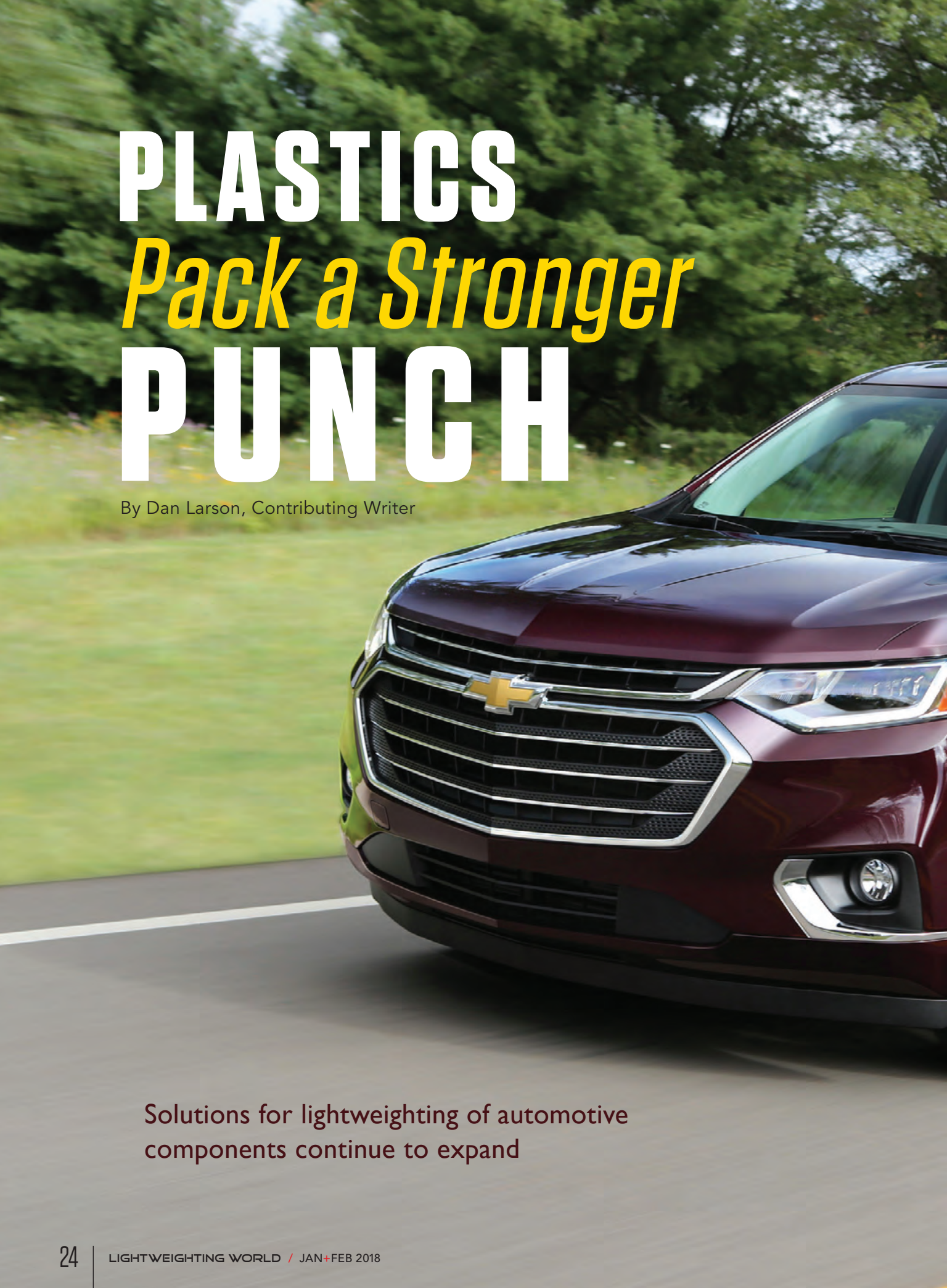


PLASTICS *Pack a Stronger* PUNCH

By Dan Larson, Contributing Writer

Solutions for lightweighting of automotive components continue to expand

The 2018 Chevrolet Traverse, recipient of the SPE 2017 Vehicle Engineering Team Award for its significant use of innovative plastic content.

The automotive industry is charging ahead into a new era, and lightweighting concepts and materials are providing the fuel.

Just around the corner is a world where self-driving cars are efficiently powered by hybrid power plants that integrate electric motors into internal-combustion engine castings, where passenger compartments double as office cubicles, and platoons of long-distance trucks hum down dedicated lanes at speeds exceeding 120 miles per hour.

Leading the way are the established original equipment manufacturers (OEMs), their top tier suppliers and sharp-elbowed tech companies that are right now exploring new ways to reduce weight, improve assembly and repair, and integrate technology into the next version of the automobile.

Our assessment of today's plastics industry reveals that its position as the supplier of a key material for components, safety, materials bonding, design and styling is assured. And, as the market demands vehicles do more than ever, additional onboard technology will require plastics to accommodate the additional mass of that technology without adding weight.

MORE THAN MILEAGE

"Manufacturers have increased use of plastics in cars since the 1950s to save weight without sacrificing strength," says Gina Oliver, senior director, Automotive Plastics Division at the American Chemistry Council (ACC).

"The trend toward lightweighting is here to stay. But in tomorrow's cars, plastics will not be selected for fuel efficiency alone. The technology required for self-driving vehicles, network connectivity, ride-sharing platforms and electrification will require lightweight materials to do much more than just improve mileage."

"We have to home in on new ways to save weight while adding technology. That's the elephant in the room," Oliver says.

Here is a look at the key roles and applications plastics play in design, manufacturing and repair.

SAFETY FIRST

There is a belief that persists among the public that smaller, lighter vehicles are related to increased vehicle fatalities, especially in collisions with larger, heavier vehicles like full-size sports utility vehicles.

Landmark research by the National Highway Traffic Safety Administration (NHTSA) in 1997 claimed that vehicle deaths increased as regulatory pressure to improve fuel economy resulted in smaller, lighter cars.

Follow-up research by the National Academy of Sciences in 2002 concurred and added that the increase in fatalities could be offset by reducing the weight of larger vehicles, specifically those more than 4,000 lbs.

Then, in 2004, Dr. Richard Evans, a recognized auto-safety engineer, published the results of his research that, for the first time, considered the effects of size and weight as separate factors. Evans concluded that vehicle mass was the more significant factor in crash fatalities and that size alone did not necessarily result in greater risk.

According to an American Chemistry Council report, subsequent research found that lightening a SUV by 20 percent reduced injuries by 15 percent, even without extending front and rear crush zones. Injuries to the other driver were likewise reduced by half. When the vehicle crush zones were "extended without increasing weight through the use of lightweight materials, incidence of death or serious injury was reduced by 20 percent," the ACC report states.

Traditional usage of plastics in automobiles has proven to save lives. For more than a half-century, seat belts, made from woven strands of polyester fiber, are reported to save 11,000 lives every year, according to NHTSA. Airbags, made of nylon fabric, reduce the risk of fatality in a frontal crash by about 30 percent. And, child safety seats, made of advanced polymers, are required in all 50 states and the District of Columbia.

A recent example of lightweight material in vehicle safety systems is an expanded polypropylene (EPP) foam in a passenger knee airbag support bracket found on the 2017 Ford Explorer and supplied by ZF TRW.

Replacing a stamped-steel bracket, the EPP foam sustains airbag deployment, according to the company, while reducing mass by 88 percent and cost by 55 percent. The lighter part allowed for further reductions by eliminating two assembly-aid clips, improving ergonomics, improving fuel economy and reducing shipping costs.

A new concept vehicle, jointly developed by BASF and Hyundai Motor Company, combines key plastics solutions from the chemical industry with purposeful aerodynamic design and specialized high-performance technologies.

An advanced four-way head restraint found on the 2018 Ford F-150 pickup was named 2017 Safety Innovation of the Year by the Automotive Division of the Society of Plastics Engineers. (See sidebar.)

The redesigned head restraint uses plastic instead of steel as the primary load-bearing component. Its design geometries uses readily available materials and is reported to save $2.80 per vehicle. Once the design is extended to new vehicle programs, the Gen 3 head restraint will result in a savings of $10.7 million by model year 2020, according to the awards program.

COMPOSITES

Like the arrival of flying cars, carbon fiber (CF) composites are sometimes referred to as the automotive material of the future, and always will be.

However, carbon fiber reinforced polymers (CFRP) offer advantages over light metals in several important applications. Increasingly, designers and automotive engineers are making carbon fiber plastics their material of choice.

In 2010, Amory Lovins, co-founder of the Rocky Mountain Institute in Colorado, said the market will "sort out which materials win for what uses. I don't think metal offers the same strategic advantages to automakers as composites using new technologies, which—when scaled and mature—seem to offer aerospace performance at automotive cost and speed."

"Right now, the door is open to different ideas," notes ACC's Oliver. "There is no one specific plastic or composite that works in every application. Along the continuum of possibilities that plastic and composites can provide, there are virtually limitless solutions. No one can say one type of plastic will be used instead of others."

Carbon fiber is often selected for composites in many applications due to its superior compression strength, high strength-to-weight ratio, rigidity and its low coefficient of thermal expansion.

With the development of carbon-fiber weaves that apply strength in all directions, manufacturers such as McLaren and BMW, among others, have taken the CFRP monocoque chassis assembly from the race track to the production line.

In the high-performance vehicle segment, carbon fiber reinforced polymers have for years provided a foundation on which the competing demands of strength, light weight and protection can be balanced.

For example, the McLaren P1, described in an auto-enthusiast publication as a "land rocket," includes a number of technological advancements in the use of carbon fiber throughout the vehicle.

> "Technology required for self-driving vehicles will require lightweight materials to do much more than just improve mileage." Gina Oliver, ACC

The passenger compartment is enclosed within what the company calls a MonoCage shell. Designed as the major chassis structural component, the carbon-fiber shell is said to have five times the strength of titanium and is twice as stiff as steel. The entire cage, including the roof, engine air snorkel and integrated battery compartment for the hybrid P1 weighs just 90 kg (198.4 lbs.), the company says.

Carbon fiber is used extensively in the interior of the P1, including what McLaren describes as "supremely strong yet comfortable" seats that are mounted on lightweight CFRP brackets and tip the scales at just 10.5 kg (23 lbs.)

The twin-turbo 3.7 L V8 engine is built from a unique block casting that includes a synchronous electric motor. Designed to fill the torque gap while the high-pressure turbos spin up, the electric motor at the heart of the P1's Instant Power Assist System weighs just 26 kg (57 lbs.). Combined, the P1's gasoline and electric motor power plant generates an astounding 916 PS (903 HP) and weighs 1,395 kg (3,075 lbs). Even with a top speed of 217 mph, the company claims the P1's fuel economy is 34 mpg.

BMW also makes extensive use of CF composites in its i3 and i8 models. Both cars are built around a CRFP monocoque passenger compartment and feature carbon-fiber covers and accents throughout the interior. The BMW 7 Series autos were also recognized for pioneering the integration of CRFP, aluminum and high-strength steel into the

McLaren calls the monocoque chassis structure on its P1 "land rocket" model the MonoCage.

passenger cell for increased rigidity while reducing weight. (See *Lightweighting World,* Sept+Oct 2017, page 34.)

The distinctive appearance of carbon-fiber parts on high-performance cars and motorcycles has, in turn, increased demand for covers and styling cues on a variety of mid-market and value models produced by several OEMs.

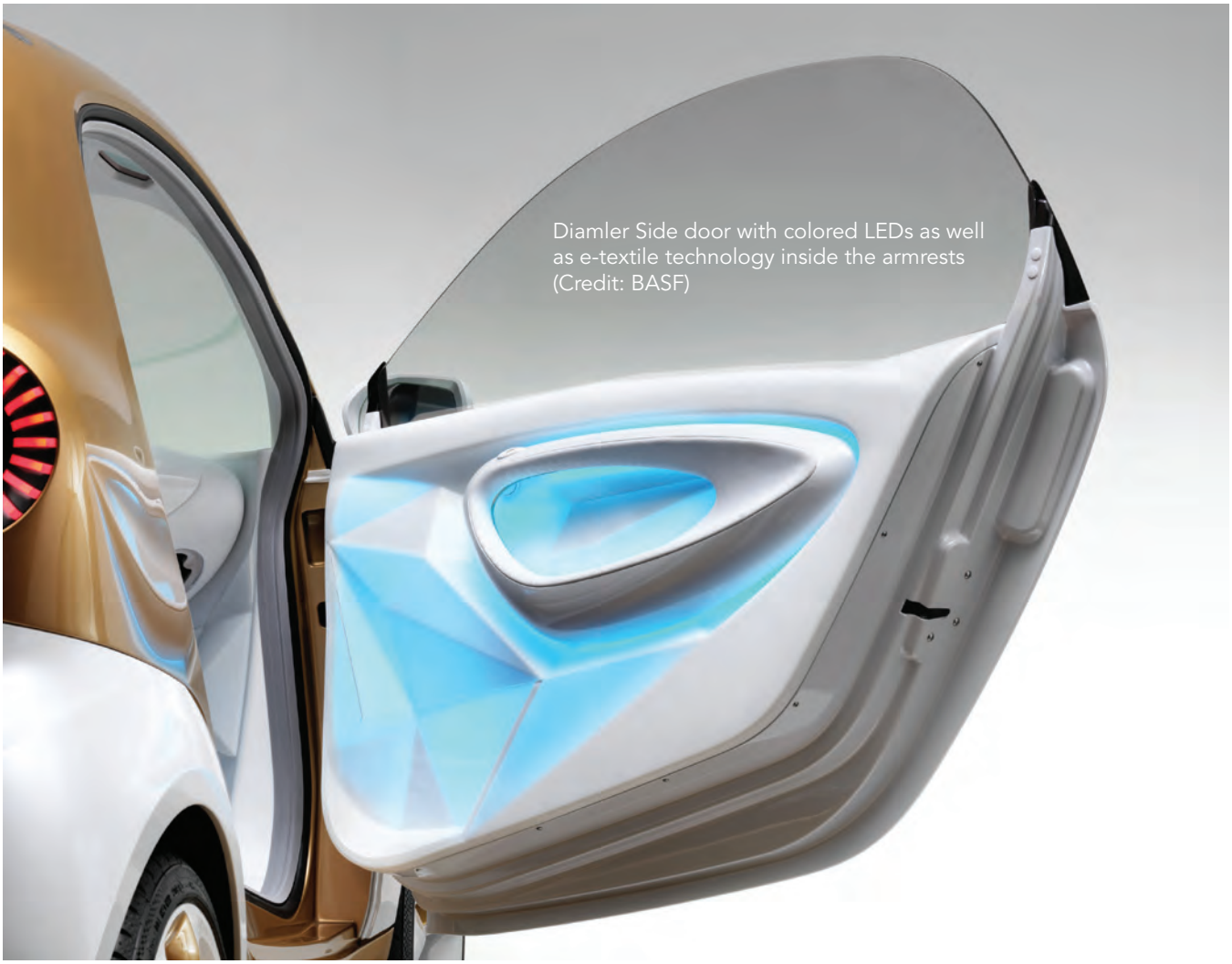
"It really is a stylistic shift," says ACC's Oliver. "Consumers now see CFRP as a premium material, and they want it on their cars. To satisfy that demand, manufacturers are exposing more carbon fiber parts in the interior. We are even seeing some applications made with thermoplastic designed to look like CFRP in places where high-strength material isn't needed."

GROWING MARKET

Overall, the amount of composite materials found in cars and light trucks has grown from an average 20 pounds per car in 1960 to 332 pounds in 2016, the ACC reports. The market for plastic and composite components tops $18.1 billion.

Globally, the thermoplastic composite segment is projected to grow at a compound annual growth rate of 6.75 percent through 2021, according to London-based HTF Group in a report issued in November.

The report asserts that demand for thermoplastic composites is increasing due to "better performance than ther-



Diamler Side door with colored LEDs as well as e-textile technology inside the armrests (Credit: BASF)

Each seat in the McLaren P1, including mounting brackets, weighs just 23 lbs.

moset composites." With their "superior mechanical and physical properties," thermoplastic composites are a better alternative to die castings, metal assemblies and traditional plastic materials. As a result, demand for thermoplastic composites has increased, the report says.

Conversely, further increases in thermoplastic composites may be hampered by their higher price compared to other materials, notes the HTF. "Despite its recyclable capabilities, many end-user industries refrain from using thermoplastic composites. Such lower demand results in prices that are 3 to 4 times higher than other composites."

A regional study of the market for automotive composites in Southeast Asia found that annual growth is projected at a compound 6.5 percent through 2022. Among some of the countries that make up the Association of Southeast Asian Nations (ASEAN), such remarkable growth is attributed to increased auto production and greater demand for lightweight materials to improve fuel efficiency and reduce greenhouse gas emissions, according to Research and Markets, a Dublin-based reseller of market research and analysis.

WEALTH OF OPPORTUNITIES

Advances in fiber-reinforced plastics, materials production and bonding technology are also making headlines across the industry, Oliver observes.

"We are seeing new applications of glass-fiber reinforced composites formed into corrugated panels used in doors and floors," she says. "There are new combinations of fibers, polymers and even metals on the way that give car makers a wealth of opportunities."

Oliver notes that many companies are examining new uses for 3-D printing technology, but predicts that it will find limited use in automotive components and assembly.

"We don't see 3-D printing in the new car plant other than for some tooling applications," Oliver notes. "There are research projects into using 3-D printing to produce an entire car, but that's farther down the road."

In the near-term, 3-D printing will be used to quickly replace a tool or for a replacement part in a repair, Oliver predicts. The supplier sends the shop a CAD drawing, and the part is produced on the spot. Eventually, assemblies will be designed around easily replaceable parts produced on 3-D printers.

GOODBYE FASTENERS

One of the most significant advancements in plastics technology is not that far down the road, Oliver says.

"For the mobility trend to continue, the use of lightweight components made of multiple materials will be essential. The ability to create a reversible bond to join dissimilar materials is what will make it happen."

Researchers at Michigan State University are investigating adhesives that form a high-strength bond between composites and metals, and that can be separated and rejoined as often as needed.

Funded by the U.S. Department of Energy and ACC, the MSU research project involves using electrically conductive nanoparticles embedded in the adhesive that are excited with the application of an electromagnetic field.

"We want joints that are easily and quickly produced," said Mahmood Haq, a researcher at MSU's Composite Vehicle Research Center. "We don't want to have to totally re-tool the assembly lines with a new technology which disrupts current manufacturing practices."

Engine brackets and cylinder head covers made of DuPont™ Zytel® and DuPont™ Zytel® PLUS respectively.

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>
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