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Thin Bondlines: The Challenge in Thermal Management of Batteries and Power Electronics

Dispensable Gap Fillers for Thermal Interface

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Power Electronics & Energy Storage Event

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Reinventing Cooling with the Next Generation of Thermal Interfaces

Power density keeps rising. Are your solutions keeping up?

Discover how latest dispensable thermal interfaces help control Thermal Management in Power Converters

The next-generation materials offer greater design flexibility, higher voltage isolation and improved thermal performance for today's compact power electronics.

Whether you're designing for energy storage or energy conversion, this session will explore how the latest thermal interface technologies align with current industry demands and manufacturing efficiency.

- **Stay ahead — transform your Power Electronics & Energy Storage strategy**

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Content

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- Market trend & target applications
- Inverter use case
- Pads vs. dispensable gap fillers
- Material classes & selection criteria
- Processing & implementation tips
- Reliability & validation
- Q&A

Market Trend: Thermal Management in Power Electronics

Electrification

Traction inverters
On board chargers
DC/DC converters

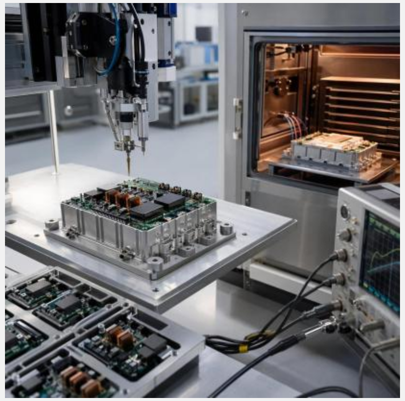
Energy storage

BMS
Power conversion
Inverter/PCS

Industrial drives

Drives & Automation
Higher efficiency
Compact enclosures

Design drivers



Higher Power density
Reliability
Automated assembly

Target Application: Automotive Inverter (example)

- Where it sits: thermal interface between power components and cooling structure
- Why gap fillers: bridges uneven surfaces and tolerances over 0.15–2 mm bondline range
- Key requirements: low thermal resistance, electrical insulation, long-term stability

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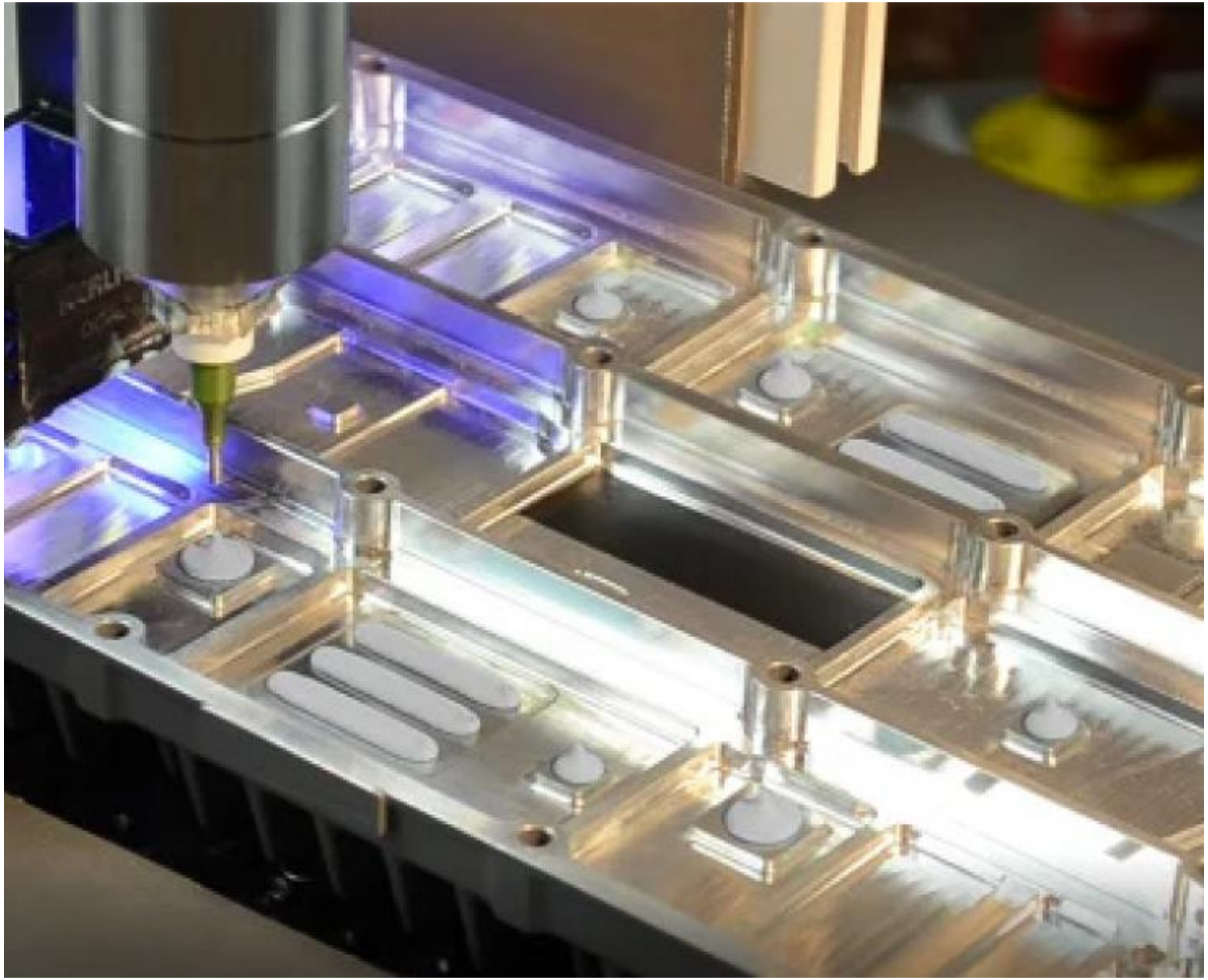
Thermal Interface Dispensable Platform



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Next Generation of Dispensable Thermal Interfaces

- Power density keeps rising → less thermal margin in power converters
- Tolerance stack-up and complex geometries make pre-cut pads expensive and hard to place
- Dispensable gap fillers enable automated, repeatable dosing and thickness tuning
- Cure-in-place materials improve robustness in vibration and thermal cycling

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Pain Points → What a Dispensable Gap Filler solves

Pain points (pads / manual placement)

- Capacity limits: manual or semi-automated placement
- Scrap & cost for complex shapes
- Adhesive / PSA reliability and cleanliness
- Many part numbers and thickness variants

Dispensable gap filler benefits

- Automated dispensing in one stage
- Programmable dosing and thickness tuning
- Cure-in-place improves adhesion and robustness
- Simplified supply chain (fewer SKUs)

Die-cut Pads vs. Dispensable Gap Fillers

Die-cut pads (pre-formed)

- Second-stage placement step
- Fixed thickness options
- Pick & place complexity for small parts
- Potential particles from cutting, tackyness / adhesive handling

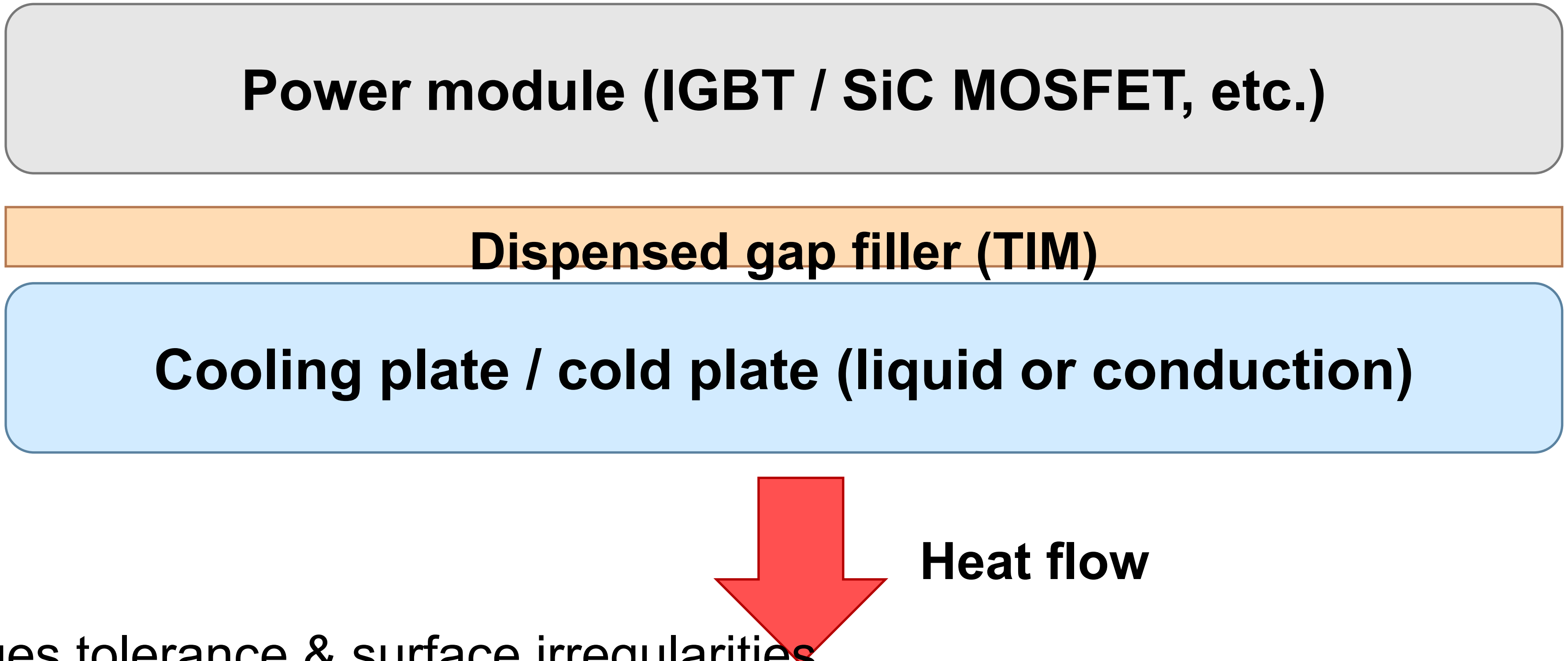
Dispensable (cure in place)

- One integrated dispensing step
- Geometry freedom (paths, dots, custom patterns)
- Thickness & volume optimized by program
- Clean process and consistent coverage

Die-cut pads vs. dispensing (at a glance)

Aspect	Die-cut pads	Dispensable (cure-in-place)
Assembly	Manual / pick & place	Automated dispensing
Processteps	Cut + place	Dispense + cure
Geometry	Fixed shape & thickness	Programmable pattern & thickness
Materialuse	Scrap possible	Dose only what you need
Tolerances	Limited	Compensates stack-up
Bonding/cleanliness	adhesive handling risk	Cures on substrate
Throughput	Handling bottleneck	High-volume capable
TCO	Higher (labor + scrap)	Lower (process + repeatability)

Where the gap filler sits in an automotive inverter (schematic)



- Bridges tolerance & surface irregularities
- Lowers interface thermal resistance by removing air gaps
- **Can combine thermal transfer + electrical insulation**
- Compatible with automated high-volume assembly

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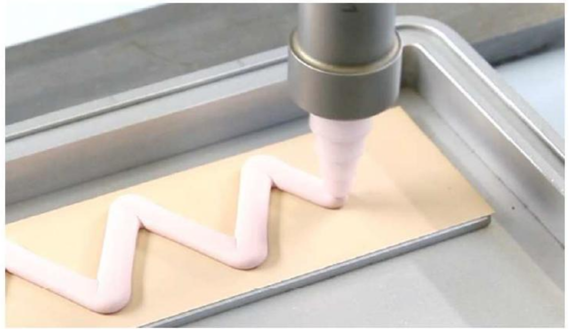
Dispensable Gap Filler: Key Features & Value

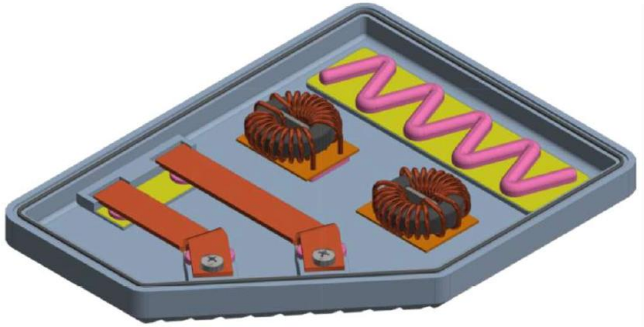
Key features

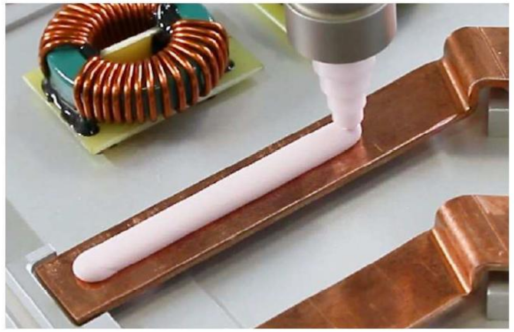
- Standard dispensing technology
- Self-levelling / compliant
- **Cure-in-place (2K) or fully cured (1K) options**
- Supports automated, high-volume production

Value proposition

- Lower Total Cost of Ownership (TCO)
- Higher throughput and fewer handling steps
- Design flexibility and material usage tuning
- **Improved reliability under vibration and thermal cycling**







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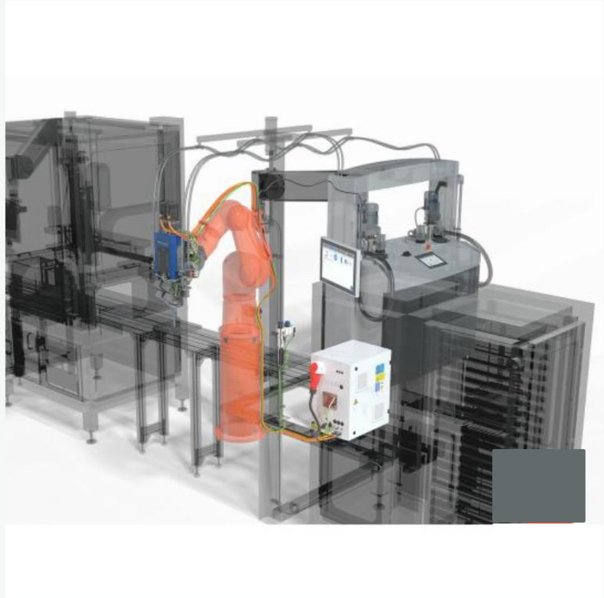
Processing solutions (dispensing equipment)



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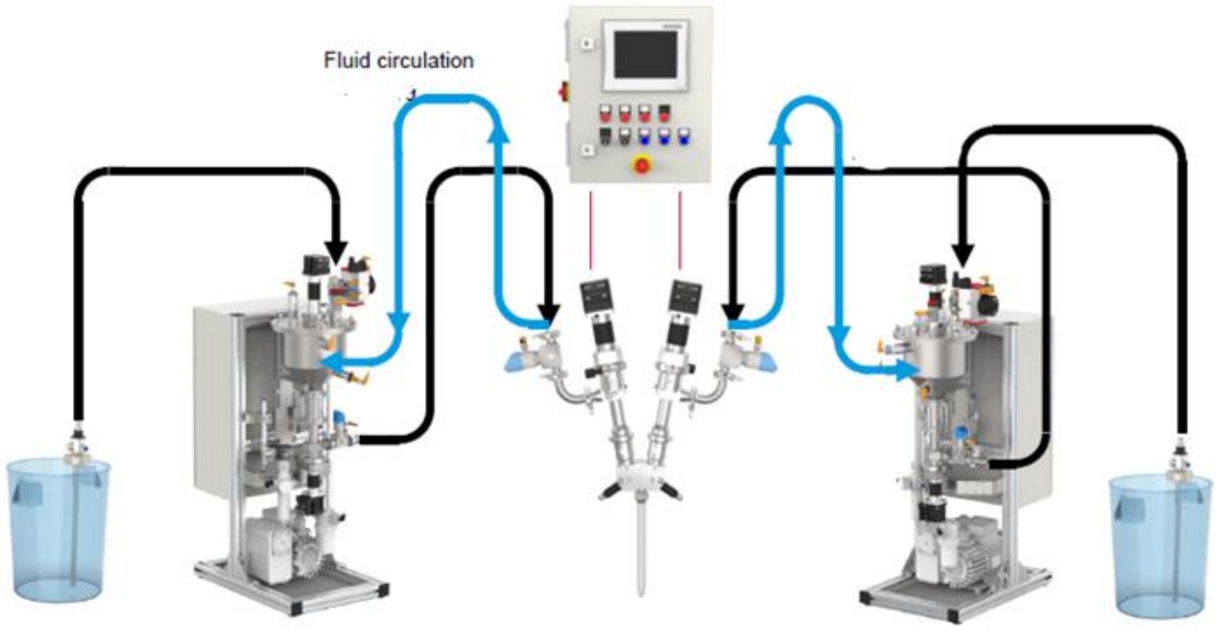
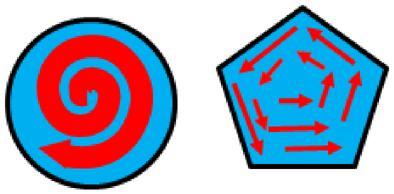
Process insights (manufacturing approach)

Process insights

- Condition: homogenize + degas
- 2K: mix ratio control + mixer selection
- Dispense & cure on flat reference to hit target thickness
- QC: bondline thickness + void check





Video

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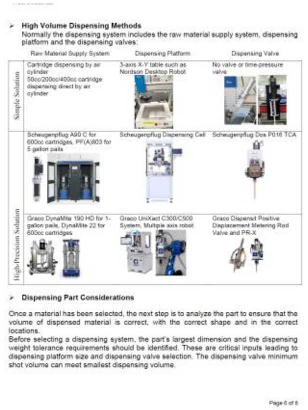
Application Notes



➢ **High Volume Dispensing Methods**
Normally the dispensing system includes the raw material supply system, dispensing platform and the dispensing valves:

	Raw Material Supply System	Dispensing Platform	Dispensing Valve
Simple Solution	Cartridge dispensing by air cylinder 50cc/200cc/400cc cartridge dispensing direct by air cylinder	3-axis X-Y table such as Nordson Desktop Robot	No valve or time-pressure valve
High-Precision Solution	Scheugenpflug A90 C for 600cc cartridges, PF(A)803 for 5 gallon pails	Scheugenpflug Dispensing Cell	Scheugenpflug Dos P018 TCA
	Graco DynaMite 190 HD for 1-gallon pails, DynaMite 22 for 600cc cartridges	Graco UniXact C300/C500 System, Multiple axis robot	Graco Dispensit Positive Displacement Metering Rod Valve and PR-X

➢ **Dispensing Part Considerations**

Once a material has been selected, the next step is to analyze the part to ensure that the volume of dispensed material is correct, with the correct shape and in the correct locations.
Before selecting a dispensing system, the part's largest dimension and the dispensing weight tolerance requirements should be identified. These are critical inputs leading to dispensing platform size and dispensing valve selection. The dispensing valve minimum shot volume can meet smallest dispensing volume.

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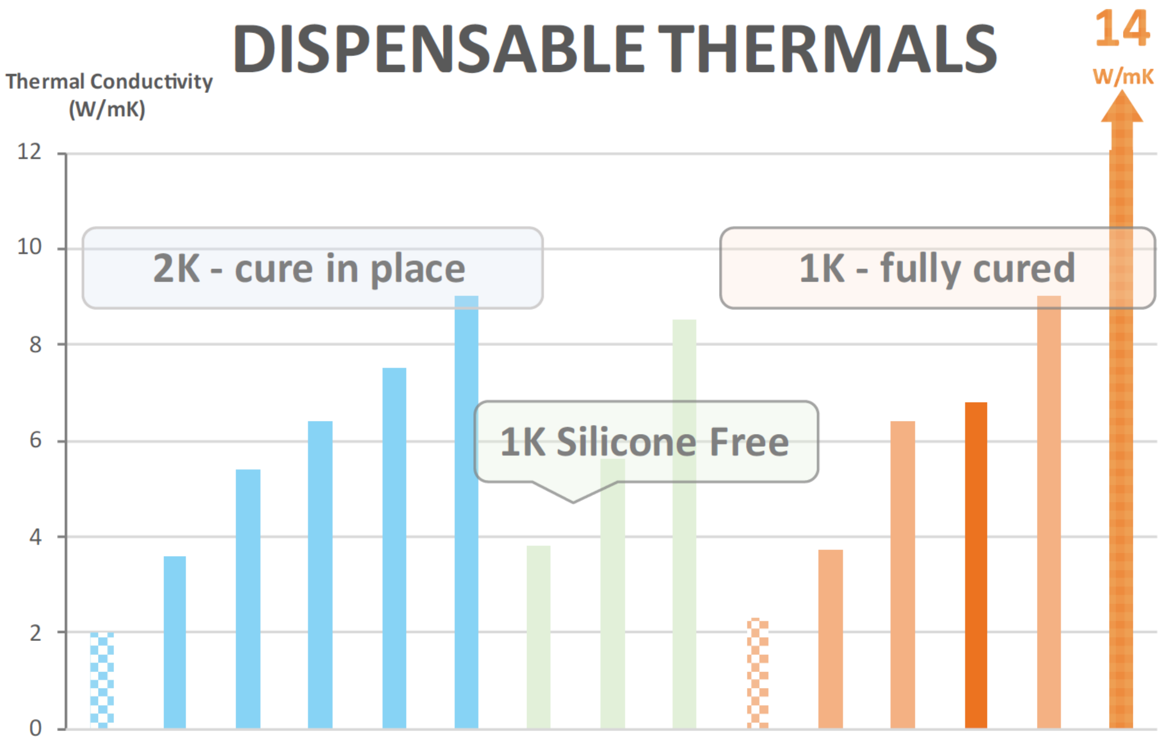
Material landscape

- Gap fillers: 1K fully cured, 2K cure-in-place
- Options: silicone-free / low outgassing / high dielectric
- Choose by requirements: gap range, thermal target, insulation, process & rework



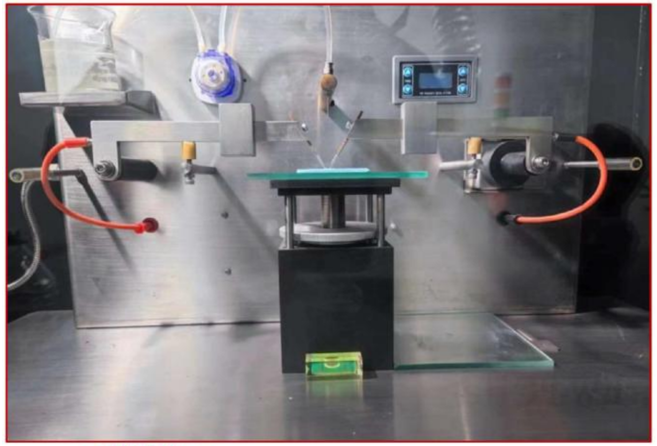
Selection criteria (what to specify)

- Gap range & target bondline thickness
- System-level thermal resistance target
- Electrical insulation need (dielectric / CTI)
- Mechanical limits (max compression force)
- Environment: cycling, humidity, vibration, fluids
- Manufacturing: pot life, cure strategy, inspection

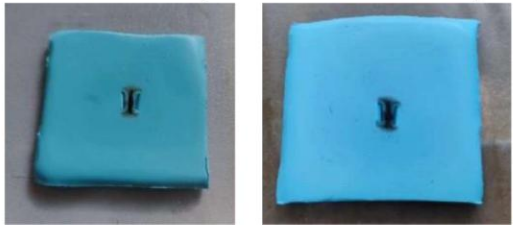
- CTI (Comparative Tracking Index) ~IEC 60112
  - Tflex CR550 (thickness: >3mm) sample preparation:
    - Conditioning 24 hrs, 23,2°C, 52% R.H.
    - Electrodes and dropper system cleaned between tests with wet wipes
    - Testing completed in closed chambre, no perceptible air flow

RESULTS

Material Name	Test Voltages(V)	Number of drops to track	Conclusion
Tflex CR550	600	50(6)	PASS
	575	100(6)	PASS
Solution A: 0.1% by mass of analytical reagent grade NH_4Cl, Resistivity of 395Ωcm at 23C°			
(1) Flamed (2) Melted (3) Eroded	(4) Melted and Eroded (5) Flamed, Melted and Eroded (6) insufficient tracking-test terminated at indicated value		



Process-50drops Process-100drops



Curing strategies (practical choices)

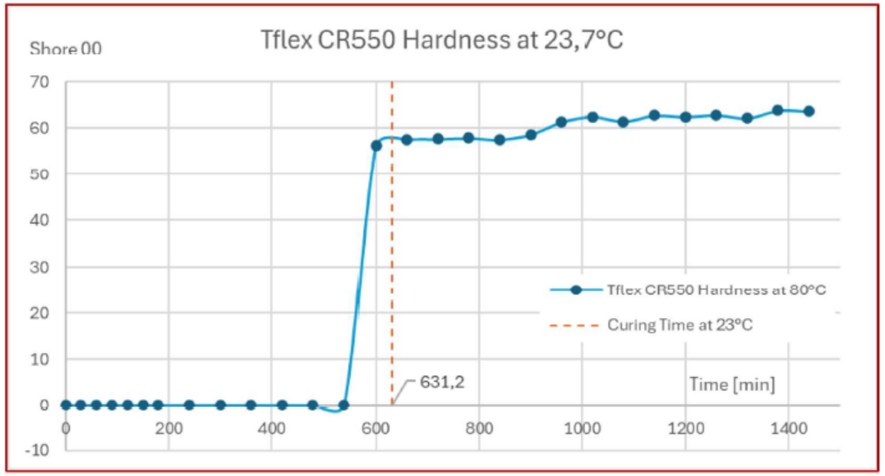
Room-temperature cure

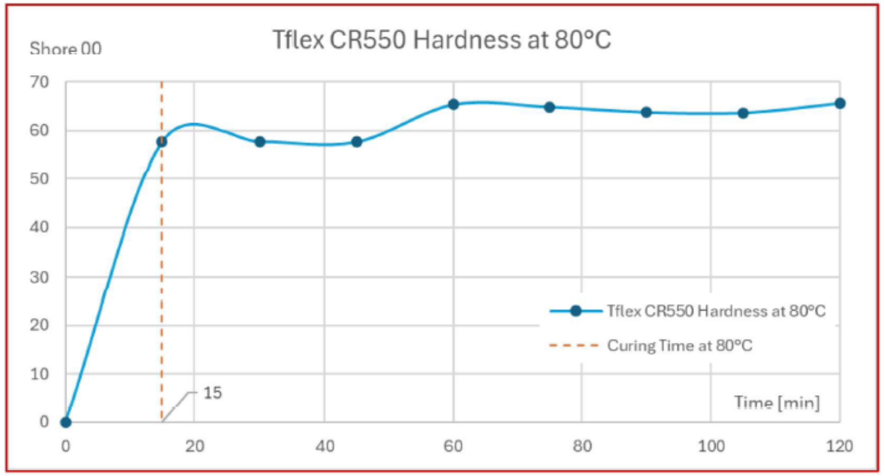
- Simple equipment
- Longer WIP / takt impact
- Fixture to keep flatness

Elevated-temperature cure

- Faster throughput
- Oven/heat + fixture needed
- Watch thermal stress

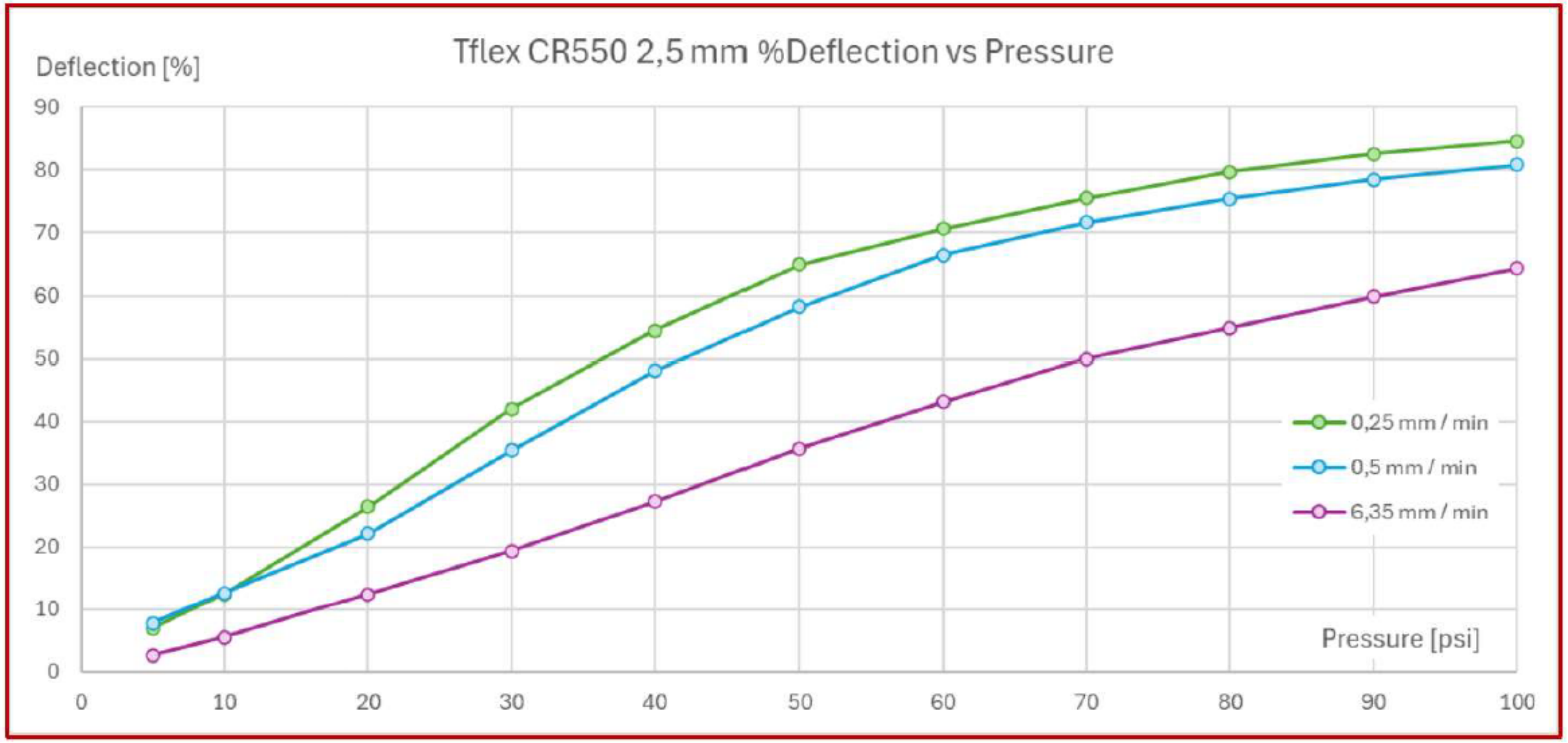
Control variables: mix ratio (2K), time-to-dispense, thickness, orientation.





Mechanical compliance (why softness matters)

- Lower compression force on components
- Better contact → lower interface resistance
- Reduces risk of cracking / warpage
- Helps under vibration & thermal cycling



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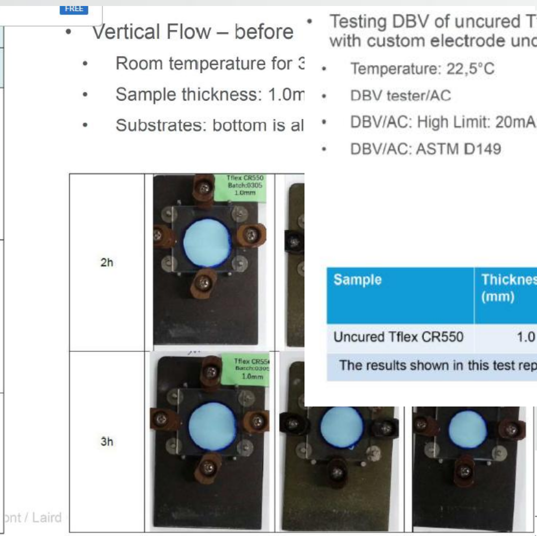
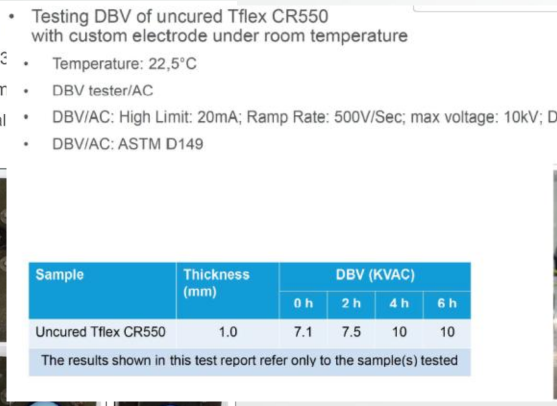
Reliability & qualification plan (examples)

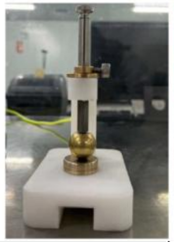
- Thermal shock / thermal cycling (ΔT, number of cycles)
- Vibration + mechanical load (application-specific)
- Post-test: ΔRth, delamination/cracks, insulation

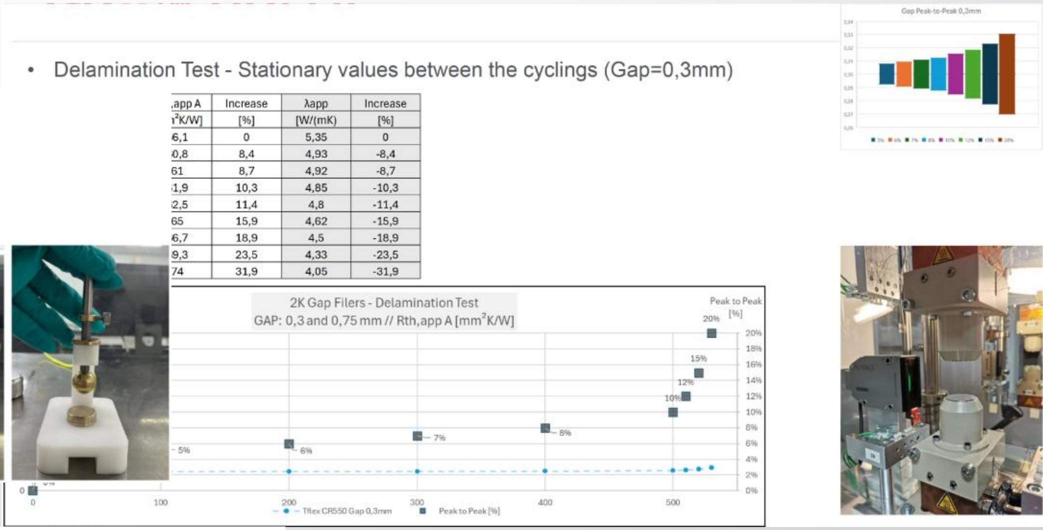




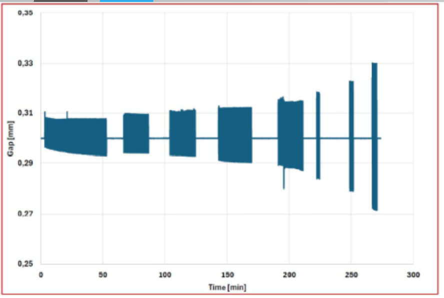
Sample	Thickness (mm)	DBV (KVAC)			
		0 h	2 h	4 h	6 h
Uncured Tflex CR550	1.0	7.1	7.5	10	10

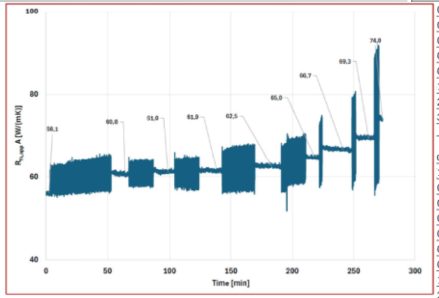
The results shown in this test report refer only to the sample(s) tested





,app A [²K/W]	Increase [%]	λapp [W/(mK)]	Increase [%]
6,1	0	5,35	0
0,8	8,4	4,93	-8,4
61	8,7	4,92	-8,7
1,9	10,3	4,85	-10,3
2,5	11,4	4,8	-11,4
65	15,9	4,62	-15,9
6,7	18,9	4,5	-18,9
9,3	23,5	4,33	-23,5
74	31,9	4,05	-31,9

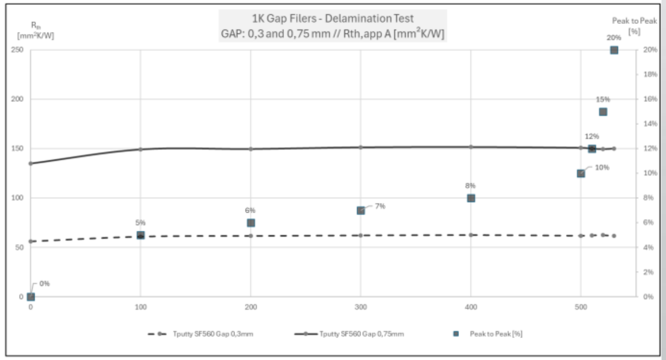


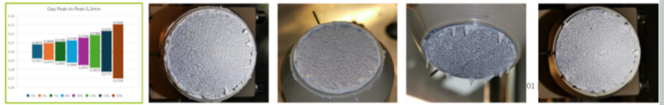


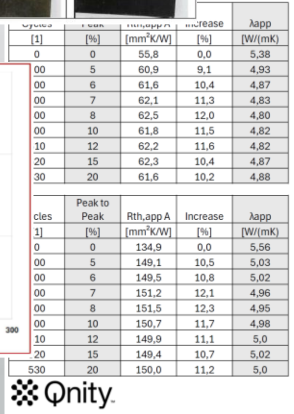
Cycles [1]	Peak [%]	Rth,app A [mm²K/W]	Increase [%]	λapp [W/(mK)]
0	0	55,8	0,0	5,38
00	5	60,9	9,1	4,93
00	6	61,6	10,4	4,87
00	7	62,1	11,3	4,83
00	8	62,5	12,0	4,80
00	10	61,8	11,5	4,82
10	12	62,2	11,6	4,82
20	15	62,3	10,4	4,87
30	20	61,6	10,2	4,88

cles [1]	Peak to Peak [%]	Rth,app A [mm²K/W]	Increase [%]	λapp [W/(mK)]
0	0	134,9	0,0	5,56
00	5	149,1	10,5	5,03
00	6	149,5	10,8	5,02
00	7	151,2	12,1	4,96
00	8	151,5	12,3	4,95
00	10	150,7	11,7	4,98
10	12	149,9	11,1	5,0
20	15	149,4	10,7	5,02
530	20	150,0	11,2	5,0

Qnity







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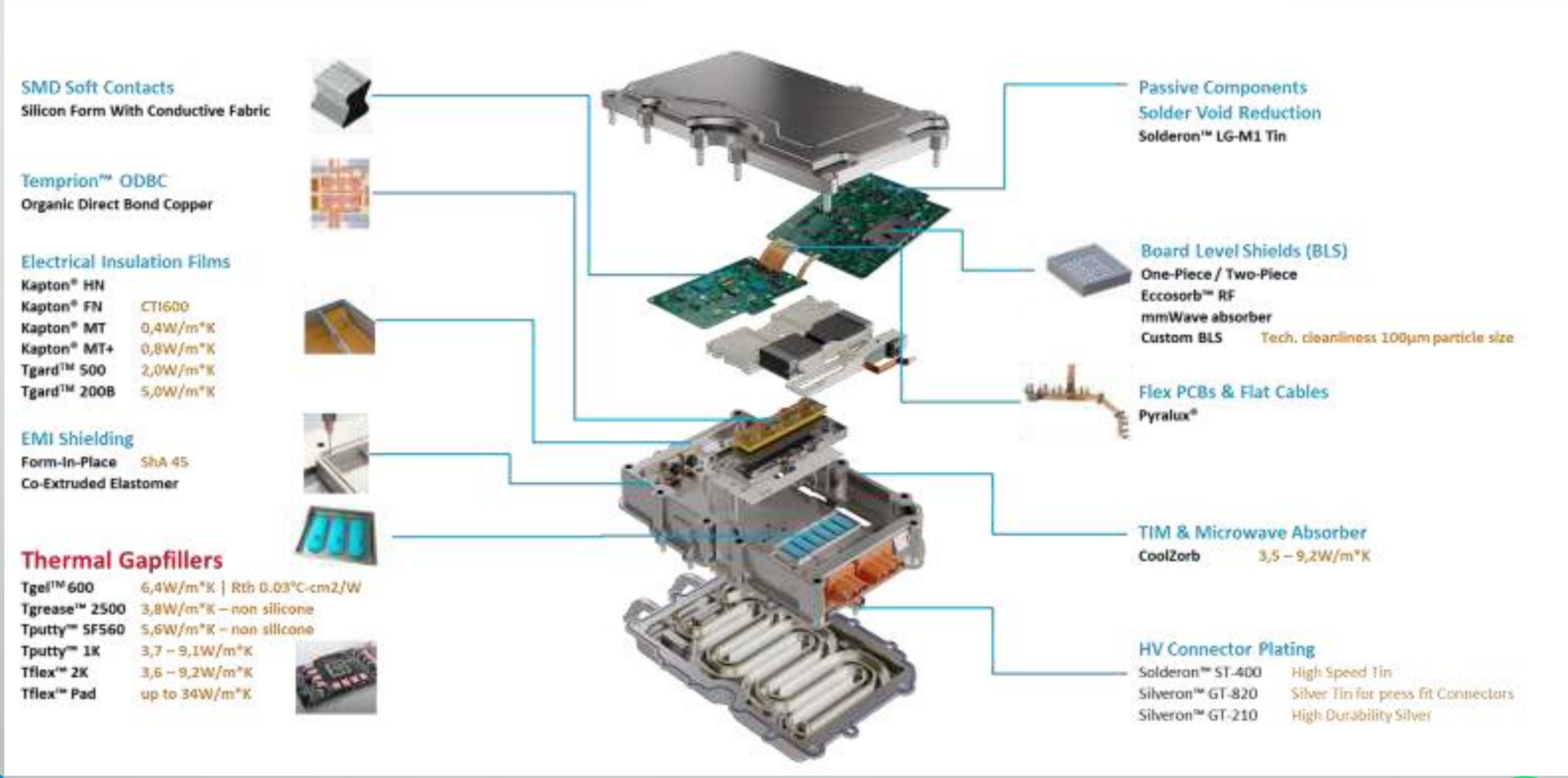
Application experience – Power Converter



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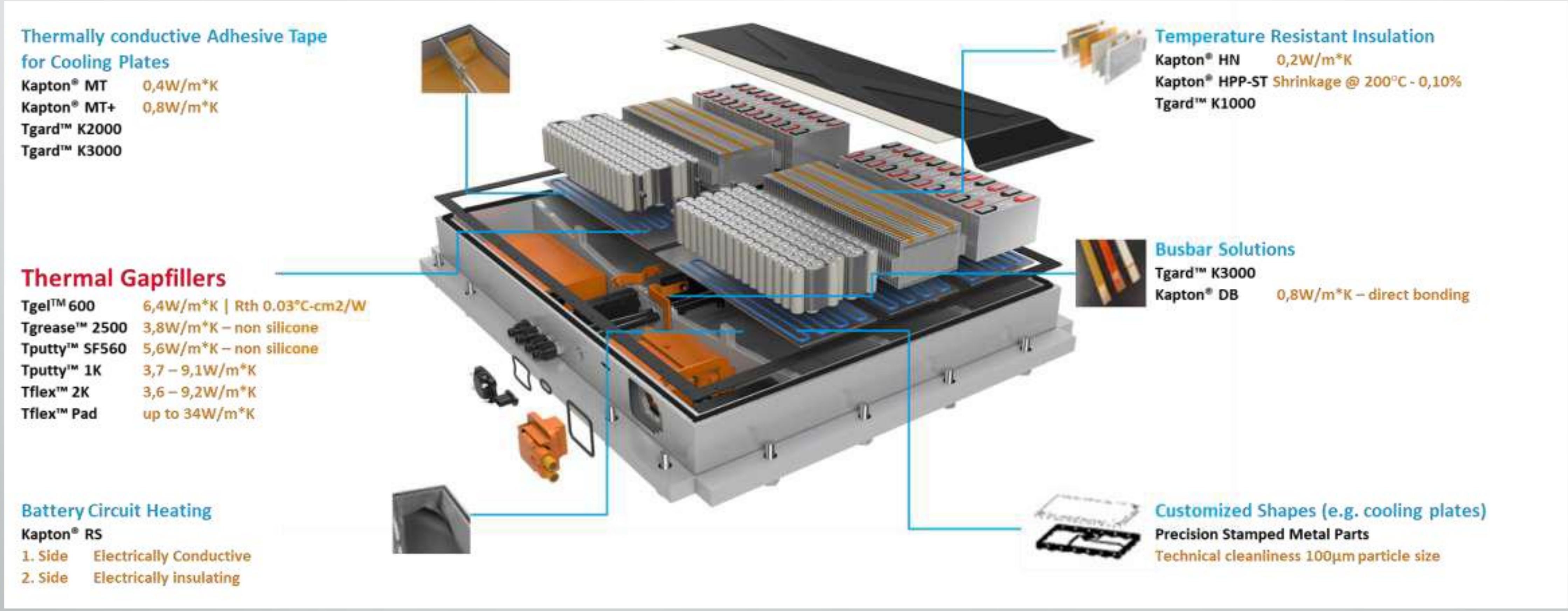
Application experience – Energy Storage



Conclusion & Q&A

Your thermal issue often lies not in the material's W/mK value, but in the tolerance stack-up of your assembly.

If the interface is inconsistent, you immediately lose performance.

That is why a compliant or dispensable TIM is often the only robust solution.

Thanks for your attention.
Happy to discuss your use case after the session.