Edited by **Ryan Gehm**

Smart materials spur additional design possibilities

An on-demand air dam that deploys without mechanical assistance is just one example of an on-vehicle technology being put in motion through the use of a smart material.

Permanent air dams can be damaged by impacts, but a shape memory alloy-activated air dam (shown) can be lowered or raised, depending on vehicle speed, weather, and other conditions.

On-demand control of airflow into the engine compartment uses a shape memory alloy-activated louver system.

Temperature, stress, or a magnetic field can make a smart material change its shape, strength, and/or stiffness. That means a smart material can move without needing a motor or hydraulics.

Shape memory alloys and polymers currently commercially available include NiTi (nickel titanium) and CuAlZn (copper aluminum zinc). These smart materials offer high stiffness—up to 270 MPa (39.2 ksi)—and strain recoverability up to 8%. In short, smart materials can be induced to change shape and induced to return to their original shape.

General Motors researchers have been using smart materials in the laboratory to accomplish tasks such as moving a grab handle into a hand-clasping position, and partially popping open a vehicle door.

A peek inside a more detailed example illustrates how a short length of shape memory alloy-formed wire becomes the catalyst for a movement task. "To activate a brake or hood release using a shape memory alloy, the energy required is 12 volts at five amps for two seconds—that's like a dome light level of energy. It's a very small amount of energy," said Jan Aase, Director of the Vehicle Development Research Laboratory at GM Research and Development.

The release can be activated manually or by pressing a button to send a current through a wire-formed shape memory alloy section. A by-wire brake release—in comparison to a traditional actuator release—would mean silent operation, less mass, and reduced cost. "The cost of the [shape memory alloy] wire is approximately $1.50 per meter, and most applications use significantly less than a meter," said Alan Browne, GM Technical Fellow and researcher.

GM researchers also developed an on-demand, situation-dependent active louver to control the airflow into the engine compartment. "There are solutions that we've looked at that are motor-driven, but with a smart material we'd have re-

A grab handle moves into position through a combination of temperature and stiffness changes to the shape memory alloy.

duced cost and reduced mass because a motor wouldn't be needed," said Nancy Johnson, Lab Group Manager, Vehicle Development Research Laboratory at GM Research and Development.

The smart material-operated louver, which would be located between the grille and radiator, is heat-activated. The heat contracts the shape memory alloy, which in turn rotates the louver blades to an open position. "It is possible to use the underhood temperature as the basis for the louvers opening, meaning that when the underhood temperature reaches a pre-determined temperature, the louvers would open," said Johnson.

A March media event at GM's Warren, MI, Research and Development Center served as a showcase for seven different smart material-adapted technologies. "What you're seeing today are affordable solutions that differ from the conventional approach," said Alan Taub, Executive Director of GM Research and Development.

GM officials would not specify which applications might move from a conventional to a smart-materials production solution, but the company is now testing and validating smart materials on prototype vehicles. "We expect to see these types of applications in production by model year 2010," Aase said, referring to brake and hood release, active louvers, remotely controlled glove box, active grab handle, on-demand front air dam, smart opening door, on-demand rear spoiler, as well as other examples.

So far, GM has received 42 U.S. patents, and an additional 175 U.S. patent applications have been filed relating to usage of smart materials. While first-generation production releases will be examples of the device being designed around the smart materials, second-generation production applications will enable new design opportunities, such as self-healing body panels. "The future of smart materials will be the frontier of 'not-just-replacing motors,'" said Taub.

Kami Buchholz

Transparent concept plays with plastic

The body and floor of the new **Rinspeed** eXasis concept car, which was revealed last month at the Geneva Motor Show, are made of **Bayer MaterialScience**'s Makrolon polycarbonate (PC). Developed by Rinspeed boss Frank M. Rinderknecht along with Bayer experts, the "cigar-shaped" two-seater features an engine and aluminum chassis that are exposed under the transparent plastic shell.

The Rinspeed eXasis concept car features a body and floor made of Bayer MaterialScience's Makrolon polycarbonate. The two-seater has a mass of 750 kg (1650 lb).

With a mass of 750 kg (1650 lb), the eXasis is propelled by a 750-cc, two-cylinder **Weber** engine. Its average fuel consumption is 6.3 L/100 km of bioethanol E85, and CO_2 emissions amount to 20 g/km (compared to about 200 g/km for a typical mid-class car). According to Bayer, the Swiss Federal Office for Energy has selected the concept car as the subject for a study on the topic of "lightweight construction and ecology."

"Cars must become even lighter to save CO_2, and you can't achieve this without modern plastics," said Ian Paterson, member of the Bayer MaterialScience Board of Management, responsible for Marketing and Innovation. "Just as important, environmentally compatible cars must be seen as fun, otherwise no one would buy them."

The outer Makrolon PC shell is molded by the Swiss firm **Mecaplex** and coated yellow by German hard coatings specialist **KRD**. The load-bearing aluminum chassis construction features a Lesonal chrome-effect finish based on Bayer's Desmodur and Desmophen polyurethane raw materials. To finish the surfaces of the knobs and levers, Bayer experts used a soft-touch polyurethane coating formulated from the high-grade, waterborne coating raw materials Bayhydrol (polyurethane dispersions) and Bayhydur (hydrophilic polyisocyanates).

The car's two seats were designed in cooperation with **Recaro**. Each seat consists of 12 transparent Makrolon PC ribs. The head restraint and armrests are made of transparent Technogel, a lightfast, elastic, and plasticizer-free polyurethane gel that feels soft and warm. The **Hightex/Sellner Group**, which specializes in interior design, was responsible for the futuristic seat coverings and the design of the fabric-covered steering wheel. The company also was responsible for the application of aluminized glass fiber material with a diamond-shape design on the wheel rims, trim, wishbones, fuel tank, and headlamps.

Two transparent indicator and function displays "hover" on both sides in the driver's field of vision. Each of the touch panels is made of a transparent CD/DVD Makrolon PC blank that has been coated with electrically conductive Baytron P polymer to trigger the switch functions. The displays were developed by Swiss safety and closure system specialists **Kaba**. The personalized access system to the car is also integrated into the touch panels.

Under the hood of the eXasis, cables are sheathed with flexible, abrasion- and media-resistant Desmopan thermoplastic polyurethane.

"With the new concept car, we wanted to demonstrate that our plastics are tailor-made materials that are suitable for both current trends in automotive design and assembly line production," said Hans-Peter Neuwald, spokesman for the AutoCreative team, which coordinates global automotive activities for Bayer.

Ryan Gehm

briefs

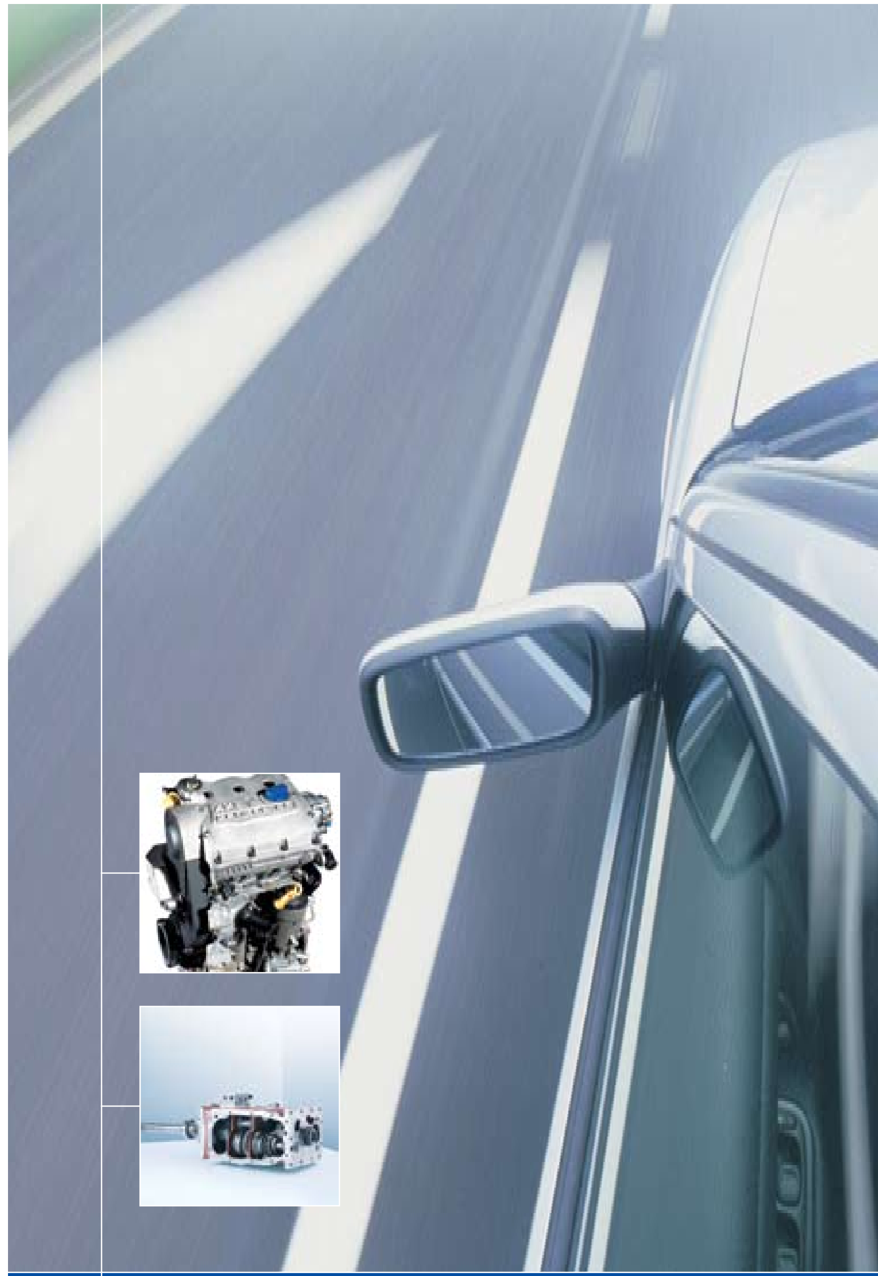
Aluminum suppliers have been busy announcing their contributions to new advanced-technology and production vehicles. **Alcoa** fabricated more than 300 aluminum structural components and built the bodies-in-white (BIW) for the **Chevrolet** Sequel fuel-cell vehicle. Working with **General Motors**, Alcoa supplied aluminum sheet for stampings, castings, and multi-hollow extrusions for the Sequel's BIW and chassis structures. The company also provided aluminum sheet for GM's quick plastic forming process, large blanks for the Sequel's outer body panels, cast front and rear subframes for the vehicle, as well as its hydrogen fuel carrier system.

Alcan will supply the new **Citroën** C4 Picasso family with its advanced aluminum front bumper system. Produced at Alcan's Automotive Structures plant in Gottmadingen, Germany, the bumper's crash management system is composed of six welded parts; its crash boxes use tailored extrusions to provide high energy absorption.

Novelis has been selected as the lead supplier of aluminum sheet for the new **Audi** R8 sports car. Novelis material will be an integral part of Audi's "intelligent lightweight construction technology," and will be used in the hood, roof, fenders, doors, and some internal components of the R8. Novelis also is supplying aluminum sheet for the hoods of the 2007 **BMW** X5 and 2007 **GMC** Acadia.

Yokohama Rubber has developed a process that combines citrus oil with natural rubber to form a new compound called Super Nanopower Rubber (SNR). The compound reduces the use of petroleum products in tires by 80% and is part of Yokohama's global EcoMotion environmental program. The first SNR product is the Decibel Super E-Spec, a new consumer passenger tire that features an air permeation suppression film. This polymer inner lining is designed to reduce air from seeping out of the tire, helping to maintain appropriate inflation levels. Said to conserve gasoline by reducing rolling resistance by 18%, the E-Spec tire featuring the SNR compound will be available in Japan later this year. No date has been determined for its release in the U.S. market.

Ford, with help from **Henkel**, has produced the industry's first production vehicle using a non-phosphate Bonderite conversion coating process. This technology is said to streamline vehicle assembly paint pretreatment operations and reduce the environmental impact from the manufacturing process, including a reduction of VOC (volatile organic compound) and CO_2 equivalent emissions.




GO FROM THIS
TO THIS

GE steers toward safety

Steering wheels are typically made from die-cast alloys and foams, but soon the in-vehicle interface for making lane changes and sharp turns will be made of a nearly cold-proof plastic.

Engineers did a chemical re-mix of an existing resin so that the resulting engineered plastic—a polycarbonate copolymer—could withstand impacts at cold temperatures. "Lexan EXL's chemical makeup allows the end use application to have ductile performance—where it stretches but does not break into little pieces—down to -30°C," said Robert Nelson, Automotive Marketing Director at **GE** Advanced Materials, Automotive.

The creation of a material that would not shatter into sharp-edged pieces on impact addressed important criteria. "This is a new material for use in safety applications. There was a stringent list of tests that needed to be completed for the validation of safety-orientated applications," said Nelson.

The Chevrolet Volt concept car features many new technologies, including the debut application of a steering wheel and airbag chute made of GE Plastics' Lexan EXL.

Being able to meet hot and cold ductility and impact performance requirements was crucial to Lexan EXL being chosen for a steering wheel and its corresponding integrated airbag chute on the **Chevrolet** Volt concept vehicle, which debuted at the 2007 North American International Auto Show in Detroit.

GE Plastics' Lexan EXL steering wheel, namely the armature and hoop structure, is complemented by an integrated chute made of Lexan EXL. "We replaced a multiple part assembly that included panel outer, panel inner, steel reinforcement, airbag module, and connector," said Nelson.

Current integrated airbag chutes are a combination of steel, reinforced plastic, metal, textile meshes, and the accompanying fasteners. The Lexan EXL chute, which employs injection molding and vibration welding processes, reduces the total part count by about 75%.

"For steering wheels made of Lexan EXL, significant weight reduction is possible. And there are environmental benefits because of the elimination of thermoset urethane foam," said Nelson. Although mass may vary, a typical steering wheel using Lexan EXL is approximately 1 kg (2.2 lb), while a typical Lexan EXL airbag chute is between 1 and 2 kg (2.2 and 4.4 lb).

Compared to current magnesium-urethane steering wheels, the Lexan EXL steering wheel provides a 15 to 20% cost savings as well as a 30 to 40% weight reduction, according to GE Plastics estimates.

GE Plastics representatives anticipate that Lexan EXL steering wheels and integrated airbag chutes will make a production vehicle debut as early as 2009. As for the next evolution of Lexan EXL, "We are continuing to look for additional interior and structural applications where impact performance and durability are requirements," said Nelson.

Kami Buchholz