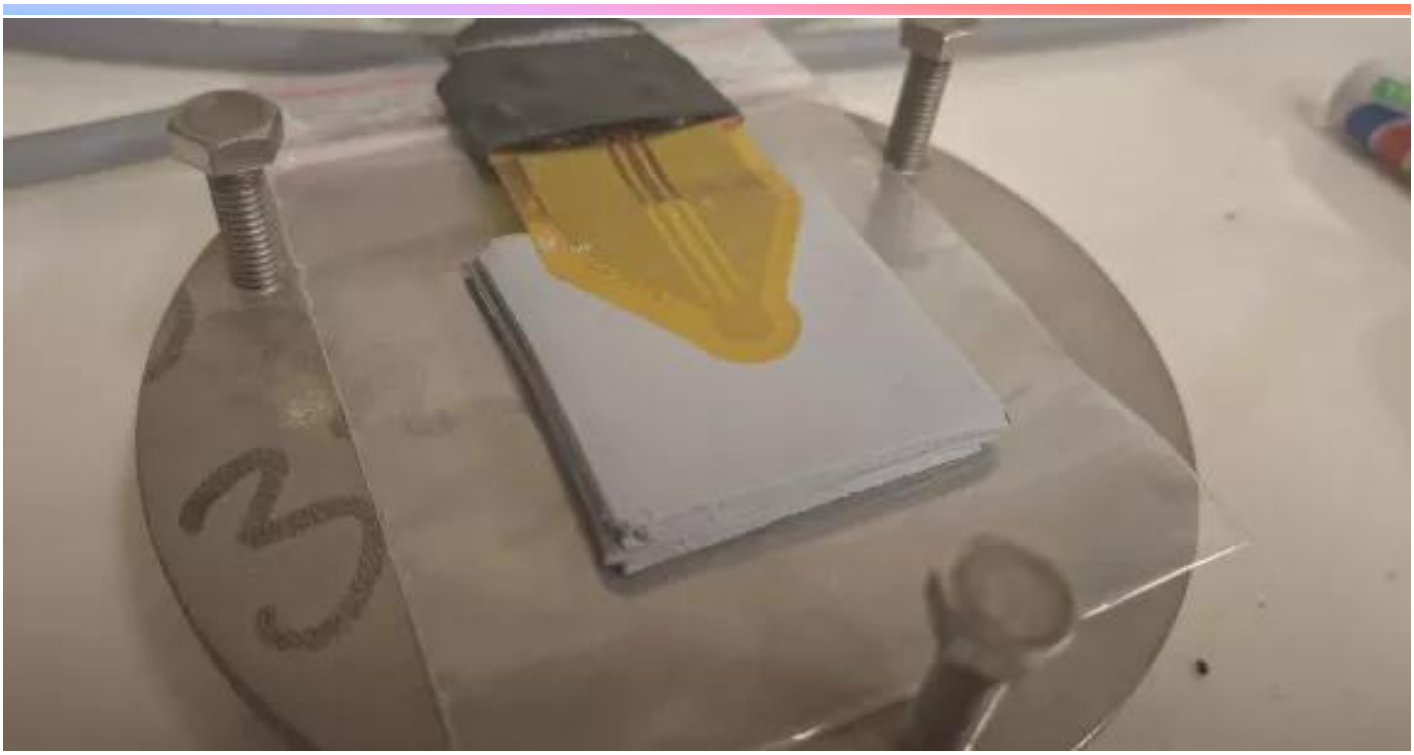


TIMs for Li-ion batteries: a crucial choice

06 August 2026, 13:56

Carl Emmerechts

The role of the thermal interface material (TIM) in Li-ion module performance

In a Li-ion battery module, the thermal interface material or TIM is often an afterthought compared to the choice of cells, the design of the cold plate or the control strategy. In fact, however, this component directly affects the heat path between the cells and the cooling system. During fast charging, high-power discharging or repeated cycles, each cell generates heat. If the TIM fails to dissipate this heat properly to the cold plate, the module may operate at a higher temperature, age more quickly, and lose some of its safety margin.

The TIM fills the gaps in imperfect interfaces

Surfaces that appear flat in a computer-aided design (CAD) model are in fact uneven and irregular at a microscopic level. At module level, manufacturing tolerances between cells, casing, and cold plate also create larger gaps.

Without a suitable TIM, these spaces become partially filled with air, one of the worst possible conductors along the heat path. The result may be a module that looks fine in CAD but operates at a higher temperature in real-world conditions. It will then age faster, develop greater cell-to-cell temperature gradients and lose some of its safety margin. [1,2]

From thermal conductivity to thermal impedance?

The thermal conductivity stated in a technical data sheet doesn't represent the interface's actual performance: it is merely one element of the thermal path.

The thermal interface resistance can be summarised as follows:

Interface resistance =
contact resistance (Surface 1) + joint thickness TIM conductivity + contact resistance (Surface 2).

In practice, a TIM with high intrinsic conductivity may underperform. This is the case if it is too thick, too rigid, insufficiently compressed, unable to conform to the roughness of the surfaces or affected by voids.

Conversely, a material with lower conductivity may perform better if it results in a finer and closer contact with the surfaces. The industrial specification must therefore address thermal impedance or thermal resistance in a representative assembly, under realistic conditions in terms of pressure, gaps, and surface finish, not just thermal conductivity. [1,3]



Measuring the thermal conductivity of a TIM using HotDisk® (photo: Sirris)

Thermal pad, thermal paste or gap filler: which should you choose??

Choosing between a thermal pad, thermal paste or liquid gap filler – a thermally conductive material designed to fill the gaps between components – is more than just a purchasing question. The choice depends primarily on the module's mechanical and industrial characteristics: interfaces that are more or less flat, variable gaps, available pressure, automation, removability, and heat dissipation requirements.

The thermal pad: simple, but sensitive to gaps

A thermal pad is a pre-formed material that has already been cross-linked prior to assembly. Clean and available in specific thicknesses, it is easy to handle and easier to remove when reworking. It is suitable for relatively flat, removable interfaces, particularly during the prototyping phase or in low-volume production.

However, it is important to bear in mind that the pad has to be compressed to conform to the roughness of the surfaces and reduce contact resistance. If the pack's tolerances are significant, contact may be good in some areas and insufficient in others, creating localised hotspots. A high-conductivity pad often contains a higher proportion of ceramic particles, which makes it stiffer and less flexible. The apparent gain in conductivity may therefore be lost at the interfaces.

Liquid gap filler for variable gaps

Liquid gap fillers and thermal pastes take a different approach. Before setting, they flow into the surface irregularities and absorb variable gaps. They can be applied using automated dosing, mixing and application equipment.

They are particularly well suited to high-density modules, large cold plates and industrial assembly lines where repeatability and dimensional tolerances are critical. Once set, a gap filler remains flexible and provides a stable thermal bridge.

However, a number of factors need to be managed:

- application pattern
- viscosity
- application time
- compression
- curing
- cleanness
- removability
- and porosity

Thermally conductive pastes, gels, and adhesives

A non-curing paste or a flexible gel may be useful when a large amount of material needs to be reworked. However, these solutions must be tested for pump-out, cracking, oil separation, vibrations, and thermal cycling.

A thermally conductive adhesive can combine thermal and structural functions, but it usually reduces the module's reworkability and transfers mechanical loads to the cells or the module's structure. [5,8]

Tests demonstrate the importance of contact

Experimental results show that the material's conformability is just as important as its nominal conductivity (see some references below).

In the Parker LORD tests [1], a liquid gap filler with a thermal conductivity of 4.1 W/mK exhibited an interfacial impedance of 0.75 K.cm²/W in copper-TIM-copper assemblies.

A commercially available pad with a very similar thermal conductivity – 4.2 W/mK – achieved a value of 4.10 K.cm²/W, which equates to a ratio of 5.5. In the same study, another pad exhibited an interfacial impedance approximately 2.3 times that of the comparable gap filler.

The difference was not due to any exceptional property of the material, but to its greater conformability: the liquid material displaced the air and made closer contact with both substrates. Another study examined the application of the battery using five prismatic cells on a cooled plate [2]. During a charge at 1.5°C, the liquid gap fillers dissipated more heat and resulted in lower cell temperatures than pads with comparable nominal conductivity.

With 1-millimetre shims simulating manufacturing tolerances, the difference became even more pronounced: a 2 W/mK gap filler with shims dissipated more heat than a 4 W/mK pad without shims.

Choosing the right TIM for the specific use case

These results don't mean that gap fillers are always the best solution. They mean that the best TIM is the one whose physical form is right for the module's mechanical characteristics.

A liquid gap filler is often a sensible option when:

- gaps vary
- surfaces are rough
- cold plates are large
- automation is planned
- and the heat dissipation requirement is high

A thermal pad remains an attractive option when:

- the interface is flat and the gap is controlled
- assembly cleanness and removability are priorities
- the programme is at the prototype stage, with simple operational activities.

A paste or gel is suitable for certain low-pressure interfaces and repairable assemblies. However, these options are not necessarily very tough.

The thesis by Maddila and Rostami [3] showed that increased pressure reduced thermal resistance for both a 2 mm pad and a 2 mm gel. However, a very thin gel subjected to high pressure may crack and lose its effective conductance.

In other words, pressure can improve contact, but excessive pressure or insufficient thickness may introduce a new failure mode.

Application quality as a key indicator

For applied materials, the quality of the process is a factor in the choice of material. A gap filler described in the technical data sheet as high-performance will yield poor results if air becomes trapped during application.

Shim, Yu, Kim, and Jang [4] used X-ray tomography to compare line-type and plane-type application of a TIM paste. The line-type application method resulted in an average porosity of around 1.99%, compared with approximately 0.30% for plane-type application.

The average difference in effective conductivity appeared to be slight: 4.855 W/mK compared with 4.994 W/mK. However, module simulations showed local temperature increases of around 0.7 to 1.0°C compared with a void-free setup. The increase was even greater when the voids were located near hotspots.

The lesson for manufacturers is practical in nature. The following must be specified:

- application path
- bead spacing
- material volume
- closing speed
- degassing
- curing conditions
- and inspection criteria

Porosity is therefore not merely a laboratory curiosity, but a key performance indicator in production.

Durability should be validated right from the design stage

The durability of a TIM must be designed and verified: it cannot be taken for granted. In a battery, the thermal interface material is expected to last for many years. It is subjected to temperature cycles, humidity, vibration, impacts, compression, electrical potential differences and material incompatibilities.

Polymer-based TIMs can undergo chemical ageing, lose their adhesion, change in hardness, crack, delaminate, bleed out of the joint line or lose their dielectric properties.

A validation plan should therefore not be confined to an initial conductivity measurement. It should combine:

- selection of materials
- thermal impedance tests at representative joint thickness and pressure
- thermal tests at module level
- ageing under thermal cycling and humid heat
- vibration or impact tests
- an inspection of the interface following ageing

Polymer composites containing boron nitride and other systems reinforced with electrically insulating ceramics show great promise. They can combine heat transfer and dielectric behaviour. However, they must be assessed as complete interfaces, and not merely as bulk materials. [5,6]

Safety: incorporating the TIM into the overall architecture

The choice of TIM is relevant to safety, even though a TIM alone is not a safeguard against thermal runaway.

A good interface keeps normal operating temperatures lower and more consistent. This helps to reduce uneven ageing between cells and preserves the design margin.

However, thermal runaway propagation involves several mechanisms: conduction, convection, radiation, and the ejection of hot gas or particles. This must be addressed through pack architecture, barriers, gas venting, detection, and cooling strategy. The designer also has to understand where the heat will flow during an extreme event.

The right approach for an industrial design team is therefore to incorporate TIM right from the earliest stages of the architectural design process. It must be included in discussions relating to thermal, mechanical, industrial, and safety considerations. In conclusion, don’t approve a material just because its conductivity seems promising. Approve it because its thermal impedance, conformability, process window, dielectric behaviour, durability, and failure modes have been demonstrated in the module’s real-world environment. [7]

Do you design or optimise Li-ion battery modules?

Sirris is a centre of excellence that supports industrial development projects. Its experts can help you select and validate your thermal interface materials, using numerical modelling, CFD (computational fluid dynamics) simulations and the creation of industrial prototypes.

We can also help assess critical material properties, in particular thermal conductivity and diffusivity using HotDisk®, as well as specific heat capacity using DSC.

Contact our experts

Interested in battery innovation?

Developing high-performance battery systems goes beyond thermal management. Discover how Sirris is developing modular battery modules, intelligent energy management systems and hybrid energy systems for demanding applications through the SHIFT project.

Discover the SHIFT project

References

[1] Parker LORD, Liquid-Dispense Gap Fillers versus Thermal Pads: A Case Study on Thermal Performance, White Paper LL3248, 2026.

[2] Parker LORD, Battery Cooling Performance: Comparing Liquid-Dispense Gap Fillers with Thermal Pads, White Paper LL3250, 2020.

[3] R. V. Maddila and S. Rostami, Investigation of the Effect of Thermal Interface Materials on the Cooling of Battery Cells, Master thesis, Chalmers University of Technology, 2023.

[4] J. Shim, M. Yu, H.-K. Kim and S. Jang, Effective thermal conductivity and cooling performance of battery pack modules as a function of porosity introduced during thermal interface material application, Journal of Computational Design and Engineering, 2026.

[5] R. Stadler and A. Maurer, Methods for Durability Testing and Lifetime Estimation of Thermal Interface Materials in Batteries, Batteries 5(2), 34, 2019.

[6] S. K. Mohonta et al., Polymer-BN Composites as Thermal Interface Materials for Lithium-Ion Battery Modules: Experimental and Simulation Insights, Batteries 11, 431, 2025.

[7] Y. Jiang, Y. Jiang and P. Wang, A review on mitigating thermal runaway propagation in battery packs: from mechanisms to modeling and design

optimization, Energy Advances, 2026.

[8] Parker Hannifin/Parker LORD, CoolTherm Materials for Electric Marine, Product Brochure PB3113, 2025.

Authors



Carl Emmerechts