



Innovative Thermally Conductive Solutions

Empowering next-gen devices to achieve efficient thermal management and total cost optimization



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Covestro

Global plastics manufacturer



Strong and global

€12.9 bn in sales

17,600 employees

46 production sites

Game-changing and beneficial

Polymer materials
of superior quality

Across numerous
industry sectors

For global challenges



Innovative and sustainable

1,300 employees
in research and development

80 years of ideas
and inventions

Pioneer of the
circular economy

Wide range of industries

Tailor-made products and solutions



**Automotive and
transportation**



Construction



**Wood and
furniture**



**Electrics and
electronics**



Sports and leisure



Health



Nutrition



Energy

Electrics and electronics

For a connected world

Whether smartphone, laptop or fridge – electronic devices and electrical appliances are an integral part of our everyday life.

But with each new generation the devices must become increasingly **sustainable, efficient, powerful and safe.**

Covestro develops state-of-the-art **materials and application solutions** for the industry.



*Infrastructure for
5G transmission technology*



*Efficient refrigeration units
and cold chains*



*Housings for slim notebooks
and smartphones*



*Personalized ID cards that
are difficult to forge*

Market Trends for Wi-Fi Network Devices



Technology Evolution

- High Power & Advanced Features enables support for higher frequency bands.
- Superior Performance to boost network speeds and capacity while delivering lower latency.



Soaring Demand

- Widespread adoption of diverse terminals and rapid market penetration of Wi-Fi 7
- Growth in high-performance use cases drives demand for upgraded connectivity

Sustainable Innovation

- Utilizes energy-efficient components and thermal management systems to reduce power consumption and enhance reliability.
- Adopts green standards and sustainable materials to lower carbon emissions and extend product lifecycles

Thermal Management Challenges Require Innovative Material Solutions



Advanced Connectivity

Supporting **higher-density antennas** for faster speeds and broader network coverage



Equipped with **advanced processors**, driving increased power consumption and heat generation



Limited space with **compact design** for integrated functions, creating greater thermal constraints

Effective Thermal Management is critical for next-gen connectivity

Effective Thermal Management Unlocks Three Key Product Benefits vs non-TC Plastics



Reliable Stability

Prevents overheating failures and reduces the risk of unexpected downtime.



High Performance

Ensures optimal operating conditions to maximize peak performance.



Extended Lifespan

Reduce thermal stress on critical parts, maximizing product's longevity.

Thermally Conductive Solutions

Makrolon® TC



Conductive TC

- High thermal conductivity
- High Vicat
- High emissivity
- Use Cases : Heat-sinks, metal replacement

Insulating TC (New products available)

- Moderate thermal conductivity
- Easy to process
- Good colorability (incl. **high-quality white**)
- Good impact resistance and flame retardancy
- Use cases: device housing, enclosure, etc.,

Sustainable Offerings

- PCR (Post-Consumer Recycled):
Waste management and low carbon emission
- RE (Bio-circular attributed):
Drop-in solution with identical properties as fossil-based materials, while achieving significantly reduced carbon emission

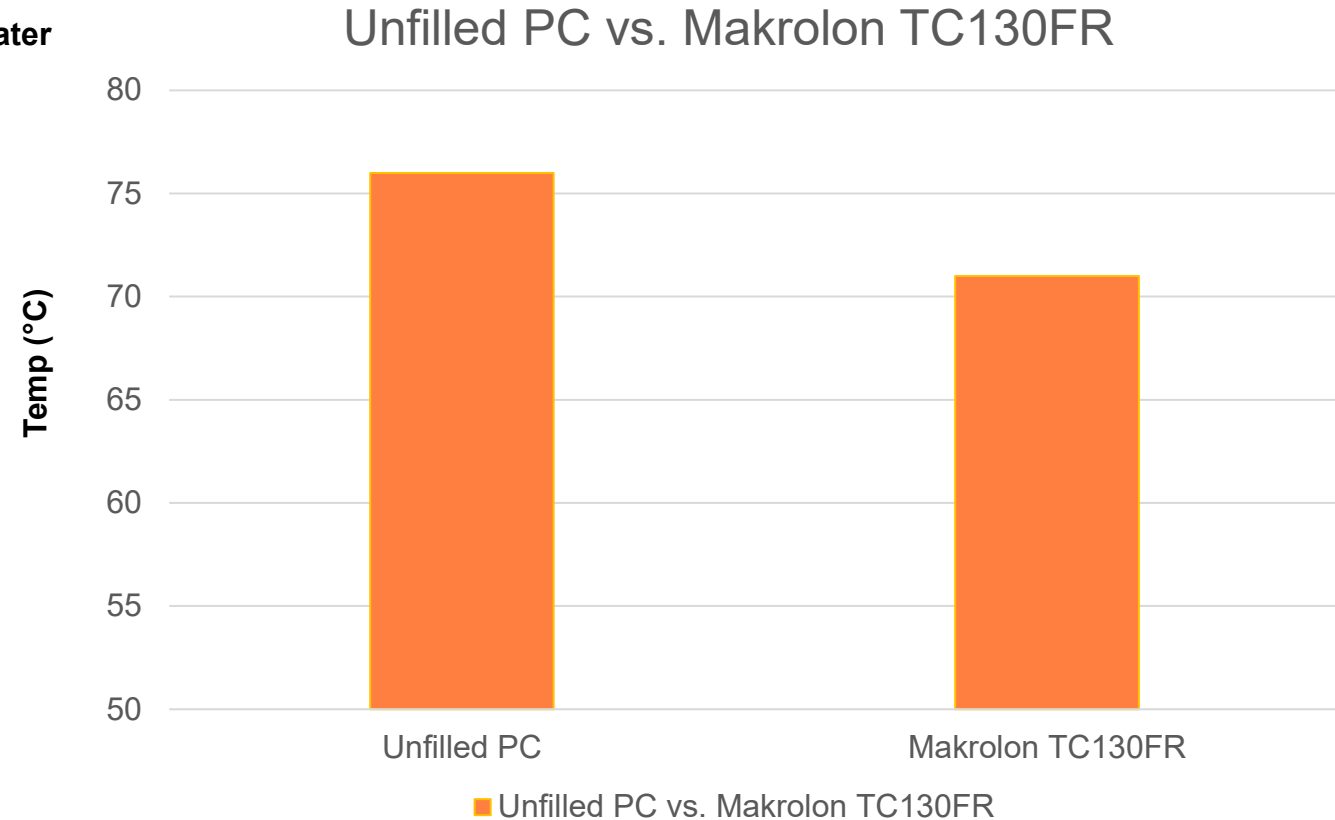
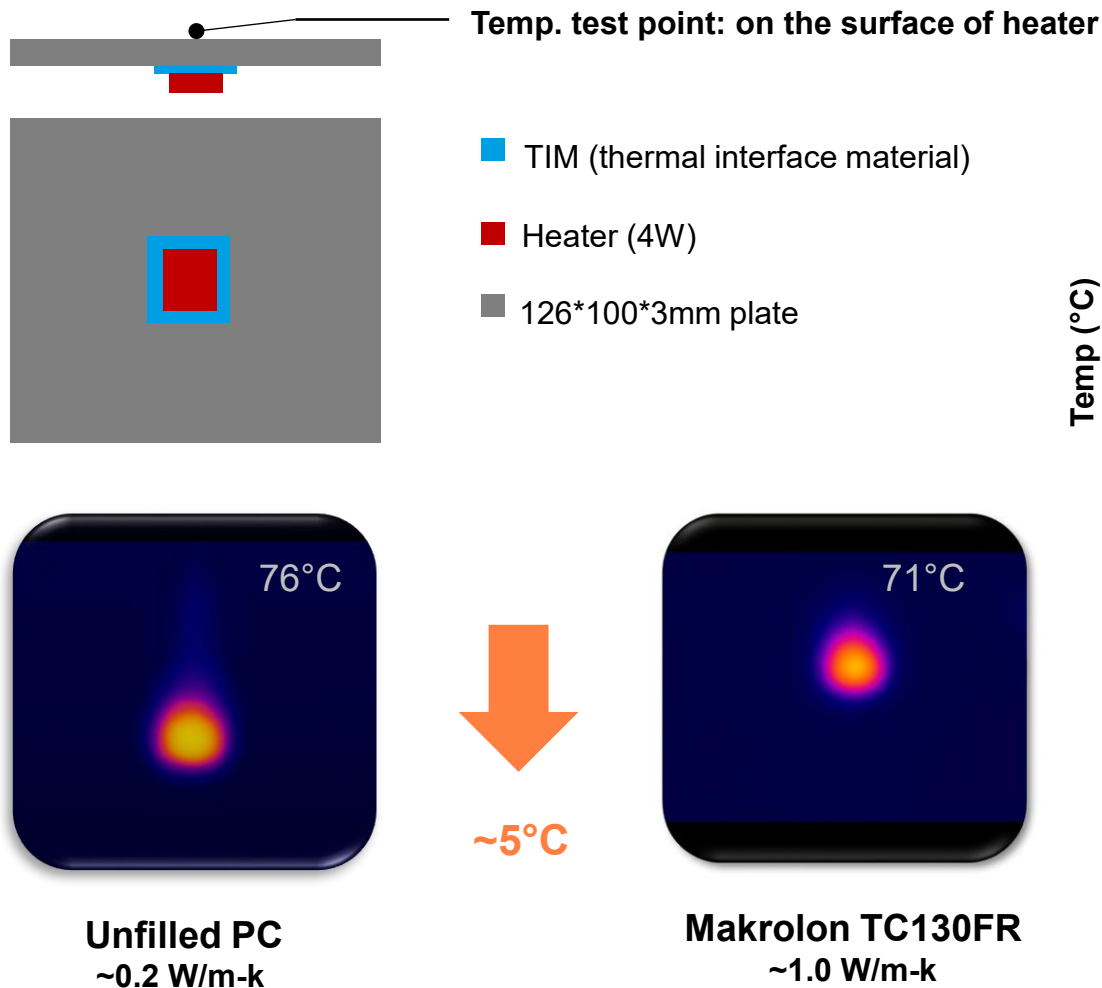
Covestro Thermally Conductive Portfolio



Property	Standard/ Condition/ Unit					New!	New!	New!
		Makrolon® TC621	Makrolon® TC210 FR	Makrolon® TC110	Makrolon® TC120 FR	Makrolon® TP5241 (50%PCR)	Makrolon® TC130FR	Makrolon® TC132FR
Thermal conductivity	ASTM E 1461-01 23 °C [W/(m·K)]	16	1.4	1.0	0.9	0.9	0.9	0.6
		1.4	0.3	0.3	0.3		0.3	0.2
Melt Viscosity	ISO 11443-A 300 °C Pa·s	180	120	170	150		240	240
Charpy impact strength	ISO 179-1eU 23 °C [kJ/m²]	<10	30	70	90	130	113	NB*
Vicat softening temperature	ISO 306 50 N; 50 °C/h [°C]	128	115	145	145	124	123	125
UL 94 rating	Class @ mm	V-0 @ 2 V-0 @ 3	V-0 @ 2	HB	V-0 @ 2	V-0/1.5mm (Covestro)	V-0 /1.5mm (UL YC)	V-0/1.5mm (UL YC)
Glow wire flammability index	IEC 606695-2-12 @ 1.5 mm [°C]	960	930	875	930		960	960
Density	ISO 1183 - [kg/m³]	1400	1514	1450	1430	1400	1400	1360
Whiteness	L*	Black	82	<90	83.6	91.1	93.3	92.4

*NB=No Break

Covestro Makrolon® TC Offers Differentiated Values vs. unfilled polycarbonates



**Enhanced thermal performance without
compromising mechanical strength and flame
retardancy.**

Covestro Makrolon® TC Offers Differentiated Values vs. other thermal conductive plastics (e.g., PA, PBT)



Which Heat-Fighting Plastic Holds Its Ground?

Comparing Thermal Conductive Plastics for Everyday Use

PC – POLYCARBONATE	PA – NYLON	PBT
BEST BALANCE Stays flat, heat flows perfectly.	PROBLEM Absorbs moisture, swells, and disrupts heat flow.	CAUTION Good, but can warp under heat.
Heat flow Moisture absorption		



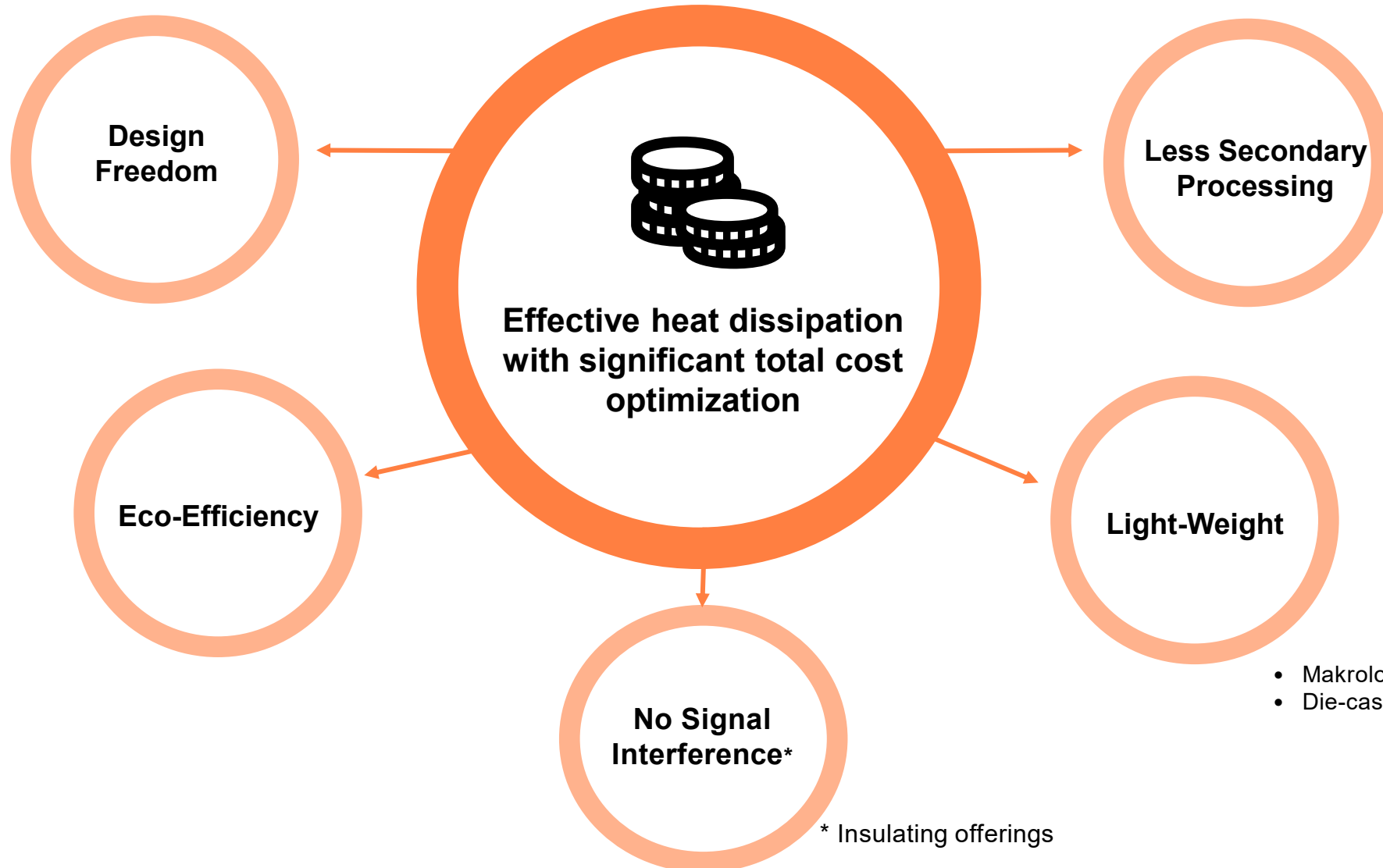
PC offers the best combination of dimensional stability and thermal conductivity.

Makrolon® TC provides advantages...

- High dimensional accuracy and low distortion tendency
- Good impact resistance
- Good surface appearance and colorability (Electro-insulating series)

Covestro Makrolon® TC Offers Differentiated Values

vs. Die-cast aluminum



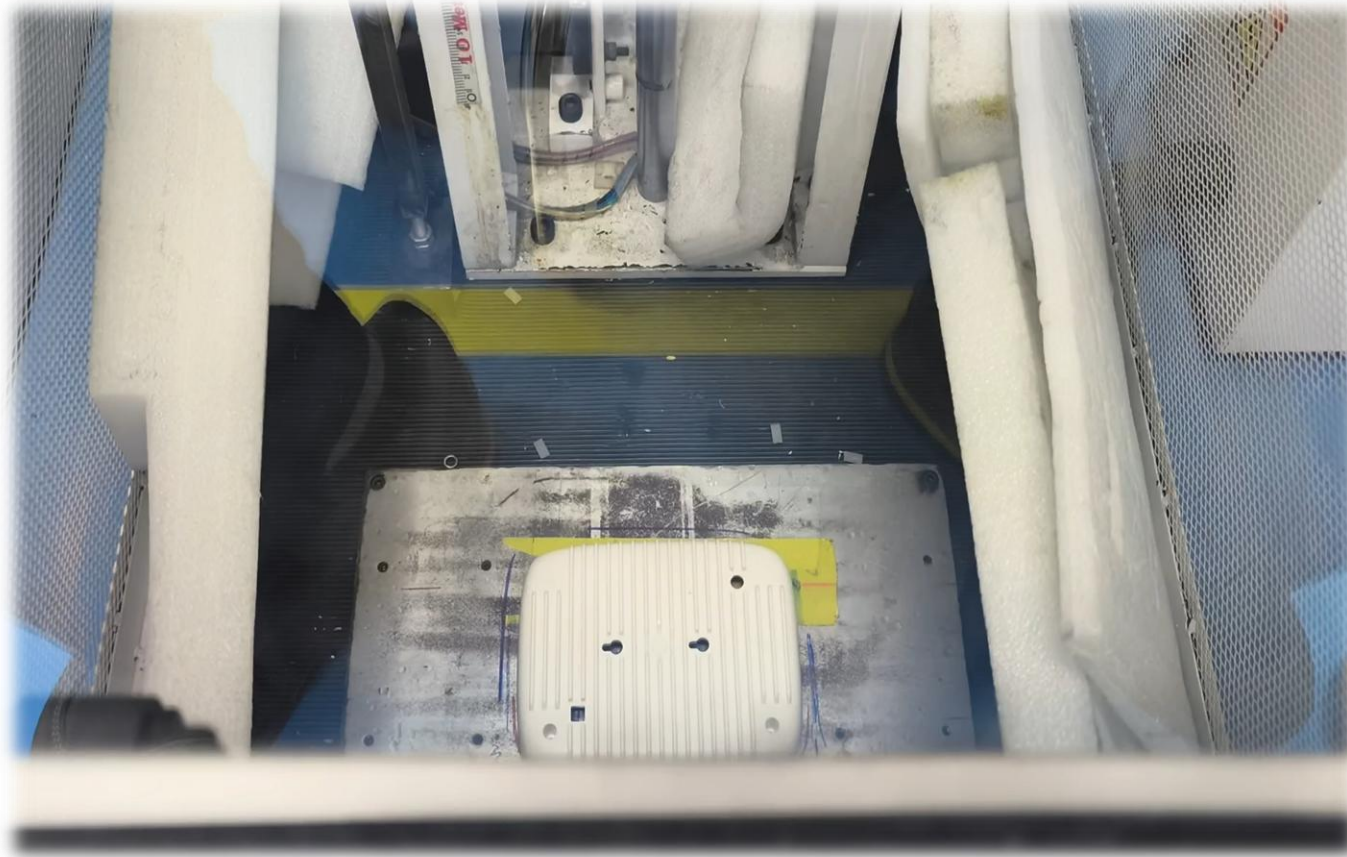
- Makrolon® TC ~1400 kg/m³
- Die-cast AL ~2700 kg/m³

Efficient Cooling Meets Premium Aesthetics



Makrolon® TC offers a wide range of colors for electrically insulating grades including bright white colors

Efficient Cooling Meets Premium Aesthetics



Ball Drop Test
Ball weight: 1.0kg
Drop height: 1.5 meters

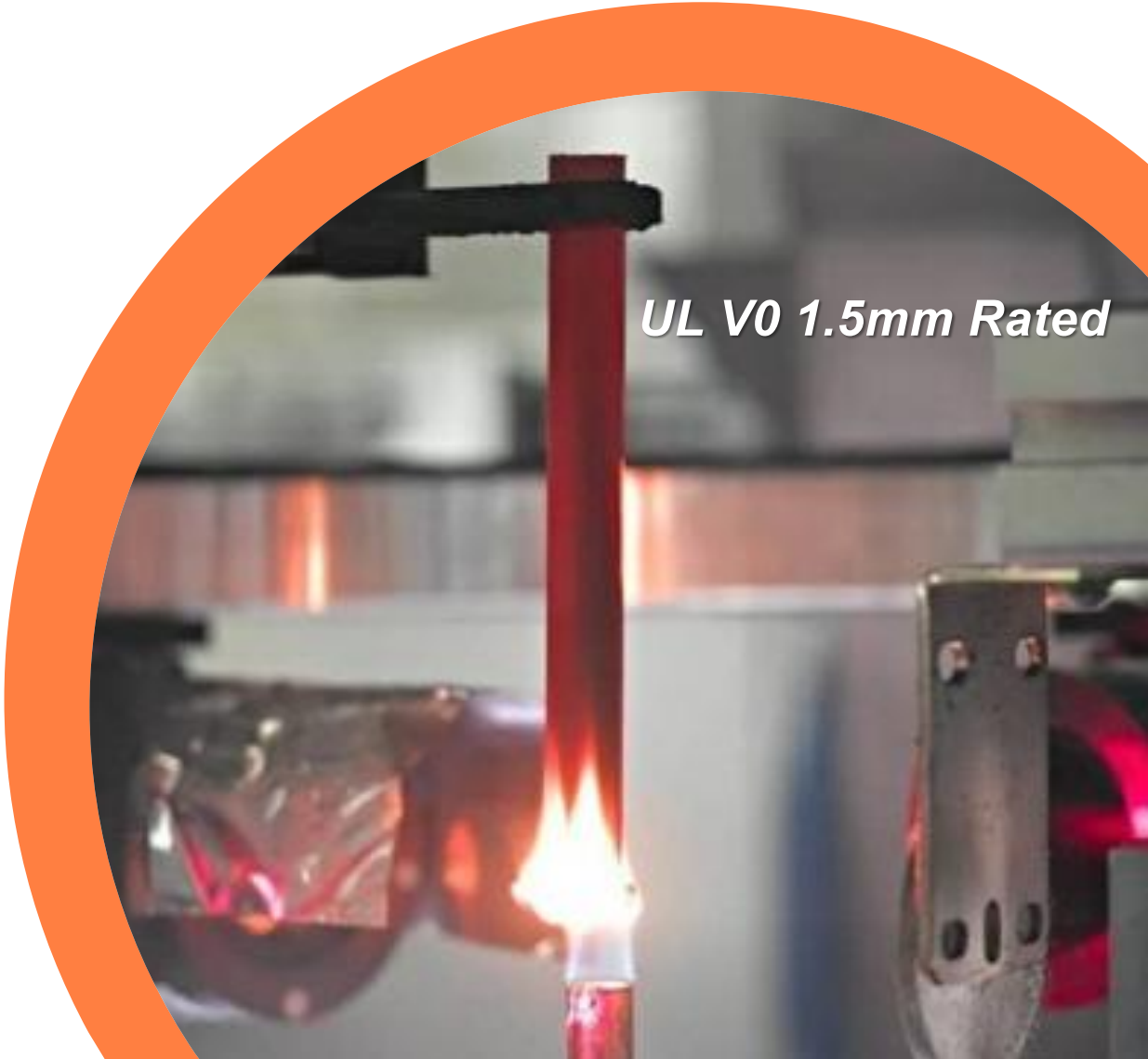
Makrolon® TC offers good impact resistance for enclosures by protecting internal components and ensuring product durability

Efficient Cooling Meets High Safety Standard



**Makrolon® TC offers
flame retardancy to
meet the safety needs
of advanced
connectivity**

UL V0 1.5mm Rated

A circular inset image showing a red Makrolon TC rod being tested in a flame. The rod is held vertically by a black clamp. A bright yellow and orange flame is at the bottom of the rod. The background is a blurred industrial setting with metallic components.

Efficient Cooling Meets Eco-Efficiency



Makrolon® TC offers environmental advantage over aluminum

- up to 60% less resources used in production vs Aluminum solution
- up to 75% less energy consumed when recycled
- up to 50% PCR offering available

- based on independent study by ENEREF(1)

⁽¹⁾ source: *Eneref Institute (British Plastics & Rubber Magazine — UK – Eneref Institute)– study: “employing polycarbonate components to design sustainable luminaires”*

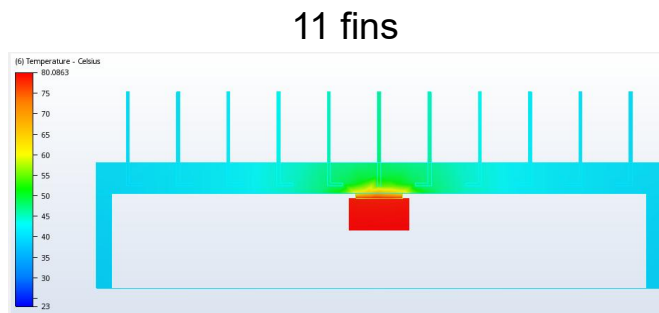
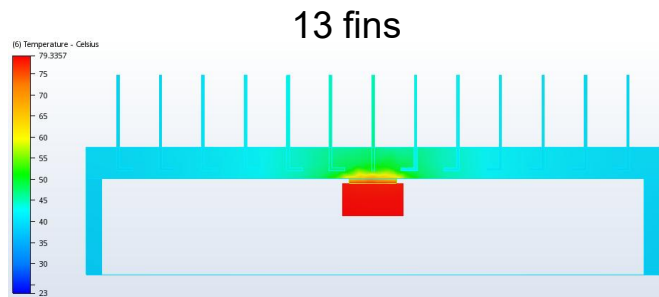
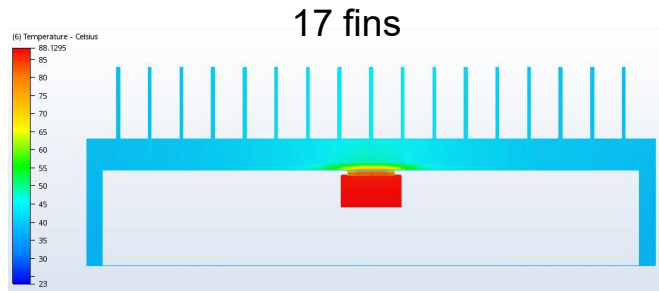
Video: <https://www.youtube.com/watch?v=MU8v2rrxp6k>





Value-added Technical Support Beyond Just Supplying Material

Value-added Technical Support



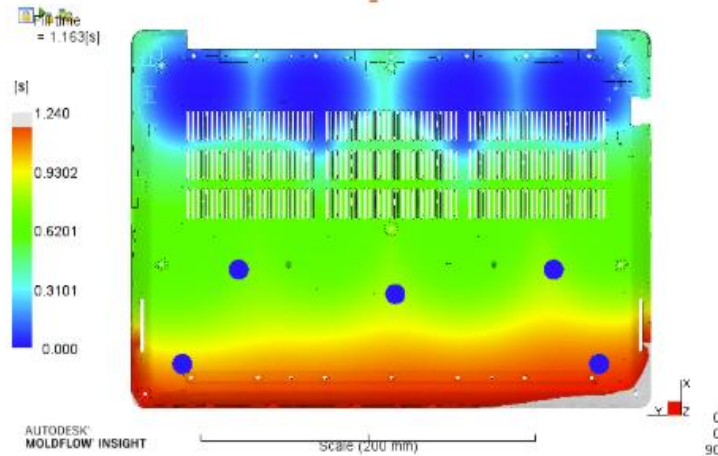
- Optimized part design improves manufacturability and thermal performance while reducing redesign and rework costs
- Optimize heat conduction from the source to efficiently dissipate heat through the part
- Use simulation to optimize thermal performance (e.g., fin count and geometry)

Part design guidance to achieve efficient heat dissipation performance

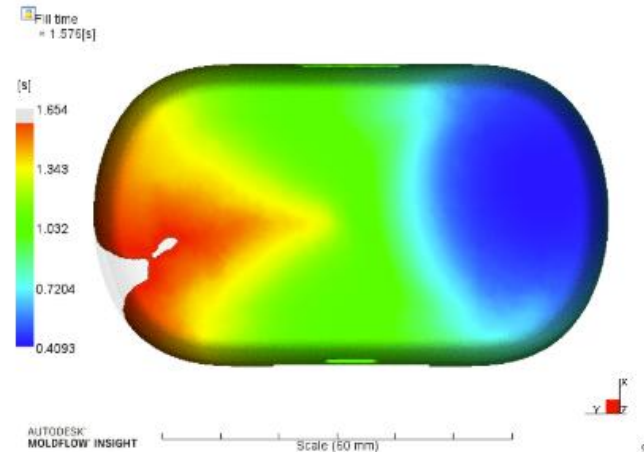
Value-added Technical Support



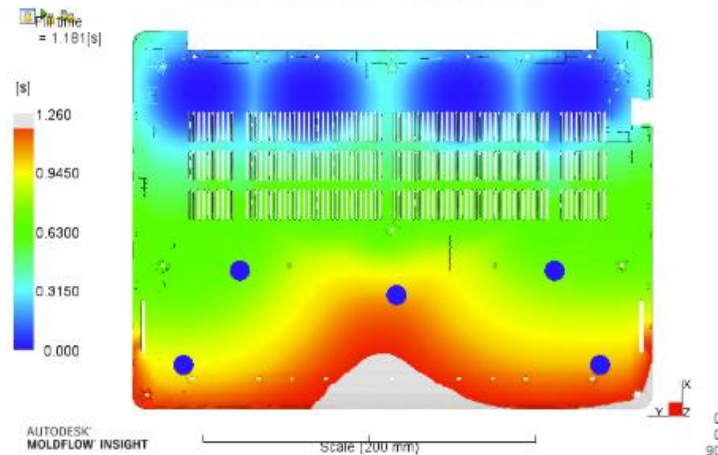
Concept A - Initial



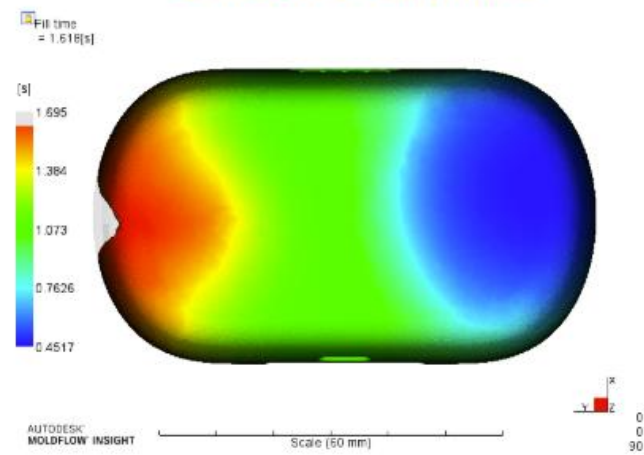
Concept A – Initial



Concept B - Optimize



Concept B - Optimize

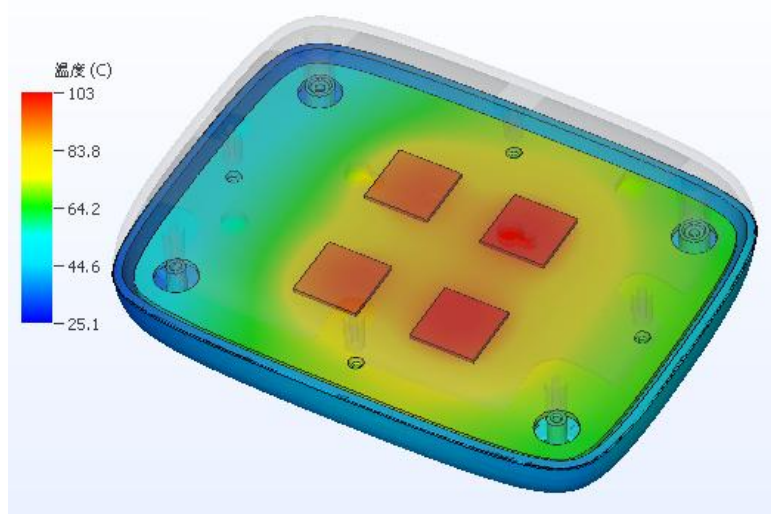


Mold Filling Simulation and Design Guidance enables

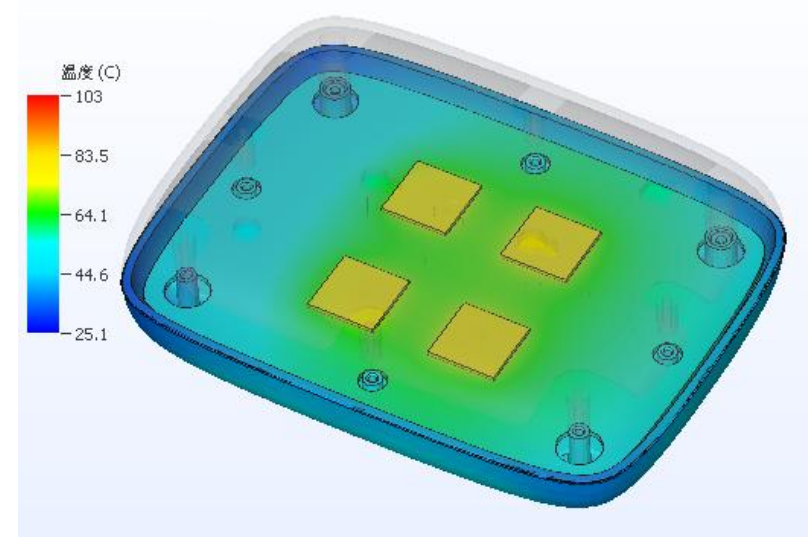
- Optimize Part and Mold Design
- Lower Tooling Costs
- Improve Product Quality and Performance
- Reduce Material Waste and Scrap
- Energy and Resource Efficiency

Value-added Technical Support

In-house thermal simulation capabilities



No cooling design
Material: non-TC PC/ABS



Covestro TC solution
Material: high TC + outer layer: Insulating TC with good toughness

In-house thermal simulation empowers customers to accelerate design validation, reduce costly iterations, and ensure optimal thermal performance before production.

Value-added Technical Support

External Heat Sink Screener to predict design optimization

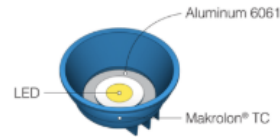


Simulation Information

Design Space

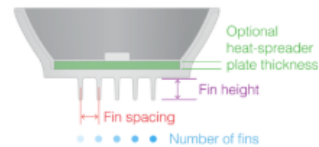
This Heatsink Screener uses two simulation models to predict LED temperatures:

1. The Makrolon® TC polycarbonate heatsink model uses a dataset based on the Design Space indicated below.
2. The die-cast aluminum heatsink model uses the same Design Space, but without the aluminum heat-spreader plate.

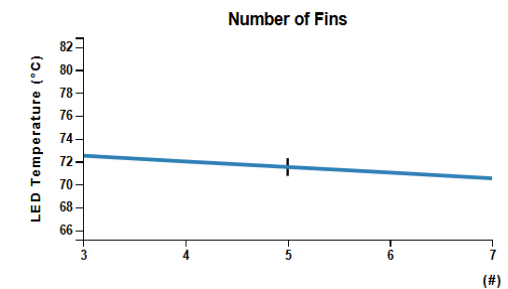
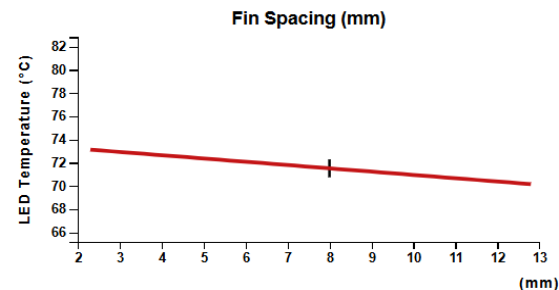
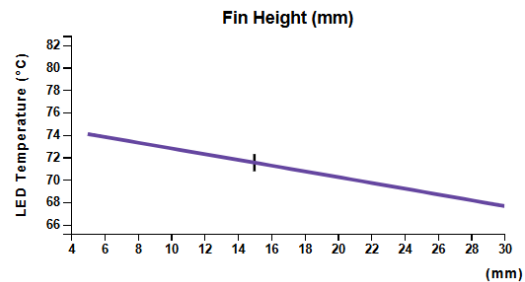
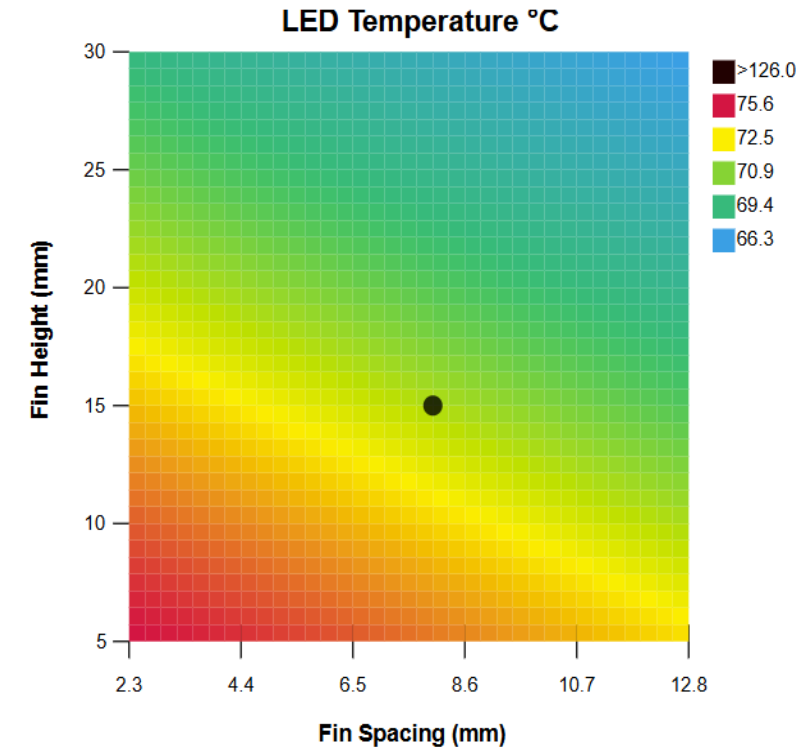


Input Parameters

Thermal conductivity:	0.5 to 22.5 W/mK
Input power level:	5 to 18 Watts
Number of fins:	3 to 7 fins
Fin height:	5 to 30 mm
Fin spacing:	2.3 to 12.8 mm
Optional heat-spreader thickness:	0 to 3.3 mm
Ambient air temperature:	0 to 90 °C
Heatsink diameter:	63.5 mm(fixed)
Heatsink nominal wall thickness:	3.2 mm(fixed)



Additional Information ⓘ





Case Study 1

Wi-Fi Router Demonstrator

Thermal Performance Comparison



Background

- Increasing router performance drives higher power consumption and heat generation, making thermal management a critical challenge for next-generation connectivity.
- Passive cooling (no fans) is widely used to reduce noise and cost, and both enclosure material and design strongly influence heat dissipation effectiveness

Test Method

- Demo size: 160 mm × 120 mm × 20 mm
- Approach: Used same test set-up and heating power for each iteration
- Test setup: Temperature sensors attached to collect real-time data
- Data collection: Real-time temperature monitoring with professional instrument

Key Objectives

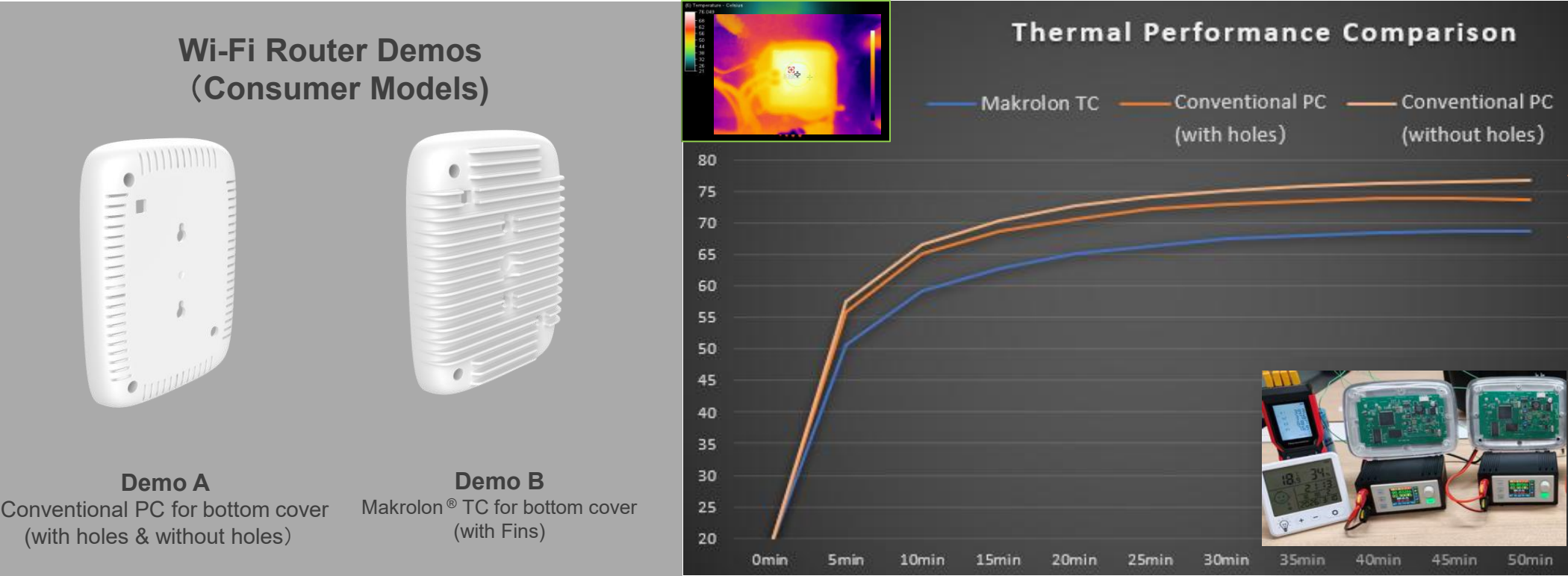
- Compare thermal performance to different materials and product design.
- Showcase Makrolon® TC performance, while offering combined values incl. total cost optimization, design freedom and eco-efficiency.





Wi-Fi Router Demo With Different Materials and Designs

Thermal Performance Comparison



~5°C

~8°C

Covestro Makrolon® TC significantly improves thermal performance by 5-8°C compared to conventional PC, while maintaining good mechanical and flame-retardant properties

Remark:
1) Heat source need in direct contact with TC enclosure
2) Working power <=20W

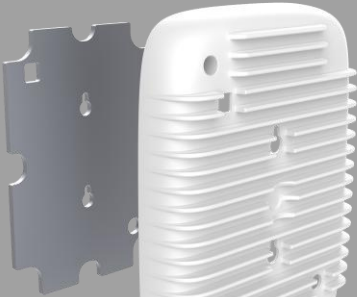
Wi-Fi Router Demo With Different Materials and Designs

Thermal Performance Comparison

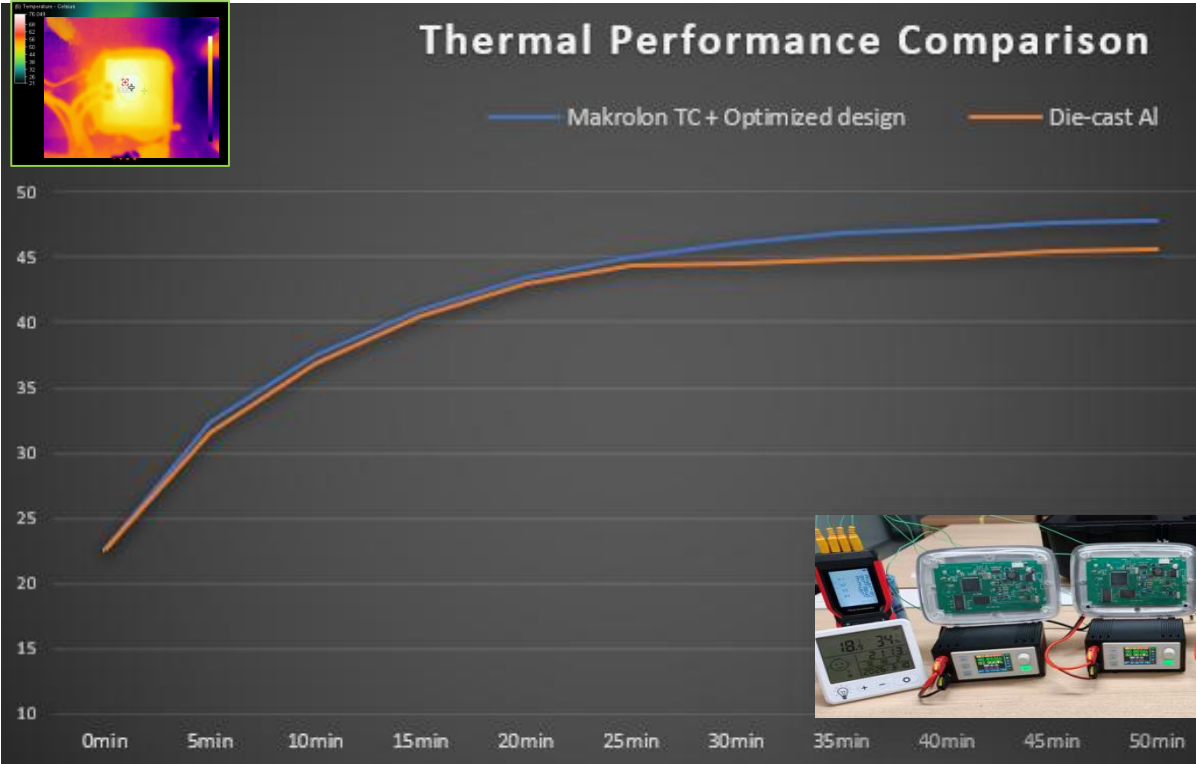
Wi-Fi Router Demos (Enterprise Models)



Demo C:
Conventional Die-cast Al
for bottom cover



Demo D:
Makrolon TC for bottom cover
(with Fins & Stamped Al plate inside)



~2°C

Covestro Makrolon TC achieves efficient thermal management performance comparable to die-cast Al, while optimizing total cost and enabling design freedom

Remark:
1) heat source need in direct contact with stamped AL plate
2) Working power <=30W

Covestro Makrolon® TC

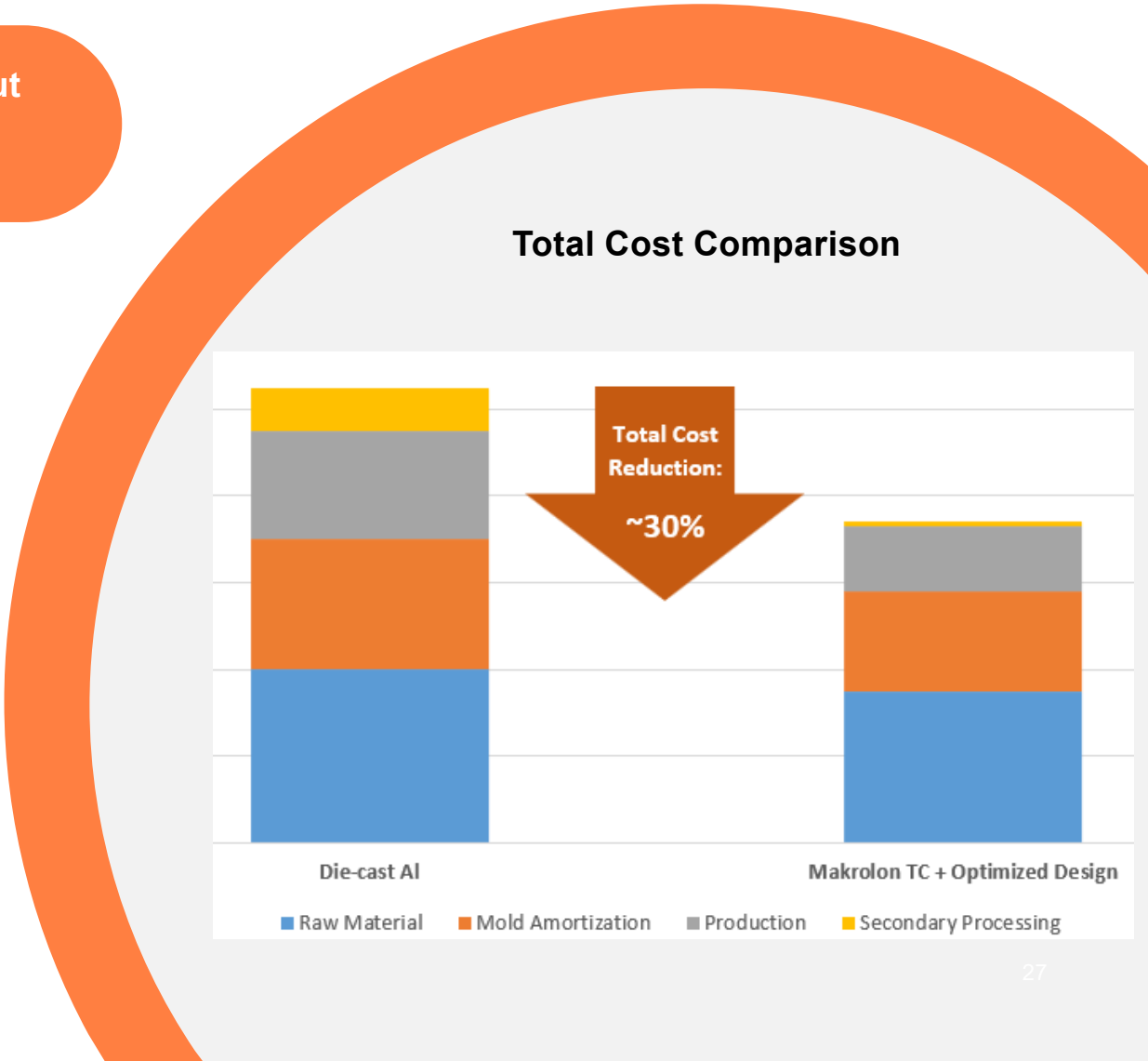
Total Cost-Efficient Solution for Thermal Management vs. Die-cast Aluminum



Covestro Makrolon® TC provides a total cost-efficient solution without compromising thermal performance, enabling customers to achieve better economics and faster time-to-market.

Total Cost Analysis

- **Raw Material**
~50% lower density than Aluminum, less material consumptions
- **Mold Amortization**
Lower tooling complexity and longer lifetime
- **Production**
Highly efficient manufacturing of Injection Molding especially for high volumes products
- **Secondary Processing**
Less secondary processing (non-painting, no need deburring, etc.,)





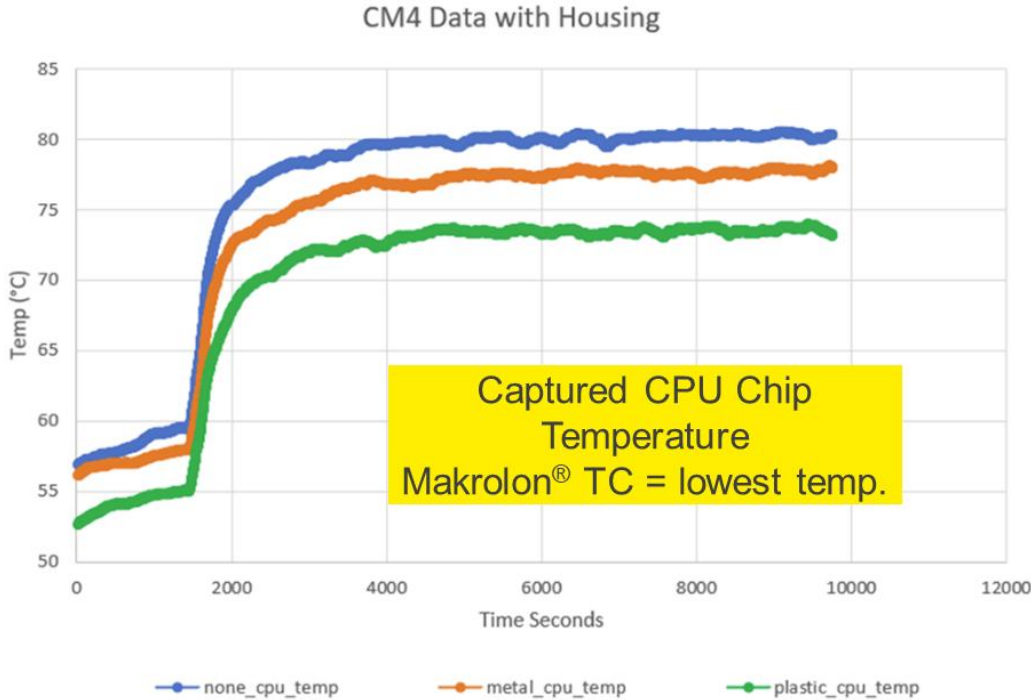
Case Study 2

Overmolding onto Circuit Boards

Thermal Performance

Set-up:

- Mimic electronic enclosure with limited air flow
- PCB chip temperature comparison with different approaches to heat management



• No Heat Sink



• Makrolon TC210



• Aluminum + TIM





Covestro Makrolon® TC

Efficient Heat Dissipation

Comparable performance with aluminum with optimized design (at certain power)

Significant Total Cost Optimization

Higher production efficiency and less costly 2nd processing

Good Impact Resistance and Flame Retardancy

Reliable performance, meeting high safety standard

Design Freedom

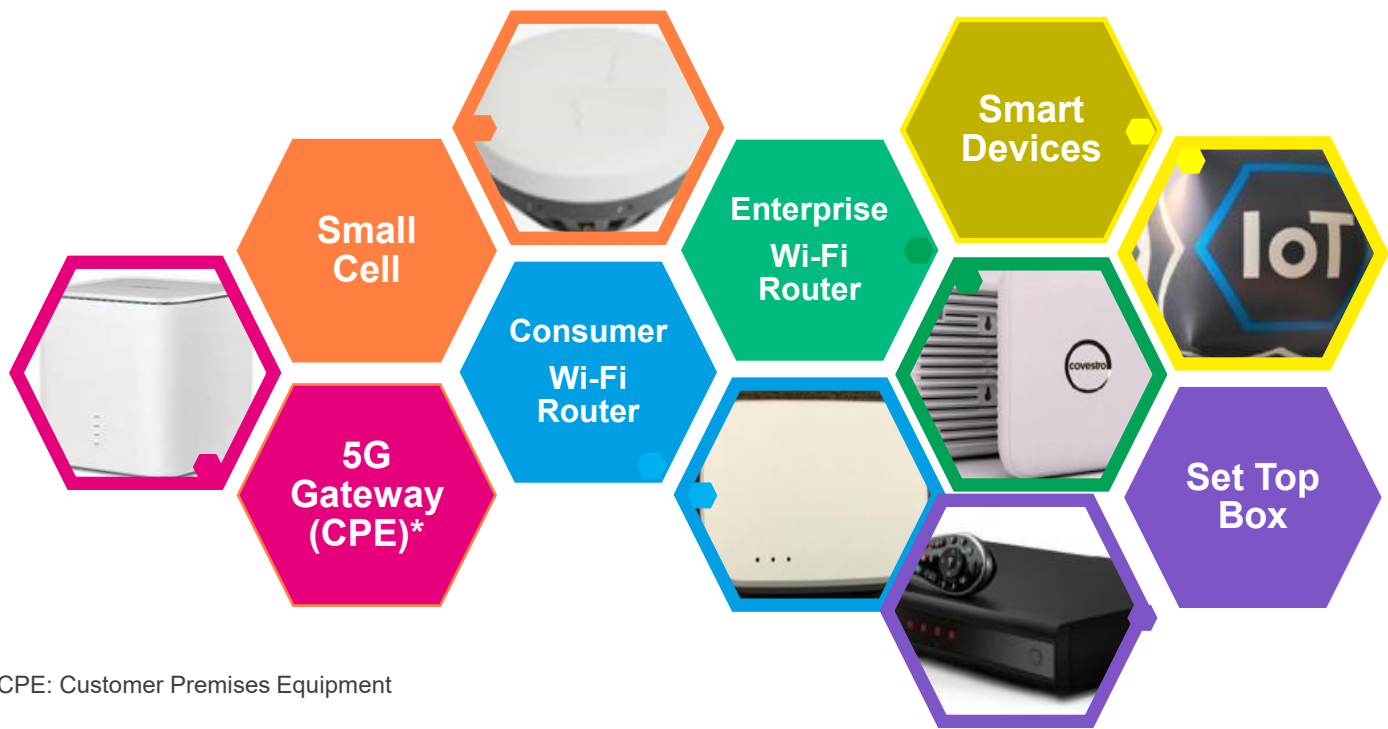
Achieve complex structure and function Integration design

Refined Aesthetics

Good colorability including high quality white

Value-Added Beyond Material

Technical expertise incl. part & mold design guidance and thermal simulation capabilities



*CPE: Customer Premises Equipment

Innovative thermally conductive solutions for next-gen Wi-Fi devices and beyond!



Thank You !

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