Automotive Technologie in Bavaria +e-Car

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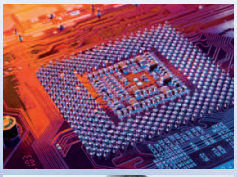



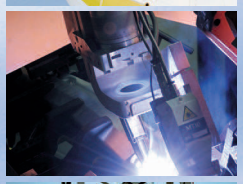


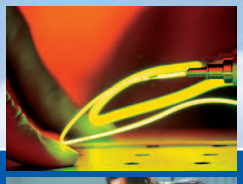


... encountering the future.

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Today's knowledge for tomorrow's innovations

Dr. Bernd Martens

AUDI AG
Board Member
for Procurement

Gateway to innovations

Innovation is what powers our economy. We at Audi know that it is imperative to promote it – passionately, every day, at every workplace. We in the Procurement division see ourselves as the gateway to innovations from the mid-corporate sector. Because there are many challenges that we solve in partnership with our suppliers. This is a process where we debate and shape; we show foresight in involving our partners through innovation forums and concept competitions – to our mutual advantage, with respect for each other's contribution, and with the goal of offering our customers that edge for which Audi is renowned.

We are competing together – on a worldwide scale. 2014 will be the first year in which Audi will build more cars internationally than in its home country. By 2016, we will have 14 factories operating around the world. That will generate growth here, too: Last year, we created 3,000 new jobs in Germany alone – most of them in Bavaria. And many suppliers from Bavaria are involved in our process of delighting customers in other countries. Procurement plays a key role in it. For instance, we have familiar partners from back home involved in a wide variety of aspects of our new plant in Mexico: the development of the plant, the Audi Q5 vehicle project, and the creation of new sources for local content. We are exploring new horizons that will keep us focused on the future – including at home in Bavaria, a hub of innovation.

The vehicle of the future

The automotive industry is looking back on a history of unrivalled success. But which features will characterize the vehicle of the future? Carmakers and automotive suppliers will contribute significantly by coming up with more innovative developments. Bayern Innovativ GmbH offers tailored services to support them in managing their innovations. Bayern Innovativ showcases trends and developments around the vehicle of the future during a congress in the BMW Welt in Munich.

Personal mobility habits are changing. Megatrends such as globalisation, urbanisation, individualisation, connectivity, new ecology and the demographic development have a major impact on people's mobility behaviour and on the products of the automotive industry. Change is driven above all by issues of customer-specific, technological, legal/political, ecological and economic relevance – challenges which car makers had to face repeatedly in the past. What is new, however, is the speed with which these changes are taking place. ■

The driver of the future has outgrown the machinist of the past. Infotainment, assistance systems and a comfortable interior allow the driver to perform of number of tasks while driving ■

Individual – the customer

The needs and expectations of customers are the major motors of innovation. They ultimately decide whether a product is discontinued on the market or not. The wish to be mobile is just one of many criteria that influence the decision to buy a vehicle. This is because vehicles have always been used to represent different lifestyles, too. „A car is a statement and each time we buy a car, we are making a decision as to how we are being perceived by others – a bit more agile, a bit better-off or a bit more sensible," concludes Prof. Lutz Fügener, a renowned designer from the University of Pforzheim. In his opinion, vehicle design and new mobility concepts can assure that cars will continue to appeal to young target groups, even though the latter's affinity for cars is in fact declining.

Dr. Karlheinz Steinmüller, Scientific Director of Z_punkt GmbH, goes even further. He is convinced that the multimobile people of the future will not consider travel time as wasted time, but rather as quality time that can be used in many ways. Advanced functionalities, infotainment and comfortable vehicle interiors allow the driving time to be spent productively, even while stuck in a traffic jam. Alluring vehicle interiors become feel-good spaces featuring a light aspect, comfortable lighting, jointless design, transparent, coloured or decorative surfaces and natural materials. The focus is on properties such as value, genuineness, quality and sustainability with a view to usage concepts such as car sharing as well as ruggedness. ■

Mobile and flexible

Individual lifestyles and flexible working environments are two factors that contribute to the change affecting traffic demand. People are looking for intelligent solutions to make them mobile and flexible. Young adults in particular are causing a shift in the

mobility behaviour: „Metromobile“ travellers use and combine different means of transport to suit different purposes, relying on increasingly complex mobility services. „The future is multimodal,“ says Dr. Steinmüller. He is certain that the boundary between public and individual traffic is becoming blurred.

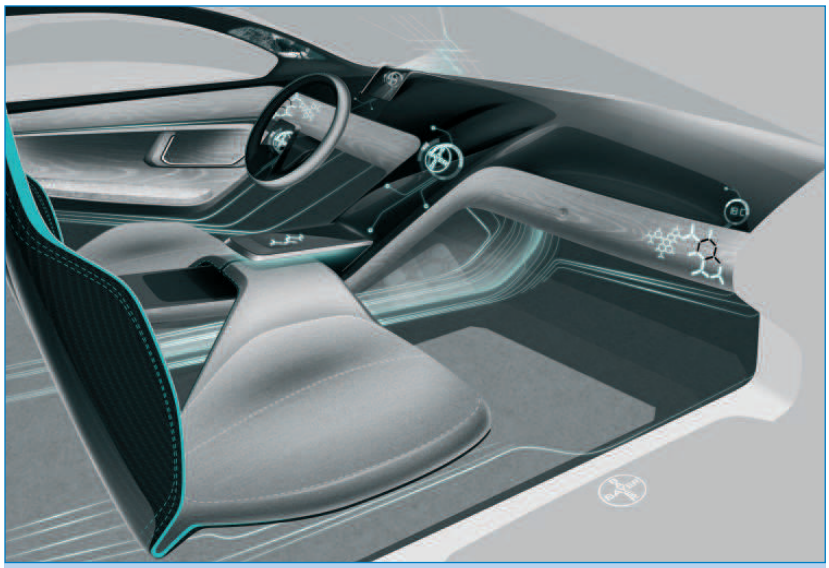
User friendliness has top priority in the networked smart mobility solutions of the future. Information technology is the key. It enables the joint use of common means of transportation – from bus and underground to electric vehicles. Mobile smart devices provide the right information in the right place at the right time.

Prof. Markus Lienkamp, head of the vehicle engineering department at Technische Universität München, is convinced that the years from 2020 and 2025 will see a massive transition towards electric vehicles. The vehicle expert believes that this change will not be driven by more stringent governmental regulations, but rather by rising mobility costs for users. „Laws to reduce carbon emissions will lose importance, whereas mobility offers including electric vehicles will be on the upswing.“ ■

Technology as the driver

The progress made in technologies, design and mobility concepts regularly delivers answers to megatrends and assures that cars will continue to be attractive for different customer groups worldwide. Some OEMs and suppliers are taking somewhat unusually approaches when developing innovative components. Leoni-Bordnetz-Systeme GmbH, for instance, are using bionics to investigate new approaches to develop on-board systems. „A vehicle equipped with multiple assistance systems can basically be compared to a living being,“ says Dr. Wolfgang Langhoff, Vice President of R&D Global of Leoni Bordnetz-Systeme GmbH. „Both have to coordinate huge volumes of information and power transmission paths with utmost efficiency; data transfer must be as robust and fault-tolerant as possible to keep up overall system operation in the event of malfunctions or „injuries“. And they must include an appropriate number of redundancies to ensure vital functions“.

Today, electrics and electronics are the major enablers of innovation. The annual growth rate in this sector is six percent with software, semiconductors, displays and drive control systems leading the list with growth rates of around eight percent. ■



Drivers are increasingly valuing the individual design of the interior Bayer MaterialScience has developed an integrated design concept to this end ■

"Swipe and Zoom"

Efficient electrics and electronics are basic requirements for one of the most important trends in the automotive industry today: automated driving. The consumer goods and entertainment industry is providing important stimulus in this context: „Swipe“ and „zoom“, for instance, are far more than just gestures. „The driver's function in the car of the future is no longer that of a machinist as in the past,“ explains Guido Meier Arendt, Ergonomics Expert of Continental AG. The car is adapting to his changed expectations and requirements. Electronic systems give him the freedom to perform various tasks while driving.

Being one of the largest automotive suppliers worldwide, Continental AG is pursuing a clear-cut agenda to implement driving functions that are party, highly and fully automated. Continental develops and produces systems for automated driving functions and for adequate control functions. Systems for driver modelling, touch-sensitive surfaces, new strategies of attraction and

Additive manufacturing is about ready for series production. KOR aims to produce a vehicle that is nearly entirely 3D printed: URBEE2 ■

gesture control as well as drowsiness detection are crucial in this context.
The BrainDriver project run by the Berlin-based AutoNOMOS GmbH is a visionary experiment in human-machine interface (HMI) technology. A driver equipped with EEG sensors is steering the car by thinking control commands such as „brake“ or „drive left“. These commands generate typical brainwave patterns which are interpreted by a computer. „It will be some time, however, until automatically driven cars are actually roadworthy. But robotic experts anticipate that by 2030 at the latest the traffic will have been fully adapted to autonomous vehicles,“ predicts Patrick Vogel, CEO of AutoNOMOS. ■

Printed cars

The vehicle of the future will not only be influenced by innovative vehicle engineering, but also by production innovations. Additive manufacturing, for instance, a prototype technology until now, is on the threshold of mass production. „The major benefits of additive manufacturing lie in the possibilities to customize products and components, to manufacture parts in small batches, to integrate numerous simple components into a few highly complex parts and to work without tools,“ explains Jim Kor, President of Kor Ecologic from Canada. His company aims to produce a vehicle that is nearly completely 3D printed: URBEE2. Combing parts in one single component drastically reduces assembly requirements. Production steps become redundant, allowing complex objects to be fabricated in a single production step. Decentralised manufacturing structures create more flexibility, increased efficiency and minimum inventories.
This also applies to spare parts which can be manufactured as needed on 3D printers directly from the software near the site of usage. Another advantage of additive manufacturing is the fact that different parts can be manufacture on one machine. „Ultimately, additive manufacturing opens up a freedom of design unparalleled so far. Good design enables creating more lightweight and robust parts with complex geometries,“ Jim Kor explains. Bionics serves as the model here as well. ■

Committed to sustainability

Sustainability, which has its origins in the green movements of the 80ies, is today seen as a responsibility of society and is also a part of automotive future viability.
This mega trend has been accelerated considerably by the soaring oil price and the carbon discussion. In order to be marketable, products developed in all industries have to be designed in line with sustainability aspects. BMWi emphasizes ecological aspects both in the development of the drive and the selection of materials. „Driving with zero emissions is not enough,“ points out Benoit Jacob, head of BMWi Design of BMW AG. "Our i-models therefore integrate particularly many renewable and recycled materials. Some fabrics are made from the fibres of PET bottles. ■

Vision of networked living

Jens Redmer, Business Development Manager with Google, is certain: „The future is now.“ In fact, there is an abundance of technological options to network our life in various areas using intelligent technologies and state-of-the-art IT and communication technologies to improve the quality of living of people and the quality of industrial locations.
„Smart Cities“ are making use of new digital options to create a comfortable urban environment for citizens. The information and communication technology assumes a key role in connecting vehicles, households, companies and other facilities to the corresponding high-performance networks.
„Smart Grids“ are one example – intelligent power grids that combine the use, generation and consumption of electricity based on demand and consumption in an efficient and intelligent way. Traffic solutions are enabled by networking vehicles with each other and with the traffic infrastructure. Real-time traf-

The symposium "Das Automobil der Zukunft" (car of the future) on 7 and 8 July 2014 brings together decision-makers from all sectors of the automotive industry ■

fic data help, for instance, to warn about accidents, prevent traffic jams, reduce emissions or to find a free electric car charging station.

On the whole, the networked life of the future promises to facilitate everyday life and make it more flexible to increase the quality of living. ■

Solutions for the future

A study conducted by the Oliver Wyman consulting agency, however, shows that the majority of today's car innovations are still based on the ideas and dreams of engineers. Innovations are frequently unsuccessful, because manufacturers and suppliers know too little about future market developments and customer preferences and also neglect innovation marketing, with only one in six innovations offered being actually sold today. Around 40 percent of all investments go into innovations that never make it into a serial car or which can never be produced in sufficient volumes because they lack acceptance with car buyers. Of the remaining 60 percent, 20 percent are spent on the necessary series development. Another 20 percent go into innovations that merely fulfill statutory provisions but do not distinguish the product. This means that only 20 percent of investments in innovations are actually profitable.

„The digital age calls for new approaches. Market research must face these new challenges," says Frank Härtl, Head of Automotive Germany, Consumer Experiences Gfk. „No other industry requires a comparable networked approach that spans the mega topics of mobility, energy and 'city of the future' like the automotive sector," Prof. Werner Klaffke, CEO of Bayern Innovativ, describes the requirements for developing future mobility solutions.

Bayern Innovativ aims to boost the dynamic development of innovations particularly in small- and medium-sized companies. For this purpose, Bayern Innovative selectively connects potential cooperation partners from various industries and technologies, bringing together stakeholders from industry and science at all levels of the value chain. Bayern Innovativ supports its customers with tailored services to close existing gaps in technologies, supply chains and distribution channels. The networks of Bayern Innovativ GmbH presently comprise some 80,000 professionals from 40,000 companies and research institutes and 80 partner network organisations. The activities centre on digitalisation, energy, health, material and mobility – five focal areas with significant future potential. Platforms such as the symposium „Das Automobil der Zukunft" (car of the future) on 7 and 8 July 2014 allow promoting new innovations in cooperation with the decision-makers from these sectors. ■

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Emotion, dynamism and high-tech – The new Audi TT

- *Audi TT and Audi TTS celebrated world premiere at Geneva Motor Show*
- *Compact sports car impresses with its design and driving dynamics*
- *Member of the Board of Management for Technical Development, Prof. Dr. Ulrich Hackenberg: "Offering drivers a technology experience that is even more compelling"*

The third generation of the compact sports car is again captivating, with its emotional design and dynamic qualities. The new Coupé is characterized by the use of innovative technologies in its engine and in its control and display concept, including the Audi virtual cockpit.

"The Audi TT is the epitome of an authentic design icon and a top-performance driving machine," explains Prof. Dr. Ulrich Hackenberg, Member of the Board of Management of AUDI AG for Technical Development. "With the new generation, we are making this technology even easier for the driver to experience – just as they would expect from a real sports car. ■

Audi TT Coupé ■

Body

Lightweight construction is one of Audi's greatest areas of expertise. The second-generation Audi TT already featured an Audi Space Frame (ASF) body made from aluminum and steel. For the new TT, Audi has systematically taken this composite construction principle even further, in line with the idea: the right amount of the right material in the right place for optimal functions. The Coupé's underbody structure has optimized axle loads and is made of modern, high-strength and ultra-high-strength steel alloys. In the sections of the passenger cell that are subject to the most structural stress, form-hardened steel panels, which are both ultra-high- strength and light are used – these constitute 17 percent of the body's weight. The side sills and roof frame are made of extruded aluminum profiles that are integrated into the structure using cast aluminum nodes. This structural principle creates a very rigid and safe bodyshell. The aluminum side sections and roof complete the structure. The hood, doors and trunk lid are also made of this light metal. All in all, the Audi engineers have, for the second time in a row, succeeded in significantly reducing the unladen weight of the Audi TT. At the first model change in 2006, up to 90 kg (198.42 lb) were saved, and the 2.0 TFSI engine variant of the new TT weighs just 1,230 kg (2,711.69 lb). This makes it around 50 kg (110.23 lb) lighter than its predecessor. The low overall weight is further proof of Audi's expertise in lightweight construction. It impacts positively especially on acceleration, handling and fuel consumption. ■

Interior

Clearly structured volumes with a taut surface and light, almost floating lines – the interior is the embodiment of the new Audi TT's pure sports car character. As with the exterior, horizontal lines and surfaces emphasize the

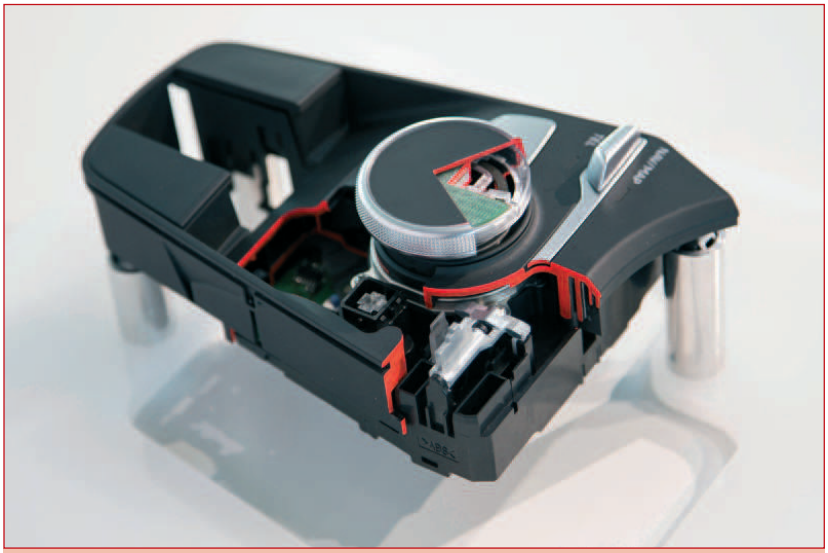
Audi TT – interior ■

width of the interior. The center tunnel console, which supports the calves when driving fast through bends, and the door panels have similar flowing shapes. The rule was once again: "less is more." Clear, purist lines underscore both the lightness and the uncompromising sportiness of the Audi TT's interior. Two other ingenious design and technically innovative tricks enabled the designers to create an instrument panel that is impressively slender: The instrument cluster and the MMI screen have been combined to form a central, digital unit – the so-called Audi virtual cockpit. In addition, the controls for the air conditioning system are positioned directly in the air vents. Seen from above, the instrument panel resembles the wing of an aircraft; the round air vents – a classic TT feature – are reminiscent of jet engines with their turbine-like design. The vents also contain all the controls for the standard air conditioning system and the optional automatic air conditioning system (standard in the TTS). The controls for seat heating, temperature, direction, air distribution and air flow strength are located at their center; the setting selected is shown on small displays in the automatic air conditioning system. The horizontal control panel is located under the central air vents. The 3D-designed toggle switches activate the hazard warning lights, Audi drive select and the assistance functions. The standard sports seats in the new Audi TT have integrated head restraints and are positioned lower than in the predecessor model. Compared with the seats in the predecessor model, they are more than five kilograms (11.02 lb) lighter. As an option – and as standard in the TTS – there are newly developed S sport seats with highly contoured and pneumatically adjustable side sections that are exceptionally comfortable and provide excellent support.

The new multifunction steering wheel has a flattened rim, and aluminum-look clasps encompass the spokes. It also has a driver airbag that takes up 40 percent less space without compromising safety, and hence emphasizes the sense of visual lightness. Countless details demonstrate the high standards which Audi places on interior design and craftsmanship. They include the newly designed, split gear lever, the very precisely engaging MMI rotary pushbutton and the finely finished loudspeaker covers with light guides in the optional Bang & Olufsen sound system. As a 2+2 seater, the new Audi TT is a sports car that is highly suitable for everyday use. The trunk has a capacity of 305 liters (10.77 cubic ft), which is 13 liters (0.46 cubic ft) more than before, and can be extended by folding the rear seat backrests forward. ■

Controls and displays

The operating concept for the new TTS has been revised from the ground up – in line with the consistent sports car character, all the elements focus on the driver. There are two variants of the multifunction steering wheel available. Drivers selecting the top version can activate almost all functions from the steering wheel without taking their eyes off the road. The second control unit is the likewise newly devel-



Audi TT – cross section MMI panel ■

Audi TT - interior: Audi virtual cockpit ■

oped MMI terminal on the console of the center tunnel. Two toggle switches activate the navigation/map, telephone, radio and media menus. There are two buttons on both sides of the central rotary pushbutton, supplemented by a main menu and a back button. The driver can easily enter destinations using the touchpad on the top of the rotary pushbutton (from the Connectivity package upwards) – the MMI touch recognizes your personal handwriting. It is also possible to scroll through lists or zoom in on maps. The menu structure of the MMI resembles that of a smartphone, including the free-text search. All important functions can be accessed directly. One special highlight is the MMI direct search. This enables you to start writing immediately when navigating, without having to use a set form. In most cases, inputting four letters is enough for you to see relevant destinations throughout Europe. The two side buttons activate context-dependent functions (right button) and options (left button). The operating logic is easy to understand and conveys a completely novel "joy of use." Alongside the operations possible using the control panel, the Audi TT offers a further possibility: the voice control system. Audi is also breaking new ground in this area, too. For the first time in the Audi TT, natural voice controls are used that enable simple commands – such as "Take me to Munich" or "I want to talk to Sabine" – to control the vehicle systems without having to take your hands off the steering wheel. Instead of the conventional analog displays, the new TT has the Audi virtual cockpit on board – this fully digital instrument cluster sets new standards with its dynamic animations and precise graphics. Drivers can choose between two display modes: In the classic view, the speedometer and rev counter are in the foreground; in "infotainment" mode the virtual instruments are smaller. The space that becomes free as a result provides ample room for other functions, such as the navigation map. In the Audi TTS there is a third, sporty mode. Here, the centrally positioned rev counter dominates the display. With a resolution of 1,440 x 540 pixels, the 12.3" TFT screen boasts brilliantly sharp images. At work in the background is a Tegra 30 graphic processor from market leader Nvidia's Tegra 3 series. At the lower edge of the Audi virtual cockpit, the displays for outside temperature, time and mileage are permanently visible. Warning or information symbols may also appear there. ■

Engine

(All consumption and output figures are provisional)

Audi offers the new TT and TTS with three different four-cylinder engines with turbocharging and direct injection. Their power output ranges from 135 kW (184 hp) to 228 kW (310 hp). The two TFSI gasoline engines and the TDI combine athletic power with trailblazing efficiency. The start-stop system is a standard feature. For the launch of the TT, the 2.0 TDI will be available with manual shift and front-wheel drive. It delivers 135 kW (184 hp) and torque of 380 Nm (280.27 lb-ft). The new sports car can thus accelerate from 0 to 100 km/h (62.14 mph) in 7.2 seconds and reaches a top speed of 235 km/h (146.02 mph). Standard fuel consumption is a mere 4.2 liters per 100 km (56.00 US mpg), which translates into CO2 emissions of 110 g/km (177.03 g/mile), a new record low level in the sports car world. The 2.0 TDI features two balancer shafts in the crankcase, adjustable camshafts and a common rail injection system delivering maximum pressure of 2,000 bar. The Audi TT 2.0 TDI meets the Euro 6 standard and, thanks to its high efficiency, bears the "ultra" label. The 2.0 TFSI is available in two versions – a 169 kW (230 hp) version for the TT and a 228 kW (310 hp) version for the TTS. In both versions it unites various ultramodern technologies – the additional indirect injection supplementing the direct injection of the FSI, the Audi valvelift system (AVS) to adjust the valve stroke on the exhaust side and thermal management, which uses a rotary valve module and an exhaust manifold integrated into the cylinder head. In the Audi TT, the 2.0 TFSI delivers torque of 370 Nm (272.90 lb-ft) from 1,600 to 4,300 rpm. It accelerates the Coupé – which has a six-

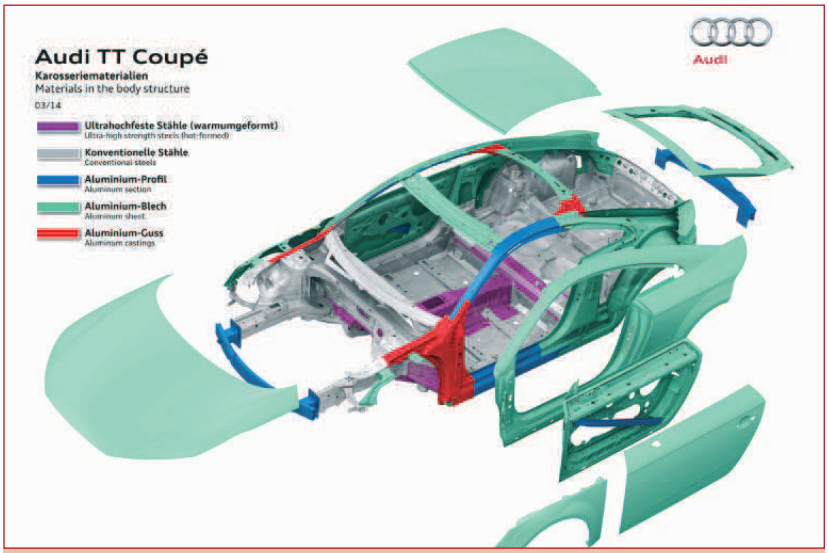
speed manual transmission and front-wheel drive – from 0 to 100 km/h (62.14 mph) in 6.0 seconds, and on up to an electronically governed top speed of 250 km/h (155.34 mph). On the version with six-speed S tronic and quattro all-wheel drive, the key figures are as follows: the sprint from 0 to 100 km/h (62.14 mph) takes 5.3 seconds; top speed is 250 km/h (155.34 mph); fuel consumption of 6.8 liters per 100 km (34.59 US mpg) and CO_2 emissions of 159 g per km (255.89 g/mile). The dual-clutch transmission shifts through the six gears without any noticeable interruption in traction, and in manual model it can be controlled by paddles on the steering wheel. In the "efficiency" mode of Audi drive select, the S tronic selects freewheel as soon as the driver takes his or her foot off the gas pedal. The Audi TTS is a peak performer. It covers the standard sprint in 4.7 seconds; its top speed is electronically governed at 250 km/h (155.34 mph). The 2.0 TFSI produces 380 Nm (280.27 lb- ft) of torque at an engine speed of between 1,800 and 5,700 rpm. Controllable flaps in the exhaust system modulate the sporty sound and make it even richer. A manual transmission is standard. The S tronic option includes launch control, which regulates maximum acceleration from a standstill. ■

quattro drive

In the new Audi TT, quattro permanent all-wheel drive delivers additional stability, traction and driving fun. It has been consistently advanced and optimized especially for the new TT. Its electro-hydraulically controlled multi-plate clutch is mounted on the rear axle. The special pump design reduces weight by around 1.5 kg (3.31 lb) compared with the previous model. The distribution of drive torque between the axles is controlled electronically within fractions of a second. The intelligence of quattro drive – in other words, the software that determines precisely the possible torque distribution between the front and rear axles – is a completely new development especially for the TT. The innovative control philosophy continuously senses the ambient conditions, driving status and the driver's wishes. This means that the ideal distribution of torque is calculated and the TT's dynamic drive characteristics enhanced in every situation. By networking quattro drive with Audi drive select, the driver of the new Audi TT can adjust the all-wheel-drive properties to suit his or her individual requirements. In "auto" mode, this produces optimum traction and balanced driving dynamics. In "dynamic" mode, torque is distributed to the rear axle earlier and to a higher degree, which means that driving dynamics are enhanced further, especially on surfaces with low friction coefficients. Alongside optimizing the driving dynamics, the advances made to quattro drive also focused on the subject of efficiency. In the drive select "efficiency" mode the torque distribution is adjusted to optimize the level of efficiency. Determining driving conditions and driver type precisely allows for efficiency-optimized all-wheel-drive control – which can even result in the temporary shutdown of the quattro drive system. In this operating state, the intelligent software carefully monitors the driving situation and activates the all-wheel drive before torque is once again required at all four wheels. In this way, quattro drive provides optimum efficiency along with a level of traction and dynamic handling that is typically quattro. ■

Chassis

The chassis also reflects the technological expertise behind the new Audi TT. The front suspension is based on a McPherson system; aluminum components reduce the weight of the unsprung chassis masses. The four-link rear suspension can process the longitudinal and transverse forces separately. One particular highlight is the new third generation of the adaptive damper control system, Audi magnetic ride. Compared with the previous version, it has been improved in terms of characteristic spread, control dynamics and precision as well as user friendliness. Audi magnetic ride can be adjusted to three settings (comfort – auto – dynamic) via Audi drive select



Audi TT Coupé – materials in body structure ■

Audi TT Coupé 2.0 TDI ■

and, at the press of a button, either makes the compact sports car hug the road more tightly or lets it glide smoothly across the road irrespective of which mode the driver selects. Magnetic ride technology delivers ultra-swift wheel-selective control of the damper forces, which means that in all driving situations there is optimum contact between wheel and road. In this way, the new Audi TT's superb driving dynamics are further optimized, and body control also ensures good comfort behavior. The system is unique in this market segment. Audi magnetic ride is standard on the Audi TTS and is available as an option for all other TT versions. Another highlight is the standard progressive steering – its rack is designed such that the ratio becomes more direct as the steering is turned. In this way, the new TT can be steered agilely and precisely with little movement of the steering wheel in downtown traffic and on winding country roads. The electromechanically driven and thus highly efficient progressive steering adapts its assistance to speed and forms the basis for the optional assistance systems – Audi active lane assist and park assist. With its elaborate chassis design and firm setup, the new Audi TT handles superbly in all situations. The body is lowered by 10 mm (0.39 inch) on the TTS, with the S line sport package and with the adaptive damper control system, Audi magnetic ride. The dynamic driving system known as Audi drive select is an option for the new Audi TT, but standard on the TTS. It controls the engine characteristics and the steering assistance. The driver can choose between comfort, auto, dynamic, efficiency and individual modes. In addition, Audi drive select influences several optional modules – the S tronic, quattro drive, the Audi magnetic ride system, which at the press of a button makes the compact sports car hug the road even more closely, and the engine sound. In efficiency mode, Audi drive select influences the air conditioning and the start-stop system accordingly. There are 11 different wheel versions available. The TT 2.0 TFSI and the 2.0 TDI come as standard with 17" forged wheels in five-spoke design, each of which weighs only 8.7 kg (19.18 lb), and with size 225/50 tires. On request, Audi can supply other wheel designs with diameters of 17", 18" or 19", and tires up to 245/35 R19. quattro GmbH also offers wheels with a diameter of up to 20". The front discs are ventilated and, depending on engine version, have a diameter of up to 338 mm (13.31 in). The new electromechanical parking brake that the driver actuates by pressing a button is integrated into the rear braking system. The TTS uses newly developed aluminum fixed-caliper brakes to slow the front wheels; these are five kilograms (11.02 lb) lighter than on the predecessor model – another example of Audi's expertise in lightweight construction. The electronic stabilization control (ESC), which can be switched off either partly or completely, perfectly complements the car's sporty handling. When driving through bends, torque vectoring takes effect. If required, the drive torque is distributed from the inside front wheel to the outside front wheel (front-wheel drive) or, on quattro models, to the rear wheels, too. Thanks to the difference in propulsive forces, the car turns very easily into the curve, which is helpful for the driver. In this way, bends can be navigated with great precision and neutrally. This significantly boosts the TT's dynamism and stability. Sport mode supports particularly sporty driving, facilitating steering and control when drifting. The way that all components interact and harmonize enhances agile handling and consequently the driving pleasure that an Audi TT offers – just as you would expect of a sports car. ■

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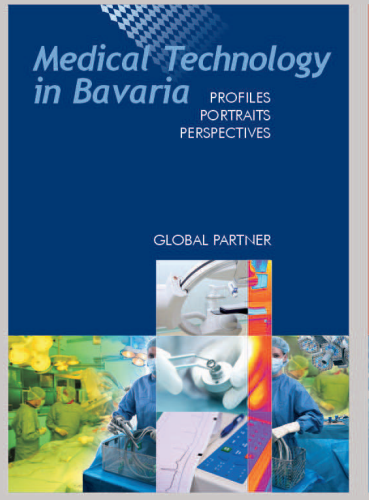
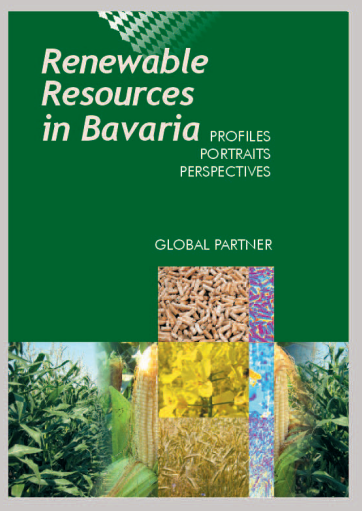
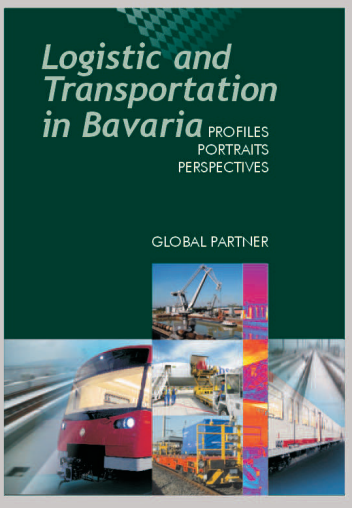
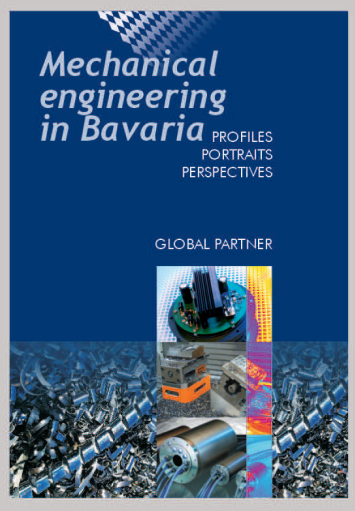
Magazines

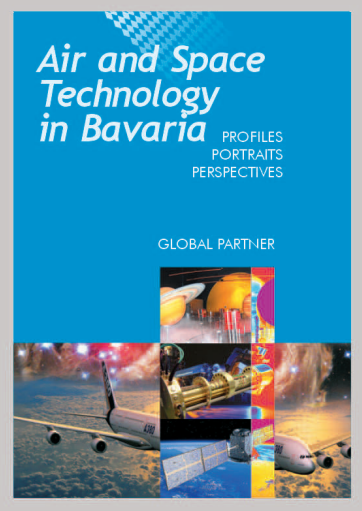
Future Technologies in Bavaria

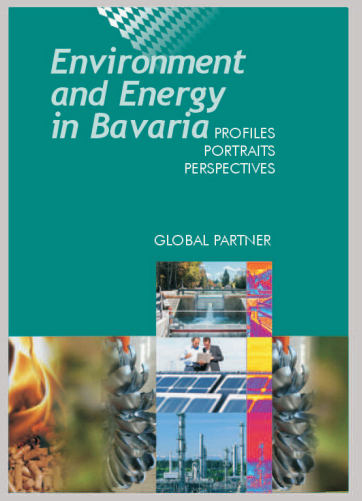


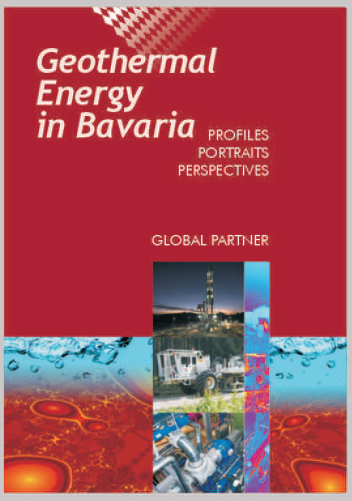


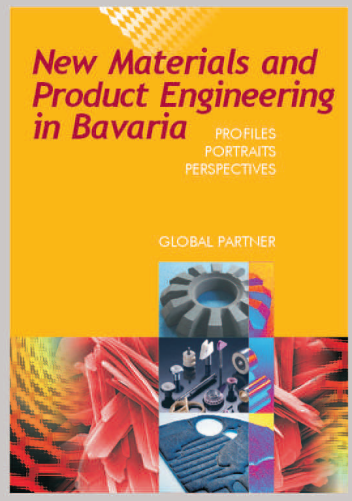


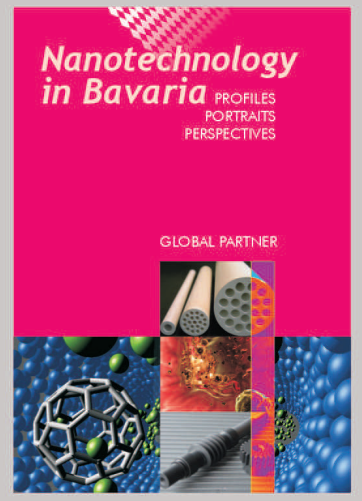












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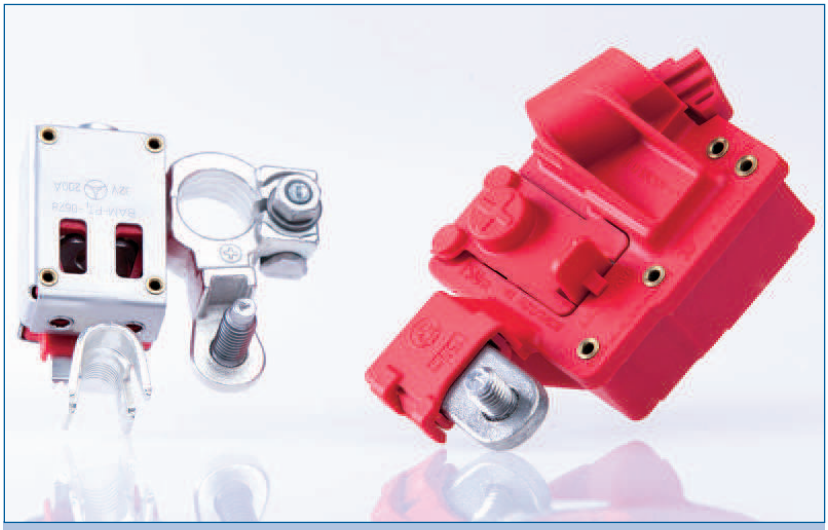
Innovative energy management for electrical systems to come

The Auto-Kabel Group encompasses about 2,300 staff worldwide. We develop and manufacture solutions for automotive energy management and distribution, as well as safety technologies for electrical systems and functional mechatronics.

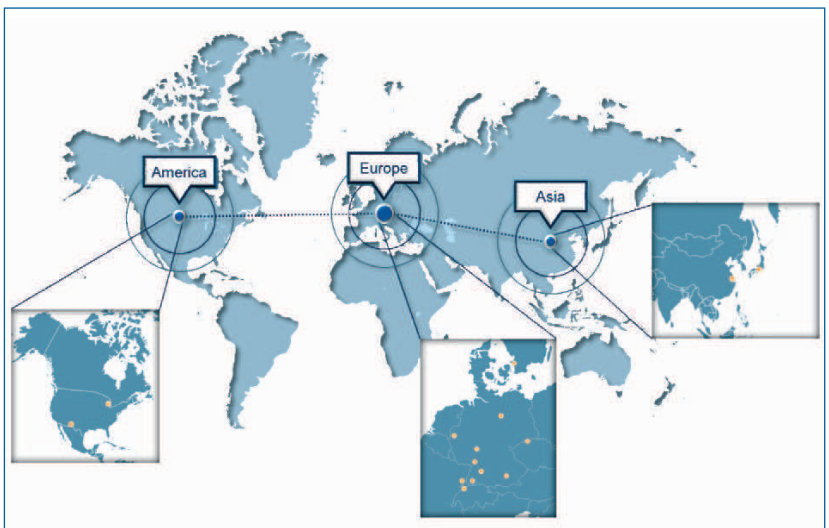
Our story of success portrays a reliable partner and specialist for holistic automotive system solutions. The constant formation of the Group, also beyond European borders, attests the high innovative expertise of our staff. To boldly question the status quo and constantly search for new technical approaches is the incentive to innovation and progress. With this philosophy the Auto-Kabel Group creates innovations and individual solutions for its customers in eight countries around the world. Efficiency is the ubiquitous catchword. Further progression and optimization potentials have to be found and realized. Demanding CO_2 limits for vehicle fleets pose a challenge to OEMs and their supplier industry that has to be tackled.



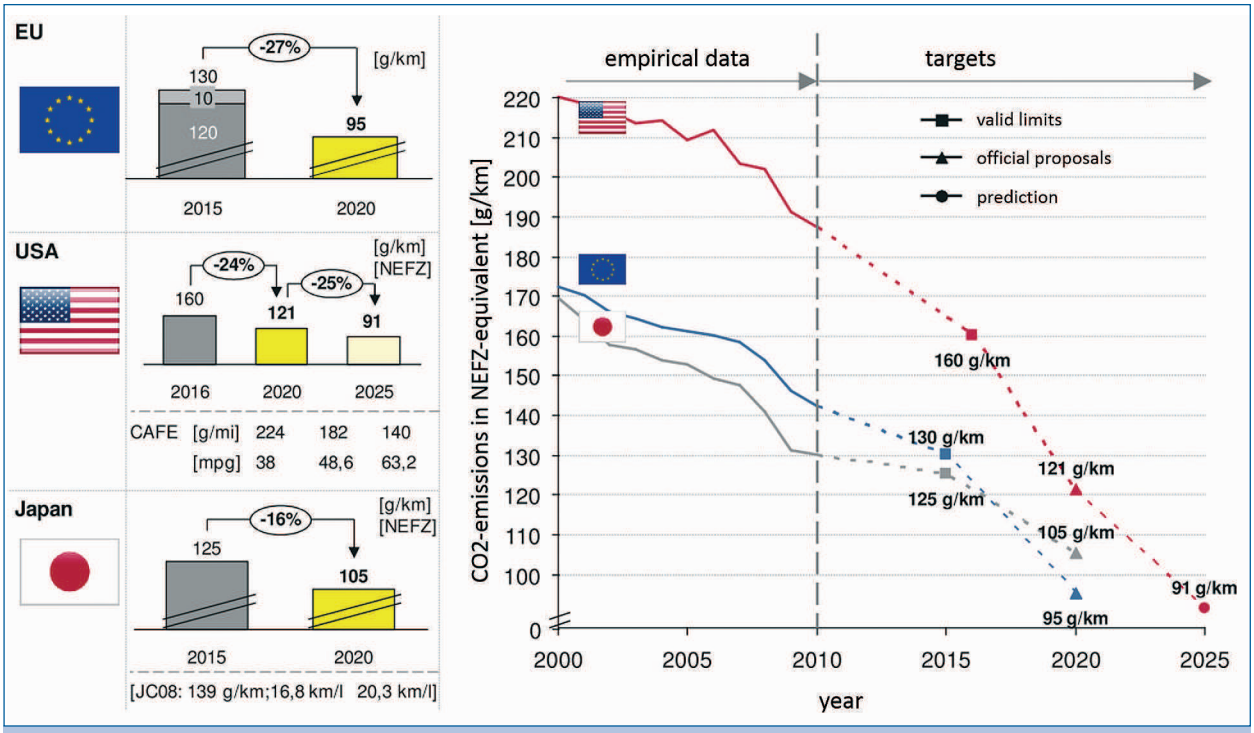
SBK3.0 (left), SBK2.0 (right) ■

The advancing electrification of future vehicles goes hand in hand with the increasing expectations regarding comfort and reliability. Particularly the electrical systems of modern vehicles have to be optimized further in order to meet quality demands of the society as well as increasing technical demands for more and more electrical loads and higher energy consumption. In the last couple of years flexibility and active energy management have become necessities growing evermore important with the advancing development of electrical systems, and these necessities are still becoming more crucial.

Established technical standards like the pyrotechnical separation unit SBK (3rd generation) have to be adapted to the technical advancement of electrical systems, e.g. the conversion to 48 V DC. Furthermore a transfer into functionally new scopes with flexible



Auto-Kabel Group with headquarters in Hausen im Wiesental, Germany ■



Development of mean CO_2 emissions of vehicle fleets and roadmap (passenger cars up to aprx. 3,5 t gross vehicle weight, based on ICC11b) ■

possible fields of application is required.

The necessity for flexible solutions with increased functionalities in due consideration of higher demands for e.g. functional safety becomes obvious. Keeping an eye on the demands of future electrical systems, the electrification of safeguarding functions is also obligatory.

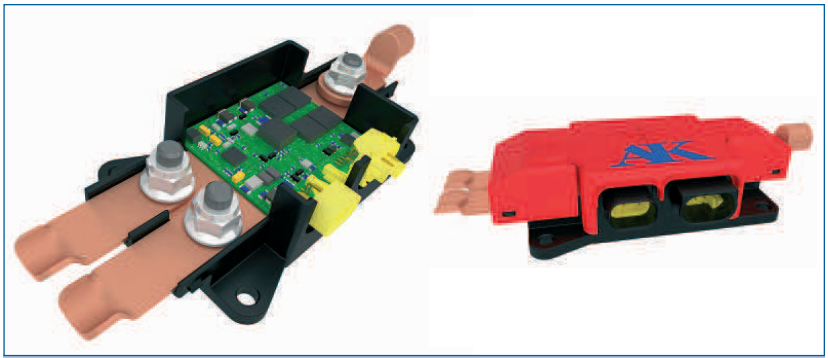
Amongst others, today's and future vehicle generations pose these challenges:

- Safeguarding the electrical system in emergency situations
- leak current corrosion especially when vehicle is immobile (statistically up to 90% of lifetime)
- necessity for decentralized enery distribution to optimize weight and efficiency
- active energy management to increase efficiency
- exponential increase of vehicle's energy demand at simultaneously tightened emission limits

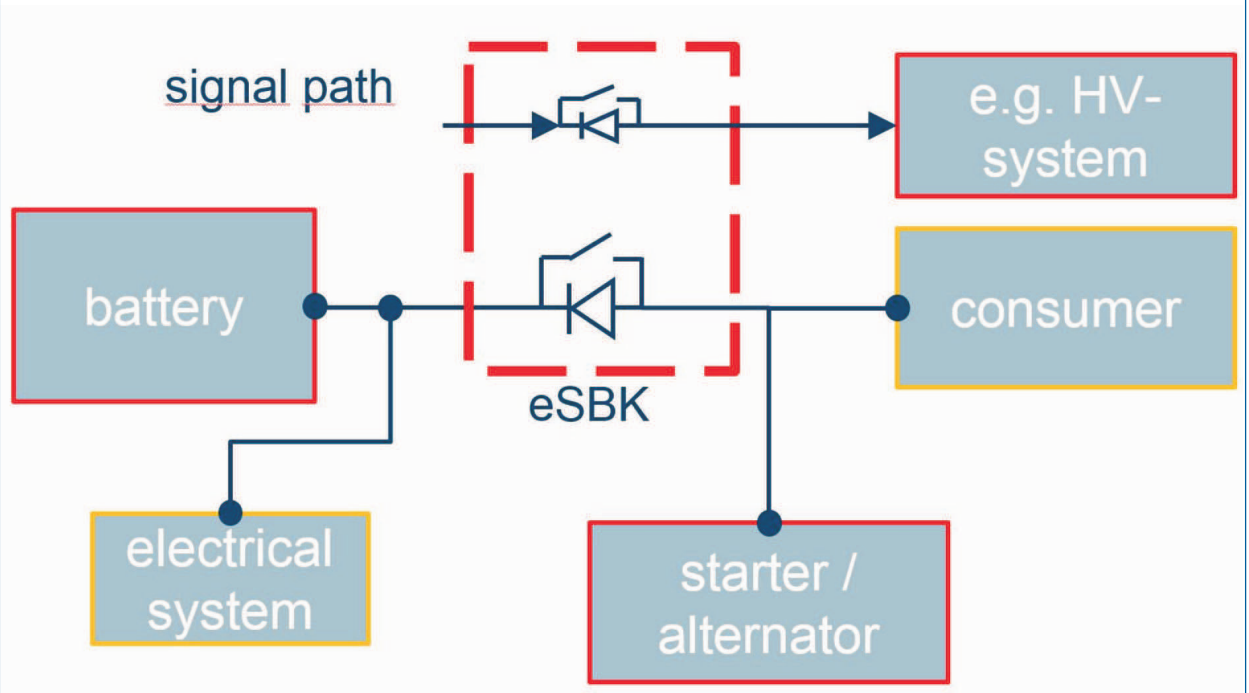
Today, safeguarding and controlling functions are distributed to various individual components, which consequently increases the number of devices that have to be integrated into limited installation space. The immediate effect is the need for more installation space. Weight and high complexity of the electrical system are two significant factors in each new vehicle generation. Today's systems react according to ambient conditions and are thus unable to cover all imaginable fault models (e.g. detection of short-circuit and subsequent separation).

The answer is to combine and integrate various control and safeguarding systems into one single unit. The electronic safety battery clamp (eSBK) is a central, semiconductor-based and bidirectional solution featuring a very low transition resistance (< 100 μΩ). Present safeguards (pyrotechnical separation units, relays, melting fuses etc.) become obsolete when replaced by an eSBK as it resumes the function of these components. According to valid developing standards, the specifications of ISO 26262 (ASIL B) are met.

The electronic switch (eSBK) enables controlled, reversible separation of the starter-generator line and miscellaneous high current loads when needed. Separation takes place within a millisecond, and the separation time is customizable if needed. The



eSBK (visualization) ■



Exemplary wiring scheme of eSBK ■

eSBK allows to easily and quickly de-energize power lines that are not in permanent use, and to activate them when needed. For example, the starter line would only be energized at vehicle start-up and remains preventively separated from the voltage supply while driving. Safety aspects in event of a crash are thus perfectly met. There is no mechanical wear and tear as in relays, and the eSBK uses as little installation space and weight as possible.

A permanently energized electrical system (cables and wires, contact parts, loads) is continuously affected by leak current corrosion and electromigration. The eSBK is able to separate the connected electrical system when the vehicle is at standstill, which statistically mounts up to 90% of its lifetime, not only to minimize the corrosion issue during standstills, but to eliminate it completely.

The jump start function either at the battery or at an individual contact has been observed during development and is sustained.

As for airbags and pyrotechnical separation units, the triggering signal of eSBK complies with the AK-LV 16 specification. The current standard of airbag control units is applied without alteration, and furthermore an activation via LIN or CAN is possible. Safety-related parts of the electrical system that feed e.g. warning lights, car phone etc. remain energized and are not affected by eSBK's separation functions.

Additionally, eSBK provides ways to integrate further functions like switching off and controlling various systems (e.g. signal separation, controlled charging of capacitances etc.) and decreases the requirements to install decentralized safeguarding concepts (Energy Backbone and Intelligent Fuse Boxes).

Diverse patented technologies have been considered during development of eSBK to achieve an optimum between functionality and also cost efficiency.

eSBK is a landmark of a new era, going hand in hand with issues like the 48 V DC electrical system which is to find its way into passenger vehicles in the years to come. So as an automotive supplier looking back on a long history of innovative development we are pleased to carry on actively contributing to the automotive future. ■

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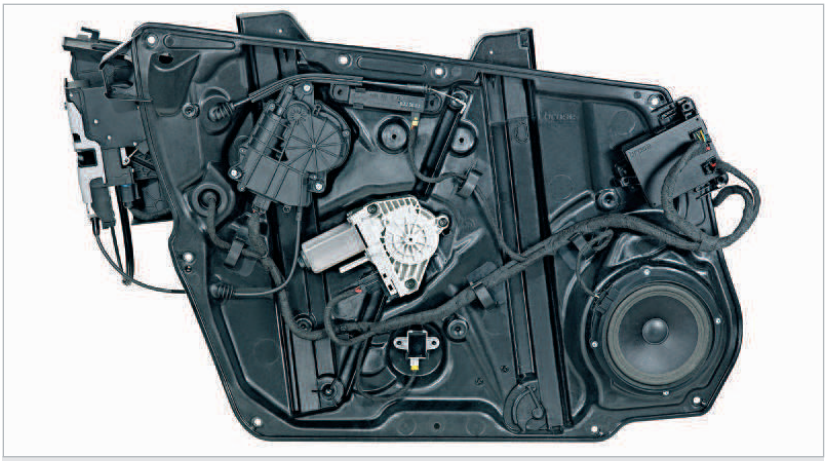
The future will be lighter: New materials in door systems

Lightweight design and efficiency remain the automotive industry's top concerns due to the ambitious global CO2 targets. Automotive supplier Brose received the "Automotive Innovations Award 2013" in the car body and exterior category last year for its lightweight solutions and the comfort and safety features for doors and liftgates. The award is presented each year by the Center of Automotive Management in conjunction with auditing firm Pricewaterhouse-Coopers AG. The judges were particularly impressed by the innovations in lightweight door systems. The international supplier has been setting new benchmarks in this field for many decades. Brose's engineers focus particularly on future-oriented materials that help design each generation to be even lighter and more functional at no additional cost. The mechatronic specialist managed to cut the weight of its door systems by some 30 percent within the last ten years. And the future will be even lighter.

Modular door system design

Brose is considered the inventor of the modular door with wet/dry side separation, laying the foundation for the functional lightweight design of vehicle doors. All essential functions are combined on a module carrier to form a pre-tested and ready-to-fit unit including window regulator, lock, wiring harness, door trim, loudspeakers, seals, sunblind, control electronics and crash sensors.

In view of the increasing pressure on prices and the multitude of options available for new models, the modular design plays a significant role in the automobile industry. In the vehicle door, stringent mechanical requirements have to be reconciled with increasing functionality and the necessary reduction in weight. Thanks to the use of new materials and technologies, Brose meets all these requirements. Highly-integrated plastic door systems have meanwhile become state of the art. Featuring a wall thickness of just 1.8 mm, they provide significant weight benefits compared to steel: almost 4 kg of weight can be saved in a vehicle.



Brose broke new ground in high-volume production with its door system made of long glass fiber reinforced polypropylene, combining light material and improved function integration. Today, this variant is standard ■

In addition to the lighter basic material, functional elements have been integrated in the plastic carrier such as window regulator rails, inner door handle, speaker frame or fixing elements for cables. Consequently, the number of components can be reduced and further weight and cost savings achieved. ■

New generation cuts weight by another 40 percent

With its latest door system generation, the supplier goes one step further: an intelligent blend of materials enables additional weight reductions while maintaining the

required strength. The carrier plate consists of glass fabric reinforced polypropylene (thermoplastic composite) combined with functional elements made of long glass fiber reinforced plastic. As a result, the aggregate carrier comes with a wall thickness of just 0.5 mm and weighs only 580 grams. This means another 40 percent saving in weight compared to lightweight solutions made of long glass fiber reinforced polypropylene.

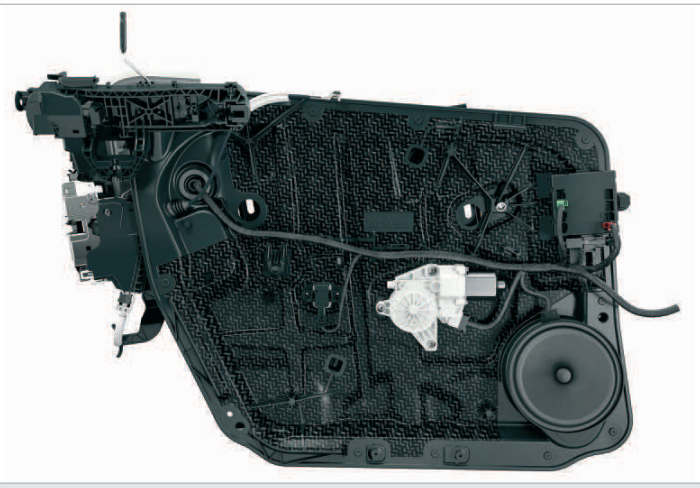
Crash tests have demonstrated that the material is as safe as standard door systems. Providing plenty of design potential for high-precision shaping of the wall thickness, fiber orientation and layer structure, additional strength-relevant functions can be transferred to the module: where more strength is required, the material can be reinforced or the fiber orientation adjusted, in all other places the carrier plate remains ultra-thin. Thus, it is possible to dispense with reinforcement sheets used in standard systems against stress caused by door sag, wind forces and torsion in the door inner panel. Adjusting the fiber orientation ensures improved strain-to-failure and hence safety.

The manufacturing process still comprises only a single step: the pre-punched, heated mat of glass fabric reinforced polypropylene is press-molded into shape while the functional elements of glass fiber reinforced polypropylene are injection-molded. Thus, the cycle time is similar to that of a component only consisting of injection-molded long glass fiber reinforced materials. ■

A glance at the future

According to Brose, carbon fiber reinforced plastics (CFRP) offer great potential for the future. The material is extremely light while retaining its strength: a composite material that provides substantial weight savings without sacrificing safety and comfort. The mechatronic specialist demonstrates its vision of the future use of CFRP by presenting a lightweight door concept that is a perfect combination of design, material and manufacturing technology. The CFRP prototype saves almost 4 kilograms of weight per door compared to aluminum and as much as 11 kilograms compared to steel. In addition, this door concept provides new possibilities for the vehicle assembly process: thanks to maximum functional integration, the number of components and costs can be reduced. The outer door panel only needs to be mounted and screwed on, thereby substantially reducing assembly time for the OEMs. Another benefit: if the wet side of the door needs to be accessed or small parking dents repaired, the outer door panel can easily be dismounted or even replaced, if necessary. Brose expects to be supplying these CFRP door systems for high-volume production from 2020. ■

Brose's CFRP door structure delivers maximum functional integration, thereby reducing the number or components and hence costs. OEMs only need to mount and screw the outer door panel, which considerably reduces assembly time ■



Compared to standard plastic door systems, the carrier plate made of glass fabric reinforced polypropylene saves some 350 grams of weight and as much as 1.2 kilograms compared to standard steel doors while maintaining crash safety and high functional integration ■

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Sales 2013
4,7 billion euros

Customers
Some 80 automobile brands and more than 30 suppliers

Workforce 2013
Approximately 22.000

Quality Assurance through Continuous Integration – What We Can Learn from Other Industries.

Whiteblue Consulting GmbH

The rapidly growing networking within automobiles and to their environment, as well as the quickly increasing range of available vehicle functions are placing growing demands on the reliability of the individual car components and their software.

For instance, a simple car radio used to be enough, but today a wide range of control devices, audio sources, controls and transmission routes are involved in enabling listening pleasure.

With expanding comfort, the complexity of the electrical/electronic architecture increases and is also associated with a greater risk of software errors.

The sooner an error is detected during the development process, the lower are the time requirements and the costs of the remedy. This is also true for the software development. Errors that initially come up in experimental runs in the vehicle could often already be detected, and even avoided, at a much earlier phase of integration on the module or component level.

Continuous integration, as shown in *Fig. 1*, is a process in which a smallest possible, self- contained development step is released by the developer (Check-in) and is afterwards automatically created and merged (Build) into the software modules. Concurrent and consecutive tests reveal any errors immediately (Test) and thus enable the rapid localization and elimination in the code. The scope of testing grows along with the software to secure the newly implemented functions, and to ensure the exclusion of regressions, i.e. the recurrence of already fixed bugs. A final process documents the input configuration, the creation process, and test results for the developed software version, and then releases the software (Publish).

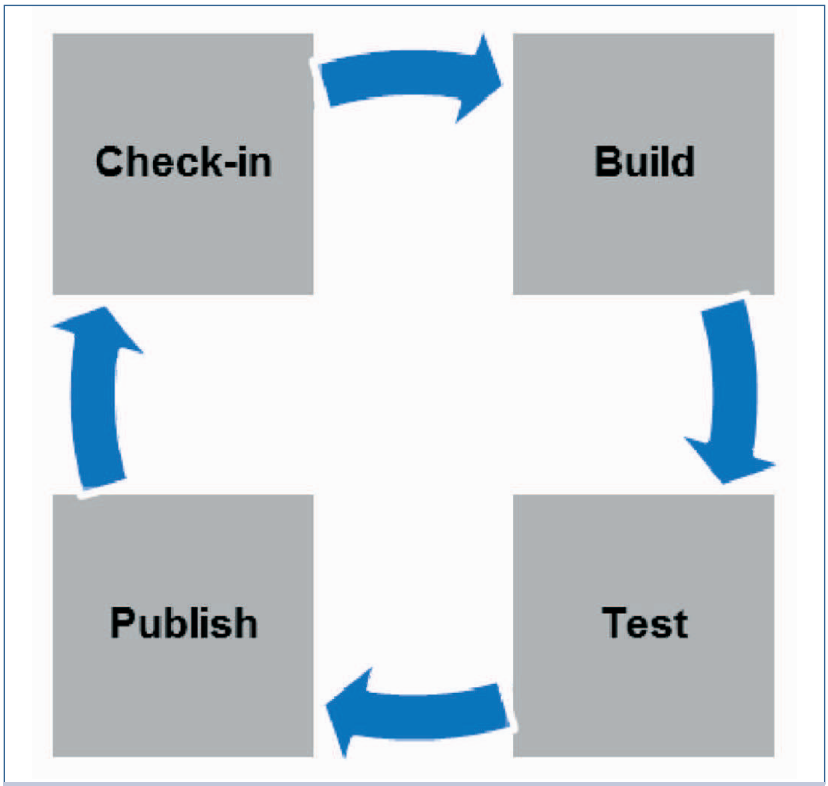

Fig. 1: *Continuous Integration circle* ■

In this connection we can learn from other industries, such as Telecommunications, which has already faced these challenges for quite some time. Whiteblue Consulting has years of experience in this area and advises and supports well-known clients on this topic.

In a concrete project with about one million lines of code and more than 5,000 component tests it takes an individual employee several hours to perform this scope of testing, including the code changes on the development computer. The introduction of Continuous Integration structures the procedure and sets the

stage for detecting and fixing mistakes early. The provision of the new source code by a developer automatically deletes the compilation of the software on a build server. If this is successful, then the highly parallelized component tests are executed. This gives the developer feedback on the success of the changes within 15 minutes. At night, the computation capacity of the software development system is used for execution of long-running application testing. Protection is provided through a comprehensive suite of component tests. The results are processed, presented centrally and distributed to the relevant locations. In this way, errors can found within minutes after a Check-in, and the necessary measures can be taken by the development team. Jenkins, a scalable and extensible open-source Continuous Integration server, is used to automate the software development. With more than 600 plug-ins already built in, Jenkins offers meaningful reporting. The results of the software development are processed and presented through the embedded web server.

At that point the challenge is to create installable setups. This is often a manual and very individual process mastered by only a few members of a project due to its complexity and the usually inadequate documentation. The automation of all the steps for creating a package of installable software components leads to the reproducibility of the processes and thus avoids errors.

In the above-mentioned project, the setup packages of the various software components are usually created in the early evening. When all the components have been successfully built, they are automatically installed on a hardware regression system. Then a series of reference tests are carried out and the results are available to developers and the integration team the next morning. This way we get a first impression of the quality of the nightly builds and can determine whether further manual integration tests are appropriate.

The described process of Continuous Integration used in our telecommunication project has proven its utility by achieving a significant reduction in the time requirements for software protection and a clear increase in quality. Our experience with this process could be effectively implemented, even in the increasingly complex software projects in the automotive industry with its expanding supplier networks.

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Network of Automotive Excellence:

The cross-sector network

NoAE is a free, open initiative for the mobility sectors and their co-operation partners. The starting point was ten years ago with the automobile and supplier industries. From there, an international and cross-company expert network developed.

The objective is the exchange of ideas on

- strategic
- organizational and
- technological

questions and challenges for the company within and beyond the sectors. NoAE was founded in 2002 by well-known personalities of the automotive sector and with the collaboration of the European Commission. ■

The new initiative: FutureCityFactory

Jointly master urban challenges

Cities, science and business in the dialogue

By 2050, over 70% of the world's population will be living in cities.
A majority of the economic power will be concentrated on a few hundred centers in the world. The city of the future presents new challenges to the infrastructure of industrial manufacturing, trade and services – challenges, which can only be overcome with interdisciplinary cooperation.

Mr. Alois Brandt, AUDI AG opened the kick-off conference www.future-city-factory.de
Image: © AUDI AG ■

Joint Initiative from the Audi factory and NoAE

With the initiative "FutureCity Factory", the Audi factory and the Network of Automotive Excellence bring together cities, science and business in order to discuss opportunities, challenges and ideas for the design of urban manufacturing of the future.

Kick-off at the end of April 2014 at AUDI in Ingolstadt

At the end of April, 140 representatives from the economic and science sectors met with city and transport planners at the kick-off conference of the FutureCityFactory in order to discuss opportunities for industrial manufacturing in an urban context. The basis for this was the keynote speeches on the specific challenges, facing the sectors in the future. This was implemented in five marketplaces.

Marketplaces as the basis for joint projects

Five marketplaces formed the discussion platform at the kick-off and also welcome cities, companies and science to join the cooperation in future:

Marketplace Employees

Cities and companies are in the same boat: The one would like attractive jobs for their citizens; the other is searching for qualified employees. Simultaneously the demands on employees at work, in the workplace and in the working environment have increased.

Marketplace Mobility

Advanced urbanization means that the population density in cities and agglomerations will continue to increase. People want to be mobile all the time, reliably, securely and more and more resource-friendly.

Marketplace Internet

The marketplace ‚Internet' places the focus on one of the most powerful developments in the coming years for industry, politics and society. The (R)Evolution to Industry 4.0.

Marketplace Future Planning

Factories and the city belong together. The planning tasks of the future will be focused more than ever on synchronizing the interests of cities and companies.

Marketplace Energy

The marketplace ‚Energy' encompasses all topics and challenges, which must be observed by communities, companies and providers within the scope of new energy concepts.

Ms. Monika Thomas, Wolfsburg, evaluating project ideas at the marketplace "City of the Future" Image: © AUDI AG ■

A sixth marketplace was reserved for the representatives of communities: Under the key heading "City of the Future", representatives from cities, in particular in Bavaria, Baden-Württemberg, North Rhine Westphalia and Austria (Graz and Vienna), exchanged ideas.

The ultimate goal was and is, to create suggestions for implementation using concrete tasks but also on the basis of ideas. ■

Mr. Ralf Winterstein, Mahle, makes his evaluations at the marketplace ‚Energy'. Image: © AUDI AG ■

The initiators, the Audi factory and NoAE, welcome cities, science and business to a continued cooperation. The first subsequent dates have already taken place. ■

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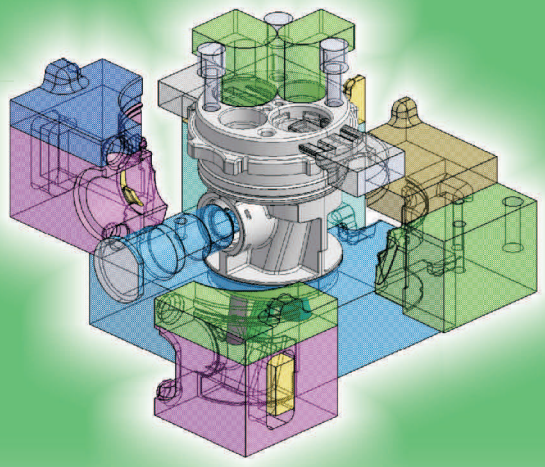
Additional information in the internet

Platform for Future City Factory
www.future-city-factory.de

Social Networks
https://www.xing.com/de/communities/groups/future-city-factory-64df-1005233



Good Design is in our Nature

Creative concepts, an intelligent implementation, validation, evaluation and optimization are elements of the product development cycles. In between are performance interfaces with their typical loss of information, communication problems and a higher control effort located. At acad all project accomplishments originate from a single source.
For more than 12 years design as well as prototyping work closely interlinked and create all the sub-processes that are a key for the efficient and competent project realization.
Due to this service offer prototype parts, designs and concepts can be supplied with a higher level of maturity.

acad engineering – driven by evolution

You want to ensure a competitive advantage over the business competition in the automotive sector with unconventional solutions? acad engineering will provide competent advice and supports complex projects targeted to a successful completion. Thanks to our 22 years of experience we are specialists in the development of interior components such as armrests, head rests, cup holders and seat components for the automotive industry in the premium segment. Our customers include the OEMs, tier-1 and tier-2 from the automotive field. Every single development step is assured systematically due to a development in 5 phases.
You decide after the completion and the analysis of every single phase when and how to proceed, which means minimizing your investment and development risk.

F.S. Fehrer Automotive GmbH: Daimler W222 S-Class centre arm rest SA rear ■

Dräxlmaier Group: BMW control unit bracket ■

Exemplary projects of acad engineering:

- F.S. Fehrer Automotive GmbH: Daimler W222 S-Class centre arm rest SA rear
- csi entwicklungstechnik GmbH: Porsche Cayenne E2 centre arm rest
- MEKRA Lang GmbH & Co. KG: MAN Neoman urban bus front mirror ■

acad prototyping – "driven by improvement"

acad prototyping manufactures plastic prototype parts in an express injection moulding process.
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Applicable are all thermoplastics which are available on the market. The 400 most important ones are always on stock. The manufacturing of prototypes is performed on rapid moulding systems. This method based on 3D-CAD data makes it possible to produce prototypes quick and easy even in the planning phase. Due to the segmented structure, all tools can be rapidly changed to meet the customer's needs. ■

Exemplary projects of acad prototyping:

- Dräxlmaier Group: BMW control unit bracket
- Alfmeier Präzision AG: Pneumatic control housing
- F.S. Fehrer Automotive GmbH: Opel Zafira centre arm rest ■

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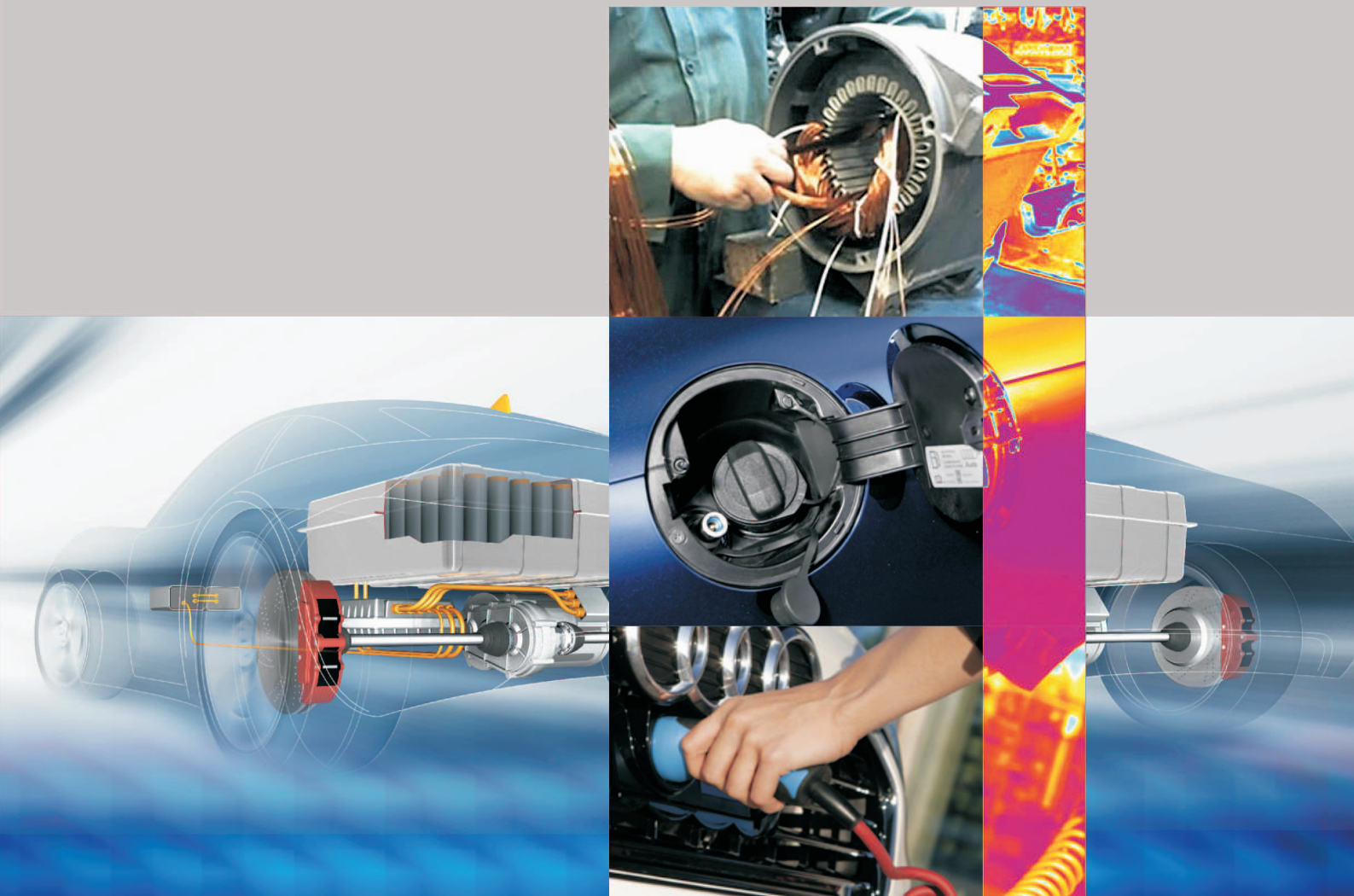

The Audi Sport quattro laserlight concept car

- *Dynamic coupe has powerful plug-in hybrid drive*
- *Prof. Dr. Ulrich Hackenberg, Member of the Board of AUDI AG, Technical Development: "This show car embodies our engineering competence and shows cutting-edge electronic features such as high-performance laser-light headlights."*

The Audi Sport quattro laserlight concept is reminiscent of the classic Sport quattro of 1983 while pointing towards the future – with the latest of the brand's technologies in plug-in hybrid drives user control and display interfaces and lighting technology.

Audi Sport quattro laserlight concept

"The new show car demonstrates technical ‚Vorsprung' on many levels," says Prof. Dr. Ulrich Hackenberg. "On-board this car we have e-tron technology with 515 kW of power and 2.5 l/100 km (94.09 US mpg) fuel economy; laser headlights that leave all previous systems in the dark with its higher performance as well as new display and operating systems with cutting-edge electronic performance. We are showing the future of Audi here." The coupe, a new evolutionary stage of the Sport quattro concept, painted in the color Plasma Red, combines the power of the historic Sport quattro with emotional elegance. Its body is tautly set over its large wheels. The overhangs are short, and the car's proportions show a sporty balance. With a wheelbase of 2,784 mm (109.61 in), it is 4,602 mm (181.18 in) long. At a width of 1,964 mm (77.32 in), the two-door model is very wide, and it is just 1,386 mm (54.57 in) tall, which is exceptionally low. In the dual headlights, a typical quattro feature, Audi is demonstrating the future of lighting technology by combining LED and laser light technologies. Two low-profile trapezoidal elements are visible within the headlights – the outer one generates the low beam light using LEDs and an aperture mask, while the inner element produces laser light for high-beam functionality. The powerful laser diodes are significantly smaller than LED diodes; they are only a few microns in diameter. Illuminating the road for a distance of nearly 500 meters (1,640 ft), the laser high- beam light has approximately twice the lighting range and three times the luminosity of LED high beam lights. In this future technology, Audi is once again demonstrating its leadership role in automotive lighting technology with a system that will also be used on the race track in the 2014 R18 e-tron quattro. The angular, swept-back C pillars of the Audi Sport quattro laserlight concept car and the blisters above the fenders are other design elements reminiscent of the classic Sport quattro. The broad shoulders of the body were reinterpreted and intensively sculpted to convey even greater dynamism.

Audi Sport quattro laserlight concept – front view ■

Audi Sport quattro laserlight concept – rear view ■

Throughout the car, sharp contours frame muscular surfaces – the interplay between convex and concave curvatures defines the athletic character of the coupe. The hexagonal single-frame grille also offers an outlook on future design of the sporty production models. The lower section is nearly vertical, while the upper follows the contour of the hood; the screen insert is a typical solution from car racing. The low grille emphasizes the show car's width. Two large, vertical blades divide each of the large air inlets; their form is repeated in the creases of the hood. The splitter, which is made of carbon fiber reinforced polymer (CFRP), is shifted far to the front, as on a race car. The combination of a swept-back glass cabin and broad shoulders defines the proportions at the rear. Another defining element at the rear of the show car is the CFRP diffuser, which extends upward significantly. Its upper section is honeycombed, while its lower section houses two large, oval tailpipes. The tail lights, which are backed by a black CFRP panel, are rectangular in form – another quattro reference. The luggage space, which is reinforced by a large cross bar stiffener, offers 300 liters (10.59 cu ft) of cargo capacity. Precise design details round out the dynamic look of the Audi Sport quattro laserlight concept. The sill extensions are made of CFRP, the door handles electrically extend from the door when they detect the approach of a hand. The center locking wheels have a five twin-spoke design. ■

Lightweight design made visible: the interior

In its generously cut interior, the elegant sporty styling of the show car is continued with dark gray colors and clean lines. The interior design and material selections demonstrate the Audi philosophy of lightweight design. The slender instrument panel is reminiscent of the wing of a sailplane. The supporting structure of the interior is a carbon shell that also serves as a storage compartment in the doors. A line of trim beneath the windshield wraps around the driver and front passenger and integrates functions such as the inside door handles. The folding race car shell seats with their high lateral supports and integrated head restraints, together with the two rear seats, provide space for four persons. The climate controls are integrated in the air nozzles; a single element is used to control the intensity, temperature and volume of the air stream. In addition to showing climate control settings, the slim display at the centers of the air nozzles also shows media data. ■

New solutions: displays and controls

The interior of the Audi Sport quattro laserlight concept focuses very much on the driver. Even the multifunction sport steering wheel points the way towards future sporty production solutions. It has two buttons which the driver can use to control the hybrid drive, a red start- stop button, a button for the Audi drive select vehicle handling system and a „View“ button to control the Audi virtual cockpit. All key information is shown on the large Audi TFT display in high-resolution, three-dimensional graphics; a cutting-edge Tegra 30 processor from Audi partner Nvidia processes the graphics. The driver can switch between different modes. For example, in the MMI mode the dominant display elements include the navigation map and media lists, while in the Classic view the speedometer appears in the foreground. Nearly all functions of the Audi Sport quattro laserlight concept can be controlled from the further developed MMI terminal that is mounted on the center console over the tunnel. Its large rotary pushbutton, which also serves as a touchpad, can be pushed in four directions, and it is surrounded on three sides by four buttons – for the main menu, submenus, options and a back function. The new user interface has a menu structure whose intuitive layout is similar to that of a smart phone. All frequently used functions can be accessed lightning fast. For most inputs, just a few steps are needed thanks to a new free text search feature; generally just four characters suffice for a navigation address. The driver can quickly scroll through lists or zoom the map image using multitouch

Audi Sport quattro laserlight concept – Audi virtual cockpit ■

gestures on the touchpad. Voice control functionality has also been intensively further developed. ■

Powerful and highly efficient: the drive system

The plug-in hybrid drive gives the Audi Sport quattro laserlight concept fascinating dynamic performance. Its system output is 515 kW (700 hp), and its system torque is 800 Nm (590.05 lb-ft). Power flows via a modified eight-speed tiptronic to the quattro drivetrain, which features a sport differential at the rear axle. The show car's combined fuel consumption, based on the applicable fuel economy standard, is just 2.5 liters of fuel per 100 km (94.09 US mpg) – which equates to CO_2 emissions of 59 g/km (94.95 g/mile). The combustion engine is a four-liter V8 with biturbo charging; it produces 412 kW (560 hp) of power and 700 Nm (516.29 lb-ft) of torque.

The cylinder on demand (COD) system, which deactivates four cylinders under part load and a start-stop system make the sonorous eight-cylinder engine very efficient. Located between the 4.0 TFSI and the transmission is a disc- shaped electric motor that produces 110 kW and 400 Nm (295.02 lb-ft). It draws its drive energy from a lithium-ion battery at the rear, which stores 14.1 kWh of energy – enough for up to 50 km (31.07 miles) of all-electric driving. An Audi wallbox that is used for charging provides for optimal energy transfer. An intelligent management system controls the interplay of engine and motor on demand. The driver can switch between three different modes. In EV mode, just the electric motor operates; its high torque propels the show car with plenty of power – even outside of the city. The active accelerator pedal indicates the transition to Hybrid mode to the driver – by a change in pedal resistance; this is done so that the driver can intentionally influence the mode selection. The Hybrid mode aims at optimal fuel-savings in the interplay between the TFSI and the electric motor, and environmental and route data are utilized here. The driver can choose the Hold and Charge modes in the MMI to influence the operating strategy, e.g. if the driver wants to ensure that sufficient electrical energy is available for the final kilometers to the destination. The Audi drive select dynamic vehicle handling system offers even more control options – individual driving profiles are set up for different levels of regenerative braking. In Sport mode, the operating strategy configures the drive system for maximum power. When the V8 and electric motor are boosting, the Audi Sport quattro laserlight concept accelerates from a standstill to 100 km/h (62.14 mph) in 3.7 seconds and can reach a top speed of 305 km/h (189.52 mph). ■

Body and chassis

A lightweight design strategy also plays a major role in the car's dynamic performance. A combination of ultra high-strength steel sheet and structural elements of cast aluminum is used in the occupant cell. The doors and fenders are made of aluminum, and the roof, engine hood and rear hatch are made of CFRP. This results in an unladen weight of just 1,850 kilograms (4,078.55 lb), including the large battery pack. The front suspension is comprised of five links per wheel, while the rear suspension is based on the self-tracking trapezoidal link principle of Audi, which guarantees dynamic performance and stability. Stiff tuning of the springs and shock absorbers make the Audi Sport quattro laserlight concept hold tightly to the road, while Audi drive select makes the driving experience even more multifaceted. The dynamic steering system varies the steering ratio as a function of driving speed. The brake calipers grip large, carbon fiber-ceramic brake discs, and the tire size is 285/30 R 21. ■

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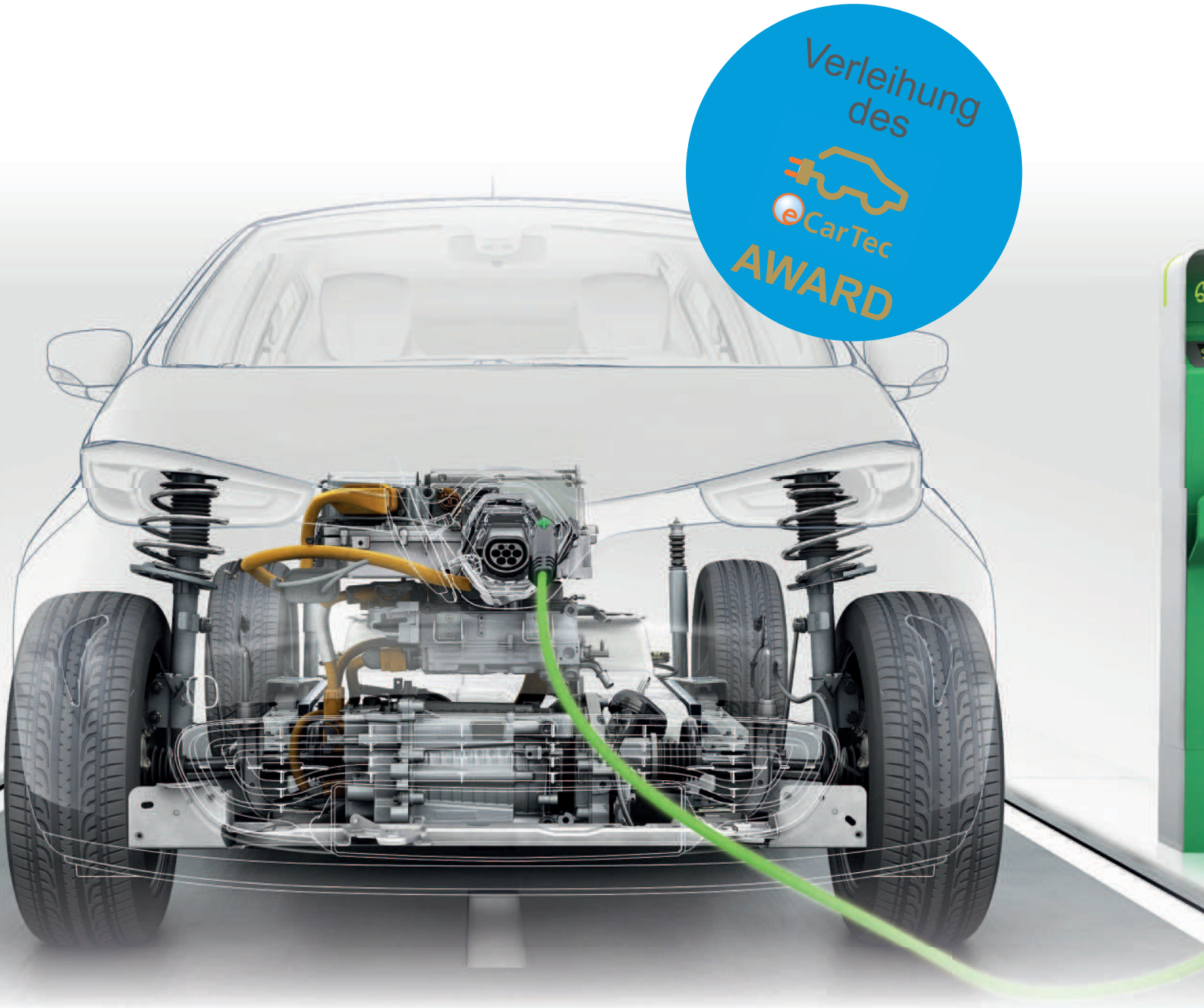

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New materials used in electric vehicles require the adaptation of joining and cutting processes

The automotive industry is increasingly focusing on the electrification of power trains. While vehicles that run purely on electric power have not been widely produced by car manufacturers, mass production of hybrid vehicles is already very popular. A particular challenge of electric vehicles is the automation of production. This is coming not only from the OEMs, but also from the need for equipment manufacturers and suppliers to develop new facilities and manufacturing processes. In several projects over the last few years, the Institute for Machine Tools and Industrial Management (*iwb*) of the Technische Universitaet Muenchen has developed new processes and procedures with tailored solutions for electric mobility. Special attention has been paid to joining and cutting processes for both pure and compound materials, which are used for high-voltage batteries and electric drive systems. This article will present the individual production steps, challenges encountered, and innovative solutions for the production of lithium-ion high-voltage batteries.

These include: trimming of electrode foils, connecting multiple cells in battery modules, pressure-tight welding of aluminum cooling plates, and joining of aluminum and thermoplastic glass-fiber reinforced plastics for the housing of the high-voltage battery. ■

Laser cutting in battery production – flexible trimming of electrode foils

As part of the BMBF-funded research projects ProLIZ and ExZellTUM, the automated production of lithium-ion cells is being inestigated at the *iwb* in a semi-industrial production line, where electrode sheets must be cut automatically. The drawback of conventional methods, such as shearing and stamping, is that tool wear results in a continuous decrease in the quality of the cut edge. In addition, shearing and stamping are geometry-bound, and thus inflexible. Remote laser cutting (shown in *Figure 1*) is an alternative method for cutting electrode films. It is a non-contact and thus wear-free process that can be used in the manufacture of battery cells of various shapes and sizes. The laser beam evaporates the electrode material along the cut edge and enables a defined ablation of the material. Particularly advantageous are the high cutting speed, the absence of wear, and the burr-free cut edges. Challenges for this process arise mainly because the material properties of the individual components of the electrode foil are different: the coating evaporates at a much lower energy input than the metallic substrate. As a result, the metal foil near the cut edge is decoated, which may cause short circuits within the battery cell. For a good quality cut edge, suitable process control is critical with respect to the temporal and spatial energy input. The trend of increasing the coating thickness and the specific energy of a battery cell has led to more challenges in trimming the electrode. More energy must be used to cut this material, which can lead to greater thermal damage along the cut edge. At the same time, damage can occur during this process, resulting in particulates, which may be deposited on the electrode surface. Therefore, the focus of this research is to quantify the influence of these effects on the quality characteristics of the finished cell, with the aim to maximize quality. ■

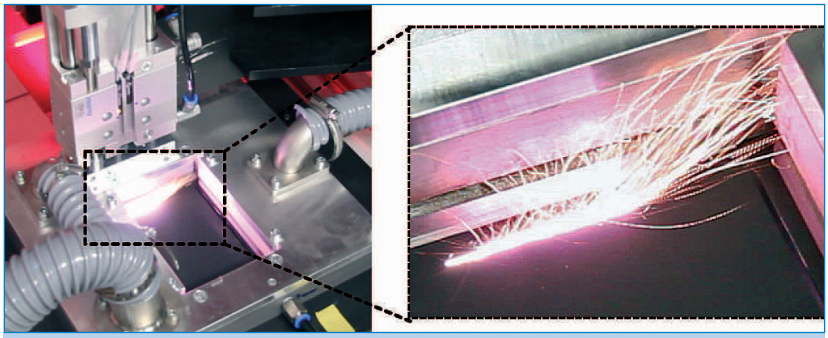

Fig. 1: *Laser cutting of electrode foils* ■

Welding of electric contacts for battery modules

For use in electrified vehicles, multiple battery cells are connected to each other, forming battery modules. Due to the fact that there are many cells in one module, the technology used for joining the cells plays an important role in the production chain. The *iwb* is investigating joining technologies for lithium-ion cells that fulfill the requirements for use in electric and hybrid vehicles. Several technologies were screened regarding suitability for joining the electric contacts, and laser welding was identified as the most suitable process. Excellent electrical properties and a low connection resistance are achieved due to the material locking.

The use of laser scanning optics has various advantages: the process is contact-free and the geometry of the weld seam can be freely adapted. In order to prevent thermal damage of the cells during joining, the length, and therefore the area, of the weld seam have to be decreased. The *iwb* developed a method to calculate an optimized geometry of the weld seam using a genetic algorithm coupled with a thermo-electric Finite Element Analysis in multiple simulation loops. Therefore, high electrical conductivities can be achieved despite the small area of the weld seam. The method was validated with a battery module containing eight lithium-ion cells; the geometry of the weld seam was optimized and successfully implemented for welding the electrical contacts. *Figure 2* shows the finished battery module with the electrically optimized weld seam geometry.

The welding time per contact was as low as 0.9 seconds. Thus, manufacturing times less than one minute per module can easily be achieved. The technology of laser welding is an excellent solution for mass production of electrical contacts with high conductivity. ■

Friction Stir Welding of cooling plates for high voltage batteries

As part of the BMBF-funded research project "eProduction", the *iwb* is using Friction Stir Welding (FSW) as a novel technology to join cooling systems for high voltage batteries. The cooling concept for the project consists of a 5 mm thick aluminum cooling plate underneath the battery module. The cooling plate has to withstand pressures up to 3 bar, as well as a vehicle crash. These requirements can be fulfilled with FSW, whereas conventional welding technologies are only partially suitable. Welding with FSW is characterized by the absence of a melt pool, hot cracks, or pores, and therefore the connection is pressure tight. The ductility of the weld seam is equal to the ductility of the original material; therefore more energy can be absorbed in a crash compared to the case of conventional fusion welding. Maintaining a high ductility also preserves the pressure tightness after a crash. *Figure 3* shows a cooling plate that was joined by FSW with the DeltaN-process (tool shoulder is stationary). The cross section shows a pore free and pressure tight weld seam. ■

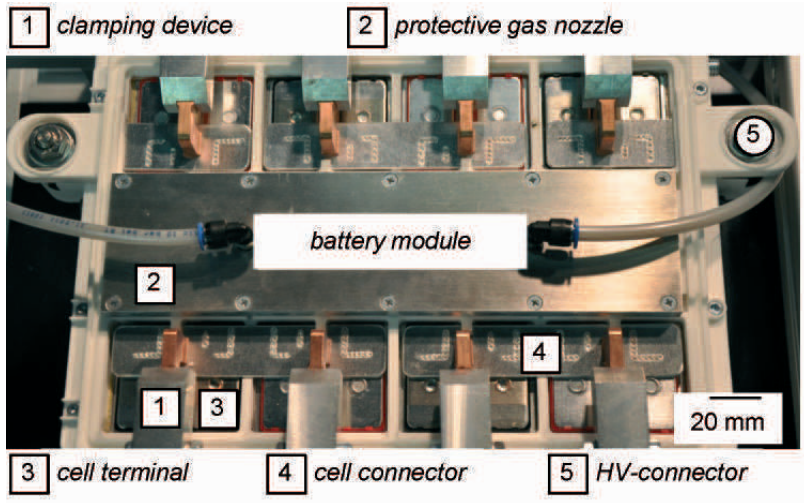

Fig. 2: *Battery module with eight lithium-ion cells and electrically optimized weld seam geometry* ■

Laser welding of thermoplastic fiber reinforced plastics with metals

Thermoplastic fiber reinforced plastics have great potential for use in the housing of high voltage batteries because of the highly flexible design options and their high specific stiffness. Therefore, they are well suited for structural lightweight construction of battery systems. The polymer has to be joined to the aluminum in several places; traditionally, technologies such as gluing, riveting and screwing are used for joining. These technologies have several disadvantages: they require a costly preparation and have long cycle times. As a result, they do not fulfill the automotive industry's production requirements. In order to overcome these issues, the *iwb* is focusing its research on laser welding of (fiber reinforced) polymers to aluminum, namely the processes of heat conduction welding and transmission welding *(Figure 4)*. A bond, based on a combination of an adhesive

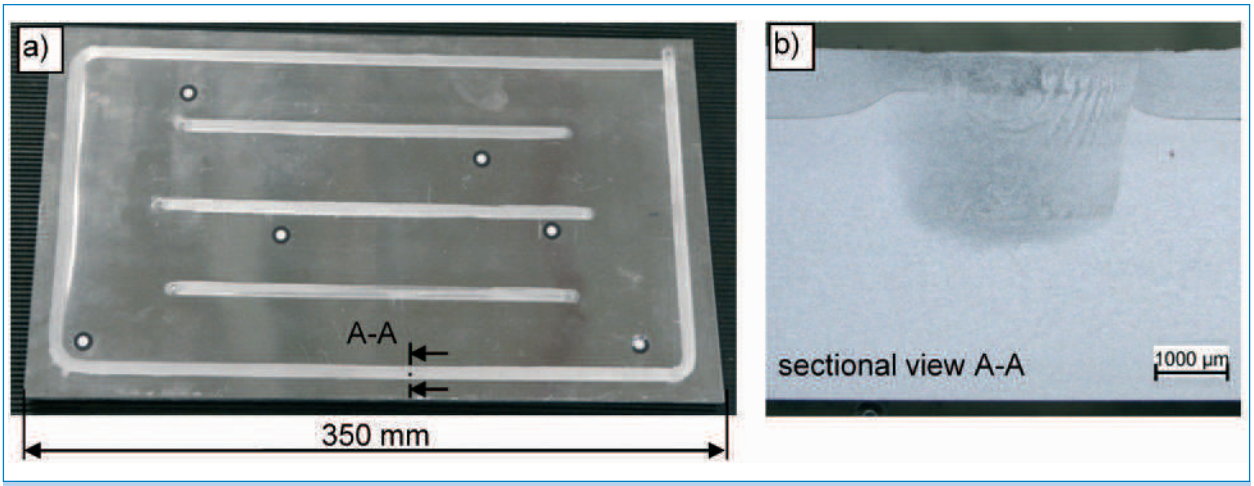

Fig. 3: *Cooling plate, joined by FSW with the DeltaN-process (a); cross section (b)* ■

bond and a form fit, is created by melting the polymer and letting it cool while pressing it against the aluminum. Laser welding is especially suitable for the joining process, because the energy can be applied in a highly defined manner on the surface of the workpiece. Laser transmission welding can be described as follows: the laser beam is transmitted through the polymer and absorbed in the interface between metal and polymer; the interface is consecutively heated and the polymer melts. For this process the polymer must be highly translucent for the wavelength of the laser beam to be transmitted. Unfortunately, the fibers in fiber reinforced plastics impede the laser beam due to their absorption effects. Heat conduction welding on the other hand can be used independently of the fiber fraction volume, since the laser beam is used to deposit the energy on the opposite side of the metal. The heat is then conducted through the metal in order to melt the polymer at the interface. Both processes require that the parts be clamped. However, this is usually done using masks or glass which is translucent for the specific wavelength of the laser.

A prerequisite for a strong metal to polymer connection is that the metallic surface is pretreated. Current research shows that higher strengths can be reached, compared to conventional techniques, by using laser irradiation for pre-treatment. Using lasers has additional advantages like the absence of hazardous chemicals and the possibility to generate defined topographies on the surface, the height of which can range from nanometers to several millimeters. The *iwb* is investigating the most promising surface structures *(Figure 5)* with regard to their eligibility for industrialization as well as their influence on bonding strength in combination with different polymers; these polymers can be reinforced with short or endless fibers. It has been shown that shear strengths up to 42 MPa can be achieved by laser welding. The strength itself depends on multiple factors, such as the surface pre-treatment and the composition of the polymer. ■

Conclusion

New challenges arise for production engineering, especially cutting and joining technologies, when using new materials and material combinations in electrified vehicles. The *iwb* is therefore developing flexible technologies in various research projects in order to master these new challenges. ■

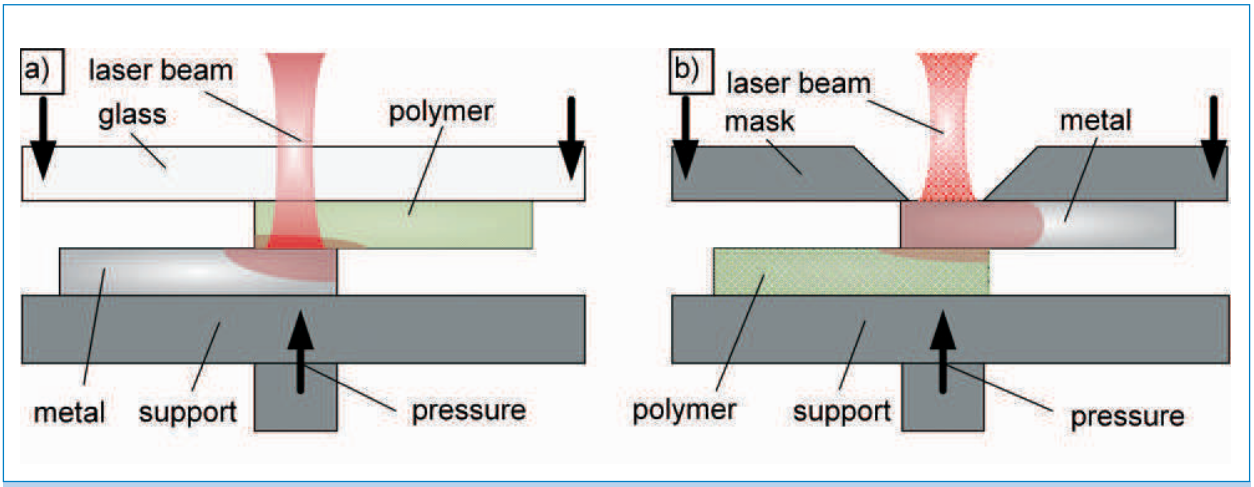

Fig. 4: *Laser transmission welding (a) and laser heat conduction welding (b)* ■

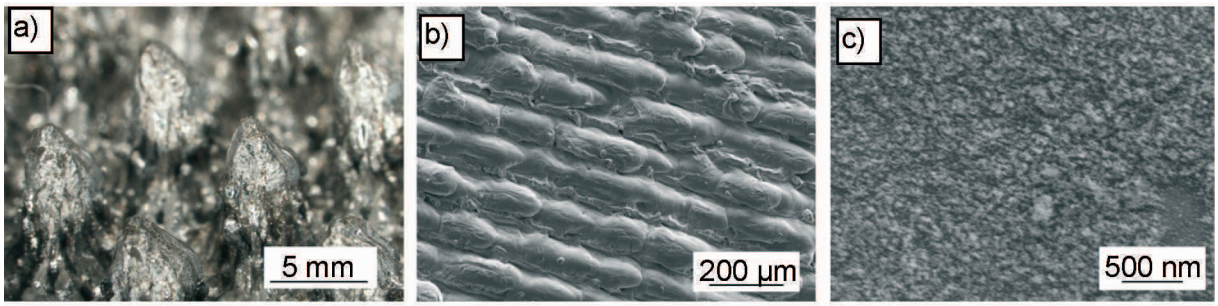

Fig. 5: *Laser generated surface structures: Macroscopic structures (a); microscopic structures (b); nanoscale structures (c)* ■

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