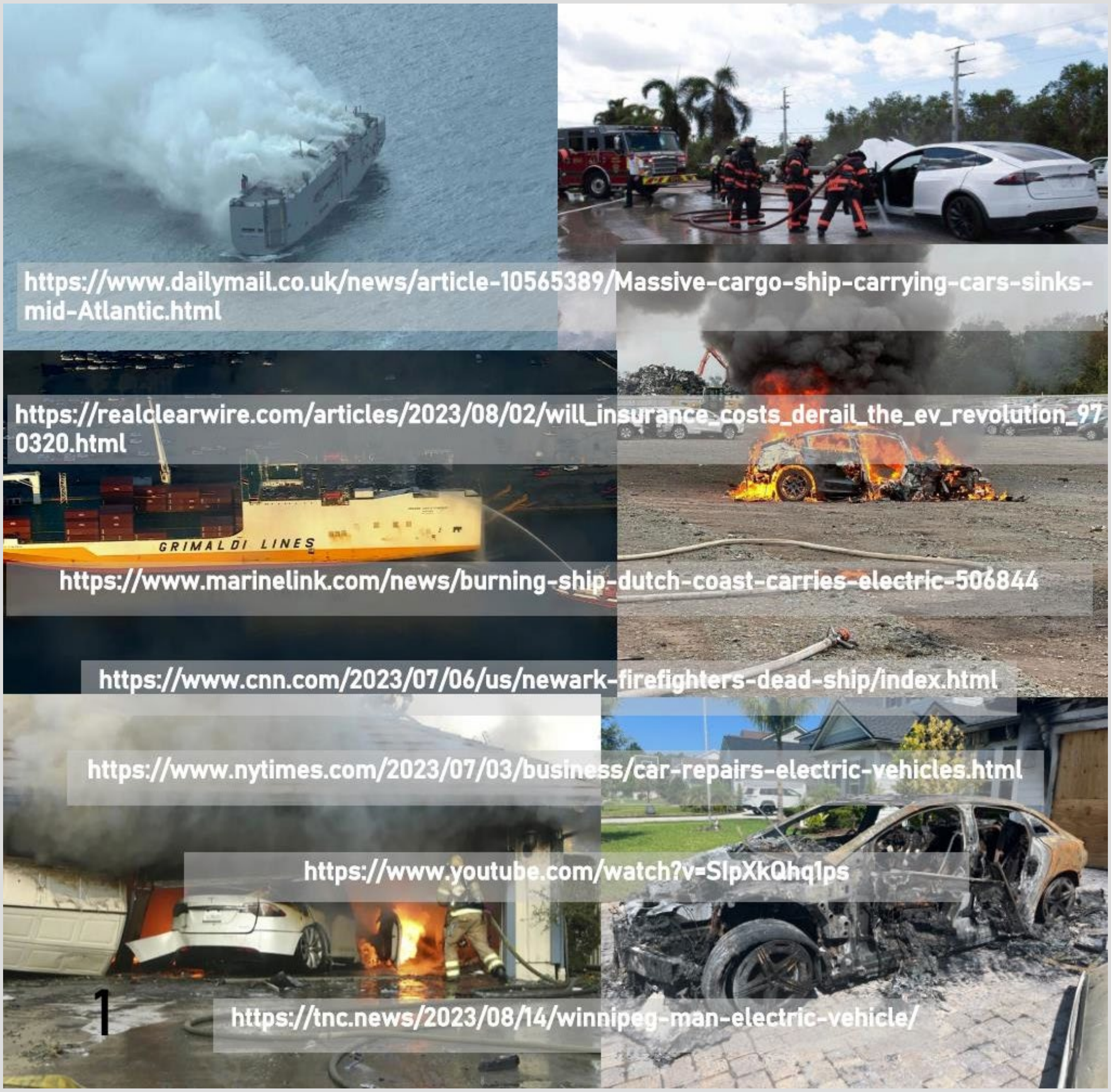
The Fear & Hope of the EV Industry

By Billy de Ming

As the growth of the EV industry transitions from the early adopter customers to the mass consumer, the day of reckoning for the EV industry draws nearer. Sustainability will never surpass safety and reliability in the hearts and minds of the public. Many legacy auto manufacturers have wagered their lifetime customers in their gambit into the EV market.



There is a white elephant in the showroom of your local EV dealer that nobody wants to talk about but will soon be unavoidable as the EV industry gains traction and more and more electric vehicles make their way to the mainstream. Imagine if you had to rest your head at night with the genuine concern that your internal gas combustion (ICE) vehicle parked in your garage might unexpectedly explode and put the health and safety of the loved ones who live under your roof at risk. There wouldn't be many that parked their vehicle in their garages with this type of risk at play. Unfortunately, this is a worry that current EV owners contend with which most don't realize until it is too late. You see, EV owners must park their vehicles in their garages as that is where the charging apparatus is located. Obviously, an EV needs to be recharged in order to be useful and the charging apparatus uses a home's electrical infrastructure fed from the main service electrical panel to power the charger. But laying the blame on the charging station is quite unfair. Rather, and more importantly, EV battery systems haven't been designed with the right materials and configuration to negate the risk of short circuiting that is caused when dendritic growth occurs during repeated charge cycles. It is sort of like a cavity that grows in the decaying region of a tooth. At first, the cavity is quite harmless and merely a slight nuisance than anything else, but once it reaches the root of the tooth, it becomes a major problem that requires a root canal procedure. The same goes for dendritic growth of lithium metal that once it spans from the cathode to anode, the battery cell short circuits and the risk of thermal runaway occurs. By the way, thermal runaway is a gentler and refined way of saying EXPLOSION!!! It seems absurd that a modern-day risk such as this even exists or is allowable, but in the rush to save the planet this dirty little secret of going green has been brushed aside.

The good news is that recent research has taught us how to combat or control the risk of dendritic growth. A team at MIT led by Professor Yet-Ming Chiang discovered that placing a strain of 200 MPa or greater in a perpendicular plane to that of the electrodes can divert the dendrites in a direction parallel to the strain rendering them harmless.

MIT News
ON CAMPUS AND AROUND THE WORLD

Engineers solve a mystery on the path to smaller, lighter batteries

Branchlike metallic filaments can sap the power of solid-state lithium batteries. A new study explains how they form and how to divert them.

David L. Chandler | MIT News Office
November 18, 2022

Researchers solved a problem facing solid-state lithium batteries, which can be shorted out by metal filaments called dendrites that cross the gap between metal electrodes. They found that applying a compression force across a solid electrolyte material (gray disk) caused the dendrite (dark line at left) to stop moving from one electrode toward the other (the round metallic patches at each side) and instead veer harmlessly sideways, toward the direction of the force.

Courtesy of the researchers

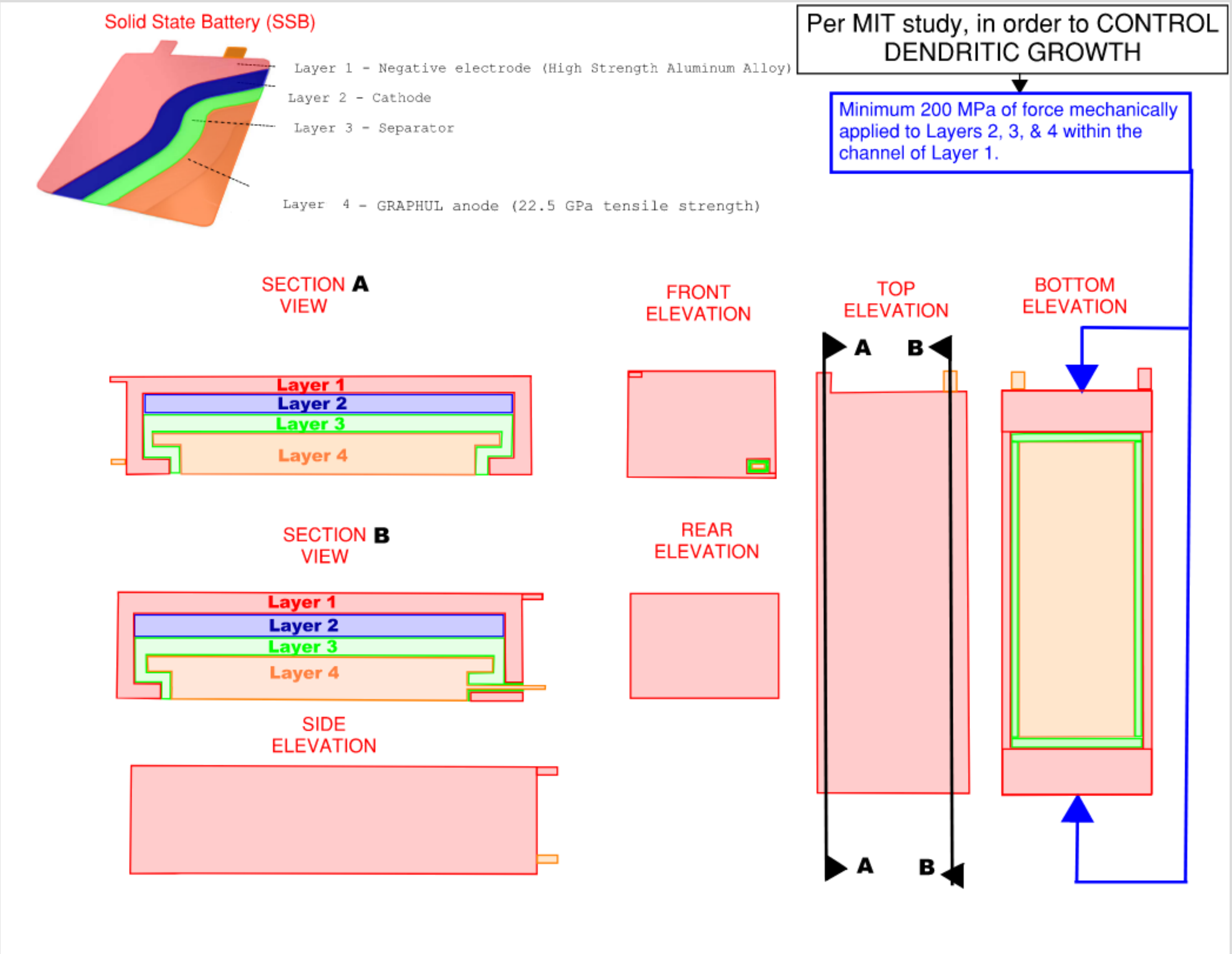
https://www.cell.com/joule/fulltext/S2542-4351(22)00520-7

Surprisingly, this gamechanging breakthrough for the industry has been met with little to no fanfare. The significance of this finding is that no longer do EV owners have to fall asleep at night unsettled by thoughts of all that they cherish perhaps falling victim to the calamity of thermal runaway parked below their bedrooms. Instead, they and future EV owners may now enjoy the same peace of mind that all ICE (internal combustion engine) vehicle owners take for granted yet to this date has been unafforded in the EV industry.

There is still a lot of work that needs to be done in order to realize the value of what Chiang's team has taught us. Currently, the cutting edge industry players and trends are solely focused on silicon-based anode technology that can't quite meet the mark. That is due to the inherent weakness of silicon which maintains a tensile strength of 135 MPa that falls short of the ability to withstand the minimum strain requirement of ~200 MPa (per Chiang). The silicon-based anode craze arose from the chemical's amazing propensity for capacitance but during a period that was unaware of the importance of mechanical strength in solving the (2) most important issues that plague the industry: 1.) rapid capacitance fade (batteries usefulness diminishing at lower limits of overall quantity of charge cycles), 2.) thermal runaway. A lot of financial and intellectual capital has been invested by way of silicon-based systems so it won't be easy for many teams to do an about face at this juncture. What's more is that this problem isn't inherent in only silicon-based anodes but is also prevalent in spherical graphitic anodes which encompasses the majority of current EV battery cell systems. Spherical graphite possesses a mere 18 MPa in tensile strength thus unable to stem the direction of lithium dendrite growth.

If one wants to know which EV battery systems will be successful in overcoming the industry's ailments, then they must focus on the mechanical strength of the protostructure of the anode along with the capacitance values of said protostructure. The future reputable EV brands will place emphasis on battery anodes that consist of a monolithic composite (one continuous member) not those made from aggregated components. These composites will need to be able to withstand a strain of 200 MPa without degradation in order for them to render harmless dendritic growth. The field of anodes will be greatly limited based upon these requirements but they will bring about the needed change of safety and durability that the EV industry currently lacks.

The mass consumer of automobiles has come to expect a minimum durability in terms of mileage from their vehicle which current EV cars cannot provide. Furthermore, the overhaul of repair costs required to replace a poorly running EV battery system due to capacitance fade or short circuiting is far too exorbitant for your average customer. Therefore, the current state of the EV world is out of reach for most, yet it is being paraded as if it will be a seamless transition for Mom and Pop consumer. Once the EV industry gets onboard by choosing the right anode these concerns will be easily addressed and it will usher in the golden era of EV that will finally live up to the aspirations so many have placed upon the industry. Consumers, automakers, and investors would be wise to be selective about what technology they chose to hitch their wagons to.


Solid State Battery (SSB)
Layer 1 - Negative electrode (High Strength Aluminum Alloy)
Layer 2 - Cathode
Layer 3 - Separator
Layer 4 - GRAPHUL anode (22.5 GPa tensile strength)
Per MIT study, in order to CONTROL DENDRITIC GROWTH
Minimum 200 MPa of force mechanically applied to Layers 2, 3, & 4 within the channel of Layer 1.
SECTION A VIEW
Layer 1
Layer 2
Layer 3
Layer 4
FRONT ELEVATION
TOP ELEVATION
BOTTOM ELEVATION
A
B
SECTION B VIEW
Layer 1
Layer 2
Layer 3
Layer 4
REAR ELEVATION
SIDE ELEVATION
A
B