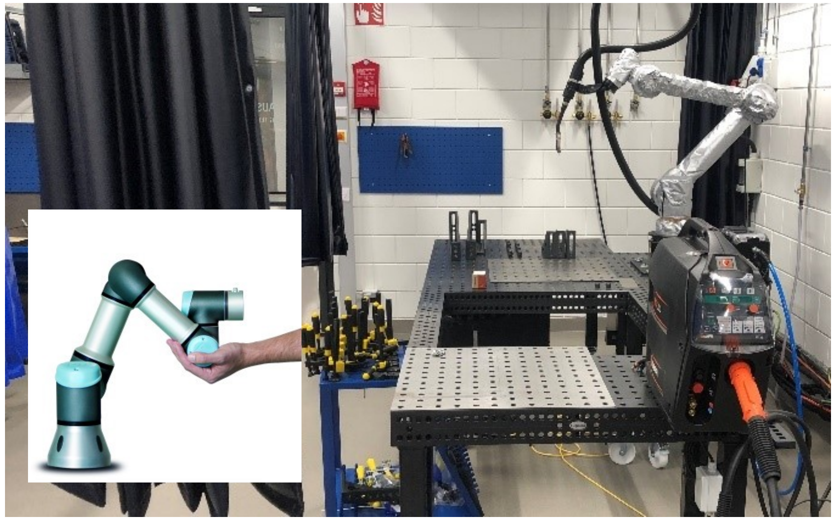
- **Tensile test machine: Matertest with ForceProof control system**
- Test load: Max 250 kN (static) Calibrated load range 10-150 kN (Accuracy Class 1)
- **Pendulum Impact tester for metallic materials: ZwickRoell HIT450P**
  - Pendulum hammer: 450 J
- **Universal hardness tester: Emco Test M4. 025/075**
  - Test method: Rockwell C, (Vickers, Brinell)
- **Micro hardness tester: Falcon 600**
- Test method: Micro Vickers, Vickers, Brinell Test forces: 1 gf-62,5 kgf
- Grinding/polishing machine Struers LaboPol-30

For metallic specimen preparation before hardness testing or macroscopic/ microscopic examination

Manufacturing process capabilities:

- Sheet metal:
  - Cutting, forming, bending
- Robots:
  - Cobot UR5 fast and smart setups
  - 3 robots group
- Welding:
  - Laser welding, CMT, TIG, MIG/MAG
  - Laser cladding with powder
  - Welding robots: Motoman, ABB, UR10
- Measuring:
  - 3D CMM – (accredited)
  - 3D scanner





Inline Quality

Inline laser welding process monitoring

Multifactor Weld Process Measurement Tool

LDD-700

The LDD-700 Inline Process Monitor:

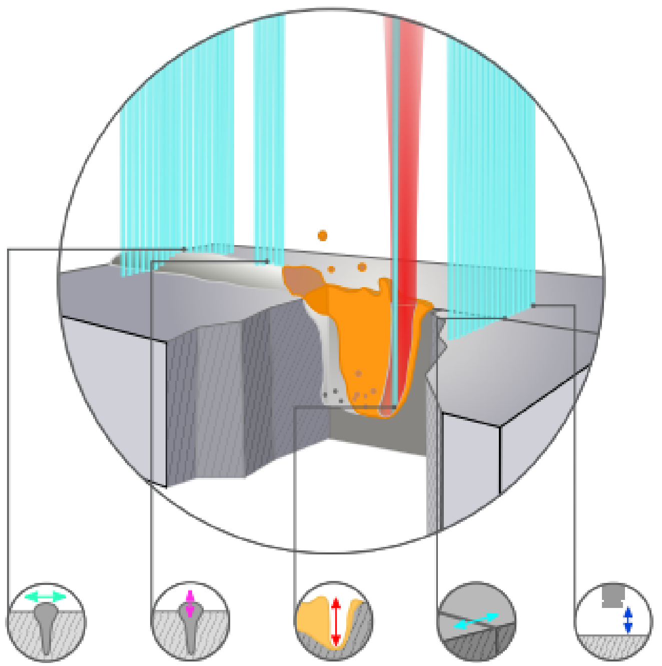
- High Speed, High Resolution
- Immune to Process Radiation
- Gives Data Similar to Sectioning, Immediately

Capable of Detecting Defects Including:

- Over and Under Penetration
- Part Misalignment: Height Variation, Gap Width
- Weld Bead Defects: Blowouts, Underfill

Applications

- Power Electronics
- Busbar Welding
- Battery Assembly
- E-mobility
- Micro-electronics



Transverse Profile Measures the finished weld bead transverse profile.

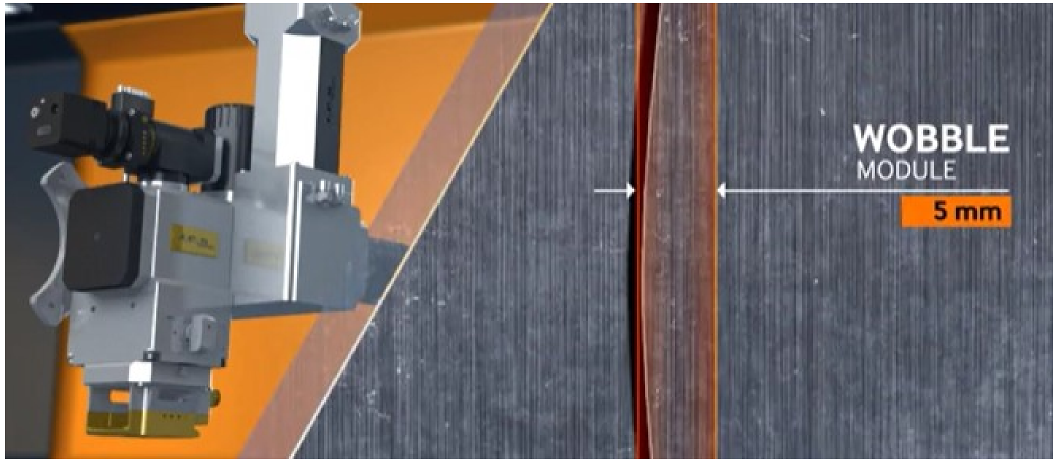
Finished Weld Surface Measured just behind the melt pool captures the height of the finished weld bead.

Keyhole Depth Measured inside the keyhole during the weld to determine actual weld penetration depth in real time.

Seam Profile A sweep ahead of the process looks for joint position on the workpiece.

Workpiece Height Measures the distance between the material surface and the welding optics.

- Fibre laser 10 kW multi mode:
  - Spot size 800 µm (fixed optic)
- Fibre laser 2 kW single mode:
  - Spot size 50 µm (fixed optic)
  - Spot size 120 µm (scanner optic)



Laser welding of AM parts

Literature revues for dedicated topics of AM parts.

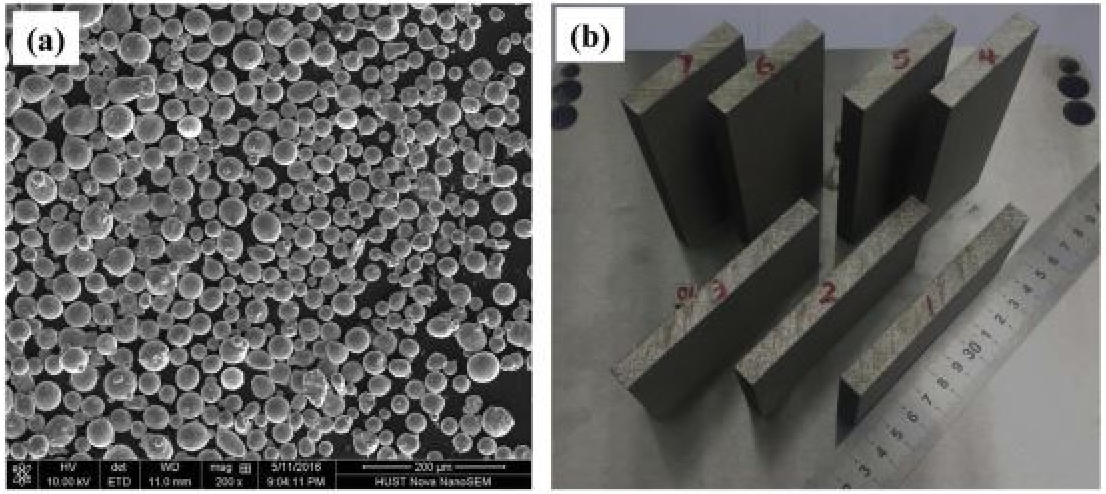


Fig. 1. Morphology of metal powders (a) and macro-morphology of SLMed plates (b) of 304 stainless steel.

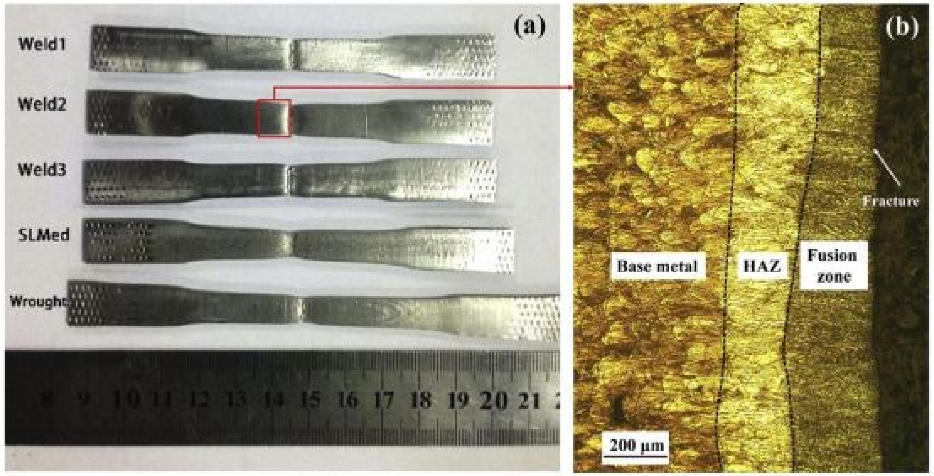


Fig. 11. Photos of tensile test samples after tensile tests (a) and OM image showing fracture path of laser-welded joint under type 2 (b).

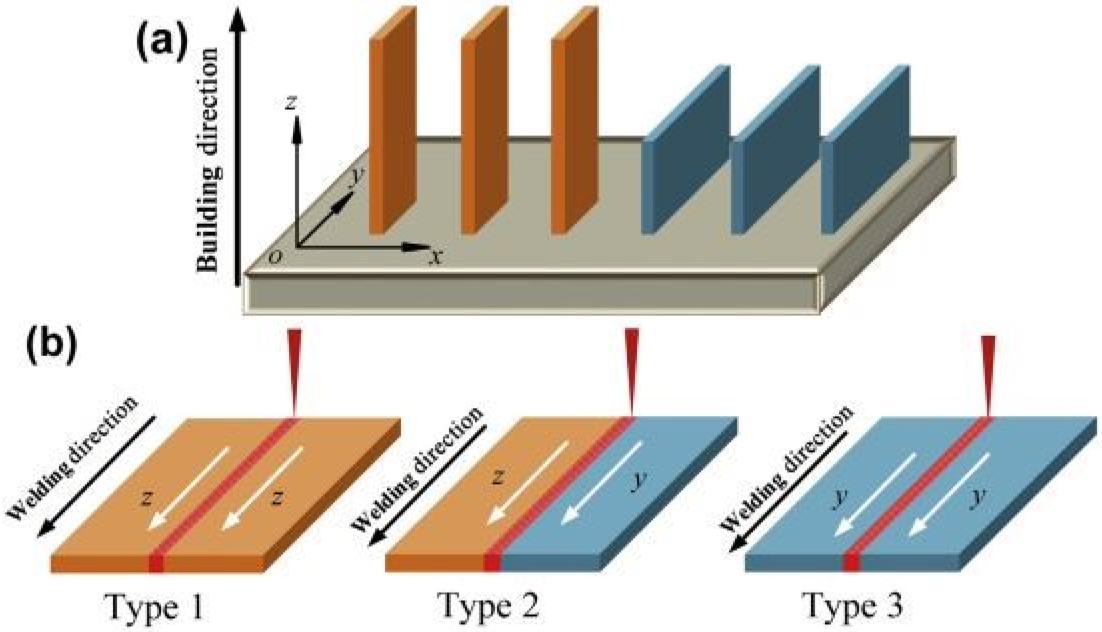
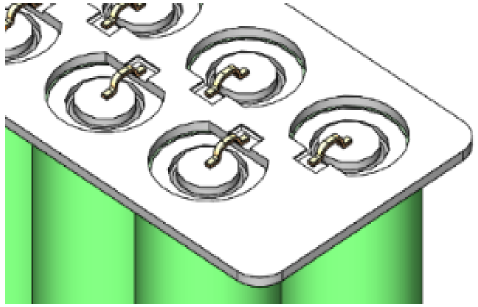
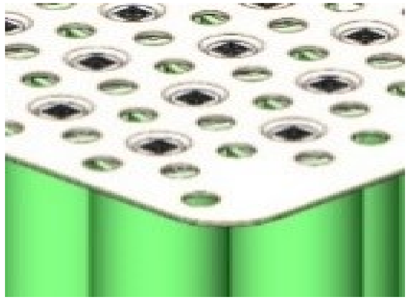


Fig. 2. Schematic drawings of SLMed plates (a) and different laser welding types (b).

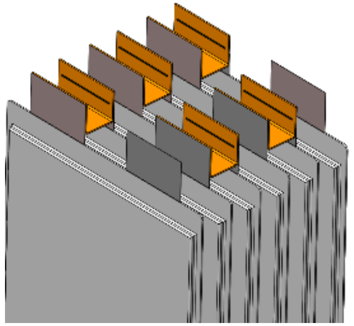
Different cell and joint types



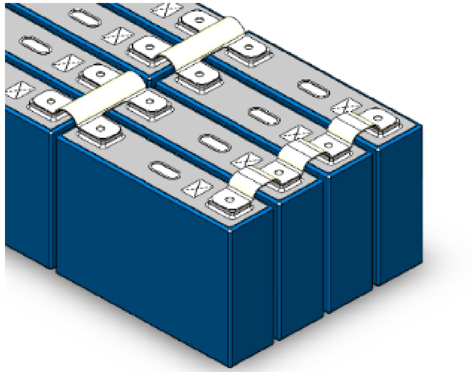
Laser wire bond



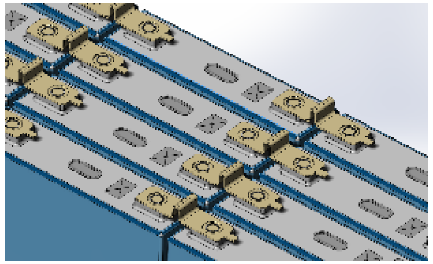
Laser spot welded



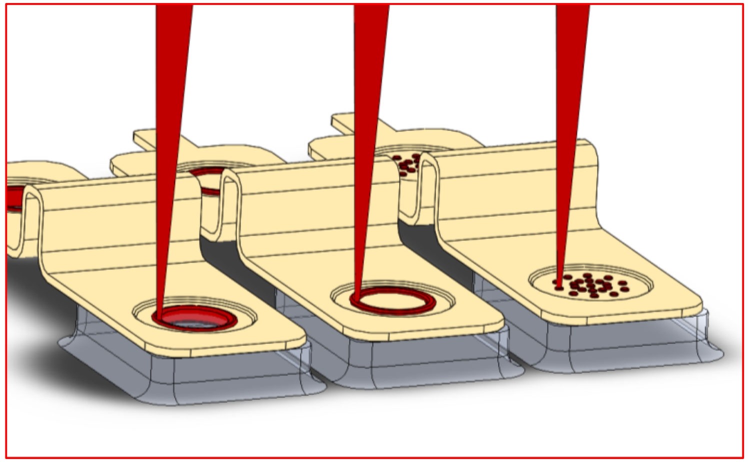
Laser lap joint for punch



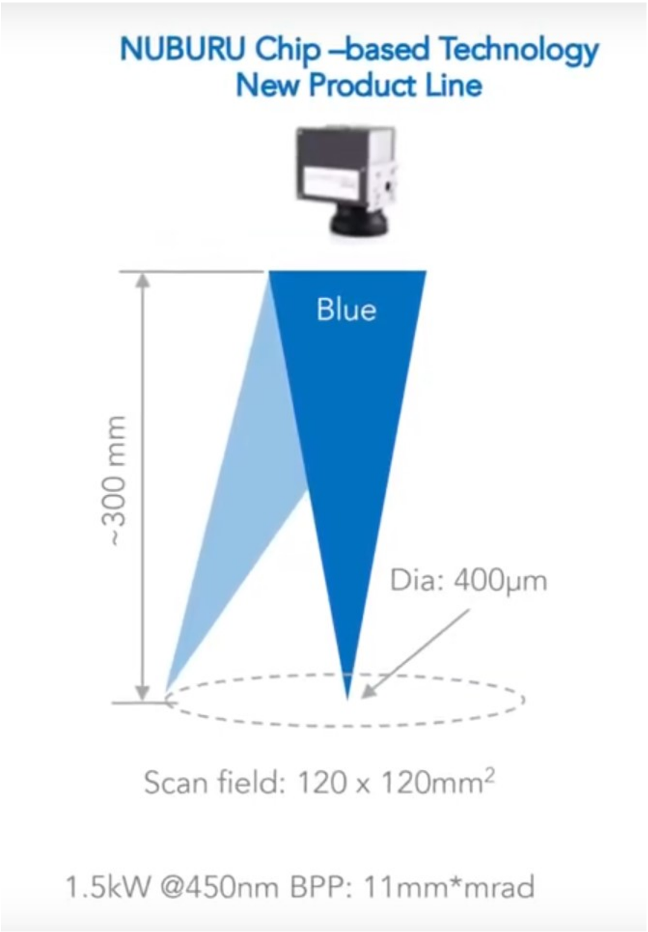
Various busbar joints



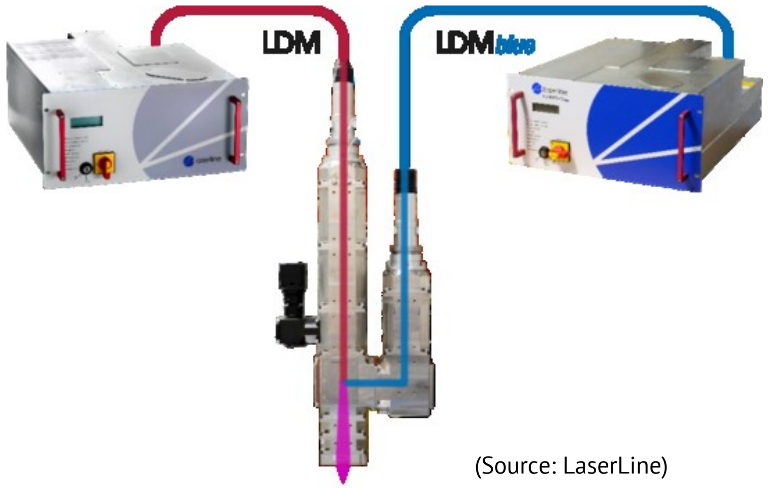
Laser lap joint



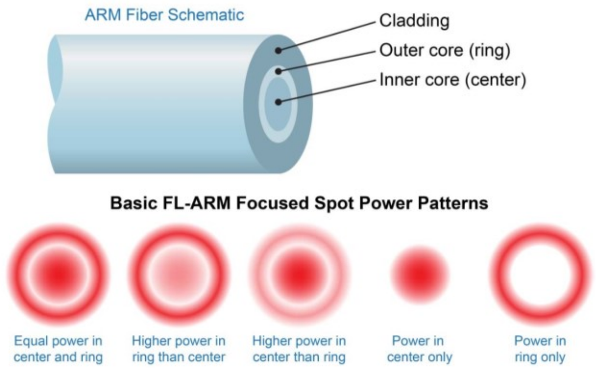
Optimal laser processes for battery materials Al-Al, Cu-Al and Cu-Cu joints – what colour?



(Source: Nuburu)

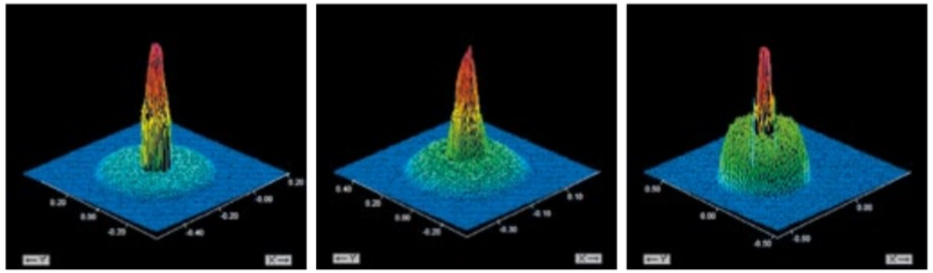


(Source: LaserLine)



(Source: Coherent)

Whether copper, steel or aluminum – with BrightLine Weld, welding is almost splatter-free and has the highest quality. The minimum spatter reduces dirt build-up on components, clamping fixtures and optics. With BrightLine Weld the feed is simultaneously increased, thereby significantly increasing the productivity.



Flexible setting of the intensity distribution with BrightLine Weld.

(Source: Trumpf)

Thank you !

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