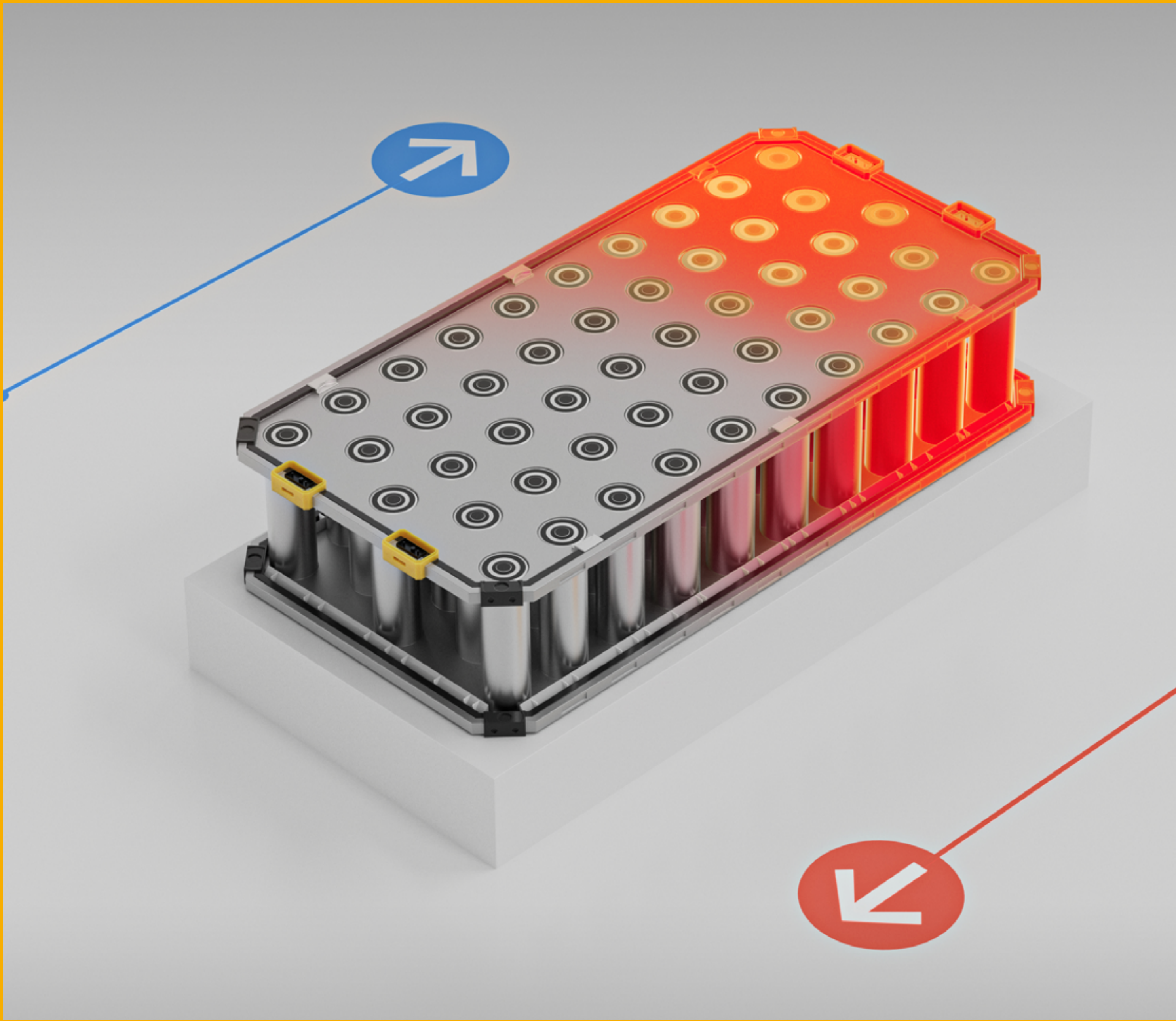

THERMAL CONDUCTIVITY IN ELECTRIC VEHICLE BATTERY PACKS

MOVING PERFORMANCE FORWARD THROUGH EFFECTIVE HEAT MANAGEMENT

BUILDING TRUST

MOVING PERFORMANCE FORWARD THROUGH EFFECTIVE HEAT MANAGEMENT

INTRODUCTION

As the demand for electric vehicles (EVs) rises, optimizing the thermal management of electric vehicle battery packs becomes increasingly crucial given the notable increase in energy density now achieved by manufacturers. Battery performance, longevity, and safety are significantly impacted by temperature regulation. Efficient thermal management relies on materials with high thermal conductivity to facilitate heat dissipation, particularly in thermally conductive adhesives and gap fillers collectively known as thermal interface materials (TIMs) used between battery cells and cooling plates.

This white paper explores the role of thermal conductivity in battery packs, highlighting the benefits of high-conductivity thermal interface materials through fundamental heat transfer equations.

THE ROLE OF THERMAL CONDUCTIVITY IN BATTERY THERMAL MANAGEMENT

During charge and discharge cycles, lithium-ion (Li-ion) cells generate heat due to internal resistance. If this heat is not efficiently dissipated, it can lead to several issues:

- **THERMAL RUNAWAY**
- **ACCELERATED CELL DEGRADATION**
- **REDUCED SYSTEM EFFICIENCY**

Optimal operating temperatures for Li-ion cells typically range from 15°C to 35°C, and maintaining this range is essential for performance and safety.

Thermal conductivity (k) measures a material's ability to conduct heat, expressed in W/(m·K) (watts per meter per kelvin). In battery systems, materials with higher thermal conductivity enhance heat dissipation from the cells to the cooling system. Thermal interface materials used in battery pack assembly, such as thermally conductive adhesives and gap fillers, should possess high k-values to minimize thermal resistance and ensure uniform temperature distribution.

MATHEMATICAL ANALYSIS OF HEAT TRANSFER

Heat transfer in battery packs occurs primarily through conduction, governed by Fourier's Law:

$$q = -kA\frac{dT}{dx}$$

where:

q = heat transfer rate (W)
k = thermal conductivity of the material (W/(m·K))
A = cross-sectional area (m^2)
dT/dx = temperature gradient (K/m)

To minimize thermal resistance in the adhesive layer, we consider the thermal resistance equation:

$$R_{th} = \frac{L}{kA}$$

where:

R_{th} = thermal resistance (K/W)
L = thickness of the adhesive layer (m)

IMPLICATIONS FOR MATERIAL SELECTION

Lower thermal resistance enables more efficient heat dissipation. If a conventional adhesive with k = 0.2 W/(m·K) is replaced with a high-conductivity adhesive of k = 2.2 W/(m·K), the thermal resistance decreases by a factor of over 11, significantly improving heat transfer.

There are several ways in which heat transfer can be increased effectively due to the proportionality of the given laws:

- **INCREASED k VALUE FOR A GIVEN THERMAL INTERFACE MATERIAL.**
- **INCREASED A VALUE HENCE THE DEMAND FOR THERMAL INTERFACE MATERIALS THAT FLOW EASILY.**
- **DECREASED dx VALUE WHEREBY THINNER MATERIALS ALLOW FOR HIGHER CONDUCTION AND LOWER RESISTANCE.**

ADVANTAGES OF HIGH-CONDUCTIVITY THERMAL INTERFACE MATERIALS

1. **Reduced Thermal Gradients: A more uniform temperature distribution across battery cells enhances performance consistency and reduces localized overheating.**

2. **Extended Battery Lifespan: Lower operating temperatures mitigate cell degradation, prolonging cycle life.**

3. **Improved Safety: Efficient heat dissipation reduces the risk of thermal runaway events.**

4. **Enhanced Charging Rates: Maintaining lower temperatures enables faster charging without excessive thermal stress.**

CONCLUSION

Optimizing thermal conductivity in adhesives and gap fillers used within EV battery packs is critical for performance, longevity, and safety. By leveraging high-conductivity materials, thermal resistance is minimized, ensuring effective heat dissipation.
As EV adoption continues, advancements in thermal interface materials will play a vital role in enhancing battery efficiency and reliability.

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COMBINING GLOBAL REACH WITH LOCAL EXPERTISE

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