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Advanced Automotive Light Technology

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LIGHT TECHNOLOGY

THE FATAL CRASH RATE FOR NIGHT TIME DRIVING IS ALMOST FOUR TIMES THAT FOR DAY TIME DRIVING (SOURCE NHTSA)

Common sense alone suggest that the longer you have to prepare for something, the better you can cope and that's probably every bit as pertinent to driving. Visibility is a critical factor of road safety and at one time or another we've probably all driven tensely through a thick fog, or driven nervously down dark winding country lanes at night. Driving in daylight or at night, the further ahead you can identify a hazard the longer you have to think and react to it, but at night and especially on curves and bends, the distance you can see and that consequential reaction time can be dramatically reduced.

Particularly for accidents involving pedestrians it is clear that the pedestrians themselves are not always sufficiently able and alert, with influences such as alcohol a contributory factor *(according to the Insurance Institute for Highway Safety study "Protecting Pedestrians and Bicyclists").*

It is clear that the pedestrians and cyclists cannot be assumed to take sensible actions for their own safety so the onus is once again on the vehicle driver.

MERCEDES-BENZ STATE THAT IN GERMANY ONLY 20% OF ALL DRIVEN JOURNEYS ARE AT NIGHT, AND YET 40% OF ALL ACCIDENTS INVOLVING FATALITIES OR FATAL ACCIDENTS OCCUR AT NIGHT.

Historically lighting has had two inherent issues to overcome; namely the brighter the light you put on the front of the car, the more it's likely to dazzle an on-coming vehicle and driver and that light can't be pointed around corners. However, like so many other technologies, the pace of development is challenging preconceptions.

There is far more to automotive lighting than brightness alone. For example, colour temperature is one factor of importance. Without going too in-depth the important factor is the position on the simple Kelvin scale. This is scale of warmth and colour, not of the physical thermal temperature of the lamp itself.

A standard incandescent light bulb will be typically roughly 2700K. This is a warm (yellow) light for promoting a relaxing environment in the home, or for street lighting. But as it is an unnatural light (i.e not daylight) it is not conducive with concentration. For office environments where concentration is required, a cooler (more blue) light is required. Whilst this is cooler the colour temperature is higher, typically 5000K. This has the benefit of being less tiring on the eyes (the contrast between warm indoor lighting and cooler VDU/TFT screen light is why we need screen breaks) so the cooler lights toward the blue end of the colour spectrum are valuable for reducing fatigue for car drivers.

With the global automotive lighting market continuing to grow, with a predicted value of $25 billion in 2018 (source: MarketsandMarkets), it is clear lighting technology will continue to advance in this competitive market.

Nissan Motor Company states that 70% of vehicle to pedestrian accidents occur at night *(source ITARDA Japan).*

40% of accidents happen at night *(ROSPA).*

HID Lighting

High Intensity Discharge

High Intensity Discharge lights are more commonly known as Xenon headlamps. These can be 80% to 180% compared to an H7 Halogen lamp. The brighter light intensity is created by an electric arc in a glass cylinder rather than a glowing filament. This is similar to street lighting, but the use of the inert Xenon gas (hence the name) allows the lights to reach sufficient intensity quicker than they would with another gas; typically Argon. The pressurized Xenon gas also has a violet hue that combines to lower the colour temperature to the daylight part of the spectrum. HID lights are also more energy efficient than traditional Halogen lights.

It is a European requirement that HID automotive lights (excluding motorcycles) are fitted with an automatic self-levelling system so as to adjust range when the vehicle angle is changed by braking, acceleration or loads, and a self-cleaning system to avoid dazzling other road users. In some global regions after-market kits that consist of just a lamp replacement without the self-levelling and cleaning functions, have been banned.

Ignition and start-up of an HID lamp can pull voltage in excess of 20,000V, which requires an electronic ballast unit to manage and regulate the start-up and power output. Safety, in particular for handling during repair, is important although ballast voltage drops to 85V once the light has reached full intensity.

An important consideration is the light temperature; with HID light being much closer to natural daylight, therefore less tiring on the eyes.

A TUV Rheinland study indicated that fatalities on German roads could be reduced by as much as 18% if all cars were equipped with HID lamps.

HID lighting market share is currently approximately 20%, but this is expected to increase further to around 27% by 2016.

Adaptive Lighting

Adaptive Lighting technology currently takes two forms:

Adaptive Beam Control; where the lights are dipped or shaped to prevent dazzling oncoming vehicles or actively adapt to the road type or urban/rural environment to provide the most effective beam pattern. Valeo mention studies indicating that drivers do not use their headlamp high beam sufficiently for fear of dazzling oncoming vehicles.

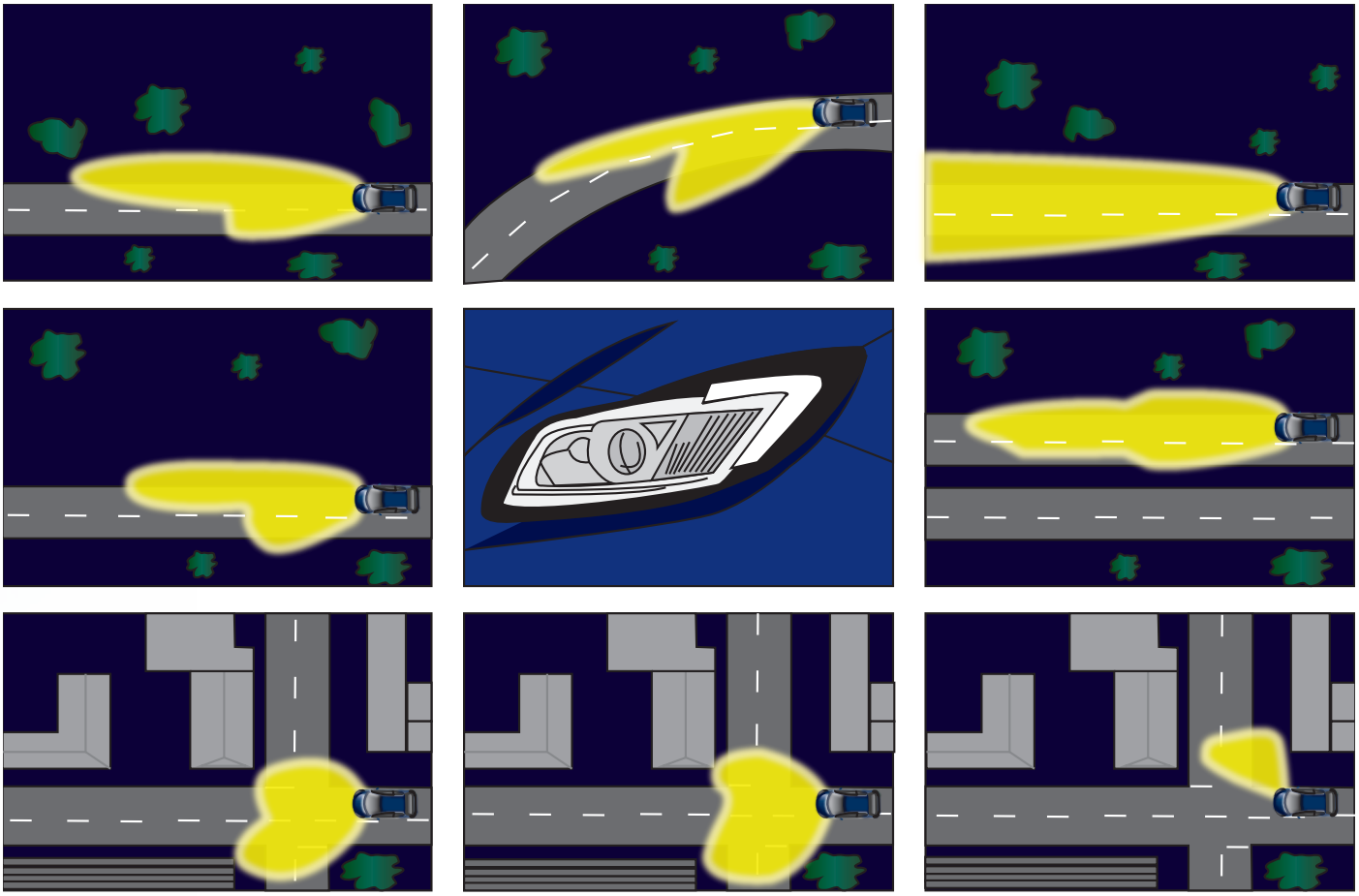
Earlier systems switched between main or dipped beam as required, but before long all systems will be using camera sensors to detect and assess oncoming vehicles controlling a gradual transition of beam intensity and trajectory to consistently maximise illumination levels.

For drivers in regions such as Europe there is an added benefit in as much as the adaptation of beam patterns can differentiate between driving on the left, or on the right side of the road.

The Vauxhall system, currently seen in the Mokka, is an example of this kind of functionality. The Adaptive Forward Lighting system uses its screen-mounted camera to assess the road ahead and to switch between beam levels and up to 9 patterns, as required. If the Mokka is specified with the Vauxhall Camera System for Forward Collision Warning, Traffic Sign Assistant and Lane Departure Warning, the Lighting system uses this camera instead to enable its functionality.

Mercedes tests have indicated that an Adaptive Beam Control system (theirs is called Adaptive Highbeam Assist) enabled pedestrians at the road side to be recognised at 260 metres, which was 150 metres earlier than with conventional headlamps.

Typically these patterns are produced by means of a rotating cylinder with varied contours, between the light source (either Halogen or HID) and the reflectors. The shape of the contours defines the light pattern created.



A pedestrian in an accident still has a fatality rate 14 times higher than a driver.

Adaptive Lighting

Curve illumination (cornering lights): where the lamp actively steers into a corner/ bend to provide a clearer view for cornering.

Both of these technologies are typically combined with the higher performance HID headlamps, rather than Halogen and there is already growing evidence that curve and cornering lighting can have a significantly positive effect on reducing accident rates.

Mercedes Benz also provides curve illumination with their HID headlamp packages. Their numbers add up convincingly: if you take a road curving with a 190 metre radius the illumination range with conventional lighting (even HID) is 30 metres. By using the steering angle sensor and speed sensor to guide the light trajectory into the curve; this increases to 55 metres, a 90% improvement. For detecting and reacting to pedestrians and cyclists at night this can make a significant difference.

It is important, particularly with Mercedes, to be aware that their Cornering Light function is different to curve illumination. By utilising the front fog lamps or the main lamp light via additional reflectors (in some models) the system provides additional light to the required side at the front of the vehicle by as much as 65 degrees. The system is activated automatically by operating the indicator or by turning the steering wheel, at speeds up to 40kmh.

Both of these technologies are available for halogen and for HID lighting systems, but it is the efficiency and intensity of HID light itself that makes HID adaptive lighting more effective and more commonplace.

It is important and a practical benefit that these systems can be integrated into existing, or emerging vehicle systems. The control units take data via the CAN network regarding steering angle, speed, inclination etc. and can also integrate with cameras (since 2009) and sensors for Autonomous Emergency Braking (AEB) and other Advanced Driver Assistance Meetings (ADAS) systems, thereby making their integration more cost effective.

Another important factor is that the camera systems can detect other vehicles at a range of 800 metres, well in excess of the 200metres headlamp beam range, so there is sufficient time for the system to react automatically to hazards and other vehicles.

LED Lighting

Light Emitting Diodes

Light Emitting Diodes offer many features and benefits that are attractive to car designers, but there are drawbacks too. A significant benefit is that the compact LED strips can be formed into attractive designs, with a modern look to add to the attractiveness of a vehicle in a competitive market. However, at the moment at least, a simple LED headlamp is still costly to manufacturer with prices comparable to an adaptive HID headlamp. Volume economies of scale will reduce these costs in time.

A key reason for the cost is the complexity required for heat management. LED systems produce less heat than traditional bulbs, but for a long service life to make this a reliable practical technology for automotive lighting, the diode needs to be maintained at a temperature below 400 Kelvin. Temperature rises quickly in an LED system, even in ambient conditions, and this can lead to LED failure. Heat transfer solutions are complicated by the need to access the LED & lens for beam alignment, whilst heat transfer routes also need to allow for the components moving for reflector movement and adaptive lighting systems. One solution being tested is replacing what was the bulb replacement cap (no longer required) with a curved heat sink with cooling fins, but other ideas are in development.

Light from LED sources is typically distributed by free-form lenses, whereby the lens is not uniform but shaped and angled to result in the optimum beam pattern. This again is a probable reason for additional cost, though these are not as challenging to produce as the cooling schemes.

Already the new LED lighting has been employed for many daytime run lamps and tail lamps and is standard equipment on prestige cars such as the Rolls Royce Phantom Series II from 2012. However, LED is now being seen on headlamps for volume cars such as the Seat Leon (albeit as an £995 option) and soon to appear on the next generation Peugeot 308 as standard on most trim levels. Ford too is expected to offer LED headlamps on the next Mondeo when it arrives on our shores next year.

A significant step forward will be the new Mercedes S-Class (W222 model), already vaunted as the world's first bulb-less car. The face-lifted E-Class also features standard fit LED headlamps, as part of the Intelligent Drive ADAS package.

A key advantage for LED tail-lamps is in the reduced illumination time compared with conventional bulb lights. Valeo estimate that for a vehicle travelling at 120km/h this earlier braking warning equates to approximately 5 metres improvement in stopping distance. Audi too believe that this technology allows greater braking reaction time.

The LED tail-lamp of the Audi R8 also features a sweeping directional pattern of LED illumination toward the intended turn direction thanks to a bank of 30 LED's in 7 segments that are staggered at 150 msec intervals.

Audi is one vehicle manufacturer who believe they have engineered their LED headlamps to be maintenance free and to have a life-span equal to that of the vehicle itself. Mercedes agree that the service life of 10,000 hours for an LED is roughly 5 times that of an HID lamp.

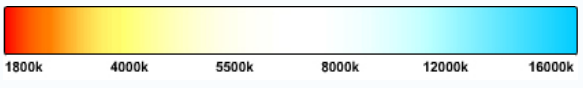
Audi also state an improvement in energy consumption of around 5%, when compared to an HID headlamp, is an added benefit to helping meet the demands for energy efficient vehicles - an LED headlamp typically requires 40 to 80 watts of power, which is a notable improvement over the 135 watts required by halogen lamps. The current A3 S Line models have a combination of HID headlamps with LED daytime running lights.

Audi also claims to be the first vehicle manufacturer to have EU Commission certification that their LED headlamps contribute to a whole vehicle CO2 reduction of over one gram per km.

The individuality of the LEDs enables other functionality, for example the ability (in conjunction with a camera) to detect and illuminate individual hazards such as animals or pedestrians, drawing the driver's attention in time for he/she to react and respond to the risk.

LED lighting market share is currently less than 1%, but analysts predict this increasing to 4% within just 3 years.

The colour temperature for an LED is approximately 5500 Kelvin; even further into the natural daylight area of the spectrum, so again causes far less fatigue for the human eye of the driver.



Adaptive LED Lighting

One of the advantages expected from LED technology for Adaptive Cornering lighting is in that the lamp unit does not necessarily need to rotate for cornering functionality. Instead, an array of light diodes can be independently switched on, brightened, dimmed and switched off to create the desired lighting patterns. So the diodes on the side to which the vehicle is turning can be utilised as required. This works equally well with active shaping and dimming of the main headlamp beam.

Audi believes that this lighting can prove much better at illuminating the area ahead of the vehicle in cases of fog or mist than a traditional fog lamp arrangement. By swivelling the HID lamps down, or by dimming or switching off the upper LED clusters in an LED headlamp, there is substantially reduced “self-glare” for the driver. The Mercedes Benz Intelligent Light System also provides this function.

Night Vision & Pedestrian Detection

Obviously the light beam and clarity is improved dramatically by these technologies and adaptive lighting makes a significant improvement in detecting hazards, but there are still potential risks outside of the beam, still obscured in the darkness.

Infrared night vision makes a contribution to tackling this problem. Infrared is too long a wavelength to be part of the visible light spectrum, but can be seen by a camera system to produce an image or at least alert the driver to hazards that cannot be seen by the human eye.

But, perhaps even more importantly, because the Infrared light is invisible and therefore won't dazzle an oncoming driver's vision, the infrared headlamp can scan the road beyond the range of the visible light beam, providing earlier warning of cyclists, pedestrians, and other hazards.

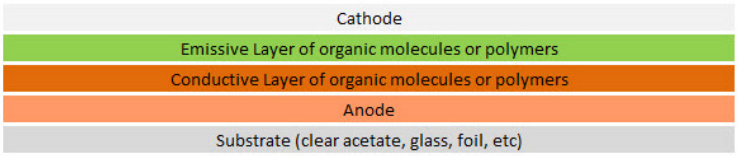
It is widely expected that the Audi A8 facelift, that is due later in 2013, will include new LED Matrix headlamps incorporating 5 sets of 5 light diode clusters to maintain a full beam pattern, with partial obscuration to prevent dazzling oncoming vehicles.

It is likely that these will have a cornering function with integrated GPS data so the light beam (not the entire lamp) can begin predictively turning into the intended direction, even before the steering wheel is turned. This same GPS data will also enable the vehicle to autonomously change lighting beam pattern for a motorway for example. These could indeed be seen as comfort features, reducing the workload on the driver, but there are also benefits to come from lack of distraction and fatigue and removing human error.

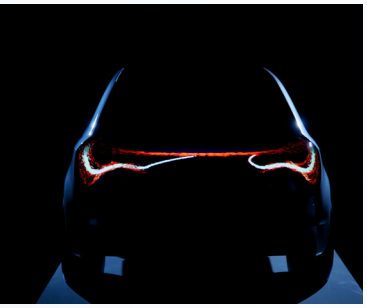
If the optional Night Vision package is selected, then infra-red camera identification of pedestrians will be possible, with the LED units flashing to alert the pedestrian if the system assesses the pedestrian to be at risk.

Nor is this the only such system in development, with technology providers and vehicle manufacturers working to develop camera-based technologies that will optimise the LED light provided, without requiring mechanical actuation.

Organic LED (OLED)



This is a development of LED technology but differs by placing a thin organic film between the two conductors to generate the light, rather than semi-conductors. Again, as with conventional LED, OLED can offer a long component service life and low electrical energy requirements. This is a new emerging technology, but is commercially available on some mobile phone displays and televisions. By controlled illumination the OLED technology allows more complex lighting patterns and creates new possibilities. An example of this was the recent Audi A2 concept vehicle that had an OLED band down the flank connecting the headlamps and tail-lamps. This band is black when not active, but activate to a blue colour when the vehicle detects the driver approaching, providing courtesy illumination of the door handles. When the vehicle is being driven the light band is orange and 'pulses' on the appropriate side in conjunction with the indicator lamps. Again the colour changes to red and 'pulses' when the vehicle is braking.



Lighting can be far more dramatic and enables effects such as "swarms" of lights as again demonstrated by Audi. But the principle benefit is that the light unit itself can be extremely thin (as little as 1.8mm) and non-obtrusive, thereby allowing vehicle designers and engineers to develop the body structure and shape without large compromising apertures within the design. Another advantage for vehicle manufacturers is that the OLED lighting packages do not require EMC shielding, further simplifying design.

An OLED is a semi-conductor device, much like an LED, but is built up of layers of flexible material including 2 or more layers of organic material. Whichever design is used the base layer is the flexible substrate that the technology is built upon, be that a metal, a glass, or a clear plastic film. This is covered by an Anode layer. These are then covered by the organic layers; a conductive layer (typically of polyaniline), the emissive layer (polyfluorine is one compound often used) where the light is made, then finally the Cathode layer. When the current is passed through the device the Cathode layer passes electrons to the emissive layer, whilst the Anode layer is depleting electrons from the conductive layer. So the extra electrons fill the 'holes' within the emissive layer, creating photons of light. The type of organic material used for the emissive layer determines the light colour, so by applying additional layers within the device, more intricate light patterns can be created. The light intensity is as a result of the level of current.

Whilst the technology itself is not new, what appears to be creating possibilities is that rather than creation of thin layers of organic materials by complex condensation processes using gasses, the new generation of organic compounds can be applied much the same as through an inkjet printer.

LG Chem has recently announced and shown a new OLED panel on a flexible sheet panel, and confirmed they will begin mass production of this new product later this year. Thin enough that they have suggested its use for self-illuminating wallpaper in the home; it has been developed for the automotive industry potentially initially for interior lighting.

Summary

The numerous statistical surveys leave no room for doubt that darkness and low visibility are significant factors in car accidents and fatalities, with incidents at a disproportionate rate to the amount of driving at night.

Lighting technology has moved forward with HID and LED illumination, but that improved brightness could be compromised by drivers not using this developing technology to its full potential. Fear of dazzling other road users or even fatigue of controlling the light system would be a real barrier to the benefits possible.

What is clear is that the Adaptive Lighting technologies, which automate lighting control and allow maximum illumination and even predictively react to the changing road conditions, offer major benefits to road safety, accident and casualty reduction. This is particularly evident for reducing pedestrian casualties where we have seen that the technology can detect risks that are impossible for the human eye to see.

There seems to be clear signs that the vehicle manufacturer and suppliers such as Valeo, Bosch, and Hella etc. are integrating these developments with other Advanced Driver Assistance Systems for maximum performance gains in a cost efficient way. The cost of the components such as LED lighting units will reduce as volume economies of scale drive prices down.

Lighting technology will continue to evolve and Thatcham will assess and evaluate these developments, however it is already clear that the safety benefits are significant. We have a bright future ahead.

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