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The all-electric Audi e-tron SUV utilizes a thermally conductive adhesive that helps maintain battery temperature at 25°C.

SEVEN WAYS ADHESIVES PUSH ELECTRIC VEHICLE DESIGN FORWARD

Adhesives offer significant advancements in electric vehicle safety, cost, durability, and performance.

By Andreas Lutz, Global Adhesives Technology Leader

The transformation of the world's vehicles from internal combustion engines (ICEs) to electric vehicles (EVs) relies in large part on what holds the vehicles together—namely, adhesives. A wide portfolio of adhesive solutions is helping automakers worldwide mass-produce EVs that are safer and perform better than ever. Here are seven ways adhesives—including some that also function as a thermal interface material (TIM)—are helping advance EV design.

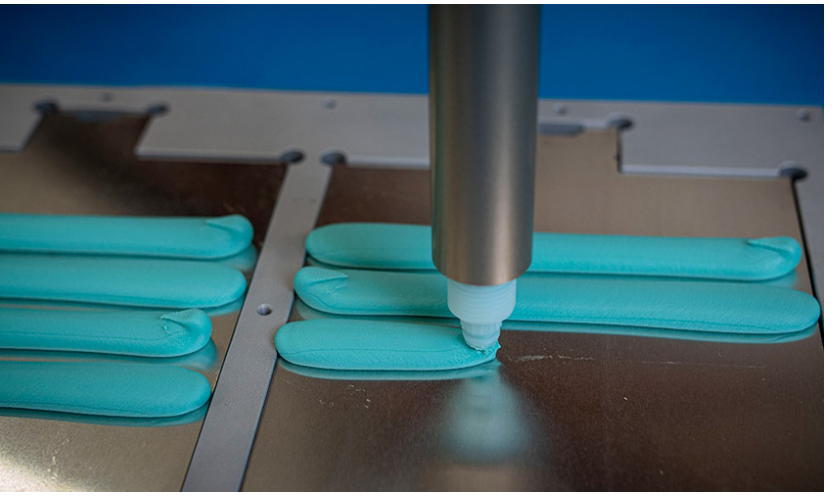
THERMAL MANAGEMENT TO IMPROVE BATTERY DURABILITY

One of the biggest challenges in designing batteries for plug-in hybrids and EVs is thermal management of the battery pack. Battery components must operate within a window of 15-60°C during operation and charging. Operation in extreme temperatures outside this range can strain batteries. If it's too cold, performance, efficiency, and range suffer. If it's too hot, the battery deteriorates, shortening its life and possibly creating safety issues.

Specialty adhesive and TIM formulations that are thermally conductive help maintain optimal battery temperatures during charging and operation, thus extending vehicle range and enhancing vehicle safety. A recent collaboration resulted in the application of a thermally conductive adhesive* for the all-electric Audi e-tron® SUV that maintains a battery temperature of 25°C—the sweet spot for optimum battery performance.

The thermally conductive polyurethane structural adhesive transfers heat in both directions between the battery and heat sink, even during the e-tron's superfast 150-kW charging. The adhesive's properties also help avoid hot spots in the battery pack that could lead to thermal runaway.

By either transferring heat or extracting heat, the thermally conductive adhesive helps extend battery cell lifetime and driving range. The material's combination of higher modulus and elongation helps ensure that the battery and the bonded substrates



Thermally conductive polyurethane material is applied between EVs' battery cells and cooling plates to help control heat by maintaining thermal conductivity over an optimal temperature range.

can last up to 15 years (i.e., the projected life of the vehicle). This is also important because sustainability regulatory bodies suggest that some batteries may be repurposed in other vehicles or gain second lives as energy storage solutions.

Efficient thermal management between battery packs and cooling units made possible with adhesives and TIM also means longer driving ranges for EVs. This longer range frees drivers from "range anxiety," which is one of the biggest reasons consumers hesitate to embrace EVs.

ADHESIVES HELP IMPROVE EV SAFETY

Foremost in every vehicle design is safety. With EVs, the massive battery pack poses a risk of fire or electrocution if it's not properly insulated and secured. Adhesive bonding is a key joining technique that provides crash durability and thermal conductivity while keeping the battery at a safe temperature.

Adhesives also make auto bodies stronger. When the London EV Co. redesigned London's classic black taxis into range-extended hybrid electric vehicles, the lightweight, extruded-aluminum body was assembled with structural adhesive. The continuous bondlines of adhesive are integral to making stiffer, stronger, and more crash-durable taxis that help protect drivers and passengers.

ENHANCED ACOUSTIC AND DRIVING PERFORMANCE

Structural adhesives help improve EVs' acoustic and driving performance. To understand why, it helps to look at how EVs differ from ICEs in terms of body construction.

Structural adhesives that replace welds and mechanical fasteners create rigidity that provides better handling while reducing noise, squeaks, and vibration. Reducing road noise is especially important in these quieter running vehicles.

In newer EVs, the battery pack itself serves as the floor of the passenger compartment. Battery packs bonded with adhesives create a low center of gravity that translates into a more dynamic driving experience.

ABILITY TO BOND DISSIMILAR MATERIALS

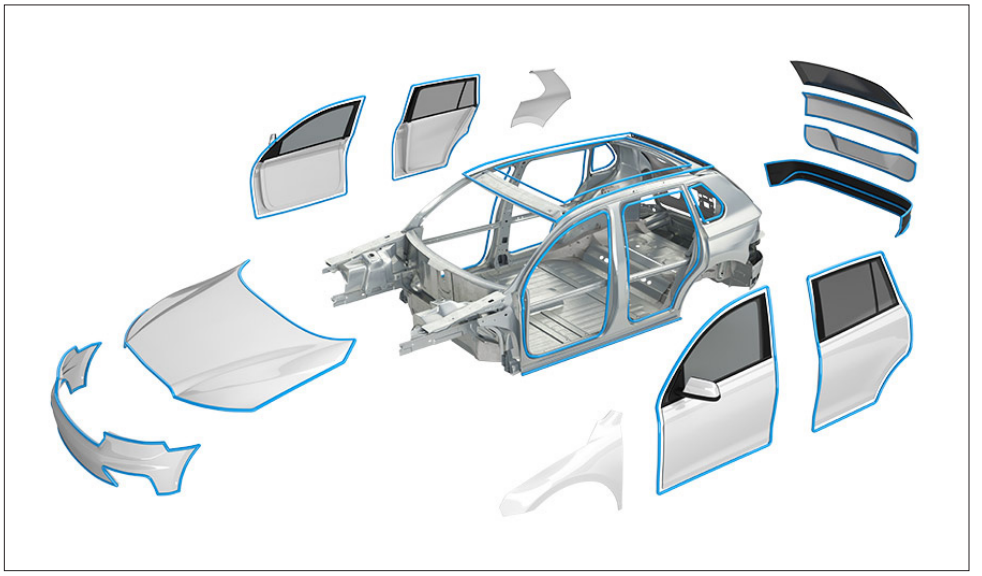
Have you ever noticed how many different materials are used to build vehicles? Traditionally, the primary material for automotive structural components has been metal. The objective to reduce greenhouse gas emissions has transformed the composition of structural components, which now include the use of plastics, composites, and other materials, creating a need for a new generation of adhesives to bond a variety of substrates.

Multi-material bonding adhesives help bond dissimilar substrates, including high-strength steel, aluminum, plastics, composites, magnesium, glass, and carbon fiber. The continuous bondlines in these structures add stiffness and strength for safety while eliminating weight associated with heavier metal structures that utilize mechanical fasteners. In fact, the composite bonding adhesives used to construct the redesigned London black taxis eliminated all mechanical fasteners.

LIGHTER WEIGHT VEHICLES

The lighter an EV is, the longer its range. However, one of the heaviest components of an EV is the battery pack. Structural and thermally conductive adhesives for battery pack assembly can significantly reduce the number of components and reduce the battery pack weight by up to 30 kg.

Body bonding solutions also help reduce vehicle weight. High-performance adhesive solutions can contribute to achieving a fully bonded structure that



Structural and multi-material bonding adhesives add stiffness for durability and crashworthiness while also reducing vibrational energy for improved acoustics.

is stronger and lighter than equivalent steel construction. In addition to increased safety for the occupants, the weight savings contributes to greater efficiency.

OPTIMIZED COSTS

Currently, EV batteries account for one-third of the overall vehicle cost. The simpler the battery pack, the less cost required for materials and assembly. The same adhesive technologies that reduce weight also enhance battery pack assembly efficiency. By enabling manufacturers to use fewer components, structural and thermally conductive adhesives help optimize costs for battery pack design.

ADVANCES IN SUSTAINABILITY

Having a great design for an EV is one thing; sustainably mass-producing and keeping those cars on the road long term is another. As EVs evolve, work is ongoing to solve the challenge of providing safe, efficient transportation for people and goods while reducing CO2 emissions.

In addition to structural adhesives that enable lightweighting to help lower fuel consumption and increase EV range, adhesive technologies advance sustainability during production and over vehicle life. Examples include:

- A VOC-free adhesive for bonding glass to other materials that does not require the use of primers, cleaners, or activators, allowing assembly and repair facilities to reduce their VOC emissions
- An adhesive that acts as a thermally conductive bonding agent that's designed to also allow easy removal of battery modules, enabling repair, reuse, repurpose, or ultimately recycling
- An adhesive** that supports sustainability in two ways: by keeping EV batteries cool during super-fast charging and operation, which extends battery life; and by reducing the number of components needed, thus reducing the need for raw materials

Adhesive formulations can be fine-tuned based on the production process at individual OEMs while integrating circular economy practices. Variables such as viscosity, application temperature, and cure time can all be addressed with customized solutions that provide the desired performance for deliverables like conductivity, Young's modulus, and strength, as well as product lifecycle impacts.

POISED TO MEET FUTURE NEEDS

These seven benefit areas for using adhesives to advance EVs are just the beginning. Innovation hubs for the next generation of adhesives will accelerate the adoption and development of new technologies that will help auto manufacturers validate new concepts faster. Ultimately, these new adhesives will reduce the time it takes to get EVs to market and get more sustainable vehicles on the road.

For more information, visit www.dupont.com/mobility.

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