3D printed liquid cooled heatsinks for power electronics applications

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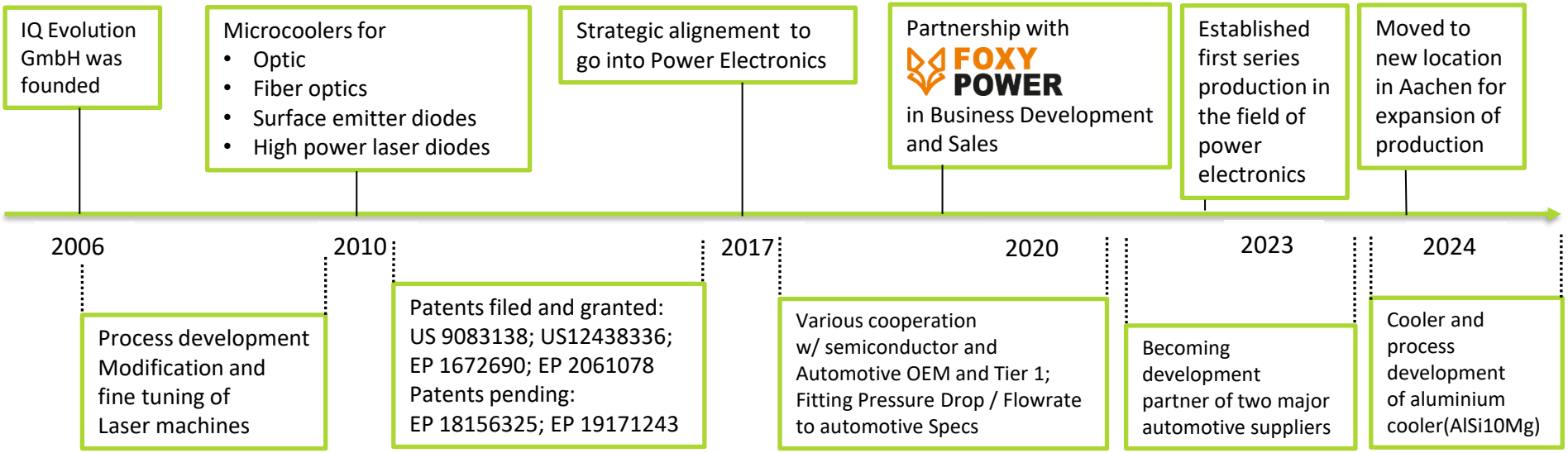
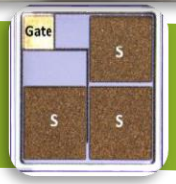
Company History



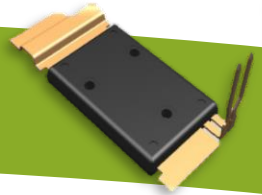
Where you can find IQ evolution 3D-printed metal cooler

GaN
Embedded

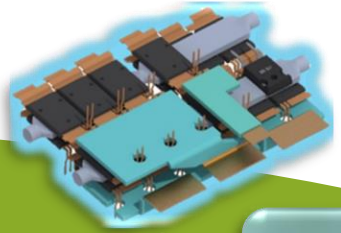


GaN

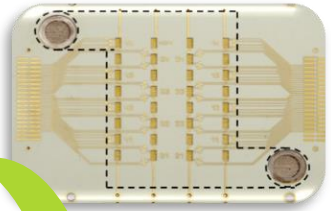
Discrete elements



Traction inverter



PCB embedding



Miniaturized
DC/DC controler

E-Mobility Applications

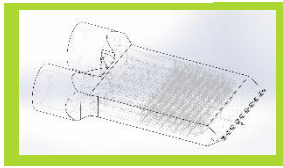
Charger

Industrial

IQ-Smart cooling:
IT Applications /
Data Center /

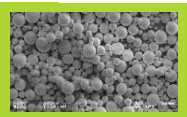
The „printing“ process

- IQE has been developing and manufacturing microcoolers using metal 3D printing for almost 20 years.
- The metal powder is melted layer by layer with the laser beam.
- This enables the production of very thin radiators (from 0.8 mm) with low wall thicknesses.
- Complex internal structures can be manufactured directly in the closed housing.
- IQE has developed a concept that makes series production of several million components per year economically feasible.

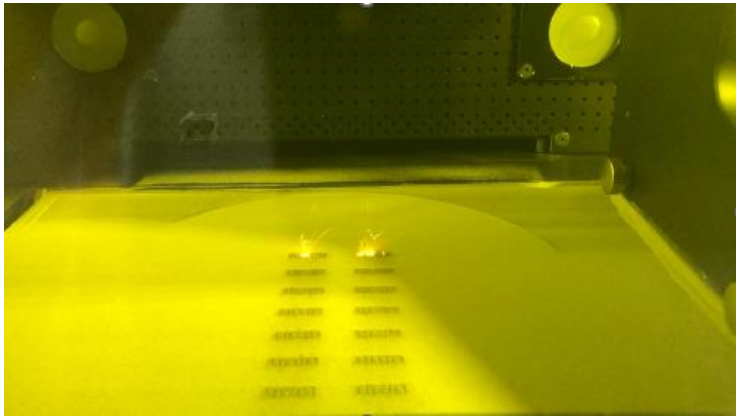


3D-CAD model

+



Metal powder



The „printing“ process

- Dividing the CAD model into 20µm/40µm layers
- Pre-processing of the individual layers (speed, laser power.....)
- Laser melting of the structures, which should subsequently be solid
- Subsequent cavities are not melted

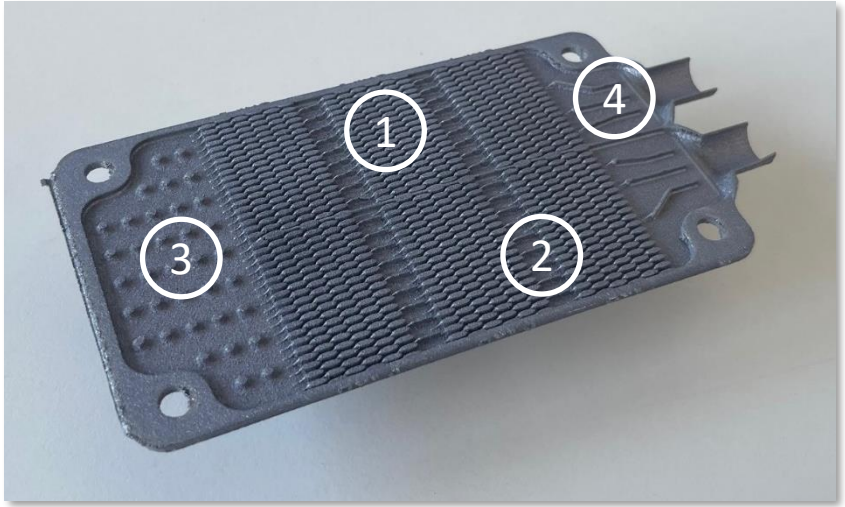
Complex internal structures in a closed housing

Cooling structures adapted to requirements

With 3D printing technology, various structures can be created within a closed housing:

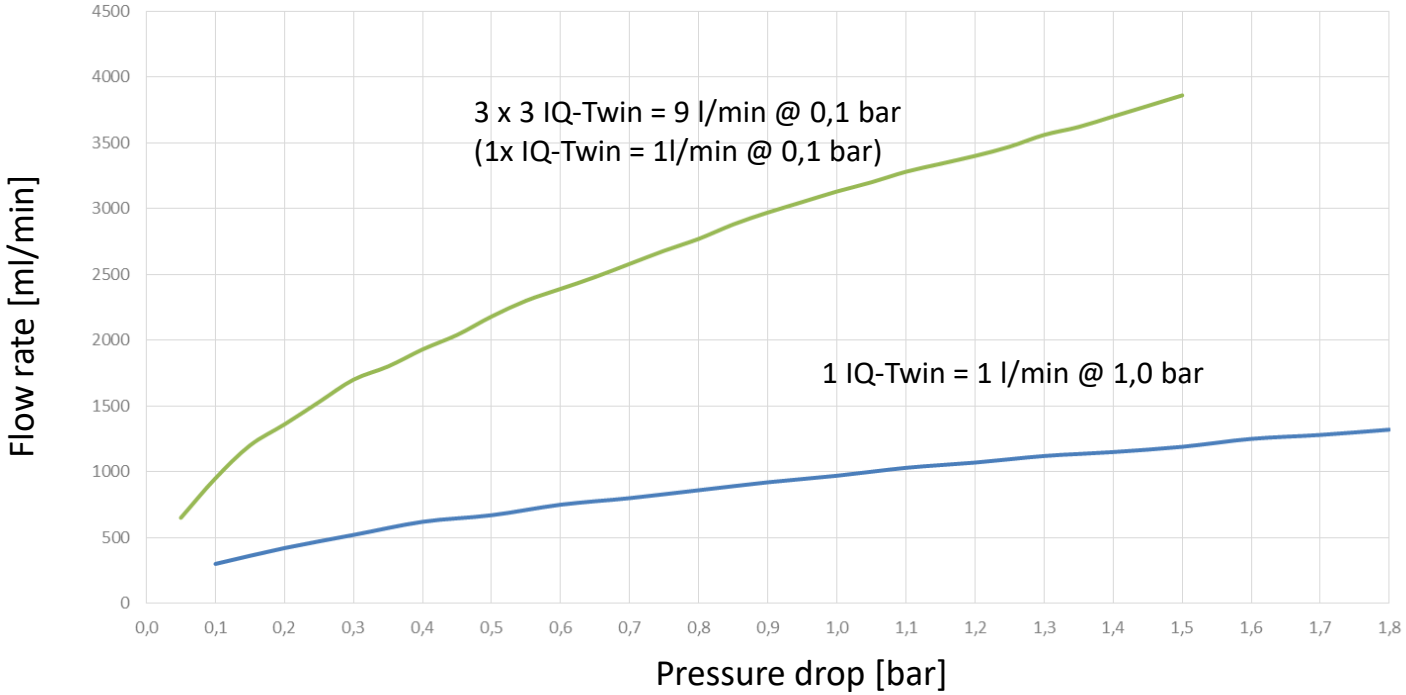
1. Cooling structures for high heat flux density
2. Cooling structures for intermediate areas with lower heat flux density
3. Supporting structures for mechanical loads (e.g. contact pressure when screwing)
4. Leading structures for demand-oriented coolant distribution

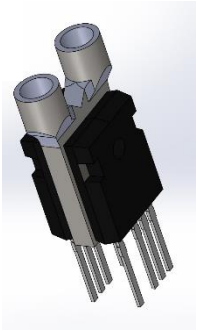
IQ-Smart 62-Alu (AlSi10Mg)



Adjusting Pressure Drop & Flowrate @ same performance

By changing the cross-section and variable internal structures,
the pressure drop / flow ratio can be adjusted to a large extent.



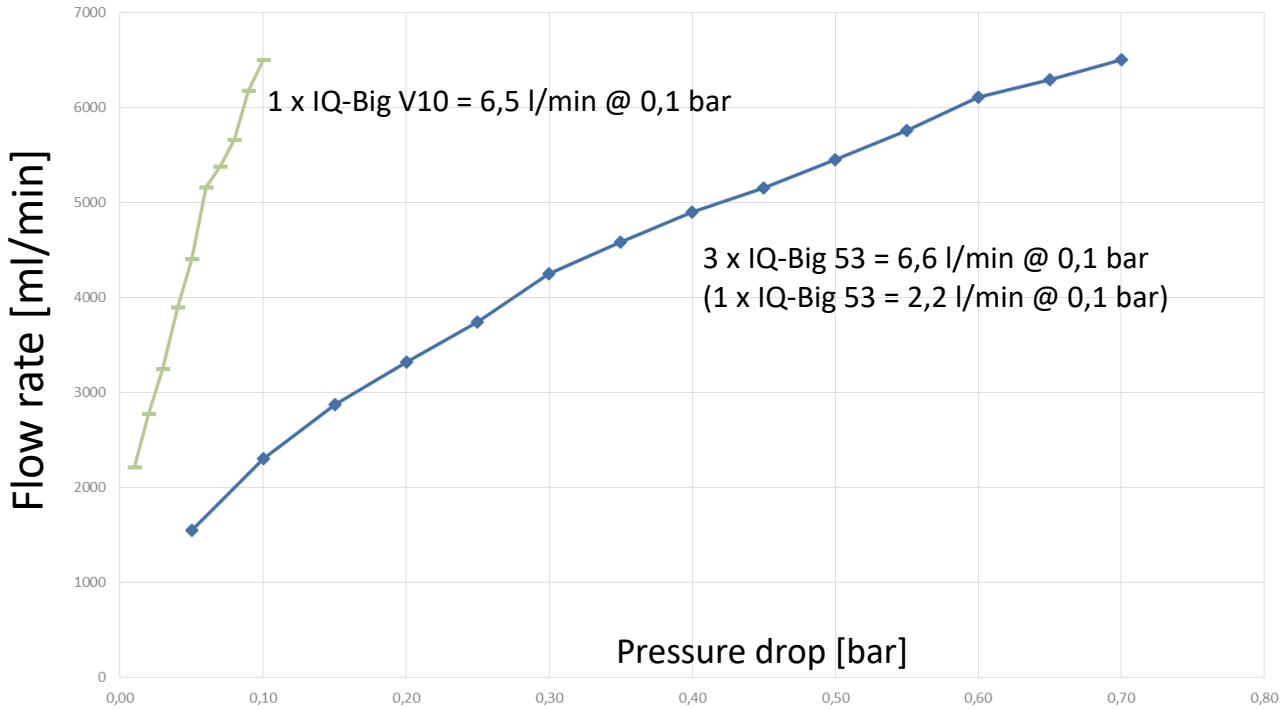


IQ-Twin Automotive

IQ-Twin Industrial

Adjusting Pressure Drop & Flowrate @ same performance

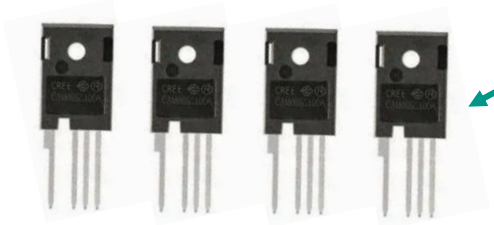
The same also applies to power module coolers. Due to the larger dimensions, even a much larger area can be covered.



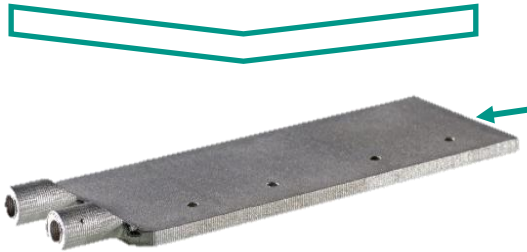
IQ-Big V10

IQ-Big 53 Automotive

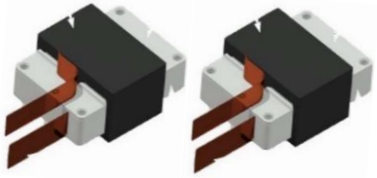
Use case: DC/DC Converter



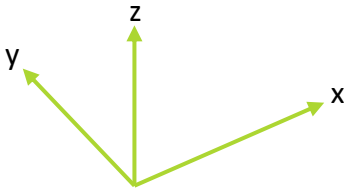
4x Discrete 1000-V-SiC-MOSFETs in TO-247 4L C3M0065100K



IQ-Eight:
8x TO-247 4L or
4x TO-247 and
coils dissipating



2x Power inductor based on copper foils

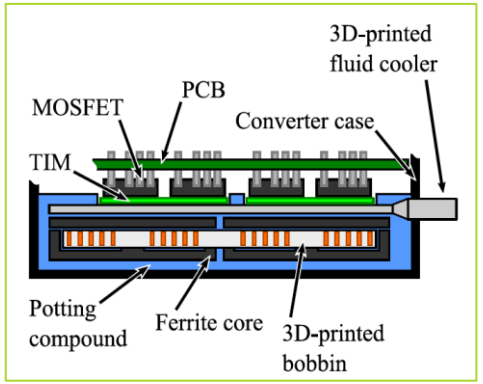


X =	95 mm
Y =	70 mm
Z =	35 mm
Volume	0,23 l
Weight	389 gr

Specification

- DC/DC converter w/o Filter
- Pout,max=20.6kW
- Vin=400V
- Vout=800V
- Fsw=450kHz
- Power density: ~100kW/l

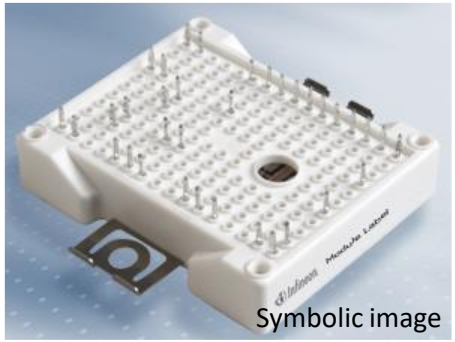
Inside view of DC/DC converter



*Done by ISEA Institute of RWTH Aachen University

Use case: DC/DC Truck-Converter


Symbolic image


Symbolic image

Symbolic image

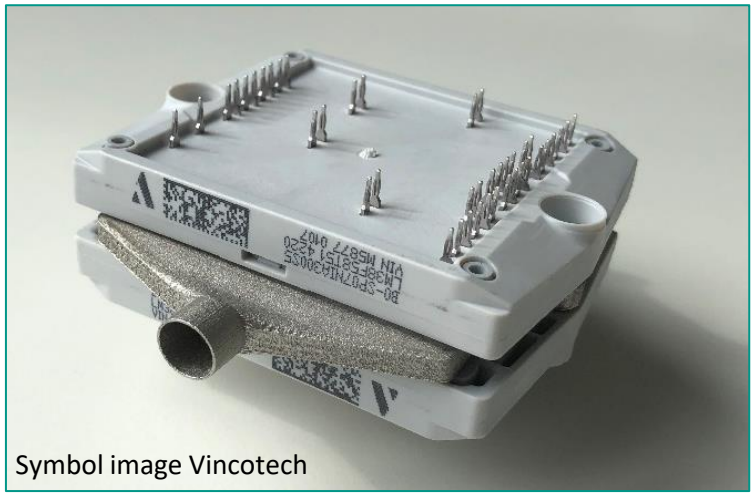
Cooler:	IQ-Big 53
TIM:	Bergquist Hi-Flow 300P
Material:	Stainless steel 316L (1.4404)
Fluid:	Pure water, 2,2 l/min@100 mbar
Modul:	Infineon
Fluid inlet temp.:	20°C
Junction Temp:	175°C
$Power_{module}$:	35 KW
$Power_{loss}$:	750 W
$Rth_{j,f}$:	0,21 K/W
$Rth_{j,c}$:	0,13 K/W
Rth_{cooler}:	0,08 K/W

IQ-Big 53 double sided use
(2 modules, one cooler)

Power:	70 KW
Weight:	96 gr (total)
Volume:	0,12 l (total)

See more: https://www.isea.rwth-aachen.de/go/id/sizdd?#aaaaaaaaaasizgg

Use case: Module test bench


Symbol image Vincotech

IQ-Big 53 double sided use
(2 modules, one cooler)
Power: 100 KW
Weight: 118 gr (total)
Volume: 0,1 l (total)

Cooler:	IQ-Big 53-V10
TIM:	Vincotech
Material:	Stainless steel 316L (1.4404)
Pressure Drop:	100 mbar
Flow Rate:	2,2 l/min
Fluid:	Pure water

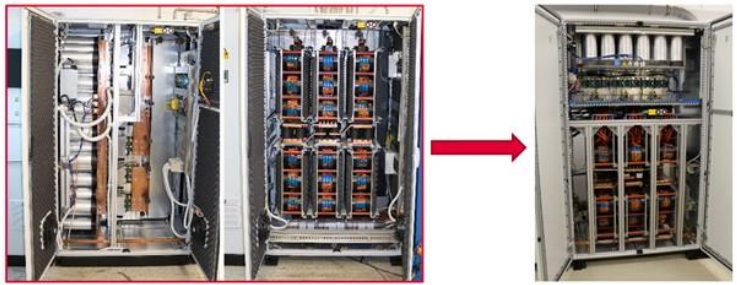
Application:	Vincotech Test Center
Modul:	Flow S3, Vincotech
Fluid inlet temp.:	20°C
Junction Temp:	151°C
$Power_{module}$:	50 KW
$Power_{loss}$:	800 W
$Rth_{j,f:}$	0,164 K/W
$Rth_{j,c}$:	0,104 K/W (Datasheet)
Rth_{cooler}:	0,060 K/W

Use case: Charger

Cooler:	IQ-Big 62
TIM:	Thermal paste
Material:	Stainless steel 316L (1.4404)
Pressure Drop:	1,0 bar
Flow Rate:	5,0 l/min
Fluid:	Water/Glycol 50%

Application:	Charger
Modul:	Infineon FF600R12KE4_E
Fluid inlet temp.:	22°C
Junction Temp:	140°C
$Power_{module}$:	
$Power_{loss}$:	1.250 W
$Rth_{j,f:}$	0,09 K/W
$Rth_{j,c}$:	0,03 K/W (Datasheet)
Rth_{cooler}:	0,06 K/W

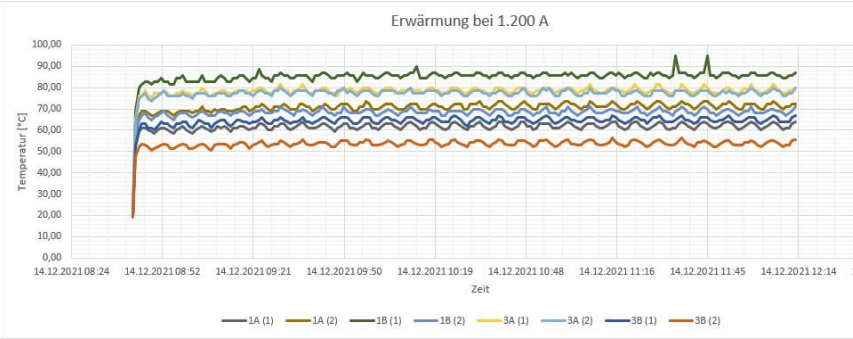
Use case: Energy supply test bench

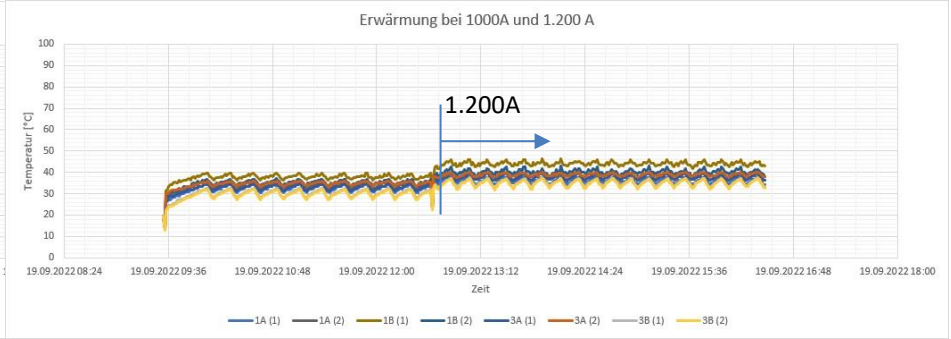


Before:
- 2 control cabinets
- 45 l/min modules serial flow
- Temp. max = 85°C
- Temp. difference first to last modul = 35°C

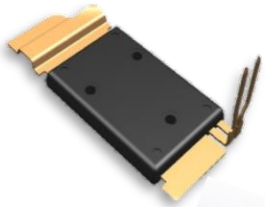
Cooler:	IQ-Big 62
TIM:	Thermal paste
Material:	Stainless steel 316L (1.4404)
Fluid:	Water, 2,4 l/min @ 0,2 bar
Fluid inlet temp.:	20°C
Junction Temp:	45°C
$Power_{loss}$:	1.470 W
$Rth_{j,f}$:	0,017 K/W

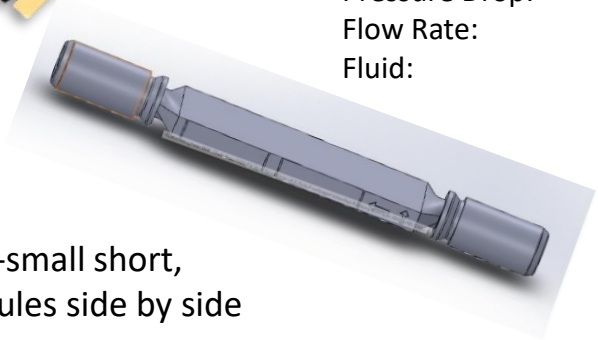
After:
- One control cabinet
- 22 l/min modules serial flow
- Temp. max = 45°C
- Temp. difference first to last modul = 10°C





NEW: Aluminium cooler for discrete elements

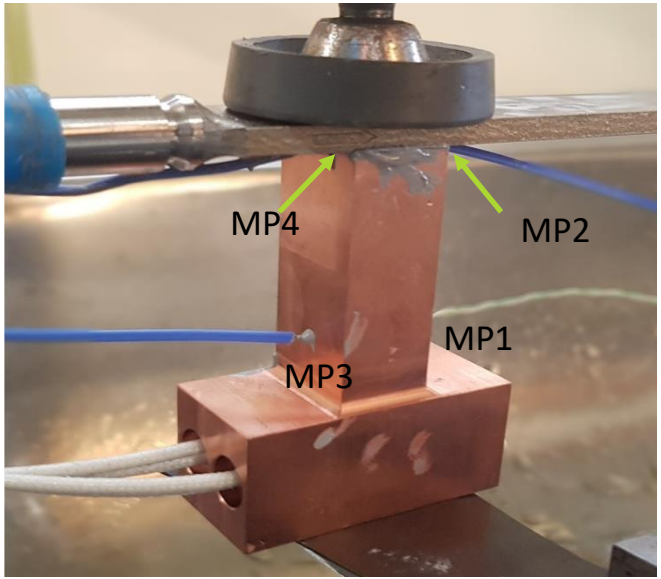




IQ-small short,
2 modules side by side

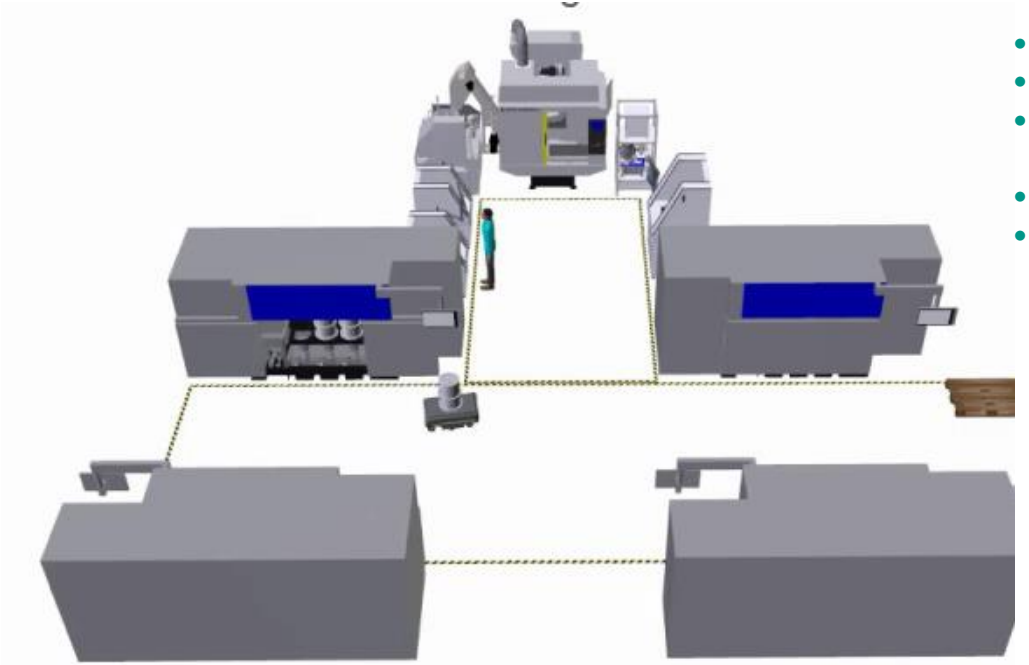
Cooler:	IQ-DDP
TIM:	Thermal grease
Material:	Aluminum (AlSi10Mg)
Pressure Drop:	100 mbar
Flow Rate:	1.280 ml/min
Fluid:	Water / Glycol 50%

Application:	Traction inverter
Modul:	Descrete package
Fluid inlet temp.:	21°C
Junction Temp:	n.n
$Power_{module}$:	n.n
$Power_{loss}$:	300 W
$Rth_{j,f:}$	n.n
$Rth_{j,c}$:	n.n.
Rth_{cooler}:	0,16 K/W



Measurements with an alternative heat source

IQ Twin automotive as example for cost and mass production



- Smallest setup with 100.000 parts per month
- 3D-printer running fully automatically (24/7)
- Mechanical machining and testing by manual handling (one shift)
- Easily scalable by doubling the number of printers
- Further scaling by increasing the number of printers, multi-shift production and/or automation of the manual activities

- IQ Twin is manufacturered, mechanically processed and tested every 90 seconds
- Estimated cost for >=25 Mio pieces per year: <10€

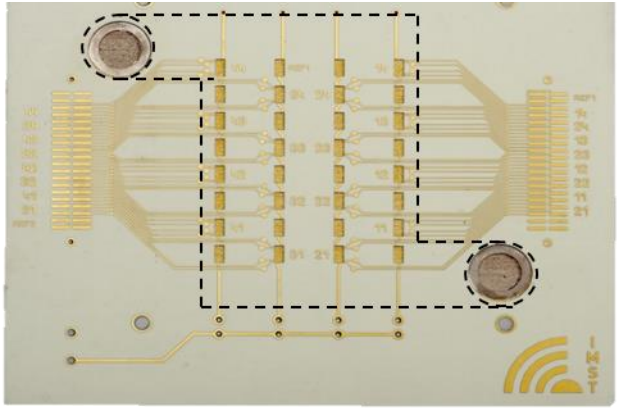
In cooperation with LEWA Attendorn GmbH

Some more samples: Embedded cooler**

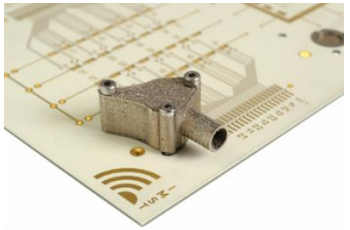
- Active water cooler inside the board
- Material: 1.4404 stainless steel
- Cooler thickness: 0.8 mm, Board 1.3 mm
- Cooling performance: up to 500 W
- Adapted for integration in
  - conventional boards
  - Multilayer-HF boards
- Developed after IMST**-Specification

Thin-cooler 0.8mm

Inlet with O-ring seat



Dashed line: contour of the integrated cooler



Connected water inlet

** IMST GmbH, Kamp-Lintfort

„In-Board“ cooler, measured data*

Location: Row 1 to 4
Thermal load: 24 W/row
Total load: 96 Watt

25.10.2024

* IMST GmbH, Kamp-Lintfort

Contact

Thank you for your attention.

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