Media Information

Volkswagen

Press workshop

EVOLUTION OF LIGHT

Wolfsburg, October 2018

Note: This press release as well as image motifs and films about Volkswagen lighting technologies can be found on the Internet at www.volkswagen-newsroom.com

[1]*e-Golf - Electrical consumption in kWh/100 km: combined 12.7, CO2 emissions combined in g/km: 0, efficiency class: A+.*

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In brief

EVOLUTION OF LIGHT:

Innovative lighting systems ensure greater safety

Overview of important facts

- Volkswagen improves safety for all road users with new, innovative lighting systems such as the IQ.Light
- Center of Lighting Excellence with 100-metre long light tunnel optimises and accelerates the development of new technologies
- New Volkswagen light demonstrator based on the ID. family takes the light of the future into the present
- Volkswagen Group Research tests interactive lighting systems on board a Tiguan with exterior displays and projection systems
- IQ.Light from the new Touareg marks the current status quo of the Volkswagen headlight systems with a total of 256 LEDs
- HD-LCD headlights with 30,000 pixels per headlight make it possible to test future lighting functions
- Micro-pixel LED headlights will introduce a new era of intelligent headlight systems in a few years
- The high-performance LED headlight from Volkswagen could become an affordable alternative to laser headlights
- The switching LED signature tail light provides increased safety when braking in the Touareg, Tiguan, Passat and Golf at night
- Personalised signatures will incorporate design, warning and sign options into the LED tail light clusters
- Using holograms, three-dimensional signs and tail light functions float in virtual space
- New lighting systems will project signs onto the road to make driving easier and safer

The light of the future will be able to communicate

Volkswagen has developed light into a characteristic feature of all the brand's vehicles. In parallel, new interactive lighting technologies ensure that road safety is improved by vehicle lighting. At the same time, pioneering LED lighting systems such as the IQ.Light from the latest

Contact:

Volkswagen Communications
Product Communications

Jens Bobsien
Head of Communication Technology, Innovation and Design
Tel: +49 5361 9-32529
Jen.bobsien@volkswagen.de

Stefanie Blabl
Communication Technology
Tel: +49 5361 9-14079
stefanie.blabl@volkswagen.de

More at
volkswagen-media-services.com

Touareg open up new, fascinating avenues for vehicle design. Volkswagen Chief Designer Klaus Bischoff: "The light of the future is developing into a means of communication. It will interact with the driver and other road users – whether in a car, on a motorcycle or a bicycle – as well as pedestrians, thereby significantly improving safety. At the same time, we will integrate the lighting functions more progressively into the design of the vehicles than ever before." The new Touareg embodies the current status quo of innovative Volkswagen lighting technologies both visually and technically. In this large SUV, lighting design and functions merge more coherently than ever before to form a technical and visual unit. Volkswagen is also answering the question of what tomorrow's interactive lighting concepts might look like with the first studies of a new generation of electric vehicles: the ID. family.

The evolution of light runs parallel to the evolution of safety

Volkswagen engineers and designers use the complete range of technical possibilities to massively improve safety with light. On the one hand, it is necessary to innovatively further develop the lighting functions of today's cars and thus improve road safety today. Intelligent lighting systems and light-based assist systems can do just that. Of course lighting designers and engineers also have an eye on the future. The assisted driving cars of tomorrow will confront road users with new everyday situations – such as a lack of eye contact with the driver. This is where new, interactive lighting functions come into play. These new lighting systems have the potential to communicate empathetically with people, providing feedback and building trust in assisted driving cars. The new exterior lighting features also allow for the customisation of the vehicle through customisable lighting compositions and scenarios. A team of 15 designers is specifically tasked with light design and lighting staging to further enhance the emotion, individuality and functionality of tomorrow’s Volkswagens. The new lighting systems will include micro-pixel HD headlights with up to 30,000

light points and high-performance LED headlights as a low-cost alternative to cost-intensive laser light. For the first time, the micro-pixel HD headlights will project information directly onto the road, significantly improving safety. New systems such as the matrix tail light cluster will also revolutionise tail lights. As soon as road traffic regulations permit, customisable signatures are to be used to integrate warning signs into the tail light clusters. So, for example, these could defuse dangerous situations such as at the end of a traffic jam via car-to-car communication. New assist functions such as "Optical Park Assist", which works with micro-lenses, will make manoeuvring easier and safer, too.

From static to intelligent light in eight decades

Eight decades lie between the first headlights of the Beetle and the IQ.Light of the Touareg. Over this time, lighting functions have developed from the static lights of the first Volkswagen to highly complex lighting systems, some of which already react interactively. The new Touareg with its IQ.Light shows this par excellence. If it has the Night Vision system on board, the LED matrix headlights automatically 'flash' at pedestrians (without dazzling them) in potentially dangerous situations to draw the driver's attention to them. As outlined above, the evolution of light will continue to progress significantly in the future.

Volkswagen has never made this progress dependent on the driver's budget. The best example of this is the Golf. It has always been a reflection of technical progress in the field of light development. Progress that has always been, and will remain, affordable. The early generations of the Golf featured halogen headlights that, over time, became brighter. The first xenon headlights followed and, with them, the revolution of light. Then came LED tail light clusters, LED daytime running lights and – with the e-Golf[1] – the first LED headlights. What's more it is clear that IQ.Light – one of

the best lighting systems of our time – will also turn night into day in the Golf class in the medium term.

In-house Volkswagen light tunnel shortens development times

In order to prepare for the challenges of the future, Volkswagen opened its own Center of Lighting Excellence at the Wolfsburg plant in 2014. The 100-metre long, 15-metre wide and 5-metre high light tunnel has been in operation since then in the heart of the Research & Development department. In this tunnel, the lighting systems of today and tomorrow are tested on a real road simulation. The tests can be precisely reproduced and repeated. In this way, systems can be compared and evaluated better than ever before. The Center of Lighting Excellence is also an ideal place to investigate the light perception of drivers and pedestrians. In addition, interior systems such as background lighting, head-up displays and infotainment systems can also be tested under repeatable conditions. The light tunnel also shortened the development time for new headlight, tail light and interior lighting systems, as the number of time-consuming night drives could be reduced. Progress in light development can thus be implemented even more quickly into series production technologies such as the new IQ.Light – providing increased safety that benefits all road users.

Key aspects

Light staging and exterior HMI

LIGHT DEMONSTRATOR

In order to optimally design, test and present future lighting functions, Volkswagen Design has developed a new, innovative working tool: the light demonstrator. This ID. model allows the designers to project the light of

the future into the present. The Volkswagen designers use it to look beyond the functions of headlights and tail light clusters of today and create light coverage that displays new, intelligent and functional exterior content.

Light writes the script of the actions

With regard to exterior light staging, the designers are particularly concerned with the script of the actions. The design of these processes is extended by time to create a product which is experience beyond a simple static impression. In the future, light will welcome you, say goodbye, give a warning, interact, communicate and give the vehicle an individual personality via editable lighting behaviour. At a time when mobility is changing, lighting designers attach the greatest importance to intelligent interaction content. The focus is always on the human being.

The following scenarios (shown with the light demonstrator) show sections of new, functional light staging for the Volkswagen of the future. There are also scenarios that currently cannot be approved, as the legal framework is not yet in place. But the task of lighting designers is to develop useful concepts for the world of tomorrow beyond the boundaries that still exist today.

Welcome scenario / 'eyes' looking at the driver

In the future, light will convey emotions and feelings. The driver will be welcomed by the car. It will wake up as the driver approaches. The welcome scenario starts with the VW logo progressively getting brighter. From this centre point, a 360-degree light path then surrounds the vehicle. The car opens its 'eyes' and looks at the driver. Finally, a carpet of light is rolled out in front of the door. It marks the entrance area. The light staging

itself is not only visually spectacular, it also attracts more attention and thus maximises safety in the dark.

Driving start / focus on front projection

Light will communicate from now on. The car projects its current driving manoeuvres – so-called "driving intentions" – visually onto the road. When driving off, for example. This manoeuvre is communicated via an animated projection at the front. Or when driving out of a parking space. A laterally directed projection represents a turn signal extended using light. This allows other road users to recognise the driver's intentions early on and react. This is particularly useful for assisted driving vehicles, where there is no need to communicate with the driver.

Assisted mode / marker lighting

Light will interact with us all tomorrow. In assisted mode – without an active driver – the car takes over eye contact with other road users. In conjunction with the communication of "driving intentions", other road users are informed in an intuitively understandable way that they have been seen and that the vehicle will react accordingly. A Volkswagen that starts in assisted mode and is on the road could also be identified as driving autonomously via special marker lighting in the future. The aim is to increase confidence in assisted driving cars and facilitate orientation in mixed traffic.

Light blind in roof / rear window as third brake light

Light will take on new forms. A striking example of this is a light blind in the roof. On the one hand, it serves as homogeneous and versatile adjustable interior lighting, but can illuminate from the outside, making it easier to locate the car in a large car park, for example. Like a blind, the light curtain can be opened and closed in the glass roof and stopped at any

position. The colours and brightness are also adjustable. If the principle is extended to the rear window, the light blind also functions as a third brake light with brake force visualisation. When braking gently, only part of the blind "rolls up" from bottom to top. If the car is heavily braked, the brake light increases to the entire rear window area. The warning effect is increased and intensified many times by this use of dynamic light. The parallel visualisation of the braking forces is also a safety measure.

Dynamic projection / warning of door opening

At Volkswagen, light always contributes to increased safety. And this effect will continue to intensify in the future. Particularly in urban areas, dynamic projections should help to increase safety. For example, if a driver moves to get out of the car as a cyclist approaches the blind spot from behind. Before the door opens, the vehicle detects the hazardous situation and dynamically projects the impending opening of the door onto the ground next to the vehicle. In addition, a red light is switched on in the window, which is visible from inside and outside and warns the driver and cyclist alike.

TIGUAN – VISUAL MODALITY

The communication channels between road users will change with the launch of the first assisted driving cars. Whenever a driver does not actively control a vehicle, the car itself must be able to communicate with other drivers, vehicles and pedestrians to ensure maximum safety and comfort. The new communication channels are also intended to optimise cooperation and build trust with other road users. Volkswagen Group Research is testing these future communication processes with a specially equipped Tiguan.

Research vehicle with exterior HMI

The research vehicle is currently equipped with three different technologies for 360-degree communication. Four large liquid crystal displays (LC displays) are integrated in the doors as well as the front and rear ends. There is also a 360-degree LED multi-colour strip all round. In addition, so-called multi-lens arrays are mounted in the corner areas of the body. Using these light projection and display technologies – known as visual modalities – the researchers can investigate the possible behaviour of road users in various scenarios in the future. The visual elements themselves merge to form an exterior HMI (Human-Machine-Interface). This HMI communicates with other road users and informs them about the planned driving manoeuvres of the car. The LC displays show information and warnings, while the multi-lens arrays in the front and rear ends generate visual protection and communication information onto the road. The 360-degree light strip interacts in parallel with the LC displays and supports external communication via animated lighting concepts. All this is combined with audio signals in order to integrate as many senses of the road users as possible into the communication. In addition, high-resolution headlight technologies are examined in parallel in order to integrate further functions into the overall concept of the exterior HMI on the basis of visual projections.

Light becomes a human-machine interface

Assisted driving is gradually finding its way into the Volkswagen of today, tomorrow and beyond. Systems such as Traffic Jam Assist, which in certain situations (that are still monitored by the driver) automatically take over the longitudinal and lateral control of a Volkswagen, are already available. In the future, there will also be modes in which the vehicles operate independently without driver monitoring (VDA levels 4 and 5 for automated driving). However, to be able to use the advantages of such assisted journeys optimally and safely, a new approach to human-machine

communication needs to be developed. For example, In the case of unclear situations on priority roads, eye contact and gestures are used nowadays – this will often be omitted in the future. However, as a result of the new type of communication, trust and understanding can be built up for such situations at an early stage. And this will optimise the flow of traffic, as the vehicle no longer has to come to a standstill. To take advantage of these benefits of the assisted driving mode, Volkswagen Group Research is working on an HMI such as the one used in the exterior of the Tiguan research vehicle.

Exterior HMI can also be used in today's traffic. The exterior HMI is designed to intuitively understand and trust the vehicle's behaviour and to enable an intuitive prediction of possible driving manoeuvres. However, the exterior HMI offers great added value not only for tomorrow's assisted driving cars, but also for today's traffic and vehicles. A general example of this is an end-of-traffic-jam warning via car-to-car and/or car-to-x communication that could help to make situations clearer, thus preventing rear-end collisions and increasing safety on motorways. The Tiguan built by Volkswagen Group Research is the first research vehicle with such a versatile exterior HMI that can be used in real traffic situations. The researchers thereby leave the closed interior, which can be controlled by the driver, as a field of interaction in order to master new areas of design and, at the same time, meet new technological requirements.

Various technologies are used, developed and evaluated here in order to derive the best possible technological and conceptual recommendations for action. At the same time – and this is crucial – Volkswagen is once again putting people at the centre of its research: pedestrians, cyclists, car users and motorcyclists. In addition to the consideration of perceptual psychological processes in a communication process, the needs of users are also identified in the studies. This is done on the basis of online surveys, interview and video studies, studies in virtual reality and with the

prototype in real road traffic. The overriding goal is to realise an increase in safety for everyone via exterior HMI.

Headlight technologies

IQ.LIGHT – LED MATRIX HEADLIGHT

For the third Touareg generation, one of the world's best headlight systems was developed: the optional IQ.Light LED matrix headlight. It impresses with an intelligent light control that makes night driving more comfortable and safer. The LED headlights use a matrix made of light spots – individual LEDs that can be activated. The matrix of the dipped beam is made up of a printed circuit with 48 LEDs while the circuit board of the main beam is fitted with 27 LEDs. The LEDs in the dipped and main beam module are arranged similar to a chessboard. There are various other LEDs in addition

to the total of 75 LEDs in the dipped and main beam. Including the surround lighting as well as the so-called signal functions (daytime running light and elevated side light as well as animated turn signal), there are a total of 128 LEDs per headlight. The Touareg therefore uses the illuminating power of a total of 256 LEDs in the various segments of the left and right headlights at the front to make the night safer and perhaps even as bright as day.

Various intelligent light functions in the Touareg are activated using the 75 LEDs of the dipped and main beam as well as seven front end LEDs (in five reflection chambers) and three cornering light LEDs. The corresponding computer uses signals from the front camera, the digital data of the navigation system, the GPS signals, the steering wheel angle as well as the current speed to precisely activate the individual LEDS for the best light in a split second. The driver switches on the main beam headlight using Dynamic Light Assist. The Touareg manages the rest itself – dim, turn up, city lighting, optimum motorway light or off-road light. As the new matrix headlights operate with the highest light output, people, objects, other vehicles and animals are made visible that would be less recognisable and less visible with conventional headlight systems at night. The increase in light output and optimised illumination is clearly noticeable. Indeed in a comparison between the already very good xenon headlights of the predecessor and the new Touareg's LED system there is a range increase of more than 100 metres for the IQ.Light – LED matrix headlights' main beam. The interactive headlights already operate in a similar way to those in a car with an autonomous driving mode. For example, the front camera registers brightly illuminated areas as "residential". In this case the Touareg automatically switches from main beam to dipped or 'low' beam. Details of the light functions of the IQ.Light – LED matrix headlight:

- **City lighting:** A particularly wide light beam with a focus on the sides; active up to 50 km/h

- **Dipped headlight:** Dipped beam with wide light distribution in the direction of the kerbside
- **Dynamic Light Assist:** Permanent main beam on country roads without blinding other road users
- **Motorway dipped beam:** Narrower light beam focussed on a wide reach for high speeds
- **Motorway light:** Narrower light beam focussed on a wide reach for high speeds if no other road users are blinded
- **Overtaking light:** Precise main beam for overtaking procedures without blinding road users. The system recognises that the Touareg pulls out to the side. This side area is now illuminated more intensely
- **Side light:** Correct lane accentuation for Dynamic Light Assist and oncoming traffic. The view is thereby directed more to the driver's own lane
- **Main beam:** Manually activated main beam to deliberately use all 75 LEDs of the headlight for maximum illumination. In contrast to the motorway light, the light beam is wider
- **Poor weather light:** Reduces glare for the driver and other road users on wet roads. The annoying reflections of the headlight on the wet, reflective road surface directly in front of the driver are reduced by the IQ.Light cutting illumination intensity in this area. In addition, the road is illuminated more broadly. The function can be activated and deactivated by the driver
- **Sign glare control:** Precise dimming of the main beam on signs so that the reflected light of the headlight does not blind the driver
- **Offroad light:** A particularly powerful static dipped beam distributed over a 90-degree width to be able to recognise obstacles on terrain

- **Spotlight (for "Night Vision"):** Focussed illumination of people detected by "Night Vision" (infrared camera) without dazzling to make them easier to see for the driver
- **Sequential cornering light:** Enables an optimum light distribution width to be generated in many of the above-mentioned light distributions by selective switching on, switching off and various dimming levels. In addition, the light is quickly "fanned out" and slowly "fanned in" again when cornering

HD-LCD HEADLIGHT

Volkswagen uses newly developed HD-LCD headlights in a Touareg test vehicle. With their high-definition LCD, they enable a resolution of up to 30,000 pixels per headlight. In comparison, today's high-end headlights offer a resolution of around 80 pixels. With their much higher resolution, the HD-LCD headlights enable developers to implement and test highly complex lighting scenarios more precisely than ever before. The precise illumination of the road and the equally precise prevention of dazzling from oncoming traffic also minimises the shadow area in the light beam and thus maximises the illumination of the road. Again, this generates an increase in safety. The overriding aim is to use HD-LCD headlights to optimise classic functions and implement new ones. To experience this, of course, you need a test vehicle like the Touareg. Thanks to the HD-LCD headlights, the lighting engineers are free to choose what functions and light distributions are represented.

In addition, important new, light-based driver assist systems can be developed based on HD-LCD headlights. The latter use visual signs and function graphics that are projected onto the road via HD-LCD headlights. In this way, new assist systems such as the "Optical Lane Assist" can be realised. In this system, the headlights project lanes in front of the Touareg, giving the driver precise information about the width of the SUV (including

trailer) and the distance to the road lane markings, for example at road works. The lanes also visually follow the radii of curves. Such useful lighting functions, bolstering safety, are being tested with the HD-LCD headlights. This also includes interactive functions for the assisted driving Volkswagen of tomorrow.

Developing functions before the hardware is available saves time

Volkswagen Research & Development is looking at the entire spectrum of HD headlight systems. Currently, the focus for the next generation of front lighting is on micro-pixel LED headlamps, which consume very little energy. The latter is of great importance particularly when headlights are used in electric vehicles, such as the future ID. models. At the same time, the HD-LCD headlights tested in the Touareg are providing Volkswagen engineers with an invaluable service. They make it possible to test useful lighting functions of tomorrow before the production-ready hardware is available. And this saves time, sometimes years. Saved development time that helps to make roads at night safer with innovative, intelligent light. Around 30 percent of all accidents involving personal injury occur at night, but the accident severity is about twice as high as during the day. Here, optimum illumination and intelligent light-based assist systems can provide an increase in safety.

In addition, purely interactive functions can be displayed – such as a welcome scenario that greets the driver as he approaches the Volkswagen. The light can also be personalised. So while one driver prefers a wide light beam, another may prefer a narrower, longer light beam. It is also conceivable that new lighting functions can be loaded to a vehicle via a type of app store.

How the HD-LCD headlights work

HD stands for High Definition as outlined. LCD – Liquid Crystal Display – is a technology more familiar from the entertainment sector. Here, several LEDs serve as light sources. Their light is split with a filter to make it usable for use with liquid crystals. This creates two paths of light, A and B. This provides the possibility of a defined polarisation, which is a prerequisite for LC displays. Both paths meet a display – the liquid crystal screen – which acts as a type of light filter. The polarisation can be used to decide for each of the 30,000 pixels whether its light should be passed through or not. This job is performed by a so-called analyser – another filter. By applying a voltage to the liquid crystal, the polarisation is changed from A to B – an on/off function. Depending on the polarisation, the light is either allowed through the pixel or blocked. This makes it possible to define which light (which pixel) falls on the road and which remains in the system. Intermediate levels are also possible, with which different shades of grey can be generated. And so it is possible to project graphic elements onto the street. However a disadvantage of the HD-LCD headlight is that the light components generated by the LEDs which do not fall on the road, remain unused as heat in the system. And that costs energy. This is why the efficiency of the HD-LCD headlight is limited at present.

MICRO-PIXEL LED HEADLIGHT

Another exceptionally interesting HD technology is the micro-pixel LED headlight. Volkswagen is currently working on the predevelopment of this type of system. The micro-pixel LED headlight is a compact, energy-efficient and high-resolution lighting system that offers a maximum range of functions. The headlight technology enables light control that is individually adapted to the respective driving situation, interactive light projections onto the road and a high degree of individualisation. Volkswagen will also use a future end-to-end electronics architecture and a new operating system to ensure that new functions can be loaded as upgrades via an app.

Three chips, each with 1,024 pixels as the technological basis

The technological basis of the micro-pixel LED headlight is formed by three micro-pixel LED chips. At the centre of these chips, 1,024 pixels are arranged on an area of only 4 x 4 mm. Each of these 3,072 pixels can be controlled individually. As shown, each individual micro-pixel LED chip is square, with an area of 16 mm^2. If this latest chip were displayed 1:1 using a projection system, the projection would also be a square. The light distribution in front of a vehicle, however, is typically rectangular for reasons of driving dynamics. By skilful projection, the optical system thus transforms the square light distribution of the source into an ideal aspect ratio of 3:1. This means that the entire basic light can be covered with a matrix and is available for the application of intelligent lighting functions. In the future, rectangular micro-pixel LEDs could simplify the design of the optical system.

Up to 30,000 pixels can be realised with this system

The entire headlight consists of a large LED light module for static surround lighting and the three outer lenses. These three lenses contain the know-how with which a completely new, powerful and interactive generation of headlights can be launched. The three micro-pixel lenses operate as projection modules. Volkswagen has developed an optical system that doubles the horizontal axis of the overall light distribution. The lighting engineers developed a rectangle in a ratio of 2:1 from a square. And this creates more width in the light distribution. These three rectangles in turn overlap. This is the only way to create a maximum width of field and the largest possible angle range in which all conceivable lighting functions can be implemented. Since the chips also project into the same area, more pixels and thus a higher resolution are available, which in turn can be used to implement more functions. The 3,072 pixels

realised now are a start – micro-pixel LED headlights have the technical potential to include and project up to 30,000 pixels per chip. The economical micro-pixel LED headlights would thus achieve the same resolution as the less energy-efficient HD-LCD headlights.

HIGH-PERFORMANCE LED HEADLIGHT

The newly developed high-performance LED headlight also shows that Volkswagen is investigating all evolutionary paths of light. It is an inexpensive but powerful alternative to laser light. The laser light is primarily used for range-generating main beam applications. The same applies to the high-current LED main beam. It is intended to improve night-time safety by maximising the light intensity of the main beam. The high-performance LED headlight was developed in-house by Volkswagen. In addition, the optical light output in these main beam systems can be reduced to provide attractive, compact headlights without reducing the light output. The same is also possible for dipped beam headlight systems.

Even the best light must be affordable

Laser light is considered to be an ideal light source because a lot of light is emitted from an extremely small area. The result is a high level of luminance. This gives rise to an almost perfect point light source. In addition, the systems in the vehicle can become smaller due to the high intensity of the laser light. It thereby offers a very large range and at the same time great advantages for vehicle design. But for a volume manufacturer like Volkswagen, there is also a downside to laser light. Compared to normal LED headlights, the costs are significantly higher for various technical reasons, and even large quantities will only slowly decrease these costs. However, the top priority for Volkswagen is the principle that safety must be affordable. For this reason, Volkswagen's lighting engineers have pushed the development of the high-performance

LED headlight as an alternative to laser light as a new, independent approach.

The high-performance LED main beam makes it possible to operate semiconductors with much higher currents than was possible just a few years ago. The new high-performance LED used by Volkswagen provides a higher luminance than normal LEDs and therefore comes very close to the laser light source. However, the luminous flux of the high-performance LED is much greater – the amount of light is thus higher than for current laser light. Noticeably positive effects for the driver include a longer range and a broader scope for headlight illumination.

Technical prototype developed in-house

The prototypes of the high-performance LED headlights installed in a Tiguan already exhibit a high degree of readiness for series-production. The design of the headlights has not yet been implemented, so purely engineering components are used. The light development (CAL Computer Aided Lighting), CAD design, thermal protection and production of the new headlights were realised by Volkswagen itself without a supplier.

the system essentially consists of a main lens and an additional main beam. The main lens is located outside in the headlight and has a particularly flat design compared to today's systems. The aim here was to demonstrate the advantages of the new LED in terms of technical space reduction. This projection module offers a wide dipped beam, which also assumes the function of a dynamic cornering light using a swivelling support. The first main beam stage is also generated from this lens. The high-performance LED additional main beam is inside, next to the main lens. Importantly, despite the triple design of the additional main beam in the prototype only one of the integrated lenses is required. In fact the test vehicle is to be used to assess three different auxiliary headlights with individual light distribution. Tests conducted by Volkswagen have shown

that almost all drivers have very individual requirements with regard to the range and width of the light beam for the main beam. The three auxiliary headlights can each be activated separately in the Tiguan. No. 1 produces a conventional additional main beam with a relatively large width. No. 2 produces a relatively small spot with a large range, while at the same time other lenses in the system illuminate the close surroundings on the right and left as well as upwards, creating a feeling of more light and thus an increase in safety. No. 3 is a concentrated spot with a range of more than 550 metres. Night driving tests should then determine which of the three auxiliary main beams is the most favoured and used in series production.

Signal lights

SWITCHING SIGNATURE TAIL LIGHT

The rear end is the area of a vehicle that motorists see most often and over the longest period of time. The reason is simple: No matter if in the city, on a country road or on the motorway, one constantly looks out of one's own car at the car driving in front. All the more important, then, is a successful design of the rear end particularly the tail lights. Moreover, it is crucial to create maximum attention for successive road users to increase road safety. This is best achieved by making both turn and brake functions easily and quickly recognisable. Volkswagen generated a new maximum signal effect for the first time in 2014 with the launch of the Passat. As an alternative to the standard LED tail lights, it is now optionally available with an LED tail light, which offers a switching signature between tail light and brake light function. With it, a new level of signal effect was introduced into lighting technology. Now in 2018, LED tail lights with switching signatures from Volkswagen are also available for the Golf, Tiguan and Touareg.

Click-Clack – Concise change between tail light and brake light

The "Click-Clack effect" of the switching signature tail light and brake light becomes visible at night when the tail light is active. When the brakes are applied, the Passat's and Tiguan's horizontal signature tail light changes to a vertical signature brake light. Visually it appears as if the horizontal tail light signature is turned down into the vertical signature brake light. The signal change underlines the recognisability of the brake and thus increases road safety.

CUSTOMISABLE TAIL LIGHT

Light is always the first focus of safety at Volkswagen. But light also distinctively highlights the specific design of a car. In the future, Volkswagen drivers will be able to individually tailor the lighting design of their cars themselves with a customisable tail light signature. This will be possible simply with an app on your smartphone or via the car's infotainment system. Volkswagen demonstrates how this works with the example of the new Touareg. Here, the lighting engineers have integrated the prototype of the new, customisable tail light.

One tail light, three signatures

The owner can choose between three different signatures at once via the Infotainment system, driving mode or a smartphone. In all three cases, the narrow, surrounding light signature of the tail light is always identical. It already complies fully with legal requirements and thus makes space in the inner area for individualisation. As a basic theme, the so-called LED wings are changed.

The customisable signature tail light picks up on the worldwide trend of increased personalisation of vehicles using electronics, thereby tailoring them to personal tastes. In the area of lighting, this trend began with customisable background lighting in the interior. From this, Volkswagen developed the idea of a customisable tail light and thus a new design feature. But while a wide range of lighting functions is allowed in the interior, the exterior light must comply with all legal requirements as outlined. For this reason, Volkswagen first realised the three signature lights shown in the prototype. Nevertheless, it is conceivable that after the market launch various other light signatures can be released individually as 'functions on demand' at a later date. It will also be possible to link the signature to the respective driving mode – in the case of the Touareg, for example, as a "Comfort", "Sport" or "Offroad" selection. The fact is that

light graphics will be an individualisation feature in the future – they will change from a static functional element to an interactive safety and design feature.

MATRIX TAIL LIGHT

The next expansion stage of the customisable signature is the matrix tail light. It shows the functional range of tomorrow's tail lights. Like the customisable tail light, the matrix tail light also has a static signature in the exterior area for legal reasons. The interior is equipped with a matrix that can be personalised in an even larger spectrum via an infotainment system or smartphone app. And not only by means of light graphics, but also – using a type of display – with symbols and text.

Individual displays will increase traffic safety

The matrix tail light opens up a new communication channel. Clear warnings such as a "snowflake" can be fed into the tail light cluster via the matrix to indicate slippery roads. And not only manually by the driver, but also automatically via car-to-X communication. In this context, it would also be possible, for example, to give early warning of the end of a traffic jam and thus help prevent accidents. It will also be important that assisted – i.e. driverless – moving cars communicate with their surroundings via tail lights .

Electric cars indicate the charge state via tail light

Countless other functions are, of course, conceivable too. A coming-home or leaving-home scenario could be personalised and controlled by an app. Electric vehicles could display the current charge level via tail lights. The advantage is that no other component would have to be integrated into the car for electric vehicles because a tail light is always present. The

technologies for the new matrix tail light are largely ready for series production. As soon as the corresponding legislation permits its use, final implementation could start. Of course, the matrix tail light could also be updated – a spectrum of around 100 different signatures is certainly conceivable.

HOLOGRAPHIC TAIL LIGHT

Holography – when this word is used, many people perhaps immediately think of "Star Wars" and Princess Lea. Little R2-D2 beamed her as a hologram into an intergalactic meeting of the Jedi Knights. Science fiction, for sure. But holography itself is by no means fiction. On the contrary. In the not too distant future, the use of holograms in the tail lights of automobiles is conceivable. A so-called volume hologram is used for this. The hologram is visible from different angles, so that a three-dimensional impression is created. Soon it could provide a completely new design and functional spectrum of tail lights. Volkswagen is therefore now presenting the first prototype of this new generation of lighting functions: the holographic tail light.

Holograms in the tail light cluster become visible using LEDs

This is how the hologram is made: an object is irradiated with a laser and then stored on an exposed photopolymer – a transparent holographic film as the carrier of the hologram. Before the object is irradiated, the laser beam is split into a reference beam and an object beam. Both parts of the laser beam reflect onto the photo plate and expose it. Here the hologram is "written" into the photopolymer. If the transparent photo plate is now illuminated with the angle of the reference beam, the three-dimensional object is created virtually. Depending on the viewing angle and light source, the viewer can even walk around the object and view it from different perspectives. With the holographic tail light cluster, LEDs

illuminate the photo plate exactly at the angle of the reference beam. As a result, a virtual three-dimensional light function appears in the tail light cluster. When switched off, the area of the light function is almost transparent. Only when it is illuminated as shown does the lighting function emerge in front of, above or behind the tail light cluster.

Light is created where there is no physical space available

The holographic tail light offers a wide range of new possibilities. You can create light where there is no physical space. You can create new lighting effects. Light can be optically extracted from the tail light to create a plastic effect. It is possible to make the representation or visibility of the lighting function dependent on the viewing angle. The light sources themselves are "hidden" – no longer visible. Classic lighting functions such as the turn signal can also be displayed. A turn signal with a different colour could be placed behind a tail light hologram, which also seems to float freely in the tail light. In addition to the classic lighting functions, graphics such as the GTI logo could also be integrated in a free-floating manner to ensure that the statutory lighting functions are not impaired. For example, the GTI logo would only be visible to the observer standing next to the car.

OPTICAL PARK ASSIST

Volkswagen uses the example of the Optical Park Assist to show what is possible with an innovative optical concept on an area of just one square centimetre. This new lighting function uses a micro-lens array (MLA) to project all kinds of signs and navigation aids onto the ground behind, next to or in front of the car. The array is equipped with more than a hundred small micro-lenses, all of which project the same image onto the street. Due to the large number of lenses, both the imaging performance and the light intensity are very good. In the case of the Optical Park Assist newly

developed by Volkswagen, red stripes are projected behind the car. They mark the width of the car, are perfectly visible via the side mirrors and thereby serve as an intuitive orientation aid when parking. The idea for the Optical Park Assist came about while parking in a situation next to a high curb, where a Volkswagen engineer did not want to damage his expensive light alloy wheels. And this is exactly what Optical Park Assist will be able to mitigate in the future.

Hardly visible in tail light or bumper

If cars are soon to be parked automatically (without driver), the manoeuvring path can be projected onto the road via the "Optical Park Assist" in order to alert pedestrians to a car being parked. The new assist system also offers increased safety in the event of a breakdown or when getting in and out of the car, since in this case a safety zone projected onto the ground in the vicinity of the vehicle indicates the situation. The multi-lens array can be integrated into the bumper or tail light, for example. The image quality remains good even if the car is tilted, raised or lowered.