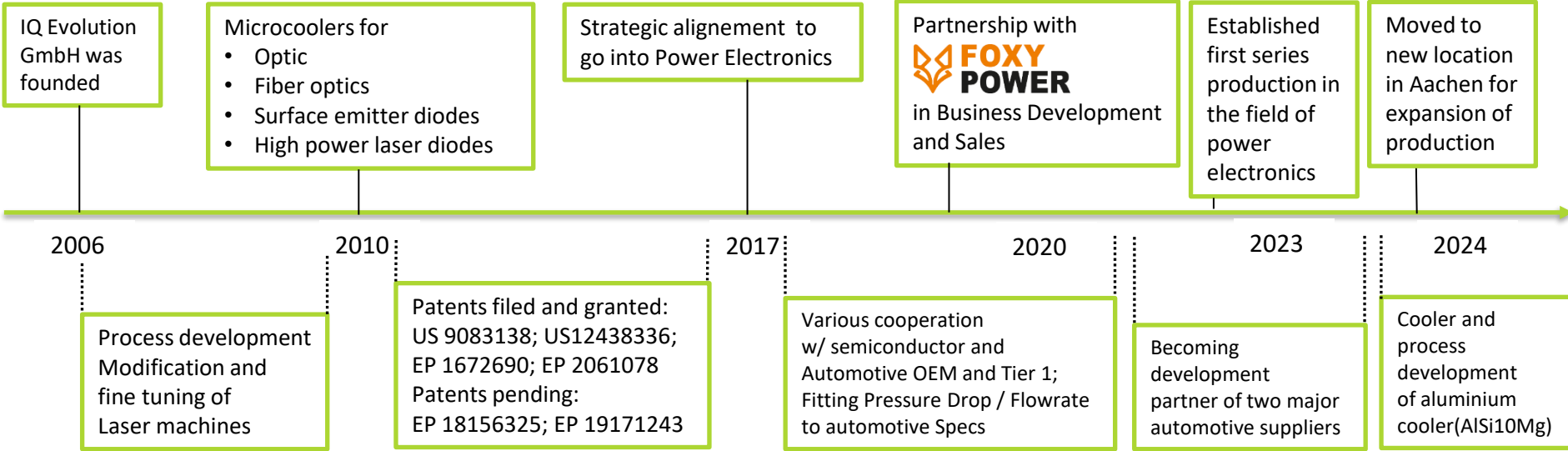


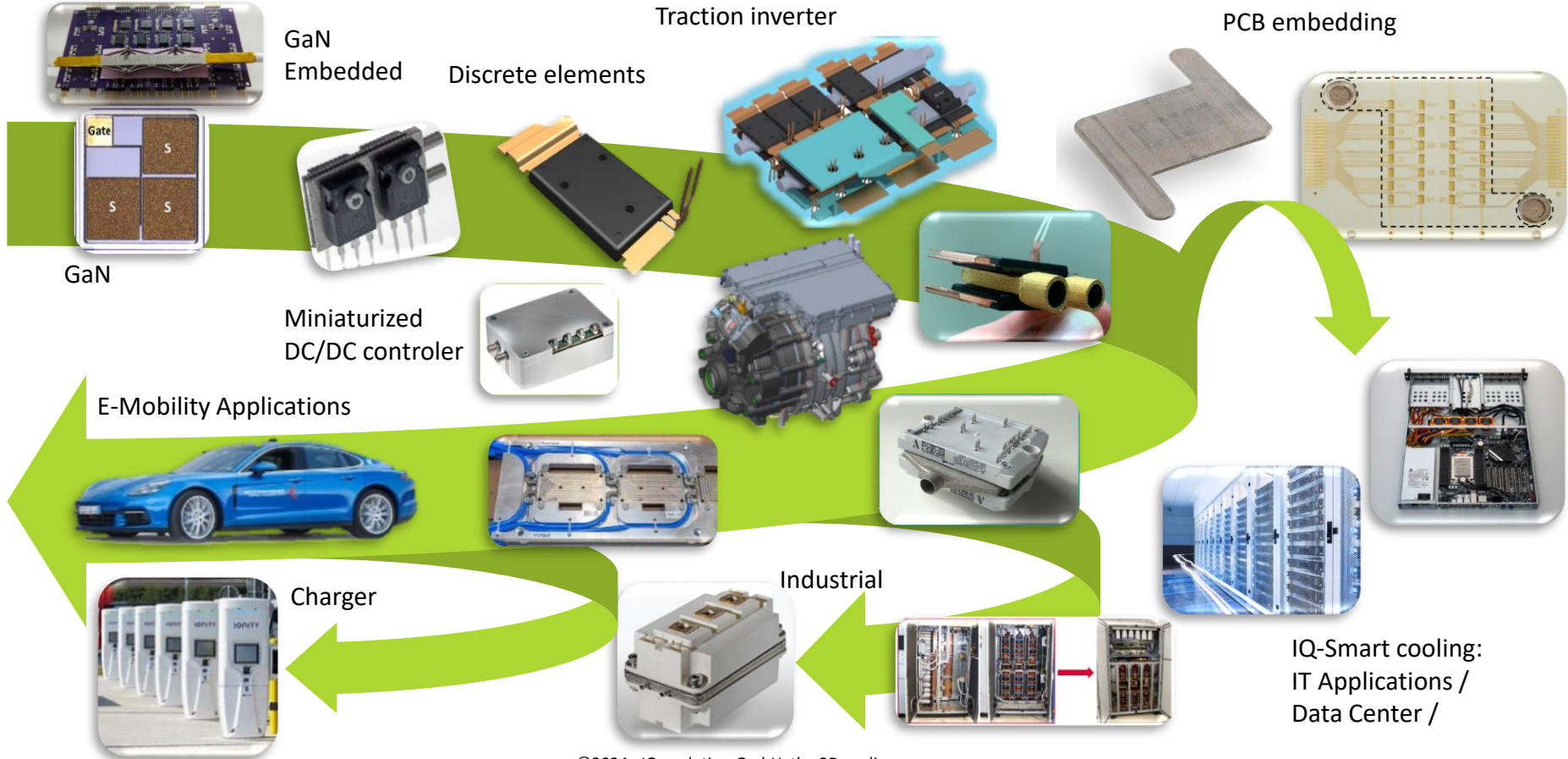
# 3D printed liquid cooled heatsinks for power electronics applications

Dr. Thomas Ebert, CEO  
IQ evolution GmbH, Kellershastr. 21, 52078 Aachen  
+49 241 913826-0  
t.ebert@iq-evolution.com  
www.iq-evolution.com





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

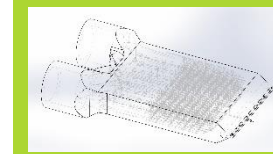


# The „printing“ process

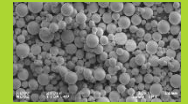
- IQE has been developing and manufacturing microcoolers using metal 3D printing for almost 20 years.
- The metal powder is melted layer by layer with the laser beam.
- This enables the production of very thin radiators (from 0.8 mm) with low wall thicknesses.
- Complex internal structures can be manufactured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

## The „printing“ process

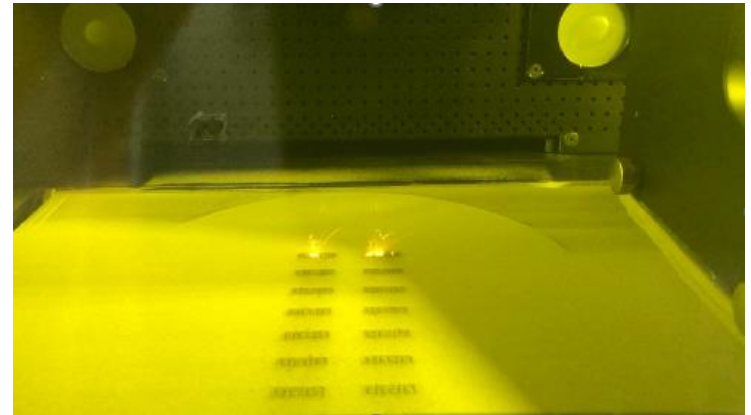
- Dividing the CAD model into 20µm/40µm layers
- Pre-processing of the individual layers (speed, laser power.....)
- Laser melting of the structures, which should subsequently be solid
- Subsequent cavities are not melted



3D-CAD model

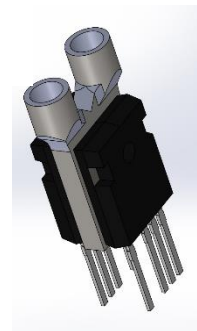
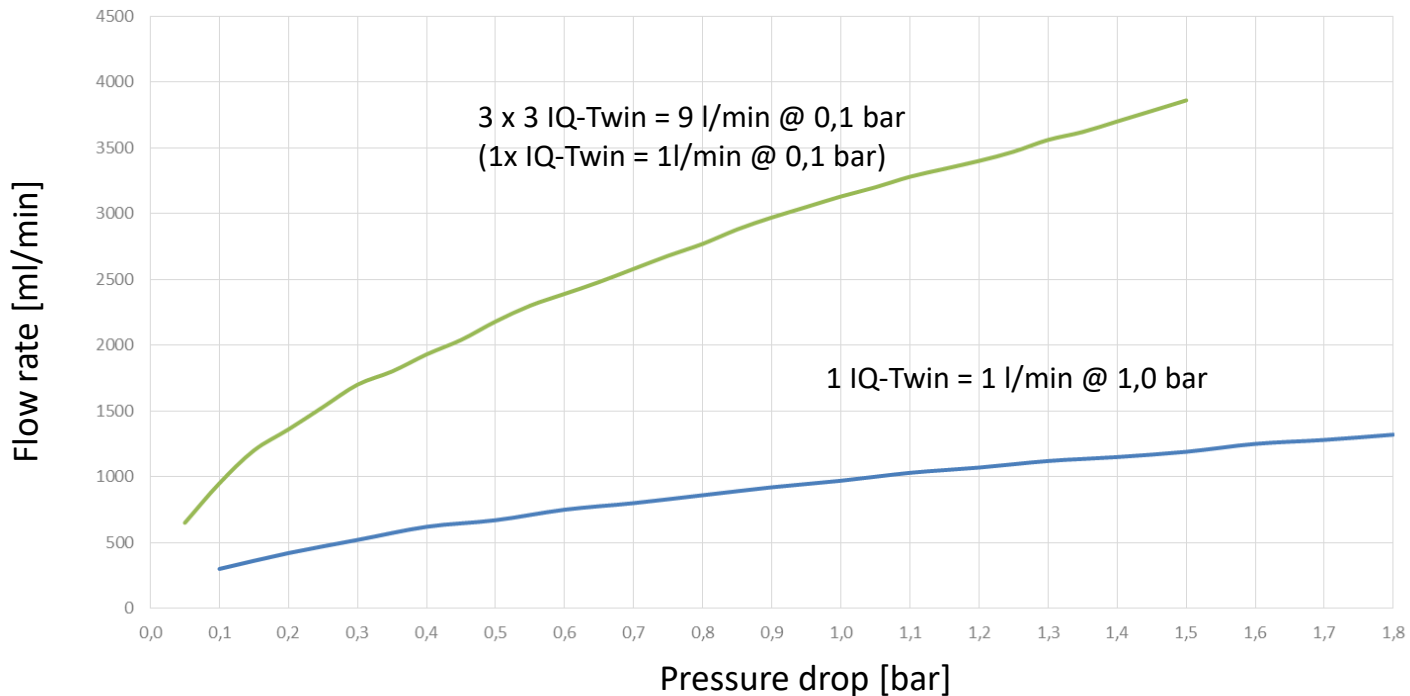


Metal powder



Complex internal structures in a closed housing

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

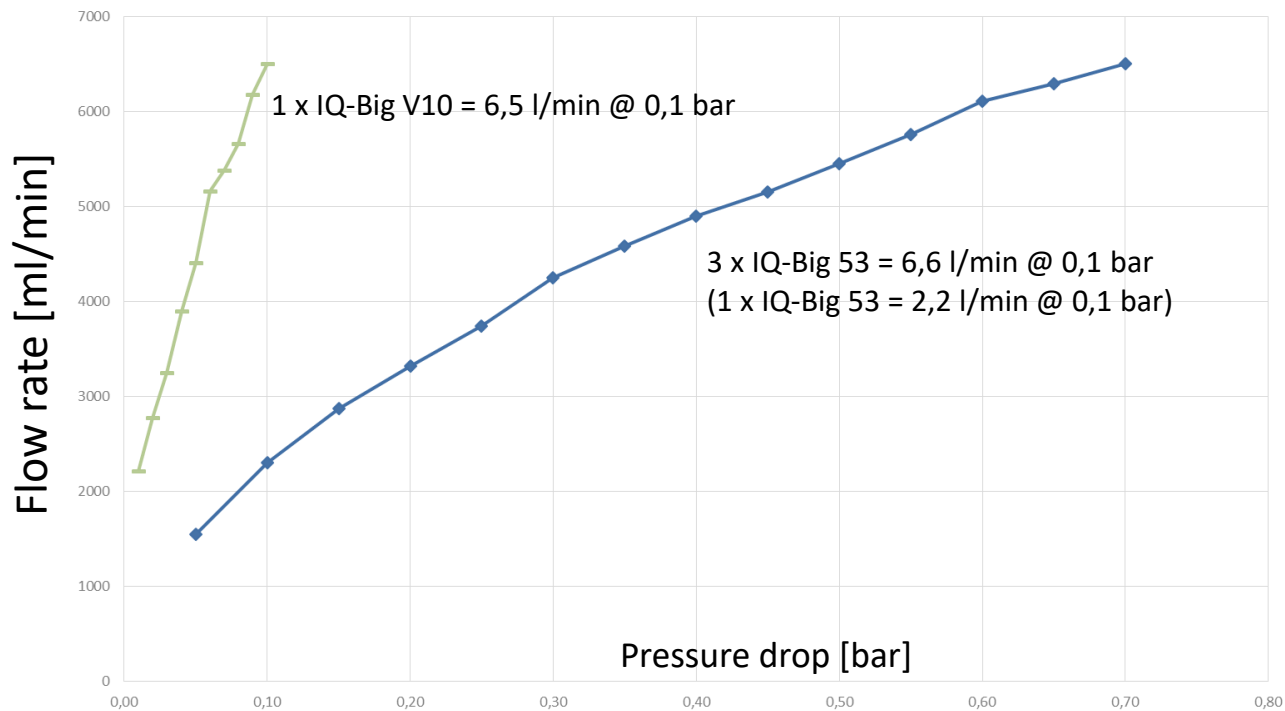


**IQ-Twin Automotive**



**IQ-Twin Industrial**

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

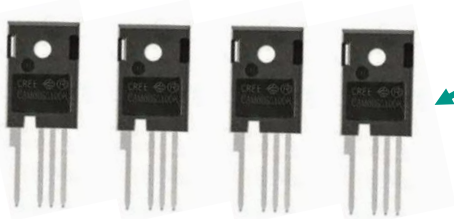


IQ-Big V10



IQ-Big 53 Automotive

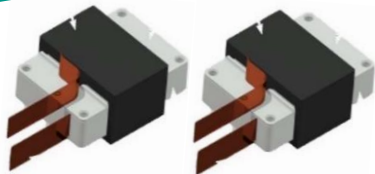
# Use case: DC/DC Converter



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



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

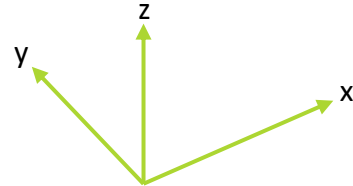


2x Power inductor based on copper foils



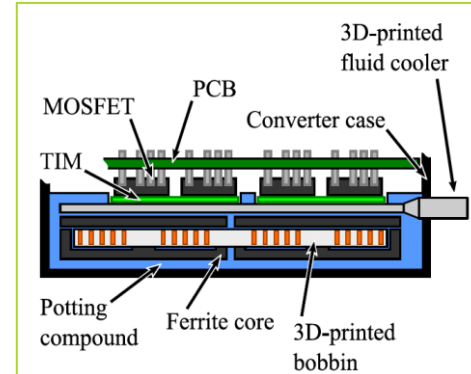
## Specification

- / DC/DC converter w/o Filter
- /  $P_{out,max} = 20.6\text{ kW}$
- /  $V_{in} = 400\text{ V}$
- /  $V_{out} = 800\text{ V}$
- /  $F_{sw} = 450\text{ kHz}$
- / Power density:  $\sim 100\text{ kW/l}$



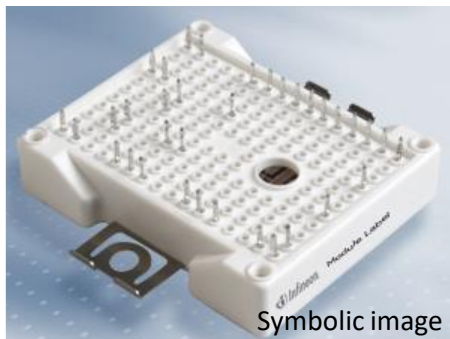
X =	95 mm
Y =	70 mm
Z =	35 mm
Volume	0,23 l
Weight	389 gr

## Inside view of DC/DC converter





# Use case: DC/DC Truck-Converter



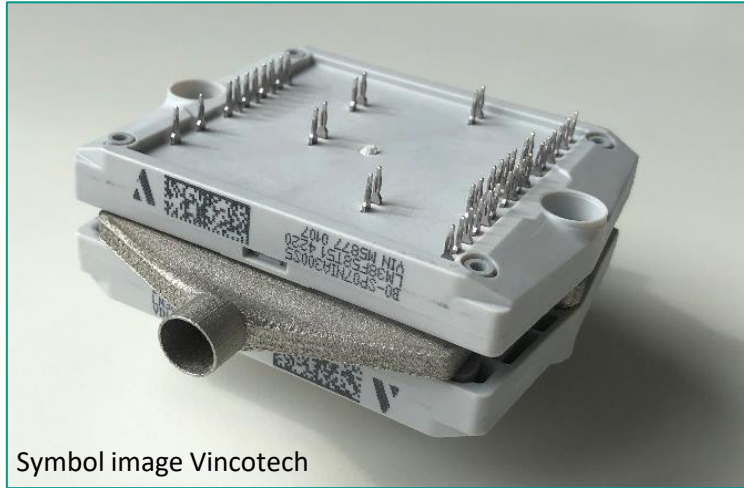
Cooler:	IQ-Big 53
TIM:	Bergquist Hi-Flow 300P
Material:	Stainless steel 316L (1.4404)
Fluid:	Pure water, 2,2 l/min@100 mbar
Modul:	Infineon
Fluid inlet temp.:	20°C
Junction Temp:	175°C
Power <sub>module</sub> :	35 KW
Power <sub>loss</sub> :	750 W
Rth <sub>j,f</sub> :	0,21 K/W
Rth <sub>j,c</sub> :	0,13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





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 <sub>module</sub> :	50 KW
Power <sub>loss</sub> :	800 W
Rth <sub>j,f</sub> :	0,164 K/W
Rth <sub>j,c</sub> :	0,104 K/W (Datasheet)
Rth <sub>cooler</sub> :	0,060 K/W

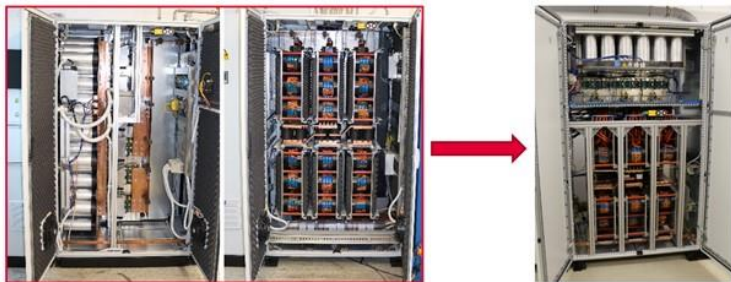
# Use case: Charger



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 <sub>module</sub> :	
Power <sub>loss</sub> :	1.250 W
Rth <sub>j,f</sub> :	0,09 K/W
Rth <sub>j,c</sub> :	0,03 K/W (Datasheet)
Rth <sub>cooler</sub> :	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:

TIM:

Material:

Fluid:

Fluid inlet temp.:

Junction Temp:

Power<sub>loss</sub>:

Rth<sub>j,f</sub>:

IQ-Big 62

Thermal paste

Stainless steel 316L (1.4404)

Water, 2,4 l/min @ 0,2 bar

20°C

45°C

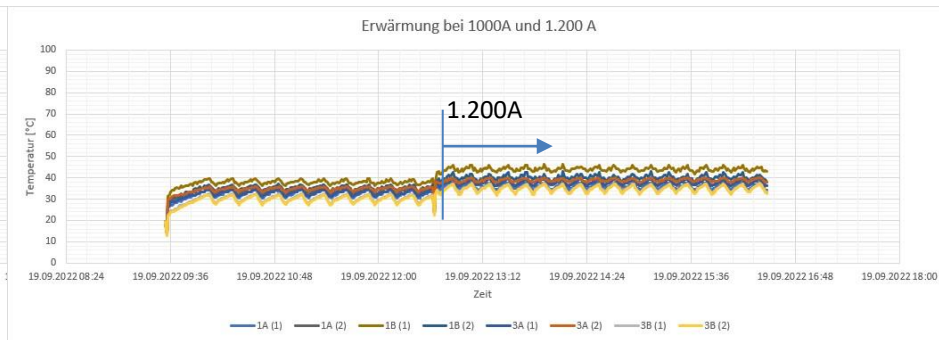
1.470 W

0,017 K/W

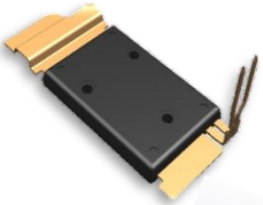


## After:

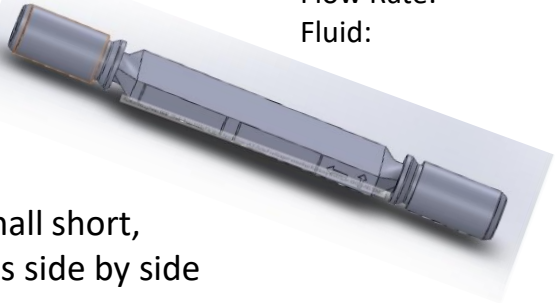
- One control cabinet
- 22 l/min modules serial flow
- Temp. max = 45°C
- Temp. difference first to last modul = 10°C



# NEW: Aluminium cooler for discrete elements

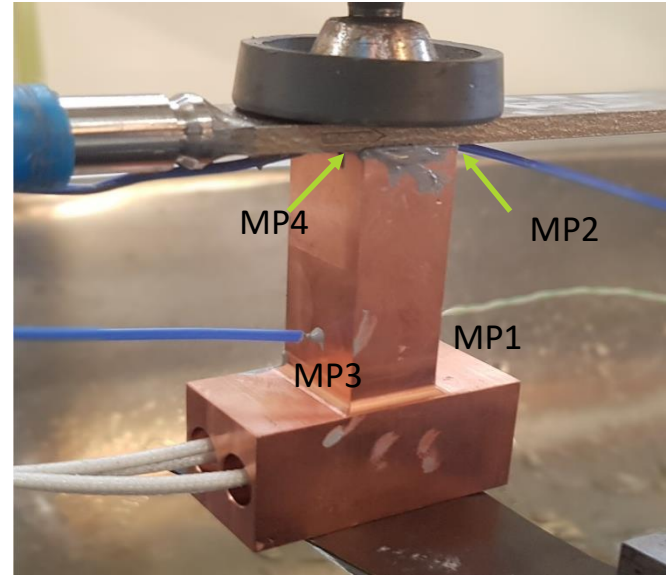


IQ-small short,  
2 modules side by side

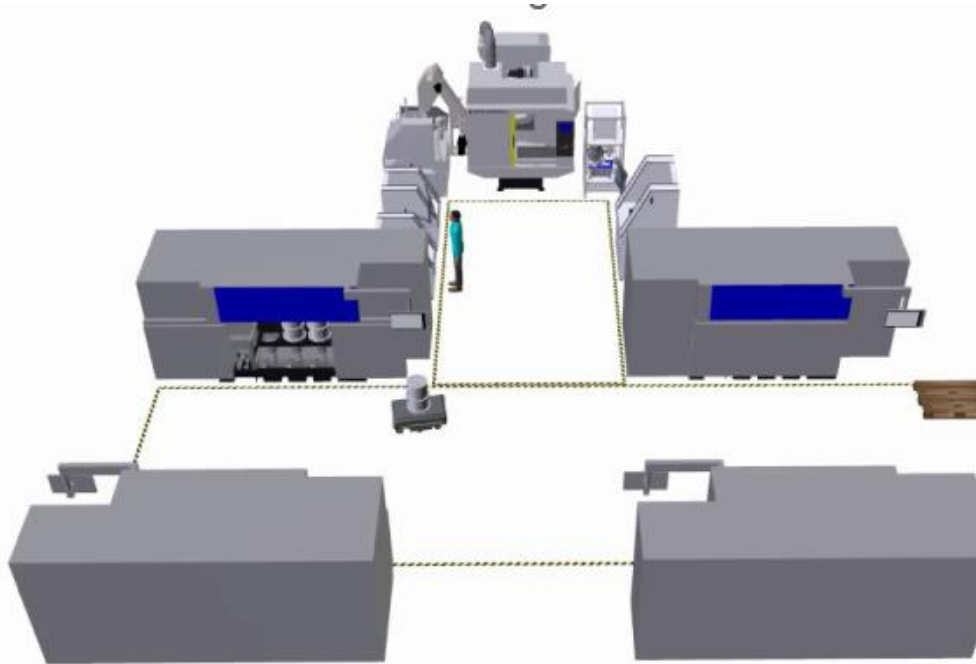


Cooler:	IQ-DDP
TIM:	Thermal grease
Material:	Aluminum (AlSi10Mg)
Pressure Drop:	100 mbar
Flow Rate:	1.280 ml/min
Fluid:	Water / Glycol 50%

Application:	Traction inverter
Modul:	Discrete package
Fluid inlet temp.:	21°C
Junction Temp.:	n.n
Power <sub>module</sub> :	n.n
Power <sub>loss</sub> :	300 W
Rth <sub>j,f</sub> :	n.n
Rth <sub>j,c</sub> :	n.n.
Rth <sub>cooler</sub> :	0,16 K/W



Measurements with an  
alternative heat source



- 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 manufactured, mechanically processed and tested every 90 seconds
- Estimated cost for  $\geq 25$  Mio pieces per year:  $< 10\text{€}$

In cooperation with LEWA Attendorn GmbH

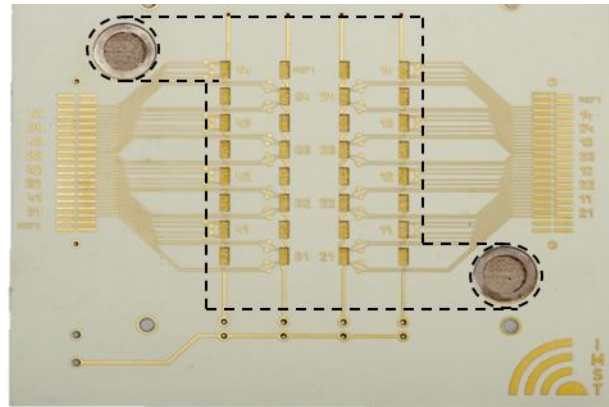
- Active water cooler inside the board
- Material: 1.4404 stainless steel
- Cooler thickness: 0.8 mm, Board 1.3 mm
- Cooling performance: up to 500 W
- Adapted for integration in
  - conventional boards
  - Multilayer-HF boards
- Developed after IMST\*\*-Specification



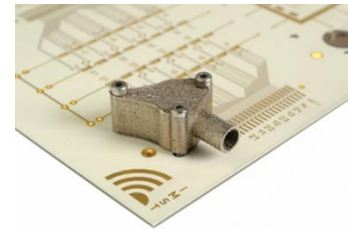
Thin-cooler 0.8mm



Inlet with O-ring seat



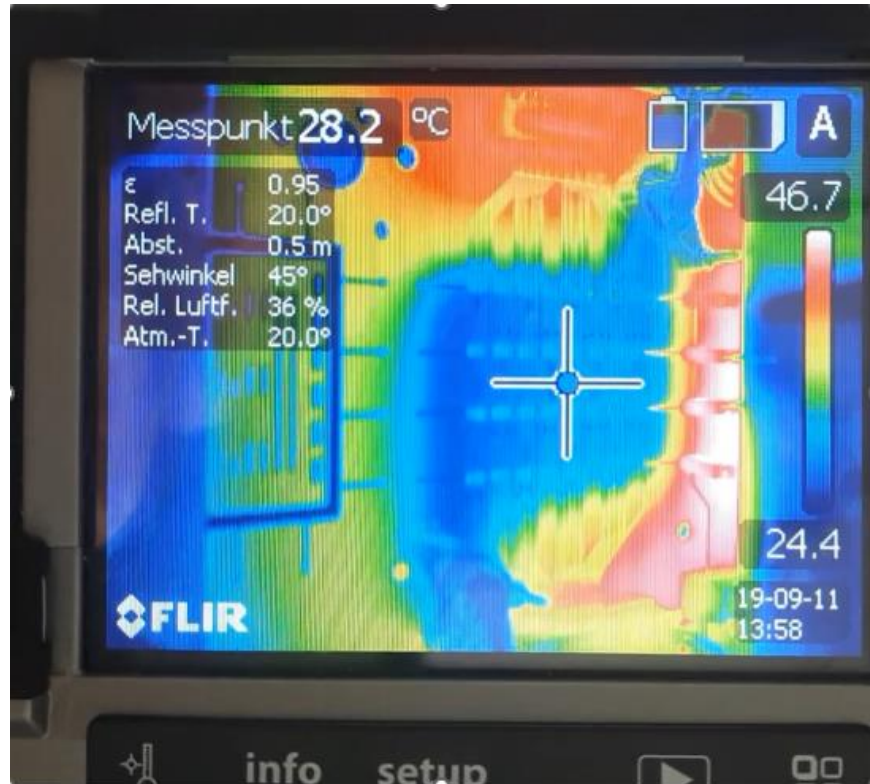
Dashed line: contour of the integrated cooler



Connected water inlet



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





Thank you for your attention.

If you have any questions or inquiries please contact us:

Adress: Kellershaustraße 21 | 52080 Aachen | Germany

Phone: +49 241 913 862 -0

Mail: [t.ebert@iq-evolution.com](mailto:t.ebert@iq-evolution.com)

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