3D printed micro cooler for power electronics

IQ evolution GmbH, Dr.-Ing. Thomas Ebert

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www.iq-evolution.com
The coolers are produced by SLM procedure, the Selective Laser Melting. The procedure is also known as LPBF (Laser Powder Bed Fusion).

IQ evolution refined this 3D-metal-printing process over more than 10 years, specially to the requirements of building micro structures.

Rapid Prototyping and complex mass production are both efficiently producible with this technology.

For more informations about the 3D-printing process please use our download-center:

http://iq-evolution.com/downloads_de/

All our products are covered by registered patents.

Registered patents: US 9083138; US 12438336; EP 1672690; EP 2061078
Patent pending : EP 18156325
SLM, Selective Laser Melting

Overview SLM

1. Deposition of a powder layer

2. Melting of the powder by a laser beam

3. Lowering of the platform

3D-CAD model in layers

+ 

Metal powder

Complex parts produced with final dimensions
Customized Microcooler

Prototypes
+ Customers Design
+ Creating 3D Model
+ Pre-Processing
+ Select material
+ Finding parameters
+ Building the first parts

Testing / controlling
+ Geometrie
+ Wall thickness
+ Flow rate
+ Cooling performance
+ Livetime

Series
+ Production capacity
+ Availability
+ Reproducibility
+ Reliability
Standard cooler for TO-247 housing

The first standard coolers were made for cooling high power components in TO-247 housings.

The coolers are available for the cooling of two, four and eight housings at the same time.

Beside the design for TO-247 housings, all other housing types are available. Customized designs in other shapes and thicknesses are also possible.
„IQ-Thincooler“, alternative designs

Due to the manufacturing procedure of 3D metal printing a lot of alternative designs are possible.

No special tools are necessary, the complexity of the parts causes no extra expenses, only the size defines the costs.
Measurement of „IQ-Four“ Transistor cooler, setup

75 Watt @ 4mm x 11mm footprint → 170 W/cm², water inlet temperature 20°C
Measurement of „IQ-Four“ Transistor cooler, flowrate

![Graph showing the relationship between pressure and flow rate for IQ-Four Transistor cooler. The x-axis represents pressure in bar ranging from 0 to 2.5, and the y-axis represents flow rate in ml/min ranging from 0 to 1600. The line on the graph indicates an increasing trend as pressure increases.]
Measurement of „IQ-Four“ Transistor cooler, temperature

Thermal load: 48 Watt @ 4mm x 11 mm footprint → 110 W/cm²

Water inlet temperature: 23°C
Measurement of „IQ-Four“* Transistor cooler, 4 Mosfets @ 50A**

| Mosfet 1  | 181,35 W |
| Mosfet 2  | 182,15 W |
| Mosfet 3  | 180,50 W |
| Mosfet 4  | 179,15 W |
| **Total** | **723,15 W** |

**Final cooling performance via water cooling:**

- **Water inlet temp.:** 32,16°C
- **Water outlet temp.:** 41,57°C
- **Overall thermal load:** 757,00 W
- **Final cooling performance via water cooling:** 670,61 W

*Design by Diabatix Material 1.4404

**C3M0016120K Silicon Carbide Power MOSFET mounted with Hi-Flow® 300P insulating foil, 1,025 ml/min@1,2bar**
Measurement of „IQ-Four“* Transistor cooler, 4 Mosfets @ 50A**

Water outlet temp.: 41,57°C
Water inlet temp.: 32,16°C

670,61 Watt

Footprint Mosfet: 1,088 cm²
Cooling performance (average): 167,65 W/Mosfet
Heat density / Mosfet: 154,09 W/cm²

*C3M0016120K Silicon Carbide Power MOSFET mounted with Hi-Flow® 300P insulating foil, 1,025 ml/min@1,2bar
*Design by Diabatix
Material 1.4404

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All IQ evolution cooler are available with electrical insulation of the cooler surface.

The kind of insulation depends on the customers demand, e.g. needed disruptive strength, and has an influence of the cooling performance.

75 Watt @ 4mm x 11mm footprint → 170 W/cm², water inlet temperature 20°C
Insulating the coolers surface is just the first step. Step two:

Creating a complete circuit on the coolers surface!

- Manufactured by Selective Laser Melting (SLM) and standard PCB process
- Material: 1.4404
- Thickness: 4 mm
- Cooling performance up to 1,000 W
- Suitable for direct mounting
Application samples, bi-directional DC/DC converter

In cooperation with the „Institut for power electronics and electrical drives“ of the RWTH-Aachen University, a DC / DC converter was developed as an application sample of the „IQ-Thincooler“. By using the 3D printed micro coolers and take advantage of the miniaturizing potential, the partners created a impressive sample:

Discrete 1000-V-SiC-MOSFETs with Kelvin-Source:
- Wolfspeed C3M0065100K
- 65 mΩ
- Three times less switching losses

Sensor integration:
- In- and outlet voltage
- Current phase

FPGA and MCU:
- Loop controle
- PC communication
- Without electrical connection to power electronic

\[ P_{\text{out,max}} = 20.6 \text{ kW} \]

- 98.1 kW/l
- \( V_{\text{in}} = 400 \text{ V} \)
- \( V_{\text{out}} = 800 \text{ V} \)
- \( f_s = 450 \text{ kHz} \)
Application samples, „In-Board“ cooler

- Active water cooler inside the board
- Material: Nickel*
- 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
- Only a third of weight in comparison to a similar board with copper core

* Long-time resistant against deionized water

** IMST GmbH, Kamp-Lintfort
„In-Board“ cooler, measured data*

Location: Row 2 of 4
Thermal load: 24 W/row

Click for Video clip

* IMST GmbH, Kamp-Lintfort
„In-Board“ cooler, measured data*

Temperaturverlauf bei 97 W | 133 W

Messzeit [min]

Grad Celsius

bar

T1
T2
T4
T5
T6
T7
T8
T1
T2
T4

* IMST GmbH, Kamp-Lintfort
„In-Board“ cooler, measured data*

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

Click for Video clip

* IMST GmbH, Kamp-Lintfort
Project: IGBT Cooler, „IQ-BIG“

Schritt 1: „IQ-BIG“ zur Kühlung herkömmlicher IGBTs

Schritt 2: Direktmontage der IGBT Chips ohne Gehäuse
Project: IGBT Cooler, „IQ-BIG“

Schritt 1: „IQ-BIG“ zur Kühlung herkömmlicher IGBTs
Schritt 2: Direktmontage der IGBT Chips ohne Gehäuse

Schritt 3: Direktmontage der IGBT Chips mit modifiziertem Gehäuse
  und / oder
Schritt 4: Direktmontage von modifizierten IGBT Chips
  im modifiziertem Gehäuse

IQ und ISEA

IQ, ISEA und Externer Partner
Please contact us:

Dr. Thomas Ebert  
Managing director

Tel.: +49 241 8906 347  
E-Mail: t.ebert@iq-evolution.com  
Homepage: iq-evolution.com

Adress: Steinbachstraße 15 | 52074 Aachen | Germany

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