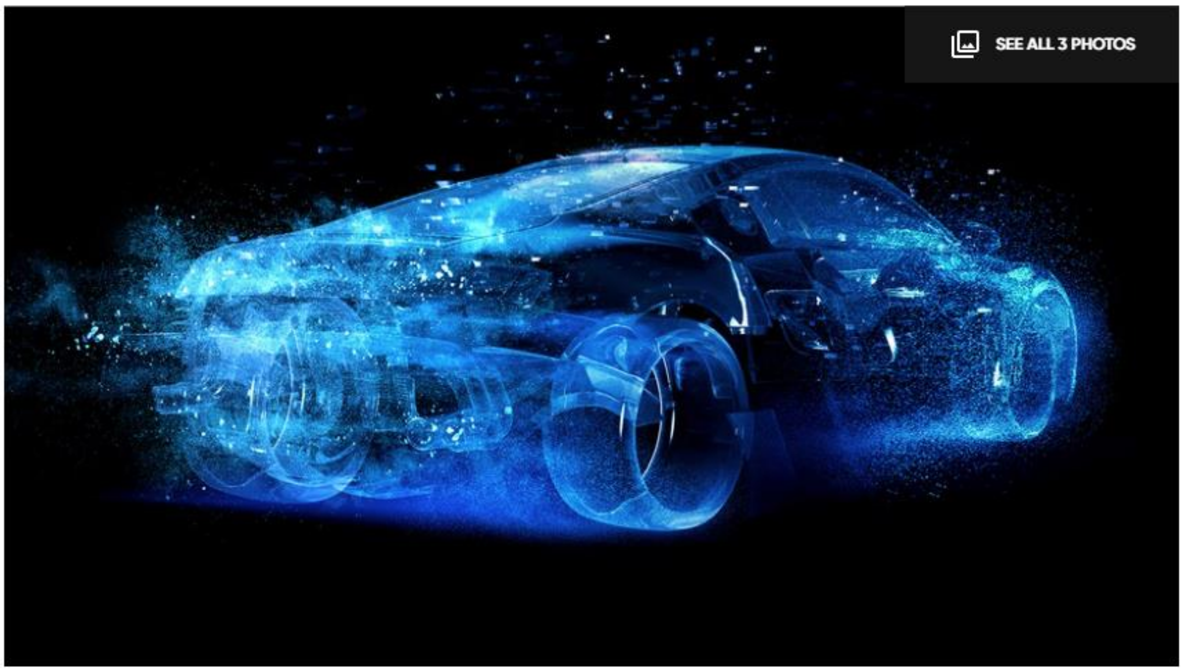
How We'll Get to Cheap, Long-Range, Quick-Charging Electric Cars, Trucks, and SUVs

Some of the recent promising developments we've reported about could be part of the solution.



Frank Markus - Writer; Manufacturer - Photographer; MotorTrend Staff - Photographer | Jan 3, 2022

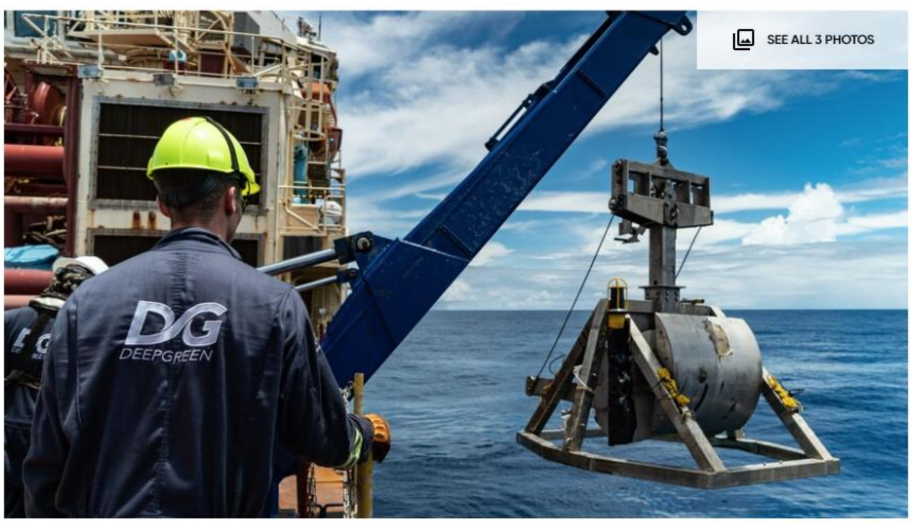
The investment in automotive electrification has ramped up sharply in recent years, with new advances in battery chemistry, motor and controller technology, and charging infrastructure being announced almost weekly. We've generally spared our readers the chemistry lesson required to describe every new battery electrolyte formula to come along, but we've passed along the most novel, interesting, and promising of concepts that promise to advance electrification. Here are highlights from just the past two years.

Maybe Pair Capacitors And Batteries?

Chemical batteries are great at storing energy. They just can't do it extremely quickly. Capacitors can accept and release huge amounts of energy quickly but can't hold this energy for very long. Capacitors on cars aren't new—Mazda introduced its i-ELOOP energy recovery capacitor on the 2014 Mazda6 sedan. But in November 2019 we reported on a joint research effort by Lamborghini and the Massachusetts Institute of Technology, to triple the energy *storage* capacity of ultracapacitors, by replacing the porous activated carbon used in most capacitors with a new powder composed of metal-organic framework compounds comprising primarily of nickel, copper, and molecular carbon that effectively doubles the surface area inside the same volume/mass of powder, which is how it doubles the energy density. Research continues, and although ultracapacitors will likely never replace chemical batteries, this Lambo/MIT ultracapacitor could greatly reduce the mass of the energy-storage battery required, guaranteeing both nimble handling, ferocious acceleration, and track-worthy regenerative braking.

Mine The Seafloor

A perennial and legitimate argument against complete electrification is the question of ethical and environmentally sensitive sourcing of the various metals and other materials required. So in June 2020 we reported on the discovery of naturally occurring polymetallic nodules that line the Pacific Ocean's abyssal deep seafloor in the Clarion-Clipperton zone (lying roughly between Mexico and Hawaii). These potato-sized blobs are typically composed of 29.2 percent manganese, 1.3 percent nickel, 1.1 percent copper, and 0.2 percent cobalt. They form naturally and sit in the silt, where they can be fairly easily scraped up using a drag bucket of sorts. This area is recognized as the planet's largest known source of battery metals and is thought to be capable of supporting production of 280 million EVs. But the metals supply and mining industries are awaiting a green light from various organizations studying environmental impact on fisheries, etc.



The State Of The Solid-State Battery

Solid-state batteries promise to solve myriad nasty battery problems: Liquid or gel electrolytes are flammable and can freeze, so they need costly warming, cooling, and safety monitoring. Additionally, fast charging can result in the formation of lithium metal spikes that can pierce the battery's permeable "separator," short-circuiting the cell. One downside of solid-state is that lithium formation on the anode causes the cell to physically expand, which must be accounted for in the pack design. In December 2020 we reported on California-based QuantumScape's promising new solid-state battery, which claimed to boost range by 80 percent and to function at temperatures ranging from -20 to 80 degrees C, all of which attracted a huge investment from the Volkswagen Group. In the months since, we've reported on Toyota's in-house solid-state battery program, which is likely to see production in hybrid vehicles first, and on Factorial Energy of Massachusetts inking a development deal with Hyundai-Kia, claiming its battery can boost range by 20-50 percent.

Gallium-Nitride Semiconductor Chips To Speed Charging

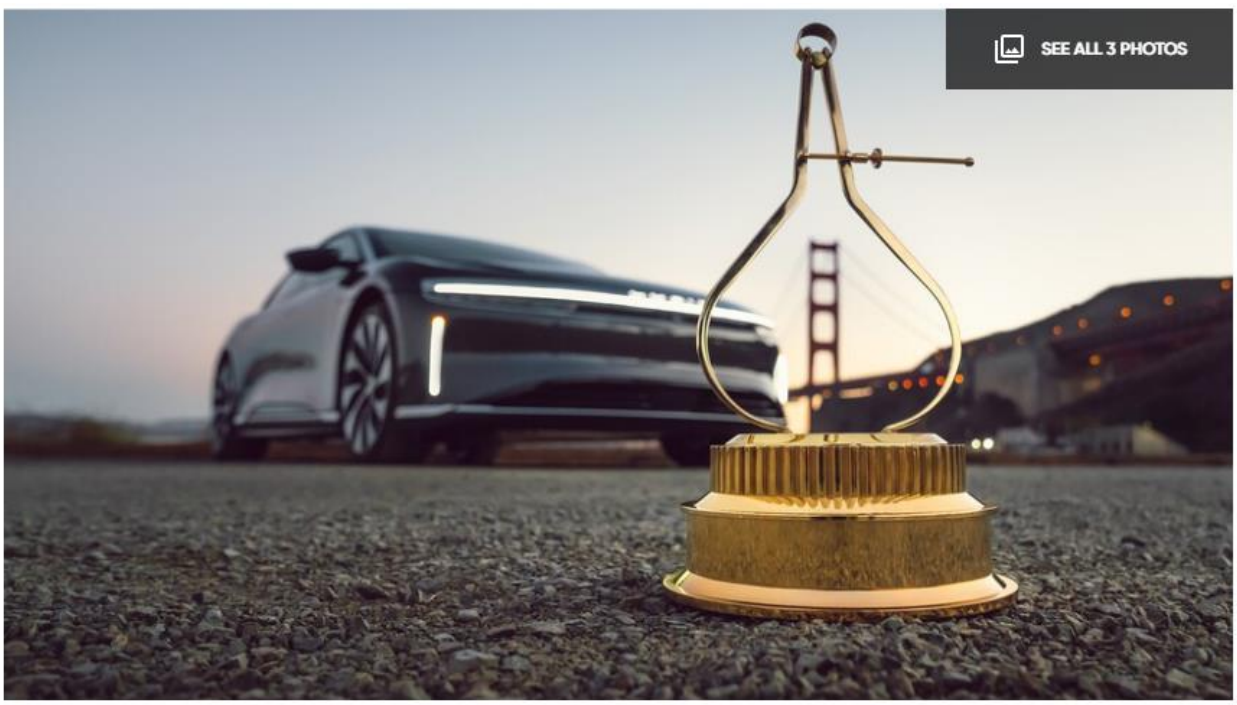
If the long Chipocalypse, currently still crippling auto sales as we write this, has any silver lining, it might be that as the industry tools up to produce more chips, some of that new production can be dedicated to gallium-nitride, rather than silicon-based chips. This semiconductor material, which enabled the first white LED lights and powered Blu-ray disc readers, is able to simultaneously withstand higher voltages and present a smaller resistance to electric current flow relative to either the silicon (Si) or silicon carbide (SiC) materials. Lower resistance means less heat buildup, which can allow smaller devices to deliver greater power flow and faster switching, which in the case of an EV's onboard power inverter can equate to faster charging and/or greater range. Our July 2021 coverage of Texas Instruments and Odyssey Semiconductors GaN chips noted that engineering samples were to be available in late 2021, which should mean production might commence after a few years of development.

"Cylinder-Deactivation" For Electric Motors

It's hard to believe, but the same concept that boosts fuel economy of a piston engine by shutting several cylinders down and making the functioning cylinders work harder can be applied to electric motors, as well. Tula Technologies, the folks who pioneered the Dynamic Fuel Management system in use on more than a million GM trucks and SUVs, has introduced Dynamic Motor Drive. During certain high-speed light-load conditions, where electric motors are not quite as efficient, DMD pulses brief bursts of higher torque to meet the steady-state need, which conserves energy by reducing heat buildup in the rotor core and the power inverter. The power savings are minimal on mainstream permanent-magnet and AC-induction type motors, but they're significant on the cheapest synchronous reluctance motors, which are only used in industrial applications today. The technology promises to eliminate some of the noise and "torque-ripple" vibration that currently disqualifies these motors from EV use. It could also make them more efficient than AC induction and sidestep supply-chain worries inherent in permanent-magnet motors.

Lower Cost Via Simplified Manufacturing

This tech story ran in conjunction with our 2022 Lucid Air Car of the Year coverage, describing the nascent Tesla Model S fighter's many innovations aimed at efficient, lower-cost manufacturing. The battery pack, for example, consists of two injection moldings. One incorporates the sides, top, and all power-delivery busbars, and the other includes the cooling plate. Because this only needs to contact the ends of each cylindrical cell, dramatically less heat-conducting glue is needed than in the radially cooled Tesla packs. The Lucid packs can be robotically assembled in a dark plant. The motor's hairpin-style square-section winding consists of just 24 individual wires that are woven for ease of assembly into the stator and the need for only 24 solder connections. And extreme downsizing of the power inverter, final drive units, and more yield impressive weight savings that pay off in cost and range improvements.



Lithium-Sulfur Triple Threat

Silicon Valley battery-tech company Lyten came out of stealth in September and revealed a battery chemistry boasting triple the traditional lithium-ion batteries' energy storage per pound. That's because a sulfur atom can host two lithium ions, while a typical NMC-oxide cathode can only manage 0.5-0.7 ions. But during charging, those lithium ions sometimes bring sulfur atoms along with them when they migrate to the other electrode, and this depletes the battery. Lyten's secret is to cage each sulfur atom in one of the millions of tiny boxes afforded by their proprietary 3-D graphene sheets. And because carbon is more conductive than sulfur, power flows better than in previous lithium-sulfur batteries. The company says it has demonstrated 1,400 charge/discharge cycles (sufficient for EV use) and that it plans to select a factory site in Q1 of 2022 to support incorporation of LytCells for use in vehicles by the 2025 or 2026 model year. Most experts we spoke with find that timing to be overly optimistic, but perhaps looming local content requirements the USMCA trade agreement calls for in 2023 will inspire overtime development, as all LytCell materials are abundantly available in North America.

"Massless" Structural Batteries

One way to get weight out of battery electric vehicles is to force the batteries to "multitask," by serving as part of the vehicle's structure. Raw, uncoated carbon-fiber strands are great electrical conductors, and because they typically include tiny voids that can easily accept lithium ions, they function well as a battery's negative electrode. Apply a lithium-iron-phosphate/graphene-oxide coating to said fibers, and you've got a structural cathode. Now researchers at Chalmers University of Technology in Sweden think they've found a suitable polymer electrolyte with a cross-linking monomer that enhances the material's structural rigidity while still conducting lithium ions. The team is targeting an energy density about one-third that of mono-tasking dead-weight lithium-ion. Still, studies indicate that replacing roughly 70 percent of the interior and exterior panels and 60 percent of the body structure of a Tesla Model S (85 kWh) or BMW i3 with SBC, should lower mass by 26 and 19 percent with range dropping by 36 and 17 percent, respectively. Alternatively, doubling the thickness and mass of these SBC panels to bring the cars back to mass parity should boost range by 20 percent in the Tesla and 70 percent in the BMW (while adding foot room). Cost estimates for this brand-new technology are not yet available.