



Presenting:

New solutions for thermal management in power electronics



Power Electronics & Energy Storage event
27 juni 2023 | 1931 Congrescentrum 's-Hertogenbosch

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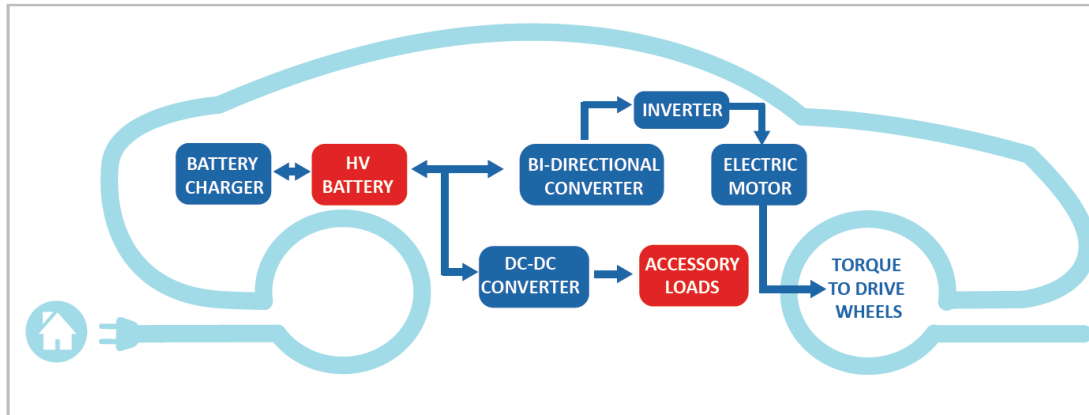
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Power Electronics in Electric Vehicles is dominated by constraints that lead to the development of smaller components, handling more power in smaller spaces. In two words: **Power Density**



Higher power in smaller packages means **higher amounts of energy per unit of time** that must be transferred through the components from and to the batteries.

A fatal failure in Power Electronics often ends up with the car stopped(best scenario) and expensive replacement of the full electrical system while a catastrophic failure could see the car **burst into flames** with very serious damage to reputation and car owners.

Most of the issues that affects Lithium batteries in EV (pressure, heating, short circuits and flame risks)are common with Power Electronics circuits and thus the same solutions apply.

Operation temperature change of $\pm 10^{\circ}\text{C}$ has a BIG impact on reliability & life

This continuous demand on higher power at lower costs, weights and volumes are pushing electronics engineers to the limits.

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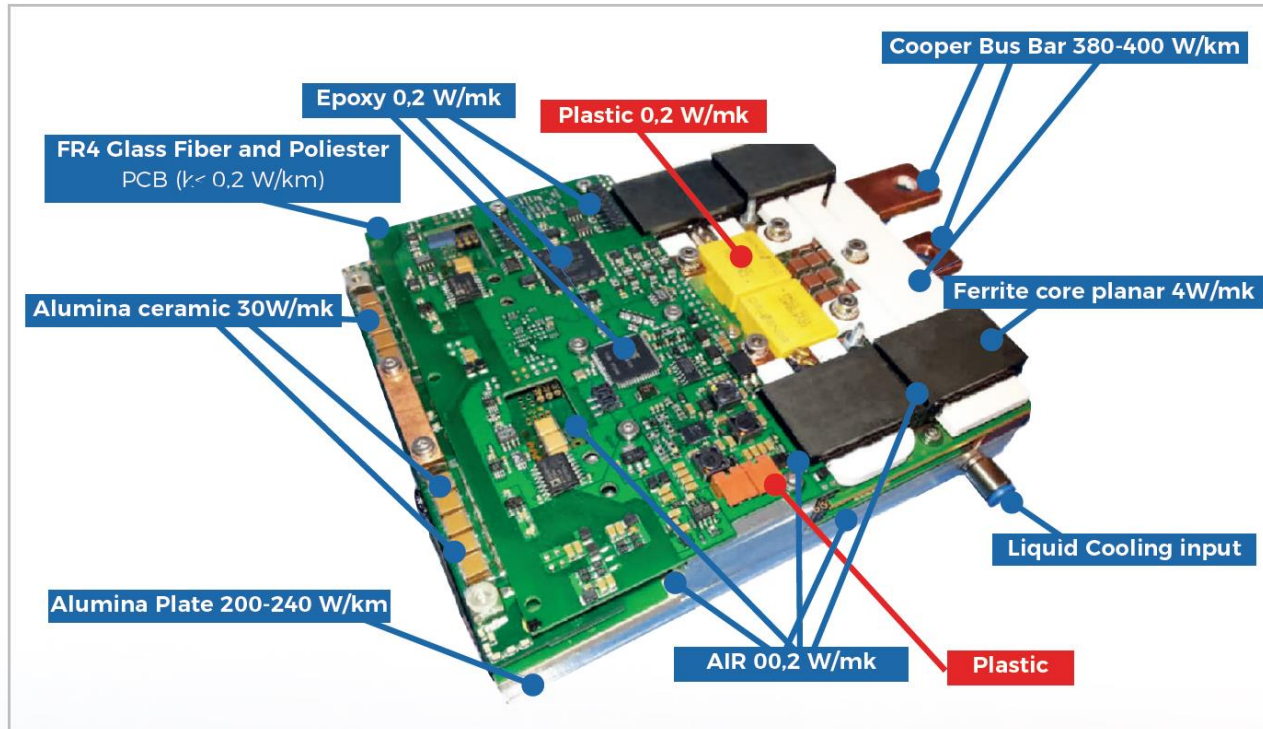
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INSIGHT OF HIGH POWER DENSITY INSULATING DC/DC CONVERTER



It is quite common to see air among components, as airflows were used to cool the whole system down.

But fans are risky and expensive part of the system. They are noisy and **if they fail, the complete system goes down** and air is a great thermal insulator (0,002 W/mK)

Most of the materials in Power Electronics **are thermally non conductive**, as we still protecting and isolating hot spots.. **instead of transferring and evacuating the heat.**

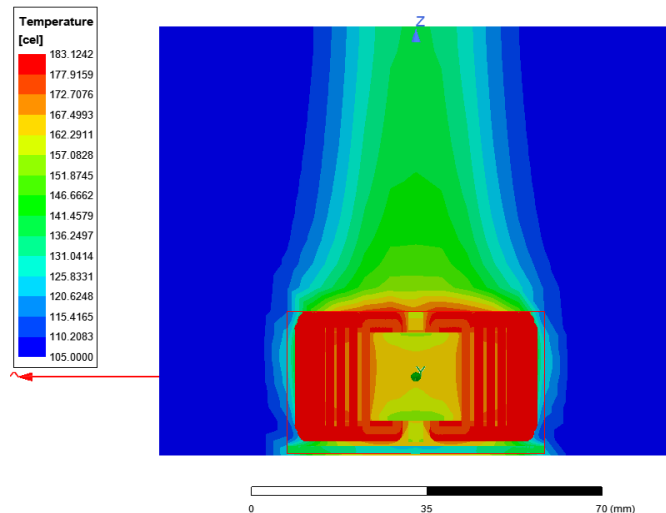
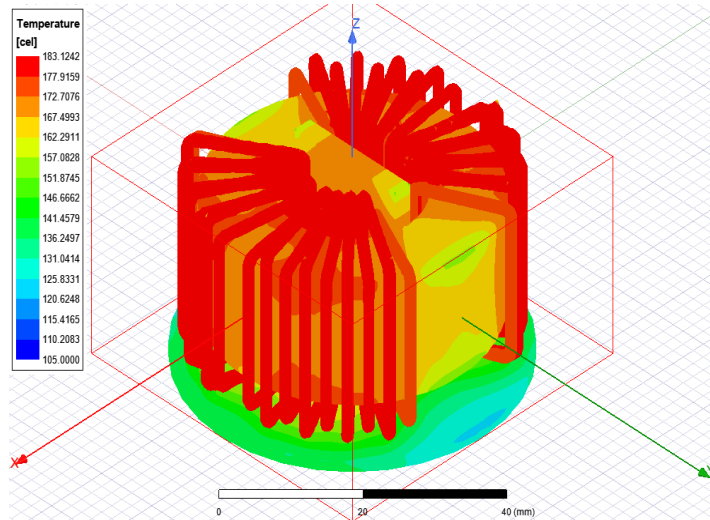
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There is not enough thermal interface to keep it working in safe operative temperature. The steady state temperature is very high, so materials cannot support it, 105°C of ambient temperature is excessive.

A thermal mechanism to sink the generated heat is needed in order to archive the required electrical performance.

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Requirements

- High Heat Transfer & High Thermal Diffusivity material
- Electric Isolation
- “Soft” material : No Thermal Stress & Mechanical protection
- Flame and fire protection (Retardant and Extinction)- UL94 V0
- Non Hazardous material

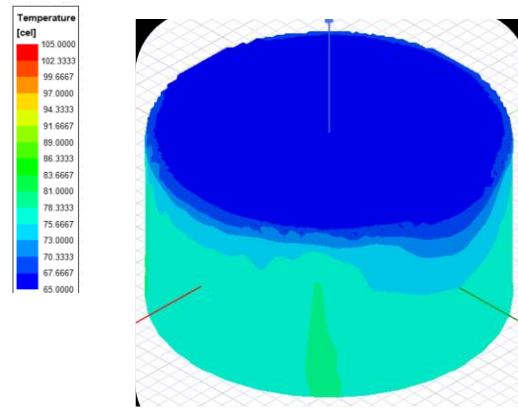
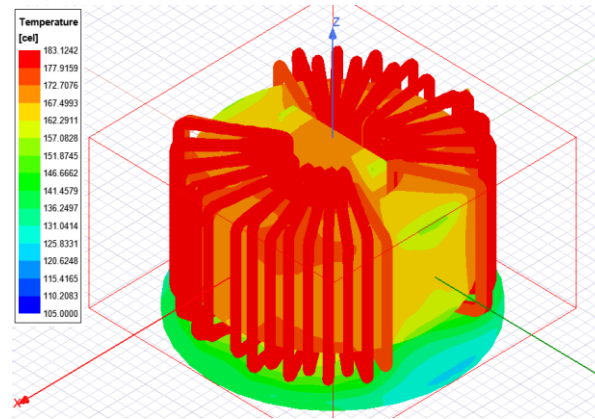
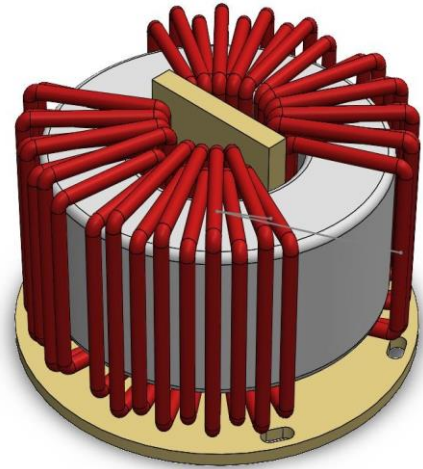
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Power Electronics

Coolmag injection with a mold provided good thermal coupling to sink the heat at the cooling plate and **total temperature decreased almost 80°C.**

- No Air
- No Thermal Stress
- 3D Heat Dissipation
- Fast Thermal Dynamics

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Thermal Performance- Stabilization Temperature

Thermal performance it's a combination of different factors (is not only about thermal conductivity!)

- Thermal diffusivity (How fast do you empty the bucket) & Thermal Conductivity (bucket size)
- Potting resin nature vs Thermal Stress
- Application (BIG IMPACT on the final performance)

Thermal Compound materials

Need for passive solutions in thermal management for EV's and Power Electronics, offering a new disruptive solution.

Design to provide thermal conductivity, electrical safety, hazard protection, mechanical and fire protection for electronic encapsulating applications.

Need to be used on:

- Power Transformers and Semiconductors
- Automotive and High reliability Power Electronics
- OBC, Inverters and DC/DC converters in Electric Vehicles
- Inter-cell coating and protection in batteries
- Gap Filler to interface with liquid cooling in Battery Packs



Provide

EXCELLENT THERMAL CONDUCTIVITY & DIFFUSIVITY
ELECTRICAL ISOLATION
DESIGNED FOR MANUFACTURABILITY
HAZARD, MECHANICAL AND FIRE PROTECTION FOR
ELECTRICAL AND ELECTRONIC ENCAPSULATING
APPLICATIONS (UL 94 V0)

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Various Compound Parameters:

Viscosity, adhesion, outgassing, hardness, thermal conductivity, how to implement

PU 10

Coolmag PU10 It's our low viscosity & high adhesion PU product, specially designed for die casting wherever injection is not possible.

SA 10

Coolmag SA 10 It's our **lowest viscosity** product, specially designed for die casting and potting by gravity or at low vacuum, wherever injection is not possible.

29 LV

Coolmag 29 LV is our standard & best seller product , specially designed for molding & injection applications but also for Gap Fillers apps. **NASA Outgassing certified**

32

Coolmag 32 is a harder version of Coolmag 29 LV, wherever structural or harder properties are needed

SA 30

Coolmag SA 30 it's our highest conductivity product, specially designed for the most demanding applications

PLAST
PA 20

COOLMAGPLAST PA20 is lightweight, net-shape moldable thermoplastic and allows design freedom in applications previously restricted to metals and ceramics

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EXAMPLE COMPOUND SOLUTIONS

Type	Thermal conductivity (W/mK)	Flammability test UL-94	Hardness (Shore AA)	Appearance
SA 10	1.0-1.1	V0	11	Resin beige liquid, 2K , Air Drying (24h) or Heat Curing(60min)
29 LV	1.5-1.8	V0	35	Resin beige liquid, 2K , Air Drying(24h) or Heat Curing (60min)
32	1.5-1.8	V0	75-80	Resin beige liquid, 2K , Air Drying(24h) or Heat Curing(60min)
PU	0.6-0.8	V0	75	Polyurethane beige liquid resin, 2K, Air Drying (24h) or Heat Curing (60min)
SA 30	2.5-3.0	V0	40	Resin beige liquid, 2K , Air Drying (24h) or Heat Curing (60min)
PLAST	2.0	V0	98-99	Solid thermoplastic(pellet)



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Applications

Wherever thermal management is a problem, Compound potentially fits and works.

There are some examples, applications and uses of thermal compound:



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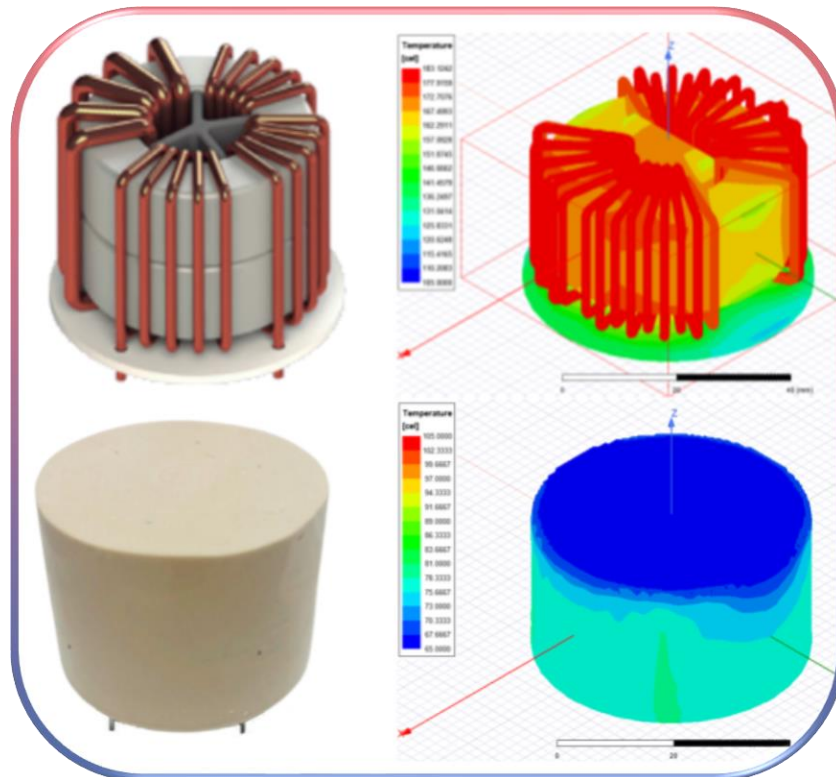
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The pictures represent a common choke.

There is not enough thermal interface to keep it working in safe operative temperature. The steady state temperature is very high, so materials cannot support it

Coolmag provided good thermal coupling to sink the heat at the cooling plate and total temperature decreased almost 80°C



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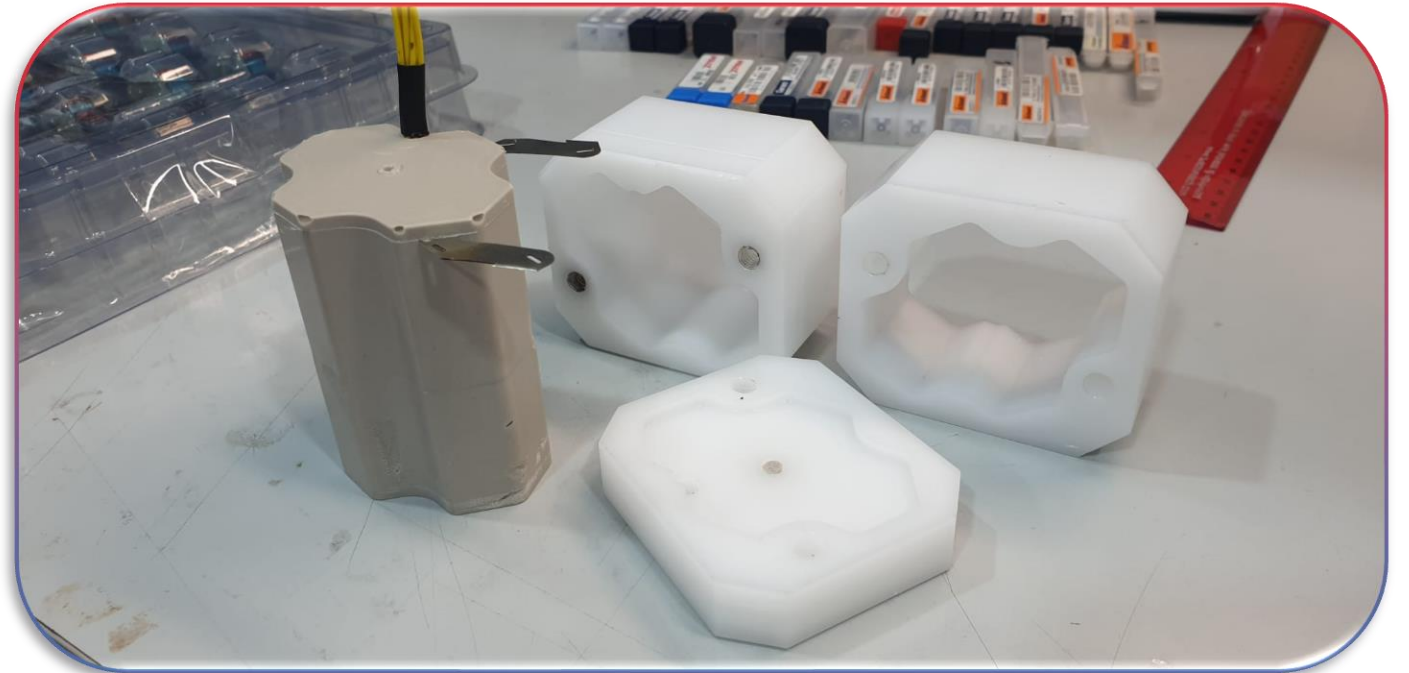
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Battery Protection

Overcharged Battery with CoolMag managed temperature extremely well and never reached the ignition temperature...and it's even WORKING.

If we take it to the EV, the driver could get to the closest workshop, as the collapse of a cell unit would not affect the battery performance anymore.



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Battery Protection (Gap Filler vs Encapsulation)



Tesla 3 Battery Pack & 2170 cell interior
[\(ARES RC Youtube Channel\)](#)



Tesla Y Battery Pack & 4680 cell interior
[\(Munro Youtube Channel\)](#)

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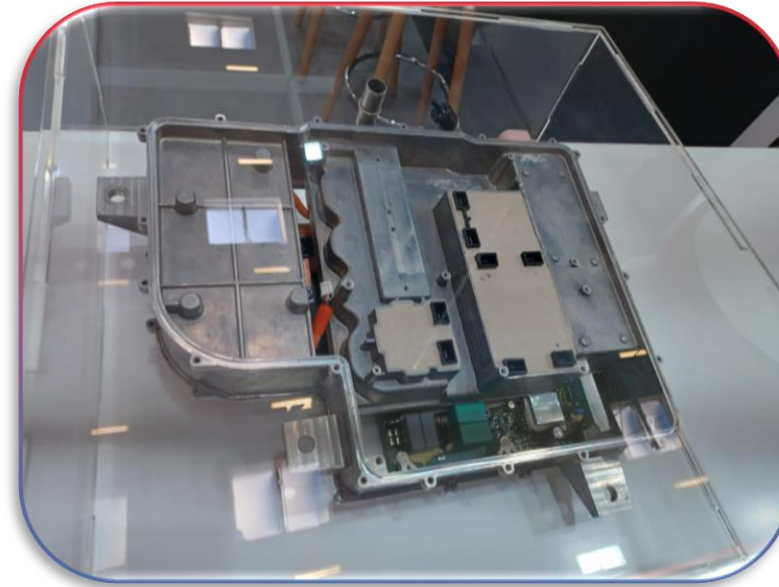
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On/ Off Board Charger

- Thermal conductive epoxies are rigid, and the different components cracked under full load capacity.
- With a simple Compound injection(no product modifications) increased power concentration x2
From 7kW to 14Kw
- OBC was able to run full load capacity with any thermal issues(up to 30% T° decrease)
- Solid thermally conductive block-All in One Solution
- Casting(gravity) or Injection available. Injection can be 20% more effective



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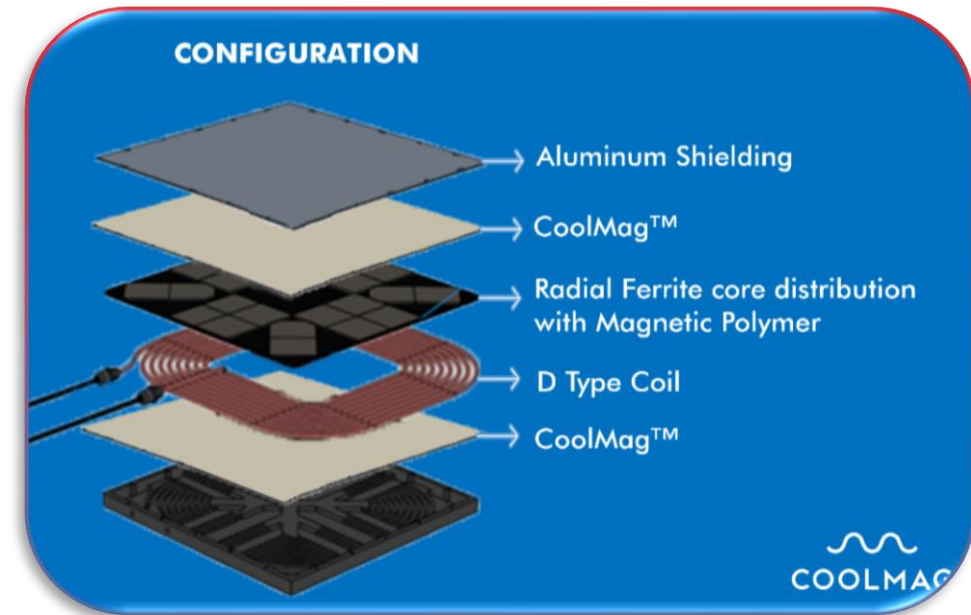
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Inductive Charging

- Other thermal solutions are rigid, and the different components cracked under full load capacity.
- Solid thermally conductive block-All in One Solution
- Casting / Injection available + Gap Filler Solution
- Mechanical & Fire Protection

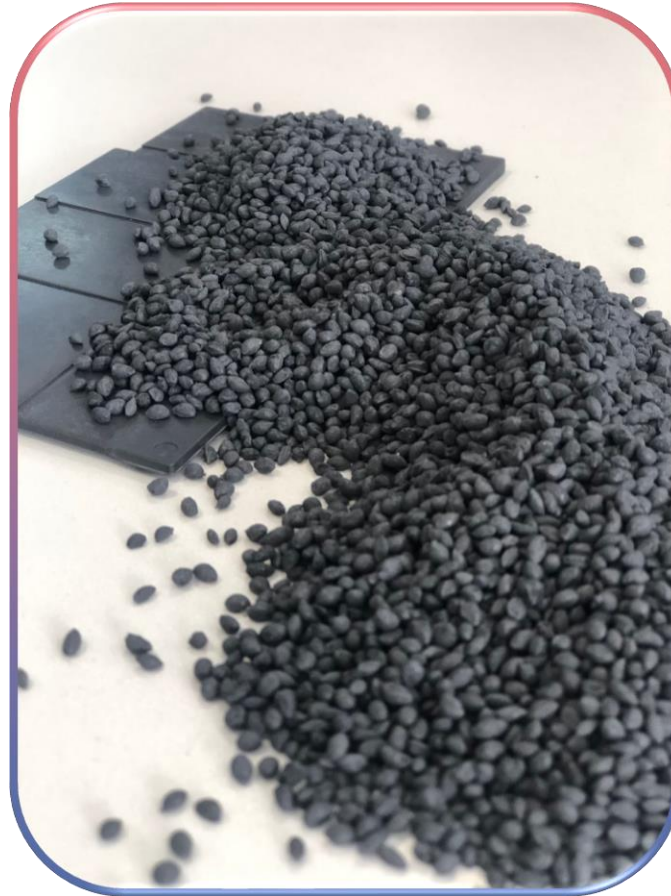
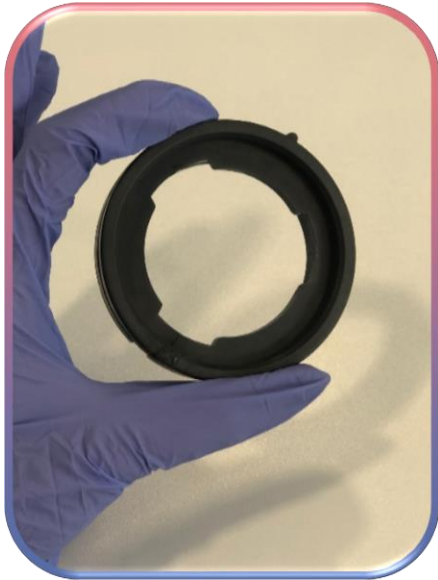


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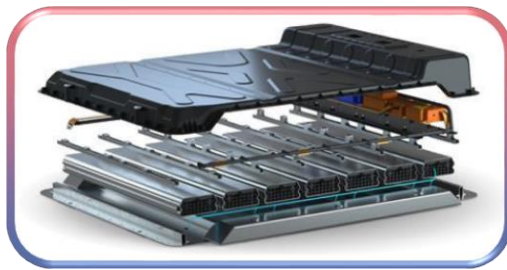
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Thermal conductive plastics

The aim is to replace all non thermally conductive materials in electronics to boost thermal management to a new level, and plastics are the most commonly used ones.

THERMAL CONDUCTIVE PLASTICS allow design freedom in applications previously restricted to common plastics and even metals, like coil bobbins, battery packs or electronic enclosures.



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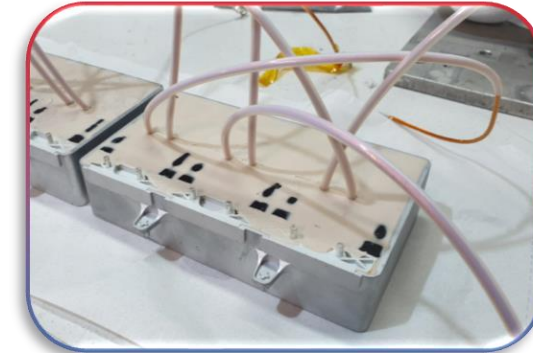
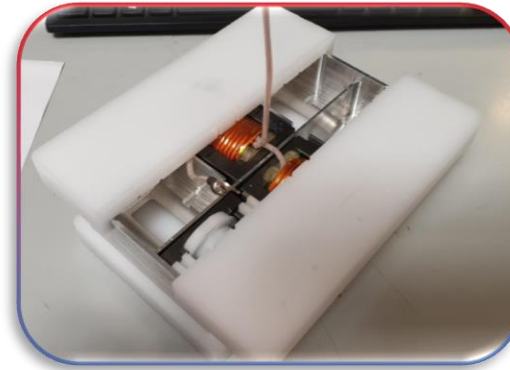
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Compound As A Service

In constant development, strive for innovation in comprehensive solutions to its clients. To do this, it has expanded its value proposition as Compound As A Service.

- Molding & Application
- Industrialization process

This end-to-end service (**from prototype to industrialization**) offers an important advantage for the automation and optimization of power electronics potting processes.



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Compound As A Service

Casting is the most used technique for potting resins but sometimes injection can make the difference!

- Compact Thermal Path(No air gaps)
- Faster & Cleaner Solution
- Perfect for open Enclosures
- Higher Viscosity
(↑ Filler content ↑ Thermal Conductivity)



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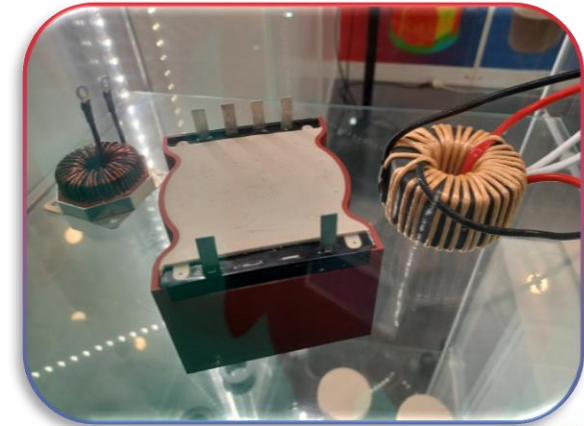
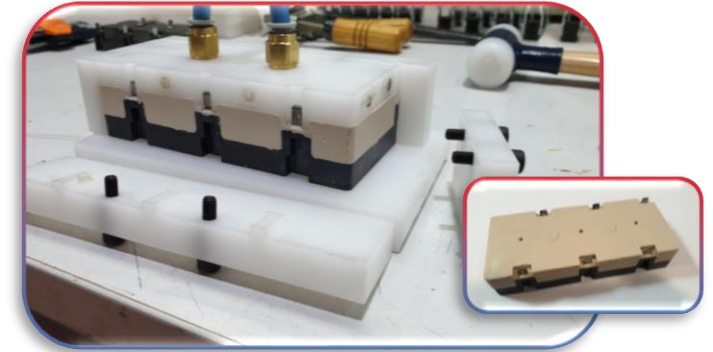
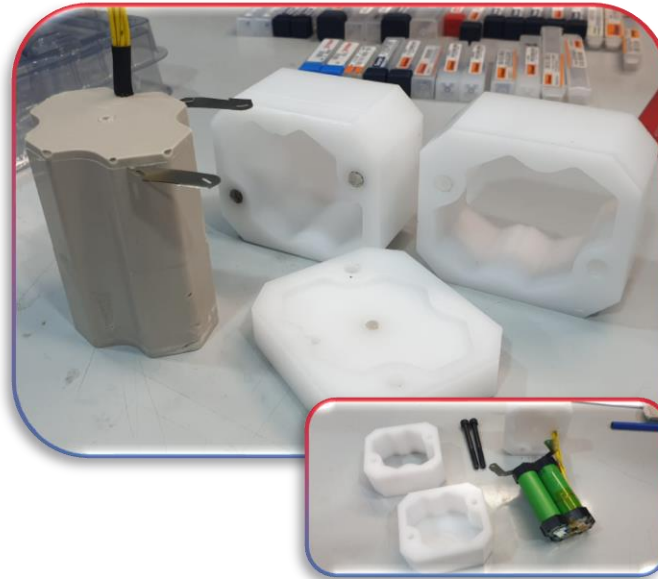
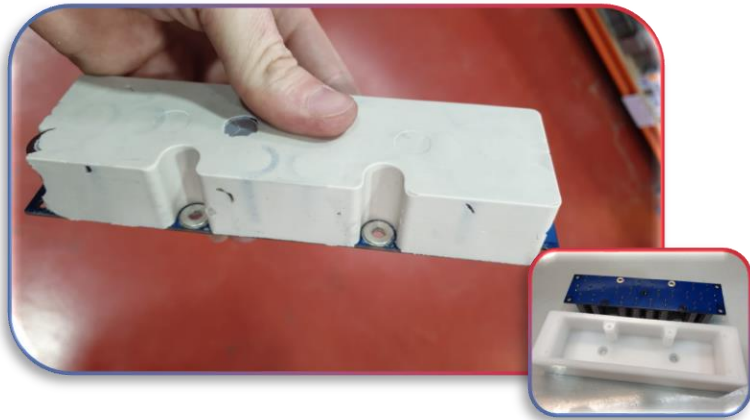
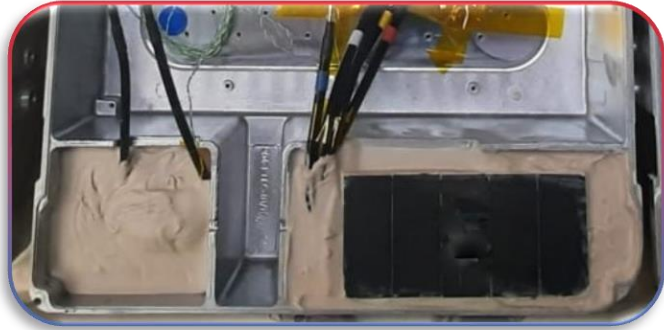
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Some examples



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Lex van Huuksloot, Norbert Engelberts

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