Thermal Management in 2022, the Rise of Multifunctional Materials

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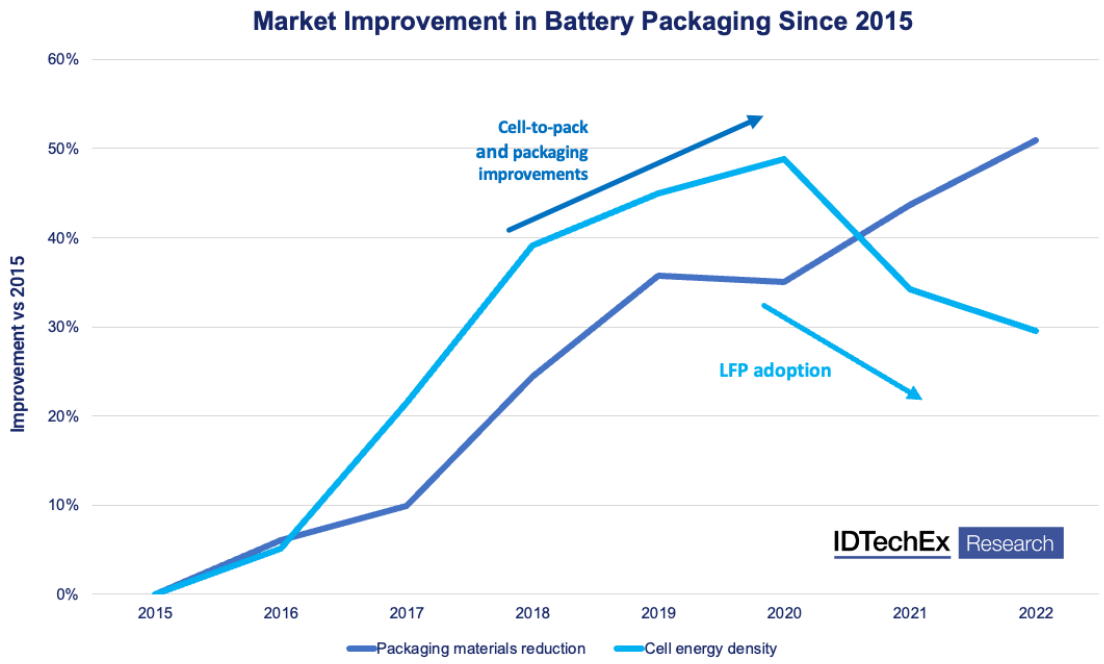
Thermal management is critical in several industries, and the trends in emerging technologies are driving material innovation. Electronics in markets from personal devices through to cars are seeing increased integration, densification, and hence an increased focus on thermal management. As these components have less and less free space to utilize, the use of materials that provide more than one function is on the rise.

Electric Vehicle Battery Evolution

The electric vehicle (EV) market has continued its trend toward higher energy-density battery designs. While the average market energy density has decreased slightly since 2020 due to the resurgence of LFP batteries, the percentage of the battery that is taken up by the cells has been increasing, somewhat mitigating the hit from adopting the lower energy density cell chemistry.



The increasing share of LFP has decreased average cell energy density, but the efficiency of packaging has continued to increase rapidly, helping offset this at a pack level. Source: IDTechEx

The trend of increasing packing efficiency is partly due to incremental improvements but also greater adoption of cell-to-pack and cell-to-body designs that have been seen in 2022. BYD's Blade battery has seen a greatly increased deployment in 2022, with BYD's market share in China's EV market reaching approximately 25% in the first half of 2022. This cell-to-pack design has each prismatic cell take up the entire width of the pack. In 2022, Tesla has also deployed its first vehicles using the fabled 4680 battery cells and a structural pack design where the seats are attached directly to the lid of the battery. These design changes greatly improve energy density by removing ancillary materials that do not directly contribute to the battery's operation. Several OEMs have announced plans for cell-to-pack or cell-to-body

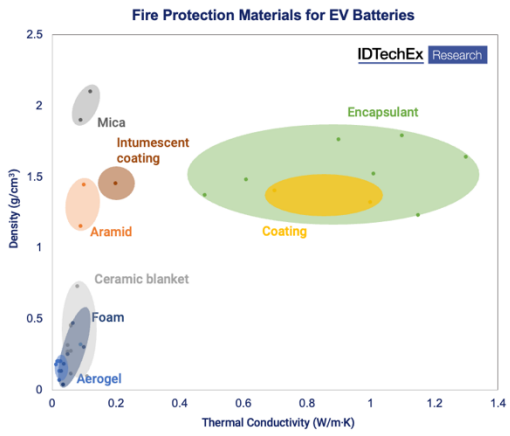
designs to be deployed within the next few years, including groups like VW, Stellantis, and several others.

Fire Protection in Future Battery Designs

Despite the removal and reduction of materials in EV batteries, there are several materials that will always be required in an EV battery design for it to function optimally. These include the thermal management strategy (cold plates, coolants, etc.) and, critically, in 2022, fire protection materials. Similar to 2021, EV fires have been prominent in news outlets but, now more than ever, a driver for material innovation. While fires are a rare event and less likely to occur than in a combustion engine vehicle, Li-ion batteries, regardless of chemistry or cell format, present a non-zero risk of thermal runaway and subsequent fire. 2021 saw several recalls relating to battery fire risks from major OEMs, including GM, Hyundai, VW, and others. In 2022, India has seen a large focus on battery fires in electric two-wheelers, which has prompted the adoption of specific safety standards relating to several battery design factors.

With the public focus and impending implementation of thermal runaway safety regulations in various regions, OEMs are forced to consider materials used for fire protection more carefully. The previously discussed trend towards cell-to-pack and higher energy density packs presents a challenge in fire protection. As energy density increases, there is less space for added materials, leading to suppliers focusing on multifunctional materials. For example, aerogels are gaining traction in the market thanks to their ability to provide thermal insulation, fire protection, and compressibility. In 2022, Aspen Aerogels was named as the supplier for GM's Ultium platform, and its PyroThin material reported revenue of U.S. $18.4 million in the first half of 2022 compared to US$6.7 million for all of 2021. Rogers Corporation, a prominent player in providing compression foam pads for pouch cell battery packs in 2022, announced its EV ProCell Firewall materials that provide both fire protection and compression management (critical for pouch cell battery packs). An acquisition of Rogers by DuPont was announced in late 2021 as one of the largest acquisitions in the materials space in recent history. However, this acquisition was terminated at the end of 2022 after DuPont failed to obtain clearance from all the required regulators

Several other material options can be used depending on the cell format and whether an inter-cell and/or a pack level solution are required. In 2023 and beyond, with the rapidly expanding EV market, several of these materials will experience rapid growth in demand, and IDTechEx is predicting a 13-fold increase in fire protection material demand by 2033.



Many materials are applicable for fire protection, each with its own pros and cons depending on battery design. Source: IDTechEx

The Evolution of Thermal Interface Materials in EV Batteries

Thermal interface materials are a critical component in the vast majority of modern EV battery designs. These help to dissipate heat from the cells towards the cooling structure (module housings, cooling, channels/cold plates). The most common applications currently have the battery cells sit on a gap-filling TIM inside a module; several of these modules then sit on another gap-filling TIM to contact the liquid-cooled cold plate below. This approach has changed in some more recent designs, especially cell-to-pack designs.

The concept is to have the cells contact the cold plate directly through a single TIM, reducing the number of interfaces and hence improving heat transfer. Due to less interfaces, the thermal conductivity of the TIM can be reduced, and less TIM is required. Initially, this can reduce the weight and cost of the TIM and make for easier dispensing. However, with the removal of module housings (or similar structures), the TIM must now provide a structural component. Therefore, this is a great opportunity for thermally conductive adhesives.

While (as above) materials around battery cells are being removed from the pack to enable greater energy density, the TIM is one that will largely remain and provide multifunctional properties to aid in both thermal management and structure of the battery pack. With larger form factor cells, the area for TIM to be applied may reduce somewhat for certain designs, but IDTechEx is predicting over 2TWh of liquid or refrigerant-cooled batteries by 2031, providing huge growth for TIMs along with several other thermal management components and materials.