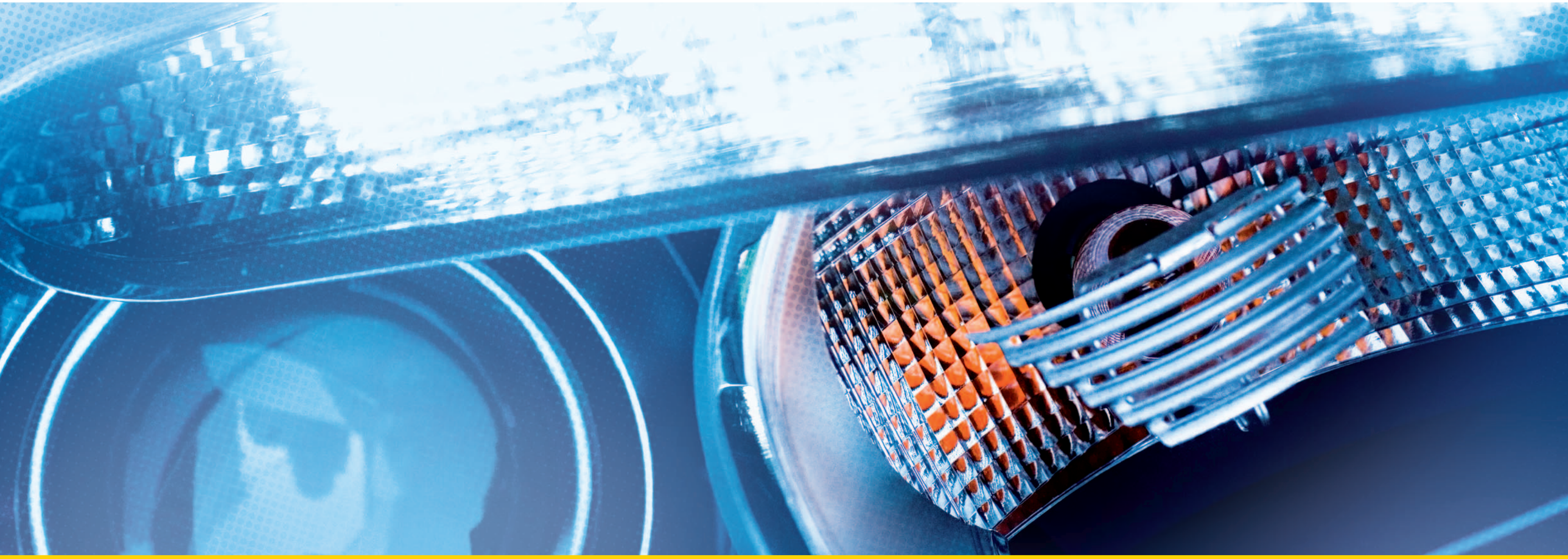
Hella KGaA Hueck & Co.
Rixbecker Straße 75
D-59552 Lippstadt/Germany
Ph. + 49 29 41 38-0
Fax + 49 29 41 38-71 33
www.hella.com

Lighting Technology

Technical Information



Ideas today for
the cars of tomorrow

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Without light we could not see. This applies to both “seeing” and “being seen”. This is why automotive lighting systems are an essential part of safety when it comes to road traffic – both day and night. Of course, safety is not the only factor that motivates our engineers at Hella in striving to optimize automotive lighting technology over the long haul. There are also climate changes and climbing crude oil prices besides the increasing volume of traffic and number of accidents that prompt us to act – or to be more precise – to research and develop.

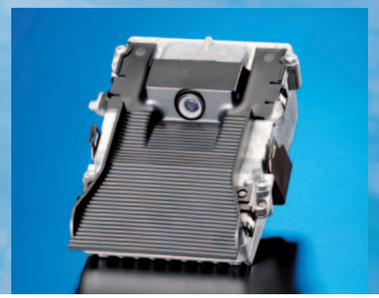
Our efforts focus on new lighting solutions which meet the requirements for safety and environmental protection and which ensure the greatest possible degree of comfort for the driver and styling options for auto-makers.

The light-based driver assistance system, which represents the innovative functionality of intelligent lighting systems, plays a key role in this case. An optimum, situation-driven lighting system increases road safety, while the adaptive and assistive function-alities provide the driver with convenient support.

A look at the role that LED technology plays within automotive lighting systems shows great promise. LEDs are regarded as the light source of the future with its ever-increasing output and efficiency. That’s no surprise, taking their high energy efficiency, optimum optical integration and addressability as well as their scope for creative freedom into consideration, not to forget the high, innovative leeway they offer within automotive lighting systems.

Vehicle lighting is also gaining importance in terms of styling. The wide variety of options for purposefully designing light offer a new dimension for vehicle design in addition to form and color. For instance, it is possible to implement identifying characteristics or a customer-specific corporate identity or simply find innovative methods for integrating light with design. By doing so, high-quality automotive lighting systems become a perceptible experience.

VarioX® module



Front camera

Control unit

Lightdriver as simulation tool

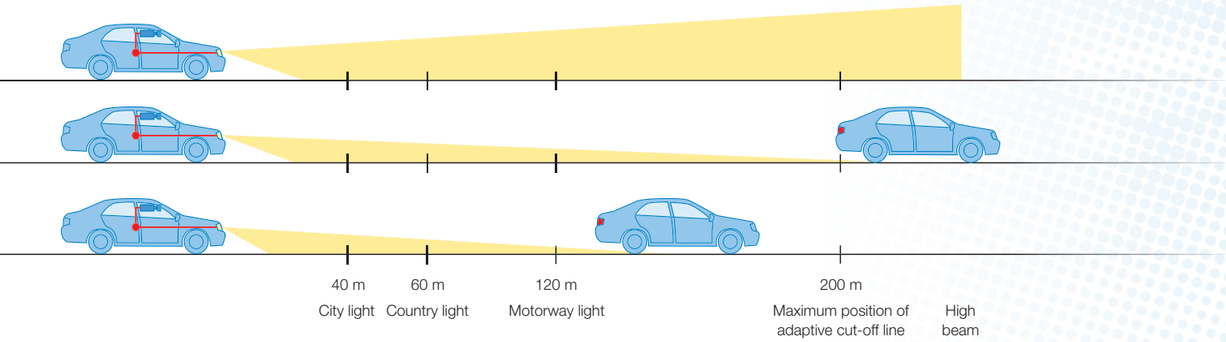
Camera-based Light Functions

Automotive lighting solutions have been focusing on how to achieve optimal illumination of the roadway for many years. The objective, on the one hand, is to illuminate the road and its surroundings as much as possible so that the driver is able to reliably identify objects on the roadway. On the other hand, they should not blind other motorists and drivers. One of the main tasks of our lighting engineering specialists is to achieve the best possible balance between illumination and blinding yourself and other motorists.

The classic solution involves switching between high beam and low beam. While high beams do provide a light distribution that is optimized for illuminating the road, low beams are for all intents and purposes a compromise to prevent blinding. That's why high beams and low beams do not represent an optimized, state of the art solution for safety when driving at night. A simple, obvious improvement for adverse weather conditions would be a vehicle equipped with special supplementary headlamps such as fog lights that drivers are able to switch on or off depending on the respective situation. A next step involves not implementing these additional light functions in individual supplementary headlamps but to integrate them in the main headlamps and automate the switching between the respective levels of light distribution. This is the basic concept of AFS headlamp systems (Advanced Front Lighting System).

AFS headlamp systems provide subtle pre-defined levels of light distribution. Light distribution is adjusted depending on the vehicle speed, the type of road and weather conditions, which represent an enormous improvement over conventional automotive lighting technology.

Change in the geometrical range by continuously adapting the cut-off line in an adaptive cut-off line headlamp system.



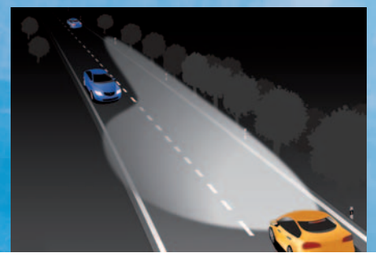
In this case, Hella's engineers all agree: the most appropriate method for implementing such a situation-driven, automatic headlamp system is the so-called VarioX® module. This module is able to generate up to five different levels of light distribution with only one Xenon light source: In addition to conventional low beam and high beam, the same headlamp module can also deliver light for town and motorway situations as well as adverse weather conditions.

The VarioX® technology is based on the principle of projection. A rotating free-form drum between the light source and lens generates the different light pattern. The drum has different contours on its outer surface which can be used to generate different levels of light distribution on the road. These contours and the entire geometry of the drum may be adapted to specific OEM requirements.

To achieve the AFS systems and camera-based light functions, the VarioX® module is combined with a swivelling module that is exceptionally silent. The swivelling module has an overall compact size and a low mass as well as an especially high swivelling rate and positioning accuracy.

Camera-based light functions will not only adjust light distributions automatically to roadway and weather conditions but to the respective traffic situation as well. They are based on CMOS cameras which act as image sensors and interact with powerful image-processing software and cutting edge lighting technology. Cameras, which are optimized by Hella engineers for this specific use, are used to realize specific light functions.

The first light function controlled by image data is the adaptive cut-off line. Hella has developed the Lightdriver simulation tool to aid with implementing forward-looking light functions. Besides checking the light performance of a new headlamp, it also allows for evaluating dynamic light functions in the early phases of development. The result is a wide variety of different functional systems that always have the same agenda: optimally illuminating the roadway for the driver while ensuring at the same time that other motorists are not blinded.



Conventional low beam

Adaptive cut-off line for an oncoming vehicle

Adaptive cut-off line for a vehicle driving in front

Conventional high beam

Glare-free high beam for an oncoming vehicle

Glare-free high beam for a vehicle driving in front

Adaptive cut-off line

This system adjusts the range of the AFS headlamps automatically such that the driver has optimum visibility which extends as far as possible. This is achieved by adapting the range of the headlamps to oncoming vehicles or vehicles driving in front. If the image processing system does not detect any motorists, the system provides the driver with light up to high beam level. For instance, the usual range of the low beams from 60 to 70 meters in the middle of the road can be increased up to 200 meters (3 lux line). The camera is able to detect other motorists that are up to 800 meters away. If an object appears, the range of the headlamps is adjusted accordingly within fractions of a second.

In spite of ensuring the best visibility possible for the driver, the system also eliminates blinding other motorists, since the headlamp beam always ends right in front of oncoming vehicles.

This system represents an advancement over the high beam assistant that is currently available on the market and which only switches between the two settings – low beam and high beam. Of course, the function of the high beam assistant can generally be achieved as a feature of a multipurpose front camera.

The results from diverse studies conducted by LLAB* (light lab) confirm Hella's development work:

- Empirical determination of the detectability distances of headlamps with adaptive cut-off line compared to conventional systems.
- Efficiency rate of adaptive systems: an assessment of the safety gain can be derived by calculating the percentage of trips, where adaptive cut-off line headlamps generate optimized visibility conditions.

* Research institute for light technology and mechatronics supported by the University of Paderborn (Germany) and Hella as public private partnership.

Glare-free high beam

The glare-free high beam based on Xenon, follows the principle of a high beam that is constantly on. If the system detects a motorist who is at risk of being blinded, it automatically blocks out the parts of the high beam light that could disturb other motorists. In this case, the drum between the light source and projection lens is rotated by a stepper motor to the requried position within fractions of a second. Based on image data and intelligent adjustment of the VarioX® modules, light is reduced only for oncoming motorists and preceding vehicles. The high beam light distribution remains almost intact for the driver such that the visibility range is considerably greater than the range offered by today's systems. Our engineers at Hella have developed the first generation of this glare-free high beam based on the VarioX® projection module.

Glare-free high beam with LED-array

Besides the solution using Xenon technology, Hella is working on implementing glare-free high beam with LED-arrays. On the one hand, the light generated by these arrays may be directed purposefully towards the area of the roadway where motorists can not be blinded. On the other hand, using LEDs, offers the advantage of dimmability compared to the mechatronic approach. This ensures that the level of illumination is always below the glare limit for the other motorists without having to switch off the light source completely in case of a great distance of oncoming vehicles. For drivers this means an optimization of the amount of light that is available for illumination purposes. Depending on the number of LED chips used, it is also possible to suppress the glare for multiple oncoming and preceding vehicles. The light distribution algorithm is being optimized for active headlamp systems in collaboration with LLAB.

Marking light with LED-array

Another innovation in the field of camera-based light functions is the optimal addition for glare-free high beam: the marking light. The advantages of LED technology are also bundled here and utilized to the benefit of all motorists; this means individual LEDs are switched on purposefully. With the aid of a camera-based system it is possible to detect and specifically illuminate objects which could result in a possible accident (e. g. pedestrians and animals) on or next to the roadway. In this manner, the driver's attention is directed to potential dangers, thus affording the driver more time to respond. The possibility of actuating LED chips individually allows for permanently illuminating a potential danger in spite of the vehicle and the object moving. Here drivers are able to identify objects in a simple manner without having to take their eyes off the road.

Prototype of a LED headlamp 2005 and ...

... 2007

First LED serial headlamp 2009

Experimental vehicle with standard module off ...

... and on

LED Technology

Full-LED headlamps

The advantages of LEDs over conventional light sources in terms of life cycle, efficiency and space required are long known – and thanks to our engineers at Hella completely usable in mass production for automotive lighting systems.

All technical light functions are realized with LEDs in a full-LED headlamp. The low beam light is distributed by superimposing the individual parts of the light distributed by the different optical modules. In the LED headlamp, the light is purposefully distributed by free-form optics (free-form lenses) in such a way that the desired light distribution is achieved.
Moreover, using multiple light modules allows for implementing customer-specific styles in terms of design and arrangement of the optical modules. This customer-specific design can be realized in the LED headlamp by arranging the optical elements in a line on top of one another. Prerequisite for using multiple chip LEDs in full-LED headlamps is maintaining a good thermal management of the corresponding optical modules. Since only about ten percent of the electrical energy is transformed into usable light power, the power loss of the LEDs must be directed away from the LED chip and released to the environment in a very effective manner. Once all of these requirements on suitable structural design and connection methods are fulfilled, it is possible to make good use of the diverse advantages of this forward-looking light source – LED.

For decades Hella used light engineering software that it developed on its own and tailored precisely to the demands of vehicle lighting systems. This software is capable of calculating special free-form lenses for LED headlamps.

Together with LLAB, who also conducts regular acceptance studies for LED headlamps with end customers, Hella's specialists measure the glare from new lighting systems and compare it with conventional headlamps.

Progress is only good, when it can be used by everybody. Or in other words, the next important step is to develop standards for the purpose of optimizing production processes and costs.

When looking at the typical light pattern of low beams, it is obvious that it may be broken down in various areas.

A symmetrical basic light distribution with a large horizontal spread provides the most uniform illumination of the area directly in front of the vehicle. In the center, close to the cut-off line, the basic light distribution is superimposed on an area of high illuminance, which creates the range of the low beam light. The asymmetrical sector of the light distribution provides an extended range in the area of the vehicle's own lane.

The application of different optical principles for creating this partial light distribution opens up a wide variety of very diverse styling options. For instance, the modules may be laid out as reflection systems, in which the light is collected and reflected by a reflector. In refracting systems (usually lenses), the light is deflected when passing through a material (glass or plastic) in accordance with the physical law of refraction. Hybrid systems combine both principles for deflecting light. The goal is to fine-tune the partial light distribution such that the overall distribution pattern is optimal. Possible variations in terms of arrangement and quantity of modules guarantee extensive styling options and thus an increased potential for automakers to distinguish themself.

Optical system with LED-array

Prototype of a rear combination lamp with organic LED (OLED) as tail light function

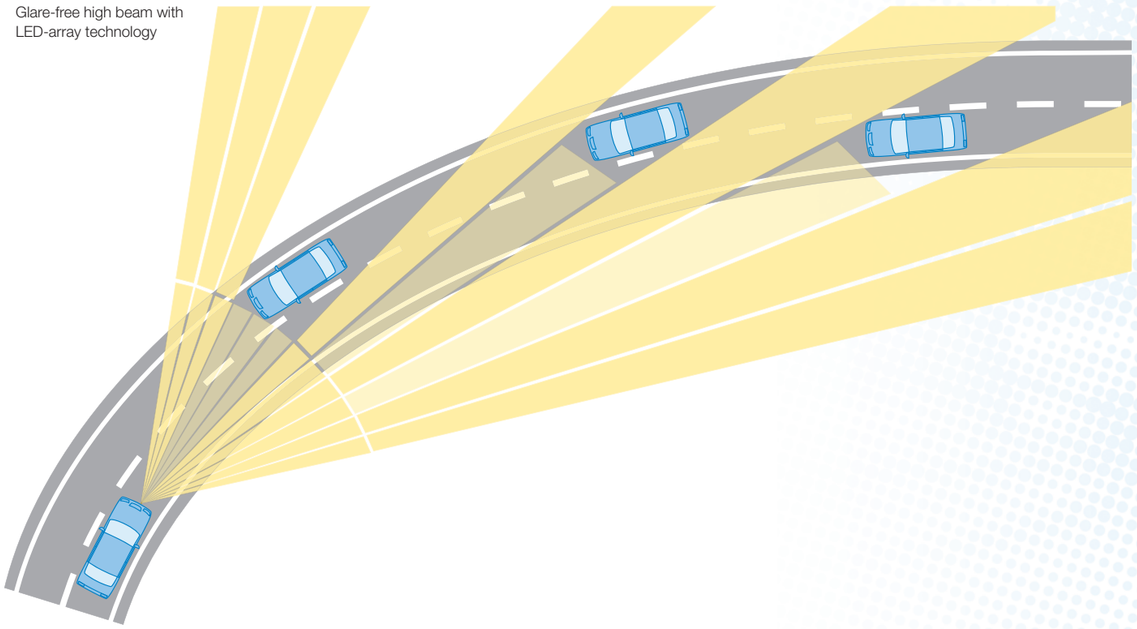
Prototype of a side light with OLED

Dynamic light functions with LED

Environmental and traffic-compatible light distribution patterns such as AFS (Adaptive Front Lighting System) are already in use in conventional technology. In addition, there are a wide variety of novel systems for further optimizing how the roadway is illuminated and which are on the verge of being launched in 2008. Implementing dynamic light functions with the aid of LED light sources represents a technical challenge. The main focal point in this case is on the development of suitable modules that create AFS light functions in conjunction with LEDs. The light distribution of a LED headlamp, which normally consists of diverse modules, places particular requirements on the accuracy of mechatronic components.

Another goal for the further development of active LED light functions is the improved illumination of intersections and tight slow. By dimming the LEDs, curves and intersections can be illuminated “softly”, while the illumination of a curve is adapted to the radius of the curve. As a result, the application of LED light sources may soon be advanced into an energy-saving variation of a cornering light.

Glare-free high beam with LED-array technology



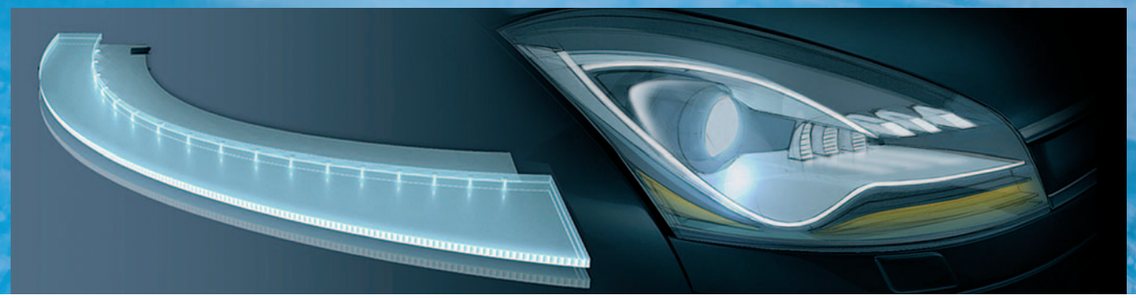
In short: the possibilities of automotive light functions with LEDs are very promising and will allow in the future the realization of further approaches with regard to an optimized illumination of the roadway.

So-called LED-arrays may be used as a light source for every form of “active” headlamp systems. These consist of a wide variety (>10) of individually addressable, white high-intensity LEDs. The actuation of LED chips with the aid of a pulse width modulator does not only permit the targeted enabling and disabling of individual chips and thus the modulation of geometry of the light / dark boundary, but also a modulation of the intensity of the light distribution. In addition to implementing AFS light functions without any mechanical elements, LED-arrays also offer in combination with a foreward looking sensor the opportunity to realize “active” light distributions such as glare-free high beam.

Organic Light Emitting Diodes (OLED)

Innovative solutions based on organic light emitting diodes (OLED) are anticipated in the near future. These thin-film lighting elements undercut every comparable light source while offering an extremely low installation space. Compared to other light sources, OLEDs offer a very uniform light distribution characteristic and are impressive due to the long service life and low energy requirements in comparison to incandescent lights. Moreover, additional control units and EMC shielding measures are not necessary. Advantageous characteristics that make OLED technology predestined for the use in several applications can be found both in the passenger compartment, e. g. ambient or orientation lighting, and in the area of signal lights.

For signal lighting, OLEDs are well suited for functions involving low luminous flux and relatively wide, uniform distribution of light intensity (e. g. side lights). For instance, a tail light or a front navigation light could be implemented as single function light with corresponding microstructures as secondary optical system.



Technological model: Low-profile light guides

Headlamp – design representation

Prototype of a headlamp with integrated low-profile light guide and light-guiding elements

Styling

Styling offers innovation

Besides quality and performance, the design of an automobile represents an especially important selling point for buyers. While design options in terms of shapes and colors are endless from a functional perspective, exterior lighting assumes an increasingly central position in the design of automobiles. A trend that will continue to grow in the future. In light of the ever-expanding technical possibilities, the light functions may complement and accentuate not only the stylistic look of the vehicle both at day and especially at night but also make an important contribution to corporate identity. Of course, that applies to the passenger compartment as well, where lighting has the task to create the most comfortable atmosphere for the passengers at night while setting stylistic accents.

Styling – an important facet of automotive light technology that is gaining more and more significance with the growing technical options. Hella has recognized these developments and adresses particular importance to this trend throughout the entire development process for automotive lighting. Simply because it makes sense. After all, the synergy effects resulting from design and lighting technology have been an integral part of Hella's corporate structure since the very beginning.

Our expertise is, on one hand, in the area of industrial design, where we handle projects and carry out developments ranging from the mood board to photorealistic day / night representation. On the other hand, Hella specializes in light-technical layout and the production of professional light, design and prototype samples in a specialized optical workshop.

With its workshop Hella is able to carry out, advance and / or support the entire development process from the very first idea and light technical layout to functionable prototypes.

Styling study
Edgelight headlamp concept

Hella styling offers customers the possibility to implement innovative light technical solutions for a new design or to utilize completely new stylistic expression forms based on novel optical systems. Creating a new corporate identity (CI) or accentuating an existing CI, Hella technologies assist in strengthening the OEM brand image. Hella styling focuses on the most important fields of light design and optics.

Light guide technology

Over the past few years the field of fiber optics has developed into a focal point for novel design options, since there is the possibility to separate the light source and light -coupling. For instance, light curtains offer uniform luminous surfaces, while rod-like light guides create precise and concise optics.

New lens and reflector optics

The classic photometric elements – lenses and reflectors – continue to provide great potential for automotive lighting technology and design. Variations in form and arrangement and the combination of different optical systems result in ever more novel forms of expressions. Lenses and reflectors are also essential components for particularly efficient optical systems. For instance, Hella is currently developing flat lenses and solid light guiding elements.

Ambient lighting

Light that does not have to fulfill regulatory requirements is used by Hella for creative expression. Here stunning light effects can be achieved even by using simpler technical elements. For instance, indirect lighting or a decorative structure can have a major impact on the look of light functions.

Surfaces and materials

Materials and surfaces play a significant role in human perception. They are in particular a gauge for the value of the product. New materials and purposeful design of surfaces help us to accentuate the value of the lighting and thus the vehicle.

Costs and energie efficiency

Our development efforts focus more and more on both product costs and energy consumption. With our design and technology solutions we make sure that cost-effective does not mean cheap and that energy efficient is not just boring.

Prototype of a tail light with light curtain as luminous element

Styling – From the idea to Production
Styling is not just one of Hella's core specialties; it should also be understood as a clear service to our customers. With our many years of experience and know-how we deliver a comprehensive range of innovative optical systems, which we use as a basis for our continuous advancements. By doing so, we always are able to generate more and more new approaches to high-quality styling. In addition to this, we also create completely new light and design solutions. Innovations that we are happy to offer to our customers as a suggestion and then tailor to their individual demands in close cooperation. Customers profit from our expertise in industrial design and light engineering during this development process, whether supported by us directly or indirectly. Upon request our designers and engineers also act as a mediator between design and technology and provide advisory support to our customers' design departments.

We verify the results of our design process for photometric feasibility and with functional prototypes. It goes without saying that we support prodution development in case of a first time application of new and innovative optical systems all the way through certification. When it comes to presenting new technologies, we assist our customers with our extensive experience in development and setup of vehicle lighting systems for trade fair and concept vehicles.

All in all, Hella's Styling encompasses:

- Design, light technology and models from a single source
- Innovation in light technology and design
- Competent advice and development for our customers

Hella KGaA Hueck & Co.

The automotive parts supplier develops and manufactures components and systems for lighting technology and electronics for the automotive industry. In addition, joint venture companies also produce complete vehicle modules, air conditioning systems and vehicle electric systems. Hella has one of the largest aftermarket organizations in the world for automotive parts and accessories, with its own sales companies and partners in more than 100 countries. Hella is one of the top 50 automotive parts suppliers in the world and one of the 100 largest industrial companies in Germany.
More than 25,000 people work in 70 manufacturing facilities, production subsidiaries and joint ventures all over the world. Almost 3,000 engineers and technicians work in research and development throughout the company group. Customers include all leading vehicle and system manufacturers as well as the automotive parts aftermarket.

Network creates added value
Cooperation rather than concentration: In line with this target, Hella enters project-related cooperations and works in joint ventures with independent suppliers, enabling the company to offer vehicle manufacturers an attractive alternative to mega suppliers in terms of innovative ability and global presence.

As a strategic investment in the innovative field of camera-based driver assistance systems, Hella took over Aglaia GmbH, Berlin, as a wholly owned subsidiary on March 1, 2006. Hella Aglaia Mobile Vision GmbH develops prototypical visual sensor systems as key components of novel driver assistance systems and integrates them into vehicles. With Cassandra the company created a very effective development platform for the implementation of these projects. It includes methods for assuring quality and monitoring the progress of developments. Hella Aglaia Mobile Vision has developed freely configurable and interconnectable application modules for detecting lanes, objects, traffic signs, headlamps and taillights.

Hella cooperates with the Japanese supplier Stanley and the Korean supplier SL (formerly Samlip) in the field of lighting technology, for example. HBPO GmbH is the only joint venture of its kind in the world and is extremely successful in the area of design, development, production and logistics for complete front-end modules with the suppliers Behr, Stuttgart, Germany, and Plastic Omnium, France. BHTC (Behr-Hella Thermocontrol GmbH), another joint venture with the Stuttgart-based supplier Behr, offers automobile manufacturers the complete system development for vehicle air conditioning and engine cooling.

These examples demonstrate how Hella defines the term "customer benefit": Expert knowledge is linked and brought together in lean organizations with efficient decision-making structures. Hella is always open for new or extended partnerships in order to be able to offer vehicle manufacturers optimum solutions with just the right partners.