DVN Workshop • Munich

Published 27 February 2018

DrivingVisionNews.com
Automotive lighting and driver assistance technologies
Published by **Driving Vision News**
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Table of Contents

Executive Summary

The DVN Munich Workshop was equal parts symposium and celebration, the occasion being the 10th anniversary of Driving Vision News. More than 330 attendees—a full-capacity crowd—were present at this, the 16th DVN Workshop, including 18 car makers, 23 set makers, and 66 Tier-2s. All in all, over 100 companies, universities, and organisations were represented. And there was a high diversity of speakers from China, Germany, Japan, France, Korea, the Netherlands, America, Czechia, and Spain. There were 24 exhibition booths where companies from all over the world displayed their products, innovations, and capabilities. Exhibiting for the first time at a DVN Workshop were Myotek, the US-based OE supplier of high-technology, high-performance LED fog lamps and specialty lighting.

With a rubric of Digital Light, the lectures ran the gamut of topics from technical and technological developments, to thorough comparisons of the relative merits of various ways of achieving digitalisation of car lights, to questions of how best to grapple with regulatory lag and constraint and matters of societal acceptance of AVs. And beyond the improvements we can expect in the performance and versatility of advanced lighting systems, there were presentations giving high hope for big improvements in the quality of the light itself—Seoul Semiconductor described their new "SunLike" purple-based technology for producing white LEDs with a better output spectrum, for example.

There was a lively panel discussion wherein participants—some of our community's best minds—sparred over tough questions like what to do about the fact that LED headlamps, initially touted as energy-, weight-, and CO_2-savers, are now growing heavier and more power hungry. There was a gala award ceremony recognising individuals for their remarkable contributions in our world, after which was a festive dinner at the fancy Munich Airport Hilton. Outside, there were flashy demonstrator cars showing off all kinds of digital light advances. And this workshop also served as the kickoff for the new DVN Workshop app for iOS and Android. The app made it easy for questions to be submitted to speakers, attendees to contact one another and keep track of the docket in real time.

Introduction

View lectures

This, our 125th report, contains full reportage of the DVN Munich Workshop held on 30–31 January. It was an especially celebratory event, being the 16th DVN Workshop and the 10th anniversary of DVN.

There is a constellation of questions surrounding the transition to highly assisted and automated driving, shared-use rather than private-ownership models of car distribution, and high-resolution digital car lighting. Naturally, there is a constellation of answers and ideas about these questions, too, and the lectures at the DVN Munich Workshop, all at a very high level of content and concept, were diverse not only in their national and affiliative origin, but also in their points of view. Attendees were treated to a step-by-step walk-through of the process of perfecting the luminance distribution of a light guide DRL…numerous different ideas about what future traffic might look like and how it might work…a wide array of new ideas of how best to make and use light…thoughtful commentary on how to identify and optimise the best practices as these new ways of using light move out of the lab and onto the roads…updates on the lagging regulatory situation in the US, and much more. The Workshop included 31 lectures from automakers, lamp setmakers, component suppliers, service providers, technical-standards developers, and academics. Each lecture is summarised and annotated with our comments and reactions. A précis and commentary are also provided for the panel discussion.

Each of the eight demonstrator cars, seven DVN award recipients, and 13 expo booths is pictured and described, and there are photos of the exellent networking opportunities (and excellent food!) characteristic of DVN Workshops, wherever they are held. All in all, there are over 127 pictures and 14,000 words here. It's a pity if you could not attend, but in this report you are about to get the next-best thing. We hope you get at least as much out of it as we of the DVN team have put into it.

Session 1:
Digital Light—Premium Car Maker Achievements and Expectations

View lectures

Session 1 Q & A

• **Digital lighting—Challenges and solutions for the development process**
Christian Amann, BMW (General Manager, Lighting & Visibility Systems)

• **New Aspects in Lighting for Autonomous Vehicles**
Wolfgang Huhn, Audi (General Manager, Lighting & Vision)

• **Digital Light—The Lighting Revolution Developed by Mercedes-Benz**
Uwe Kostanzer, Mercedes-Benz (General Manager, Exterior Lighting Development)

• **How Digital Light Enhances Safety and Improves the Customer Experience**
Wickramasinghe Shammika, Jaguar-Land Rover (Technical Specialist, Exterior Lighting)

View presentation

Digital lighting—Challenges and solutions for the development process

Christian Amann, BMW (General Manager, Lighting & Visibility Systems)

Christian Amann started out his presentation by reviewing the pace of technological change in vehicle lighting: first with a linear chart highlighting some of the key developments over the years: electric headlamp–asymmetrical low beam…halogen bulb…rear fog lamp…HID bulb…BiXenon…and so on and on up through today's proliferation of technologies, noting that the density of innovations grew and grew as the years went on. Then he showed the comparison another way, by presenting an operational logic chart for a vehicle master light switch of decades ago—very simple by today's standards. With this established as a firm basis, he then presented a table clearly showing the exponential acceleration in development and innovation, with technological complexity on the vertical axis. The state of the art today is shown with a yellow box, and a key point (aside from the shape of the progress curve) is that we are not at the peak; there remains room for ongoing development.

But where will this development take us? It will follow along the path plotted by demand for new lighting functions over the coming decade and beyond; functions for safety (increasingly dynamic light, new attentional guides and highlighting, warning functions, and integration of online services), new driver assistance functions such as width display, advnced lanekeeping, and integration of navigational data, and brand-new ways of using light to facilitate autonomous driving and its integration into the traffic environment with its mix of human-driven cars, self-driving cars, pedestrians, bicyclists, and whatever other kinds of participants we may not yet foresee. So functional demand is one lever for lighting advancement.

Another is design. Amann pointed out that styling competition drives ongoing innovation, which implies a need for fast development time. Numerous examples were provided in a splashy, colourful composite image.

Elements of successful function development and implementation are design, software, network, testing, database, and robustness—a key point being that a variety of testing and simulation techniques are needed; work in a light tunnel and a simple night drive are no longer sufficient.

DVN Comment

This has been another interesting and timely lecture by Christian Amann, who is likely quite correct that the exponential shape of the development curve will only carry on accelerating. Traditional testing and development techniques grow increasingly outmoded; some of them remain valid, but must be augmented with new perspectives and methods to keep up the pace of development in design and function.

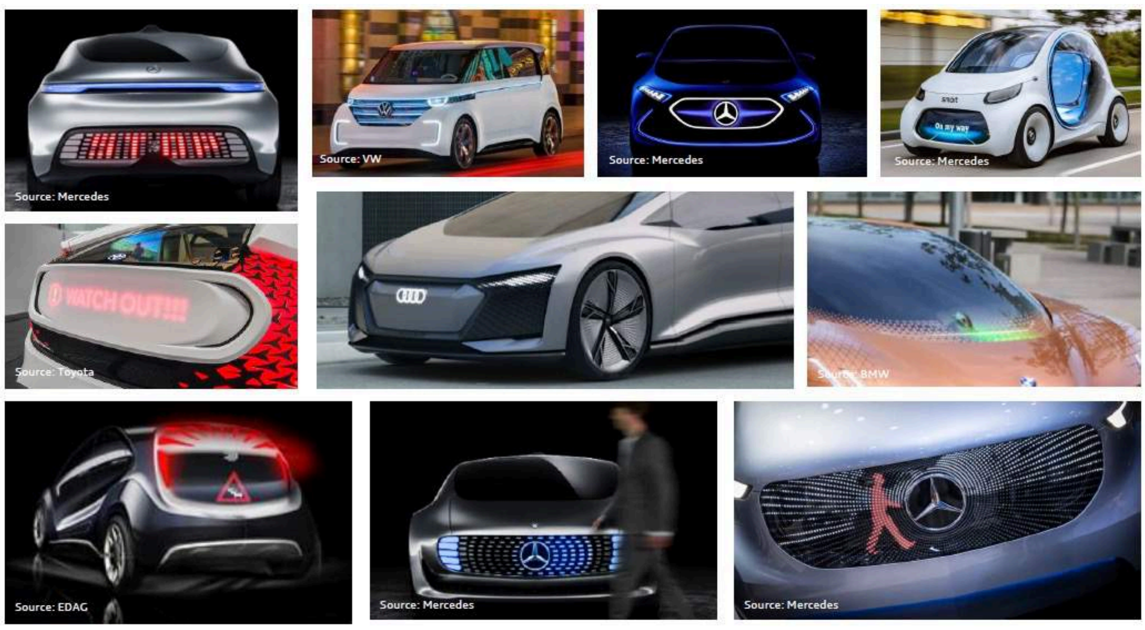
New Aspects in Lighting for Autonomous Vehicles

Wolfgang Huhn, Audi (General Manager, Lighting & Vision)

View presentation

Audi's Huhn took a critical look at the new kinds of lighting that will be required when autonomous vehicles join into traffic in significant numbers. Because they will mix with human-driven vehicles and humans themselves, many new lighting functions will be needed. The basic exemplar of a new need is: there are many situations in traffic when a driver or pedestrian or bicyclist will normally make eye contact with a driver: "Do you see me?" "I see you." "May I please go?" "Go ahead, I'll wait." When there is no human driver, other means of communication must fill this need.

Huhn showed a variety of lighting ideas for autonomous vehicles, and made the important point that the good ideas must be fished out of the pool of ideas, but not all the good ideas will eventually make it to the road: there must be standardisation and uniformity adequate for unambiguous communication, preferably worldwide.



Huhn described Audi's testing facilities at their lighting assistance centre, and showed examples of light display panels to the left and right of the front licence plate of an Audi vehicle, showing a variety of different messages. These are among the new lighting functions being researched, developed, and tested to see which of them will work as imagined, and which must be redesigned.

Other new modes of light-based communication could include functions like a visual distance signal. It would be projected in the low-beam coverage area, that is in the field 10 to 35 metres ahead of the car, by means of additive or subtractive light imagery on the road surface. It could project a series of chevrons behind the car ahead, for example, helping the following driver slow, stop, or keep a safe distance to the car ahead. This would join other functions under development such as the construction zone guideways that project the vehicle's width forward with curved lines to guide the driver through unusually narrow laneways. Or frozen-road warnings to the driver in the form of a snowflake projected on the road surface.

DVN Comment: It is an exciting but also challenging time for the lighting world, tasked with devising all-new kinds of car lights that convey complex messages immediately and unambiguously…then shepherding them through regulatory approval!

View presentation

Digital Light—The Lighting Revolution Developed by Mercedes-Benz

Uwe Kostanzer, Mercedes-Benz (General Manager, Exterior Lighting Development)

Uwe Kostanzer presented an update on digital lighting, a term first coined by the Mercedes Makers for a system they largely first devised. After first setting the context by describing conventional headlamps as very simply digital (1/on or 0/off), Kostanzer analogised vehicle lighting systems to wristwatches: analog watches and lights are purely hardware-based systems, mechanical in nature and with a limited number of outputs: hours and minutes for the watch, low beam and high beam for the headlamp. Then came chronograph watches giving hours, minutes, seconds, date, moon phase, and extra functions like a stopwatch; comparable to first-generation intelligent lighting systems giving low beam, ADB, bending and cornering light functions. Following that came digital watches adding functions like calculators and weekday trackers. The analogy here is to the Mercedes Multibeam light: there's a fusion of hardware and software, and the Multibeam light adds selective bending light, selective spot light, selective traffic sign de-glaring, and more advanced ADB.

The culmination of the comparison is the smart watch, which brings highly diverse functionality via apps. It's got sensor inputs and connected software, it's programmable and can be updated, and there's the possibility of paid content upgrades. This, Kostanzer says, is comparable to digital light in its present form, and he described the rubric under which digital light is proceeding at Daimler. It's envisioned as an intelligent, connected, high-resolution light system with a trio of functional targets: performance, assistance, and communication. To achieve this, Daimler engineers have been working on a variety of technologies, notably µAFS and DMD, toward a system with a resolution of over 1 megapixel, 3D rendering software, and high-performing ECUs. Testing is done not only in Europe, but on five continents in a venture Daimler call "Intelligent World Drive". The variety of conditions encountered around the world are key to understanding interactions with AVs and smart lights. New functions like construction zone light (projecting the vehicle width forward to aid the driver through narrow laneways) and driver information (projecting warnings and symbols on the road for the driver) explore how drivers interact with light, and trajectory projection and crosswalk projection are being explored as access points to interactions with acceptance of AVs.

Finally, Kostanzer listed the challenges and goals presently being worked on: hardware needs to be developed for better contrast and sharpness, better intensity and efficiency, and a larger field of view. Software and vehicle infrastructure, for its part, needs work on sensor fusion, comms bus speed, interface flexibility, and artificial intelligence for the various functions.

DVN Comment

Uwe Kostanzer's wristwatch analogy is interesting and thought-provoking; who knows what will be the next "killer app" for car lights!

View presentation

How Digital Light Enhances Safety and Improves the Customer Experience

Wickramasinghe Shammika, Jaguar-Land Rover (Technical Specialist, Exterior Lighting)

JLR's W. Shammika started out with a review of the basics: night driving is much more dangerous than day driving. Fewer people drive fewer kilometres in darkness, but more crashes happen in darkness. Recent lighting improvements (DRLs, adaptive front and rear lighting, automatic high/low beam, ADB, high beam boosters...) can all improve safety, but more can and must be done with digital light.

The advantages of digital light, from JLR's perspective, include finer-grained control to give smooth transition between modes, escape from the constraint of on/off (allowing the ability to have a grey scale of variance between full-off and full-on), reduced eyestrain, and V2x communication by means of light.

With the integration and fusion of sensors, digital lighting's advantages move from the theoretical to the practical: with fused data from sensors, predictive algorithms can be generated, AI can bring self-learning into the picture, driver eye gaze and attentional focus can be guided and directed. And there's even an advantage, Shammika says, to moving information off the dashboard or HUD and onto the road surface projection: the black-and-white informational images reduce eyestrain because the driver needn't constantly adapt to the colour display of a HUD.

DVN Comment

After a fairly lengthy section of the report reviewing already-known information and showing JLR vehicle lights, it was good to hear Shammika's perspectives more precisely on how digital lighting ideas will translate to real, actual implementations and advantages for traffic safety and integration.

Session 2:
Digital Light—Generalist Car Maker Achievements and Expectations

View lectures

Session 2 chair: Hitoshi Nakagaki, Nissan

• **Digital Lighting for a Generalist OEM:**
Complexity, EE Architecture Impact, Value for Money and Competition with Other ADAS
Paul-Henri Matha, Renault (Lighting Expert)

• **Digital Challenges in Lighting and the Desire of Car Makers in Front of Suppliers**
Carlos Elvira, SEAT (Lighting Manager)

• **Future Lighting Opportunities for the Automotive Industry**
Thorsten Warwel, Ford (Lighting Core Manager)

• **PSA Group Strategy Towards the Digital Lighting Era**
Whilk Gonçalves, PSA (Specialist on Lighting and Signalisation Innovation)

• **A North American Perspective on Digital Lighting**
Michael Larsen, General Motors (Exterior Lighting Specialist)

Digital Lighting for a Generalist OEM: View presentation

Complexity, EE Architecture Impact, Value for Money and Competition with Other ADAS

Paul-Henri Matha, Renault (Lighting Expert)

Renault's expert Paul-Henri Matha started out with a disarmingly basic question: what does "digital" mean, anyway? There are many millions of hits on Google. How many of them are relevant? And more specifically, what is digital lighting? Should the definition of digital lighting be constrained to that envisioned by one company, or some small group of companies?

Matha then put forth Renault's working definition of digital lighting: To put light where we want, thus helping the driver's eyes and the ADAS sensors to see—and to communicate with vulnerable road users and other drivers.

Of course, then this idea must be brought to reality, and that takes a list of requirements and factors to think about. Matha's includes EE architecture, field of view and accuracy, design, styling, mass, power consumption, packaging, and price.

Of these, the first merits special mention. The hardware will necessarily grow more complex: before it was a control switch, an ECU, and a set of headlamps connected by wire. For digital lighting it will have to be numerous sensors and cameras, a control switch, multiple ECUs, headlamps, and the whole works connected by a mix of LIN, CAN, ethernet, and other connectivity techniques.

As for the field of view and accuracy, that involves dividing up the whole FOV and figuring out which zones within it need high-resolution, high-precision light control and which ones offer opportunities for cost control by dint of lower resolution without giving up actual performance.

Mass (weight) and power consumption were discussed in terms of the conflicting goals between system capability and performance, and meeting packaging constraints while not overly contributing to the vehicle's CO_2 emissions. It was pointed out that the industry is drifting increasingly far from the original idea that LED headlamps would offer a large power reduction versus previous technologies; the example was given of a particular Porsche model with LED high beams which by themselves consume 92 watts and emit 4 g/km CO_2.

In the last part of his leture, Matha described the other constraints: part price strategy and tolerance, competition between lighting and various ADAS and other technologies (who will be the winner with augmented reality for drivers, for example?), and disadvantages that tend to hold back lighting development (perceived as only useful at night, for example).

DVN Comment

Matha's lecture was a well-rounded look at the interesting challenges and constraints—all intertwined, many not intuitively obvious—in the transition to digital lighting.

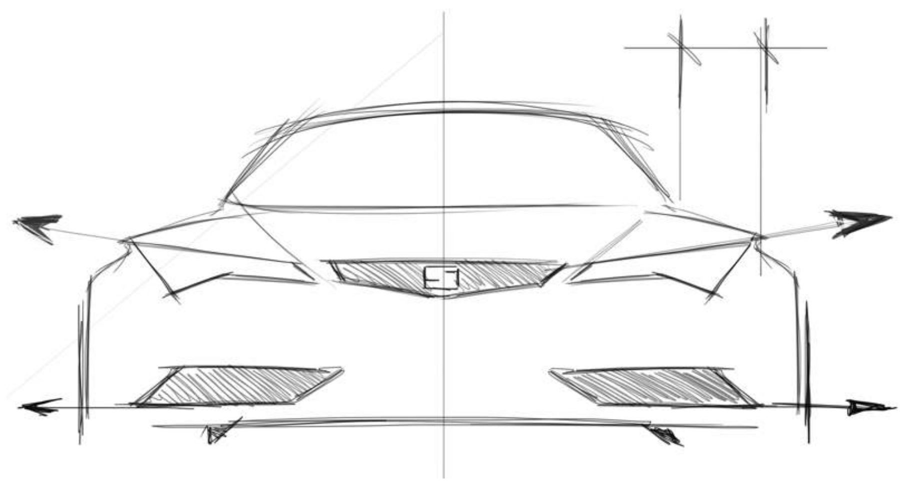
Digital Challenges in Lighting and the Desire of Car Makers in Front of Suppliers

Carlos Elvira, SEAT (Lighting Manager)

View presentation

SEAT's Carlos Elvira started his lecture by pointing out that the future is digital—everything is going digital, including car lighting. Digitalisation, he said, is the next station in a long evolution and we must prepare for it. Like many other presenters, he described a technological timeline—but Elvira's was divided up in an interesting way. Starting with the dawn of electric lights on cars a little over a century ago, there was a 100-year period of limited possibilities. That ended with the onset of the LED revolution, which ushered in what Elvira calls the "tsunami phase" of massive, profuse technical and technological development. His vision has this phase giving way to what he calls the "fusion phase" around 2020, wherein winning technologies will coalesce to bring about full-scale digitalisation.

Elvira then stepped back and asked a basic question: what does digitalisation mean in the lighting realm? It's the process of converting information (a physical quantity or analog signal) to digital format, for use in computers. Megatrends defining the hard points of digitalisation relevant to the driver vision world include electric vehicles, autonomous vehicles, and connected vehicles of many descriptions.



The next part of the lecture was devoted to describing the efforts toward lighting digitalisation within SEAT. Three main rubrics at work are design, creativity, and innovation. Looking at the first one, Elvira suggested the future could easily be cold, lifeless, and hard (examples from popular culture: Blade Runner, Tron, Minority Report). But new technology allos to create a future that is instead warm, lively, and easy. To do so means drawing inspiration from surroundings (Elvira mentioned the city of Barcelona, for example) and shifting from a product-centred to a customer-centred strategy. To emphasise the importance of this, he quoted Steve Jobs, late of Apple: *"You have to start with the customer experience and go back to technology, not the other way round"*. Examples of how this works in practice include changing workflow from a pyramidal, hierarchical structure to a circular, collaborative, solution-orientated structure and operating philosophy drawing on the experience and views of everyone involved (including suppliers and customers) to arrive at fully optimised solutions.

In the last part of his lecture, Elvira gave examples of how these kinds of new operating philosophies and structures can be applied to the working relationships among suppliers, between suppliers and the automaker, and between the automaker and customers.

DVN Comment

What an amazing point of luxury we have reached, that grand views like Elvira's (look at Barcelona for inspiration of car lights) can be considered as fully realistic! His points are very solid about the necessary primacy of the customer experience, and it is interesting to learn how that philosophy is reshaping relationships between SEAT and their customers and suppliers, as well as their work team organisation.

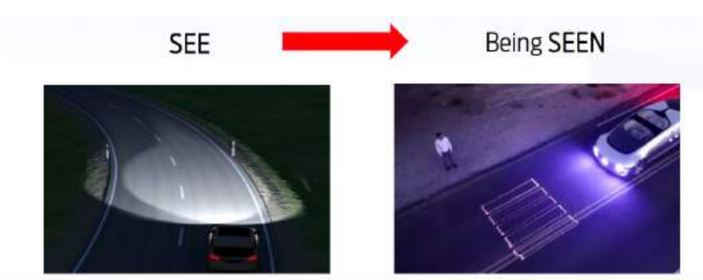
Future Lighting Opportunities for the Automotive Industry

Thorsten Warwel, Ford (Lighting Core Manager)

View presentation

Thorsten Warwel began his talk by describing Ford's vision of the city of tomorrow, with mobility centred round the notion of highly mixed-use streets. The main idea is that the streets in the smart cities of tomorrow ought to cater to all comers—whether on foot or on however many wheels with whatever motive power. When advanced automobiles make it safer and easier for pedestrians, bicyclists, and motorists to commingle in shared space, there'll be less need for traditional hard barriers dividing the space into "car" and "other" zones. This will facilitate a greatly expanded mix of uses for the streetscape.

First zooming out, Warwel said realising this visionwill require an unprecedented degree and diversity of interconnectivity and autonomous coördination. Then zooming in, he described the rapid changes taking place as vehicle lighting becomes digitalised. Warwel stressed the importance of taking an adaptive, customer-focused, human-centred approach to designing and specifying the car lights of tomorrow. Autonomobiles will bring new use cases for lighting functions, as it becomes less important to use light to allow human drivers to see and more important in new varieties of ways to use light to allow increasingly-autonomous vehicles to be seen and understood with regard to their intent as traffic participants. The perennial question was raised: will AVs actually need exterior lighting? Maybe so: to identify if the vehicle contains people or freight, to identify a taxi or shared vehicle to its next customer, etc.



And the same applies to interior lighting: the present priority is not to disturb the human driver or spoil their dark-adaptation. As the car itself becomes the driver, and the use model shifts from personal ownership of a vehicle to shared usage of a vehicle, the priority shifts to meet a broader range of needs of vehicle occupants. Light can be used to augment and optimise design, human health and wellness, and to convey a wide array of information.

To round out his presentation, Warwel described a variety of new use cases that could be imagined for lighting in tomorrow's vehicles, and discussed the advantages of additive manufacturing as a lighting innovation enabler.

DVN Comment

Perhaps this sunny, green view of tomorrow's cities is a latter-day effort at atonement for Ford's zeal to carve up and pave the world's countrysides last century, to the detriment of the communities Ford now seem to have in mind. We can certainly hope to see this vision come real. Warwel's description of a shift in focus from seeing light to conspicuity and communication light seems realistic. But why does an AV need to advertise whether it contains people or goods?

View presentation

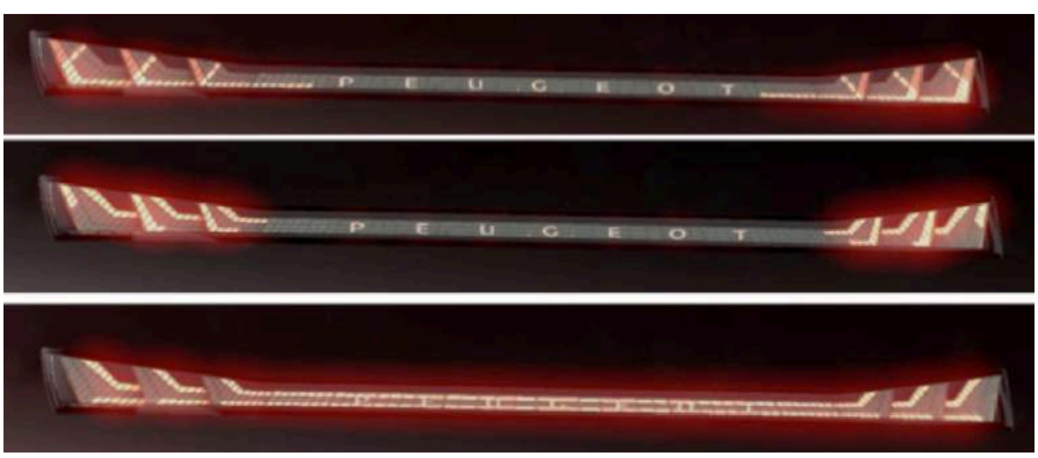
PSA Group Strategy Towards the Digital Lighting Era

Whilk Gonçalves, PSA (Specialist on Lighting and Signalisation Innovation)

Whilk Gonçalves got started by describing the high degree to which lighting is centrally important in PSA Group's branding and identity strategy. He showed examples of familial-kin usage of the triple vertical red bars forming the taillights of a variety of Peugeot models and some different iterations of the triple ice cube headlamp signatures. He repeated this show-and-tell for Citroën and DS brands, as well.

Continuing with the familiality theme, Gonçalves described the prerequisites for deployment of high-performance, up-to-date lighting across the whole range of PSA models. These include maintenance of brand differentiation, a new electronic architecture that facilitates modularisation, optimisation of cameras and sensors to minimise cost and maximise polyvalence for component use on more than just one model, and finding an appropriate balance between cost and functionality, factoring in the different functional and design priorities brand by brand.

Like Lumileds' Dirk Vanderhaeghen, Gonçalves showed how different advanced headlighting technologies, with different resolutions and different costs, lend their strengths to different areas within the headlamps' coverage area: the central region needs high-precision, high-resolution, high-output lighting for optimal performance, while the lateral regions can get by just fine with lower resolution which can in turn lower cost. Other functions, like a spot marking light module for highlighting pedestrians, have their own balance of resolution/output/cost requirements.



In the last part of his lecture, Gonçalves presented a prediction of how established light signatures for PSA's various brands might evolve in step with the technology and technique used to make car lights. New floating-structure versions of existing shape traditions, for example, with multilayer transparency to allow additional functions to shine through while providing space for new functions such as display of messages or pictograms.

DVN Comment

This is an interesting and thoughtful look at how brand identification equity through lighting signature, cultivated over years, can be preserved and built upon using tools made possible by the jump to digital lighting.

View presentation

A North American Perspective on Digital Lighting

Michael Larsen, General Motors (Exterior Lighting Specialist)

GM exterior lighting expert Michael Larsen gave an interesting and unique talk: the others in the session focused on the particulars of lighting philosophy and achievement at their companies, while Larsen discussed the broader picture of North American progress as a whole. The main theme of Larsen's lecture was a longrunning one familiar to anyone who has spent much time in the vehicle lighting world: North American regulations, laws, and drivers prioritise seeing distance even at the cost of more glare than is considered acceptable in Europe. After reviewing the classical presentation of this difference—US low beams are aimed higher than ECE low beams, and new influences such as the IIHS headlamp rating system are encouraging even higher aim in America—Larsen moved on to discuss the new context for this old difference, and its new relevance for ADB.

Specifically: in America the distance to another driver, at which one is expected to dip from high to low beam, is much shorter than in Europe. UN Regulation 48 requires that automatic high beam systems switch to low beam when an opposing car is 400 metres away; this is a matter of state-by-state law in America, and the most common specification is 155 metres for an opposing car, 91 metres for a leading car. That's a large difference, and Larsen explained how it has been baked into SAE J3069, the American specification for ADB systems. J3069 explicitly states that systems need not control glare illuminance to low-beam levels at separation distances greater than 155 metres. This gives automakers the option to provide their customers with more seeing light than a UN-type system would give, but it also means more glare for other drivers, Larsen said, while noting that automakers must take care to pick an "appropriate balance" between seeing and glare light.

Larsen also gave attendees reason to be hopeful about the North American situation: he said Canada is on track to permit ADB systems soon that comply with SAE J3069 or with UN R123, and NHTSA have said they will issue a notice of proposed rulemaking this coming June to allow ADB more or less in accord with SAE J3069.

The rest of Larsen's presentation was devoted to describing a new NHTSA request for comments about research and specifications needed for lighting for autonomous vehicles—with a very short deadline for submissions; comments are due by 5 March.

DVN Comment

All along the development of advanced headlights, it has been hoped that differences between European and American practice, resistant to harmonisation bridge-building, could be smoothed over and made unnecessary by advancing technology that can more precisely and dynamically balance the conflicting goals of seeing and glare. It is interesting to see that basic philosophical differences in fundamental matters such as what constitutes an appropriate balance between seeing and glare will apparently survive the impending deployment of ADB in America. Evidently there are still no right or wrong answers to this question! We are encouraged by the reported intent of Canada to permit ADB very soon, and the United States to formally propose legalising it, but we do note that NHTSA's promised dates have a tendency to come and go without action from that agency. We must try our luck, as it seems.

Session 3
Digital Light—Set Makers' Latest Innovations

View lectures

Session 3 chair: Jean-Phillippe Benoist, Renault

- **HD 2.0**
Kamislav Fadel, Hella (Lighting R&D Director)

- **From Conventional Matrix Beam to High Resolution Systems out of Setmaker's Perspective**
Andrea Stella, Automotive Lighting (Front Lighting R&D Director)

- **Digital Light—Pst, Present & Future: ZKW View**
Ralf Klädtke, ZKW (CTO, Vice Chairman)

- **Benefits of a Global HD System**
Laurent Evrard, Valeo (R&D Director, Visibility Systems)

HD 2.0

Kamislav Fadel, Hella (Lighting R&D Director)

View presentation

Kamislav Fadel started his lecture with a slide showing the rapid acceleration of the pace of change with eight major headlighting innovations in 80 years, then eight major headlighting innovations these last ten years, and probably more speed in the future with the digitalisation. Then he presented ten challenges in the vehicle lighting industry to be cracked by 2020.

Fadel says the answer to the questions posed by each challenge will guide companies to sharpen their HD 2.0 understanding.

Technology

1. Is high-definition mostly hype? If it's real, will it come to predominate fast or slowly?
2. What is the maturity roadmap of the different HD technologies?
3. In the future will HD technologies drive product complexity up or down?
4. Additive or subtractive technology, which will triumph?
5. Is the monopolist situation (component or module) a constraint or a chance?

Use cases

1. Does the lighting community think and act in terms of use cases?
2. How to experience the use cases and thus determine their value?
3. Which use cases will rise to the top: safety-related ones or "wow effect" ones, or both?
4. Shall the use cases be only end customer oriented?
5. Use cases may vary depending on the market's specificities. Which use cases to de decided for which markets?

Resolution

1. How to measure the resolution: in mm or in degrees?
2. Which use cases need what resolution?
3. Which technology performs what resolution?
4. Is resolution in contradiction with the luminance or the contrast?
5. Is there a common definition for resolution and contrast for technology comparison?

Field of View and Performance

1. Will or shall HD technologies address only portion of the field view?
2. Will or shall HD technologies evolve to the full digital field and what for?
3. Does it make sense for HD technologies to address the area above the horizon with high resolution?
4. What is the relation between field of view, illuminance, and use case?
5. Do we need more than just resolution to efficiently define the use cases in the field of view?

Business

1. A few automakers are leading on HD; how will other makers behave? Passive or Active approach?
2. Will new use cases trigger new business models, such as pay per demand?
3. Will high cost and volume capacity to develop HD tech bring coöperation, alliances, and new policy?
4. Will HD technologies cause disruptions in the value chain?
5. The winner-takes-all approach, will that work in the automotive lighting industry?

Legislation

1. Are the HD use cases Today homologation friendly?

2. Do all regulatory authorities (ECE, SAE, CCC...) have the same position towards the new HD features?

3. Will legislation slow down the development of the HD technologies?
4. How will the current ECE legislation situation influence the HD penetration?
5. Do we still need the low and high beam when the front field of view will be digitalised?

Cost
1. How much is the market ready to invest in HD technologies?
2. Will high HD cost drive automakers and suppliers to more aggressive carry over strategy?
3. Will this situation then influence the automaker supplier panel management?
4. How will HD lighting fit with decreasing headlamp volumes?
5. Will HD drive down the total cost of ownership?

Style
1. Style will drive packaging constrains. Which HD technologies are affected and how they will adapt?
2. How will EVs' style affect lighting technologies and more precisely HD?
3. Will autonomous & automated cars have a style that will influence HD technologies?
4. Is HD considered as high lever by automaker styling departments?
5. How will HD technologies adapt to the personalisation trend?

Marketing
1. Will the "wow effect" remain after two years' ownership of the car?
2. Is HD considered as high marketing lever by the automakers?
3. How to deal with disruptive technology evolution from the marketing point of view?
4. How will HD affect automakers' option strategies?
5. HD will bring a multitude of commercial function names. How to avoid confusion and dilution of HD benefits towards the end customer?

DVN Comment

Fadel's list of challenge points and questions as we embark on vehicle lighting digitalisation is a very fine one. His last question reminds of the plea from NHTSA at the DVN US Workshop in 2015, when that agency urged our industry to facilitate rapid and smooth regulatory acceptance by picking a single name for each function rather than each automaker and lamp supplier having their own name for a given function. More broadly, it is clear that HD technology will change and disrupt quite a lot of the assumptions we have easily taken for granted in the past.

From Conventional Matrix Beam to High Resolution Systems out of Setmaker's Perspective

Andrea Stella, Automotive Lighting (Front Lighting R&D Director)

View presentation

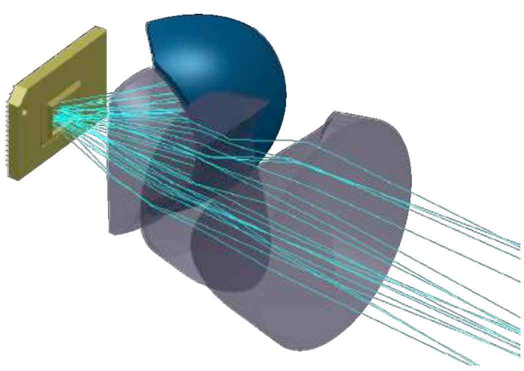
Andrea Stella started his presentation defining the start of ADB with Xenon systems, before switching to LEDs All-LED Matrix, started in 2014 in the Audi TT3 (Matrix reflectors 5 + 5 + 1 segments), and in the Mercedes-Benz CLS (Matrix module, 24 LEDs arranged in 16 segments and silicon primary optic)...

...then in 2017, in the Mercedes-Benz S Class with 84 Pixel "Multibeam" with 84 LEDs arranged in 3 pixel rows and silicon primary optics.

The next step is to improved the performance based on high resolution...

- Glare Free HB (precision of the shadows)
- Dynamic bending light (precision based on high resolution)
- Flexible cut-off line shaping (Country – motorway - town)

...and to create new lighting functions enabled by high resolution:



- Guidelines
- Lane Departure Warning (LDW)
- Distance warning
- Symbols (ice, speed, etc)
- Communication by light

All of these increases and improvements in function mean concommitant increases in the complexity of electronic systems integration into the vehicle; these challenges, too, must be managed for effectiveness, efficiency, dependability, and cost.

DVN Comment

AL are certainly at the epicentre of the digital-light revolution, being an important partner to (among others) Mercedes-Benz in that automaker's deployment of cutting-edge lighting technologies. This lecture was a good presentation of the stepping stones that led us to where we are now, and the ones that could lead us forward from here.

Digital Light—Past, Present & Future: ZKW View

Ralf Klädtke, ZKW (CTO, Vice Chairman)

View presentation

Ralf started his lecture explaining that adaptive lighting functions, with the help of camera and light fusion represent the present and future:

- Bending light
- Bad weather light
- Freeway light
- Cornering light
- Glare-free High Beam (ADB)

- Targeted Illumination, e.g. pedestrians
- Infrared Light
- Communication light

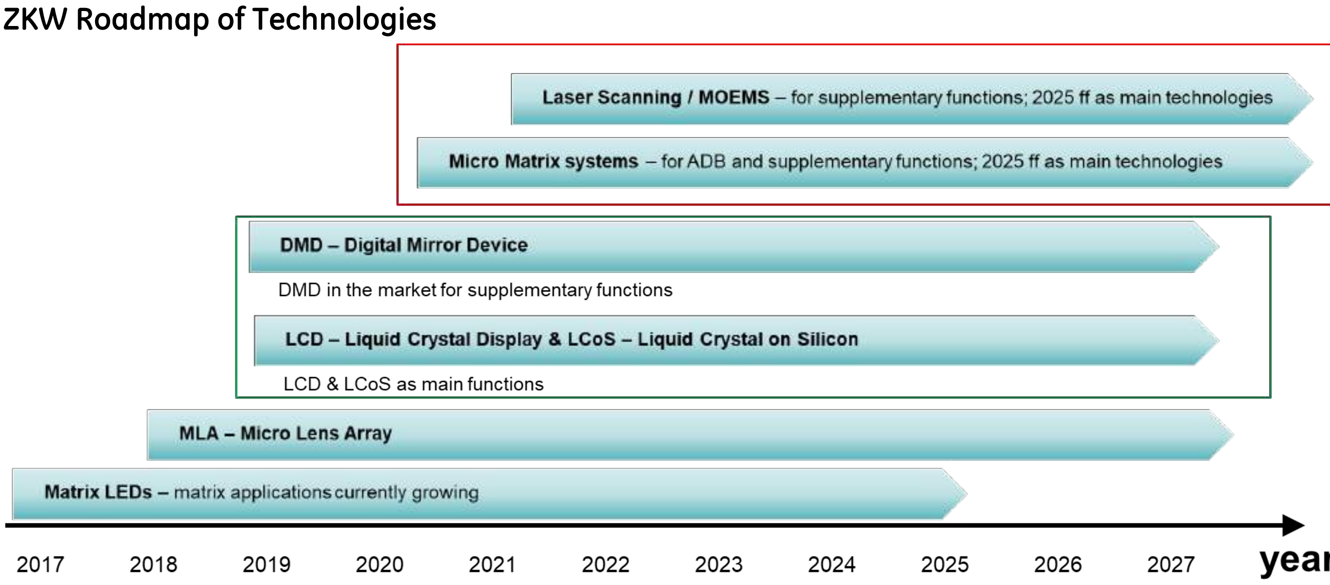
Resolution is becoming more and more important

Low-Medium Resolution >1.5° with <100 Pixel

High Resolution 0.1° – 1.5° with 1000 – 10,000 Pixel for ADB and object marking

Ultrahigh Resolution <<0.1° with >400,000 Pixel for ADB, object marking, and symbol projection

ZKW Roadmap of Technologies



Ralf closed his lecture with two important items concerning digital light: it facilitates design, safety, and autonomous driving, and the GTB strategy group must pave the way for regulations enabling digital light.

DVN Comment

This idea of different technologies' differing resolutions and output potentials suiting them for coöperative selection (rather than competitive elimination) seems to have gained major traction. It makes sense, and Klädtke's lecture was a well-focused prediction of how the constellation of various technologies could evolve around that idea.

Benefits of a Global HD System

Laurent Evrard, Valeo Visibility Systems R&D Director

View presentation

Laurent Evrard, head of R&D at Valeo Lighting Systems, made one of the best lectures at the workshop, explaining the importance of mastering a complete HD of lighting systems.

He started explaining the information exchange in a car which has dramatically increased over the years:

- Between 2005 (old E-Class) and 2015 (new E-Class), the rate of Data transmission per vehicle has been multiplied by 60.
- Today, a midsize car exchanges 1 MB/sec.
- Tomorrow, a midsize car will exchange 100 MB/sec.

Evrard gave examples of leveling with vertical tilt (chassis angle with 1 byte), then bending light with horizontal tilt in 2005 (steering wheel angle with 2 bytes), then ADB in 2010 (camera consolidated data with 140 bytes) and lidar consolidated data with more than 500 bytes, then presented the HD lighting electronics architecture assembling headlamp, LED driver module, HL control module, photometry control system, perception data fusion emphasizing that Lighting is getting more and more accurate and uses more and more information to deliver enhanced performance. Sensors are required to deliver more accurate information.

HD lighting needs to address three challenges

- Mechanical tolerances
- Sensor accuracy: in curved roads the margins pile up and then require the shadow tunnel to be up to 7 times larger than average car width; in a straight line, margins on both sides of the oncoming car don't exceed 0.2 m
- System latency, which creates glare since part of the car is illuminated even when the ADB function is active.

Evrard concluded his presentation by explaining that the design of a road marking function calls for expertise from opticians, electronicians, and data scientists—opticians alone, he said, would be like an engine without fuel, and optics is nothing without a deep underdtanding of the limits of camera, lidar, and data fusion.

DVN Comment

Of all the points raised in Laurent Evrard's presentation, probably the most salient was the increasingly-urgent need to address the stackup of tolerances and variances that tend to constrain the precision practically available from a digital lighting system.

Session 4
Digital Light—Set Makers' Latest Innovations

View lectures

Session 4 chair: Ingolf Schneider, Opel

• **Safety Benefits with New Lighting Functionalities**
Rainer Neumann, Varroc Lighting Systems (VP Global Technology)

• **Seeking Greater Performance and Styling**
Satoshi Yamamura, Koito (R&D Deputy General Manager)

• **Illuminating Comparison of Laser High Beam Between RGB and Blue to White**
Dr. Liang Deng, XingYu (R&D Team Leader)

• **Adverse Weather Conditions—The Benefit of Digital Lighting and its Assessment**
Dr. Benedikt Kleinert, IAV (Light & Vision Project Team Manager)

View presentation

Safety Benefits with New Lighting Functionalities

Rainer Neumann, Varroc Lighting Systems (VP Global Technology)

Varroc Lighting was formed five years ago. The evolution of the turnover is very positive with an annual growth of 15%

Varroc are involved in high technology development, for instance the Range Rover's lighting package includes:

- Pixel low beam with base and kink combination of 17+ 27 segments, non-mechanical dynamic bending, and AFS modes available;
- Matrix high beam with 27 LED ADB segments, and
- Laser high beam booster with two µLARP modules

Current ADB systems already give a benefit of 30 metres' visibility distance compared to traditional systems, but new functionalities must be developed in the future and carefully analysed for real potential (+) or neutral/drawback (-) in terms of safety. Examples:

(+): Parking operation warning, parking spot departure warning, road construction hints, obstacle avoidance lighting, accident warning, door opening light, find-your-car lights

(-): Overtaking, distance control, direction change indication, zebra crossing projection, front stop lamp, optical lane assist lighting for missing road markings, warning functions (projected stripes to slow speed, etc), turn signal projection.

For each, an evaluation has to be done, with 3 possibilities:

- Yes for safety potential, but better placed in the head up display
- Yes for safety potential
- No, confusing or otherwise undesirable

Consequently, several independent Research studies are under way to determine the real benefit of each proposal, organised by a specific group of the GTB.

The results will after follow the traditional process for ECE Regulations, also taking into account the wish of governments to simplify the lighting regulation.

Rainer Neumann concluded that the remaining 50 million vehicles per year still equipped with halogen could not only be made safer in nighttime driving but also contribute significantly to a reduction in CO_2 if they were instead equipped with low power LEDs.

DVN Comment

It is always edifying to hear from Rainer Neumann. His thoughtful comments about the actual, real safety effects of the many new potential lighting functions remind that just because we *can* do something does not necessarily mean we *should*.

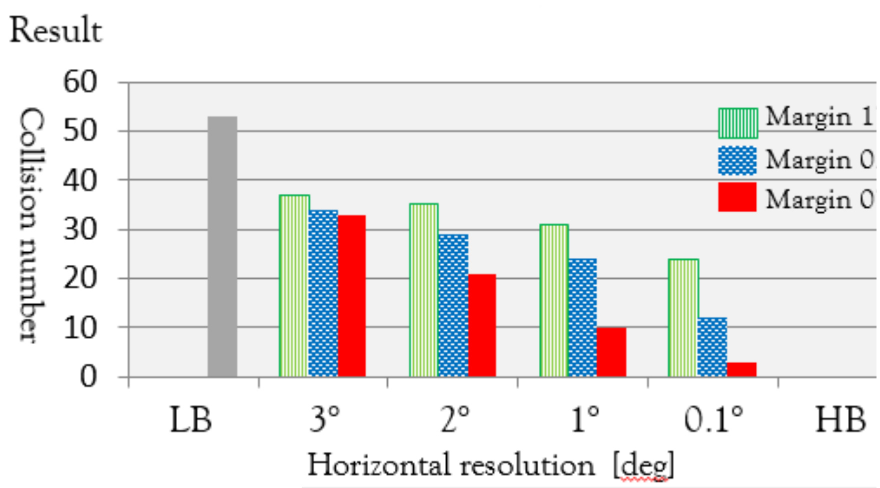
Seeking Greater Performance and Styling

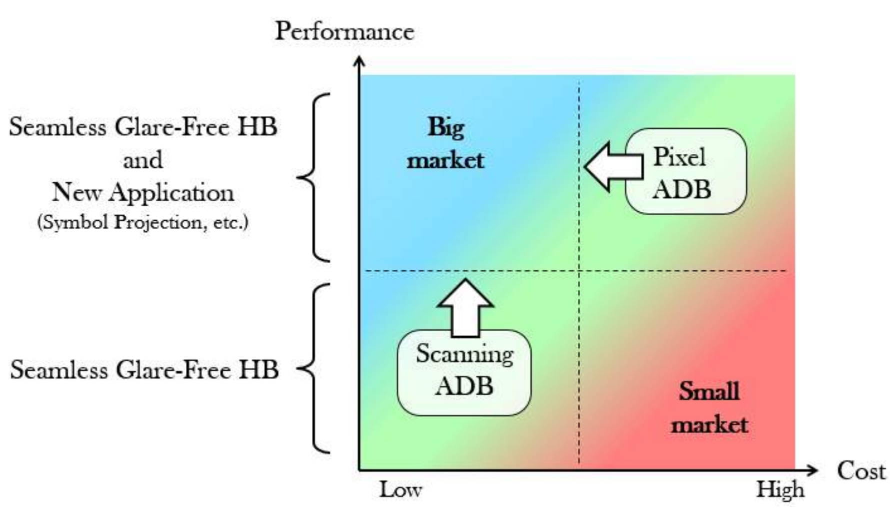
Satoshi Yamamura, Koito (R&D Deputy General Manager)

View presentation

Lighting performance and style have improved during recent years thanks to new technologies, with three main phases: no electronic control, then analog electronic control, and more recently digital electronic control systems, particularly for ADB LED arrays.
To improve performance and optimise systems like ADB, Koito have developed a specific simulation evaluation of risk of collision for pedestrian in relation to the resolution and the lateral margin considered for the ADB system, showing that the better is this resolution and smaller the margin, the greater the crash risk reduction.

To improve this resolution, Koito are developing a scanning system including a rotating mirror, with a complementary benefit of LED number reduction.
Koito are also evaluating other SLM (Spatial Light Module) systems such DMD, LCD, and LED arrays.
The global strategy is to go to a larger market with a with high resolution ADB system at an acceptable cost.





Concerning the evolution of style, The height of multi-units bifunction systems was decreased from 45mm in 2016 to 30mm in 2017-2018 and will go to 15mm in 2019. The volume of bi-function units was decreased from 1300cm3 in 2016 to 1100cm3 in 2017-2018 and is targeted to reach 800cm3 in 2019. In parallel the number of units necessary for a function is too decreasing. In the future, there will be an evolution with still narrow appearance, but with more and more sensors in the lighting systems.

The upcoming challenges will be to develop first projection systems, and then systems adapted to smart cars with artificial Intelligence. And to prepare this digital future with AI everywhere, Koito opened a lab in Silicon Valley last year.

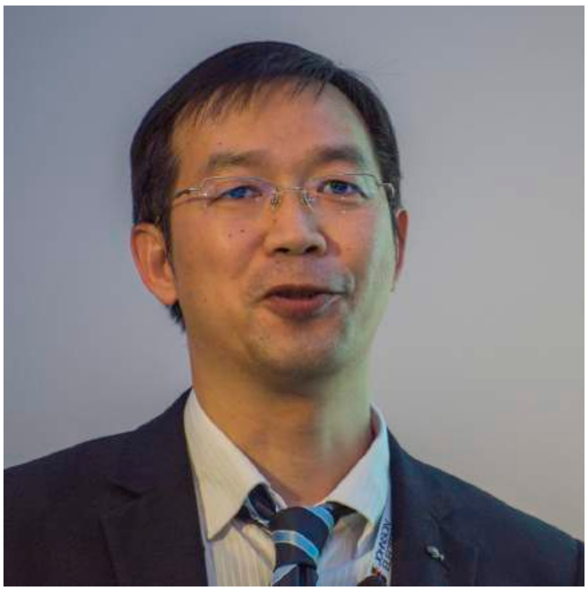
DVN Comment

This detailed look at the effect of ADB system resolution and the safety benefit the system yields is very valuable in terms of knowing what to work on. Clearly higher resolution (smaller shadow tunnel) is better for safety, but as Laurent Evrard pointed out, a system's theoretical resolution is not fully available, because of tolerance stackup, curved roads, etc. How to resolve…?

Illuminating Comparison of Laser High Beam Between RGB and Blue to White

Dr. Liang Deng, XingYu (R&D Team Leader)

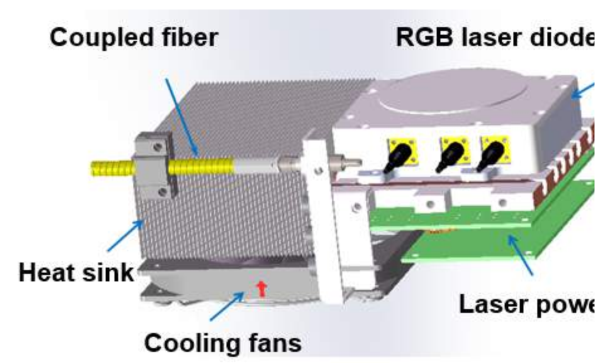
View presentation



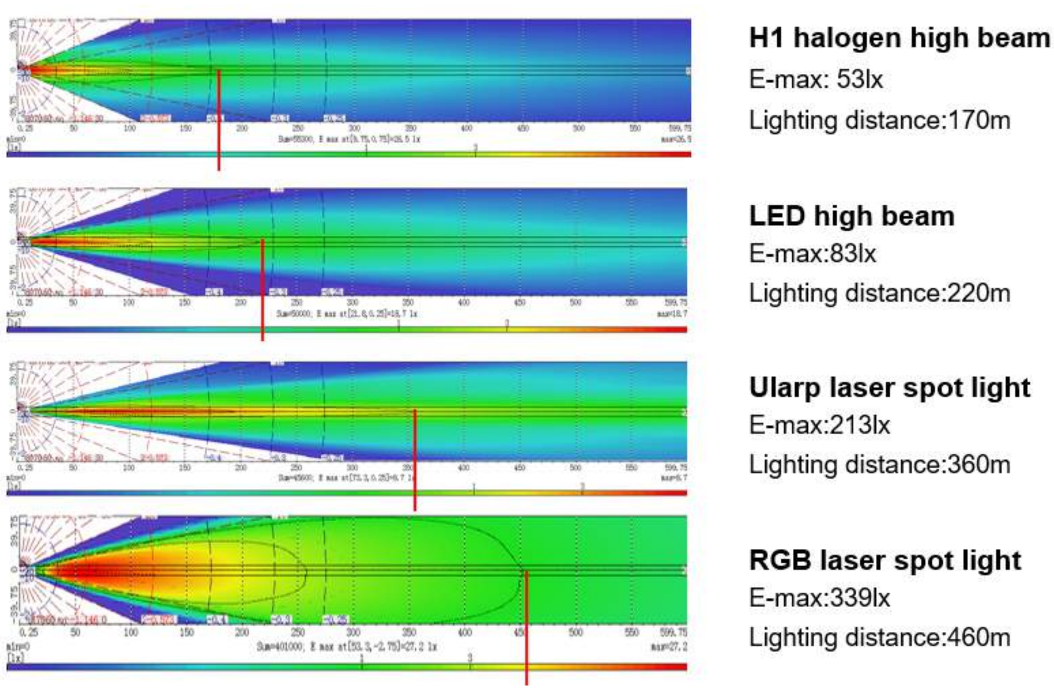
Xingyu presented their realisation of a performant RGB laser high beam system, which includes three laser diodes—Mitsubishi for Red, Nichia for green, and Osram for blue— with their cooling system and the coupled fibres. With an input of less than 100W, the optical output is higher than 10W.

With a diameter of 80 mm for the lens, the E-max for the spot light output is 212 kcd, and the total luminous flux is 2190 Lm, so a very high-class performance. The RGB system can adapt the colour temperature from 3500K to 6500K.
Compared to halogen, LED or ULARP high beams, the RGB beam gives higher intensity and better visibility distance, with the 1-lux line reaching to 460 metres.

But with the RGB system's three narrow-spectrum inputs, is such a system going to give adequate colour rendition? Xingyu used a luminance meter to test the brightness and the chromaticity of traffic signs, and the results were reasonably good—better in many cases than the more traditional sources.



The prototype demonstrates that RGB system can be very performant for visibility range and luminous flux, with adequate colour rendering except for a relatively high chromatic aberration on blue targets. For wide adoption, RGB systems will need lower power consumption and lower cost, but improved laser diodes could yet make this kind of system an interesting option.



DVN Comment

This is an excellent look at a new technology (RGB laser) versus other known technologies LED, halogen, and LARP for high beams. The scrutiny of colour rendering is particularly impressive; this is an aspect of performance that often gets short shrift. The performance of the RGB laser spot beam is quite impressive.

Adverse Weather Conditions—The Benefit of Digital Lighting and its Assessment

Dr. Benedikt Kleinert, IAV (Light & Vision Project Team Manager)

View presentation

A project began with a survey done in 2011, in which glare and adverse weather were considered very important co-factors in roadway discomfort.

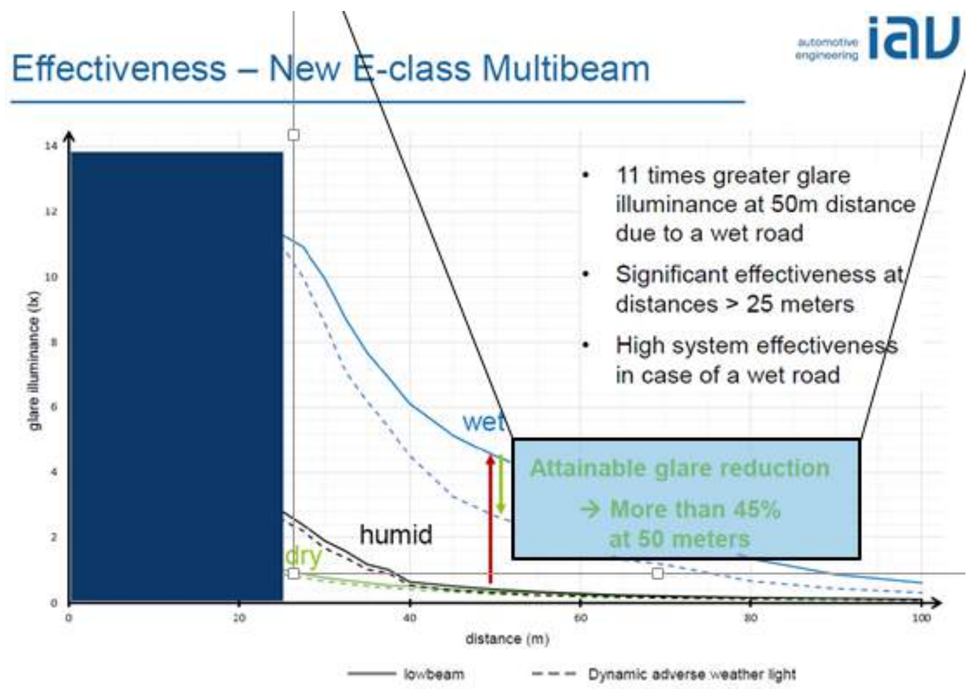
A specific survey was done to understand why drivers are glared: by the lighting systems themselves, by the surrounding road, by adverse weather conditions, etc. The conclusion was that an adaptive adverse weather light is necessary.

So specifications for such a lighting systems were defined, integrating wet road surface, fog, glare and visibility. And virtual development tools were developed for the good assessments of these conditions.

IAV have evaluated that digital lighting systems such as the new E-Class Multibeam is allowing a 45% reduction of glare compared to a traditional low beam.

IAV have done complementary studies with modules of 32 × 32 pixels for a better evaluation of risk of glare. The conclusion is that digital lighting must be optimised taking into account adverse weather conditions to reduce glare.

In next steps, IAV are working to develop a light optimiser—a virtual assessment platform with assessment methods based on VIRAP.



DVN Comment

Wet-road glare has long been a difficult, intractable problem: wet roads occur during bad weather, mostly, which is when traditional bad-weather lighting (e.g., front fog lamps) are used. However, these tend to put lots of light in the foreground, worsening wet-road glare to other drivers. The same is true of foul-weather modes of adaptive lighting system. Digitalisation for the first time affords an opportunity to fix the problem.

Session 5
Digital Light—New Light Sources

View lectures

Session 5 Q & A

• **Digital and Efficient: the Future of Front Lighting**
Dr. Claus Allgeier, Osram (VP Automotive OEM Business & Technology Development)

• **Future Light Source Solutions for Digital Light Applications**
Dirk Vanderhaeghen, Lumileds (Senior Director, OEM Strategic Marketing)

• **Automotive Lighting Technology—SSL in the Coming Generation**
Dr. Ulf Meiners, Nichia Chemical Europe (Deputy Managing Director)

• **Next Generation Automotive Ambient Light**
Shawn Li, Everlight (Chief, Lighting Source Development)

• **Human-Centric Digital Lighting for Better Customer Experience**
Dr. Chai Won Kwon, Seoul Semiconductor (Director, Automotive R&D Centre)

Digital and efficient: the future of front lighting

Claus Allgeier, Osram, VP Business & Technology Development Automotive OEM

View presentation

Allgeier first explained the historic digitalisation of lighting starting at 1 digit (switch off/on), then 2 digits (low/high beam), and now going to more than 1,000 digits while being communicative, connected, thin, distributed, and efficient.

He then compared thin-aperture projector systems considering matrix ADB**:** A projector system with direct imaging of LEDs and a projector system with primary lens (2 × Smartrix® modules)
With lens ø50mm, the optical efficiency is 33% vs 29%
With lens 50mm × 24 mm, the optical efficiency is 18% vs 28%.
Smartrix modules are used on Jaguar's E-Pace and Range Rover/Sport launched end 2017.

1: Secondary optics; 3: Primary silicon optics; 6: LED board

Then Allgeier re-ran the comparison with new Smartrix® Gen2 modules.
With lens ø50mm, the optical efficiency is 45% vs 33%
With lens 50mm × 24 mm, the optical efficiency is 40% vs 18%.

Next came a comparative look at ADB with digital front lighting technologies using additive versus subtractive light.

E-Class	84 pixels	35Lm/W
Smartrix gen2	up to 100 px/lamp	55Lm/W
Smartrix HD/Eviyos	up to 4k px/lamp	35Lm/W
LED DMD	> 1 million pixels	10Lm/W

Allgeier presented the different possibilities offered by Smartrix: Full FOV, AFS, ADB, marking, Resolution of ~0.25° H, ~0.25° V, warning light, distance warning, DRL.

Osram's conclusion:
Discrete LED rows/arrays with silicone primary optics will provide highest energy efficiency at low resolution for ADB and AFS functions. DMD systems will be well suited for information projection, but limited to partial illumination due to low energy efficiency. LCD technology offers moderate efficiency at lower resolution than DMDs. And Eviyos is additive and very energy efficient with potential for even higher resolution.

DVN Comment

It is fascinating and exciting to watch the evolution of a technical product such as Osram's Smartrix module. The optical efficiency gain in the gen-2 product is very impressive!

Future Light Source Solutions for Digital Light Applications

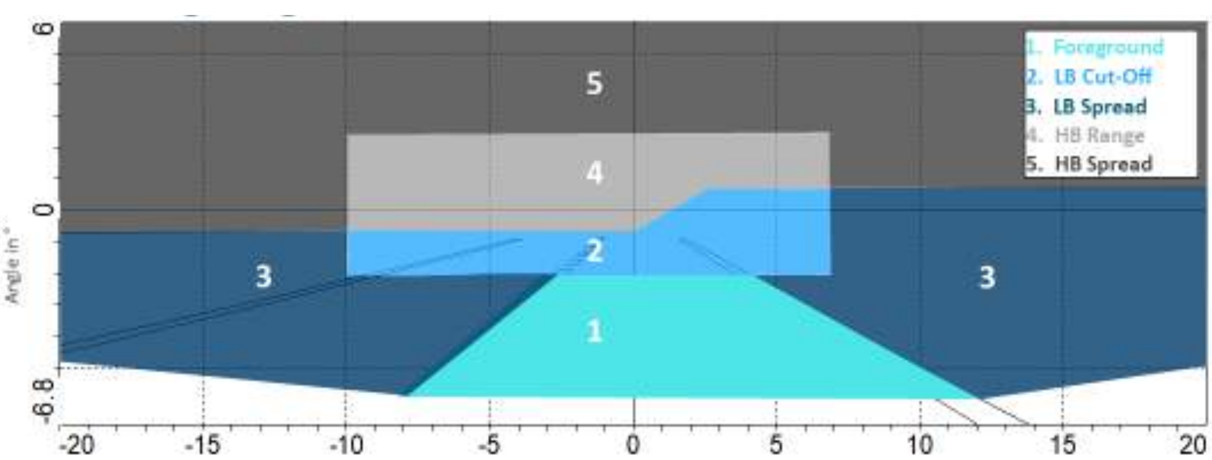
Dirk Vanderhaeghen, Lumileds (Senior Director, OEM Strategic Marketing)

View presentation

To compare the different technologies, Dirk Vanderhaeghen defined zones of interest of the headlight beam, defined and numbered as follows in the diagram:

1. Foreground
2. Central low beam hot spot and cutoff area
3. Low beam lateral spread area
4. Central high beam seeing distance/range area
5. High beam lateral spread area

These various zones and areas have differing needs in terms of intensity and resolution. The lateral spread areas don't need much in the way of resolution. The foreground traditionally hasn't, either, but if we will project navigation or warning messages there, resolution becomes important. Resolution has always been very important in the low beam hot spot/cutoff central area because of the close adjacence of high intensity for seeing and low intensity for glare control; this area now even more needs excellent resolution for performant ADB.



As in Osram's presentation, technologies LED matrix, µLED, DMD, LCD, and scanning laser were compared with their benefits and drawbacks.

LED matrix	µLED	DMD	LCD
~100-200 LED Small die 0.5mm^2 Flux > 15,000 Lm Power: 40 W	**~10 K pixel LED** @ 60x60 μm^2 Flux: 7,000 Lm Power: 25 W	**High Lum. LED** 200 Mcd/m^2 Flux > 4,000 lm Power: 60 W	**LED array** ~70 Mcd/m^2 Flux: 20,000 Lm Power: 140 W

The three main takeaway points:

• LED matrix is the base stepping stone for digital headlighting

• Light source technology maturity timeline means we see LED matrix in 2018 and can expect high-luminance LED + DMD / LCD in 2019, µLED in 2021, and scanning lasers in 2022-'25.

• Synergy across industries could affect how fast and widely they move into the automotive market.

DVN Comment

The older question of which HD lighting technology will win appears to have been superseded by what's addressed here in the Lumileds presentation: different technologies are optimal for different regions within the headlighting system's coverage area.

Automotive Lighting Technology—SSL in the Coming Generation

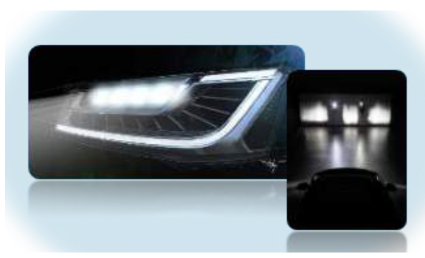
Dr. Ulf Meiners, Nichia Chemical Europe (Deputy Managing Director)

View presentation

The speaker started his presentation by explaining that digital is everywhere, then he presented Nichia's three core competencies:

- Advanced chip technology
- Advanced packaging technology
- Advanced phosphor converters

Numerous examples and use cases were described and shown.



Optimised light sources

Individual CSP LEDs, brighter and smaller, from 315 Lm in 2015 to 375 Lm this year

High resolution for MEMS scanning

Optimised light sources for HD ADB

LED with super high resolution for DMD, with high luminous flux > 4000 lm (230 cd/mm^2) target, and a single light emitting surface of 1.4 × 3.5 mm

Laser system luminous output: 644 lm with a system optical efficiency of 61%, hot spot of 35,200 cd, and a 1-lux line 70 degrees wide.

The Light Source is the Key Enabler for Digital Lighting

In the next 5 years, an Improvement of existing solutions is expected:

- High luminance and efficacy, more pixels
- Higher Contrast, System Simplification
- Next Leap: communication with light
- Projection, displays, etc.

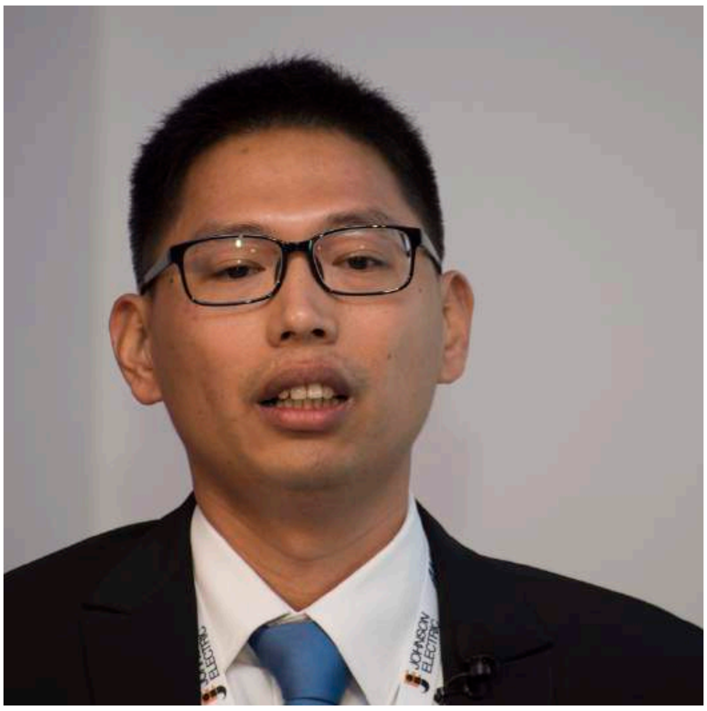
DVN Comment

Nichia are clearly at the deep end of the pool with regard to research and development of light sources and supporting technology for their continued evolution and advancement.

Next Generation Automotive Ambient Light

Shawn Li, Everlight (Chief, Lighting Source Development)

View presentation



Shawn Li introduced new ideas and product of next generation automotive ambient lighting
The current design tries to achieve these requirements for interior ambient lighting.

Everlight "Smart Multi" LED Chain

- Space saving design with LED chip and driver chip encapsulated in same package
- Minimal wiring & simple connection with RGB LED packaged with smart LED driver chip.
- Feedback Data: from LEDs to microcontroller with diagnosis of the temperature and condition of individual LEDs (IC close to LED die) and each LED being controlled independently.

The light module is connected to the microcontroller which will transmit binary signal to control the light module and emit not only RGB colour but a wide range of colour and design patterns, on customer's choice.

Ambient light can be applied on surrounding, cluster and switches. Since Smart Multi is a digital light source, the ambient light's effect can be customised by each individual driver through simple modification.

Furthermore, making an even light effect requires high pixel density. To achieve high pixel density with limited space, our package is well suited for such application due to our small package size.
- The smart multi not only can be applied on interior ambient light but also exterior lighting.
- Surrounding ambient light to set a mood that suit the driver, for (example: peaceful, calm, warm or romantic.)
- The ambient can also change with the music, for example changing with weather condition.

In conclusion, Everlight Smart Multi-LED save more space for more Design flexibility, simplify module design, fine PWM Grayscale (12/15bit), with self-diagnosis capability.

DVN Comment

Everlight's new products for the automotive sector demonstrate that they are committed to innovation in this field. The feedback and self-diagnostic capabilities of the described "smart multi" LED chain are interesting as a countervail to the tendency of increased complexity to pose reliability and repairability challenges.

View presentation

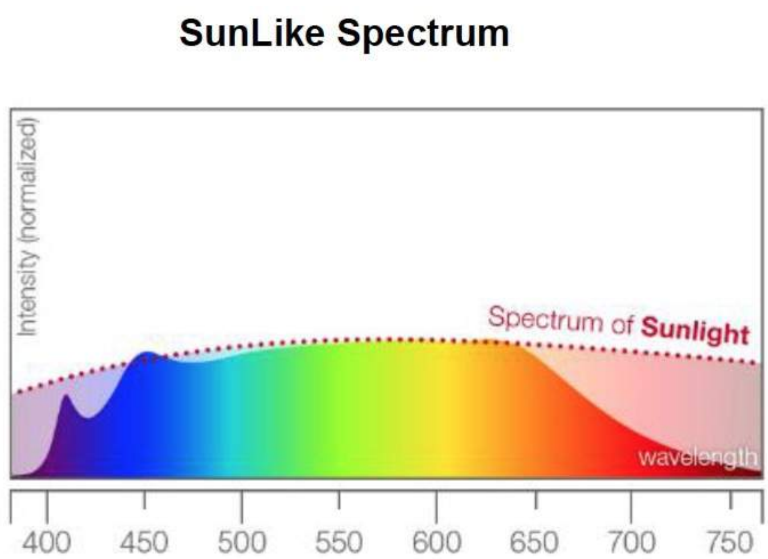
Human-Centric Digital Lighting for Better Customer Experience

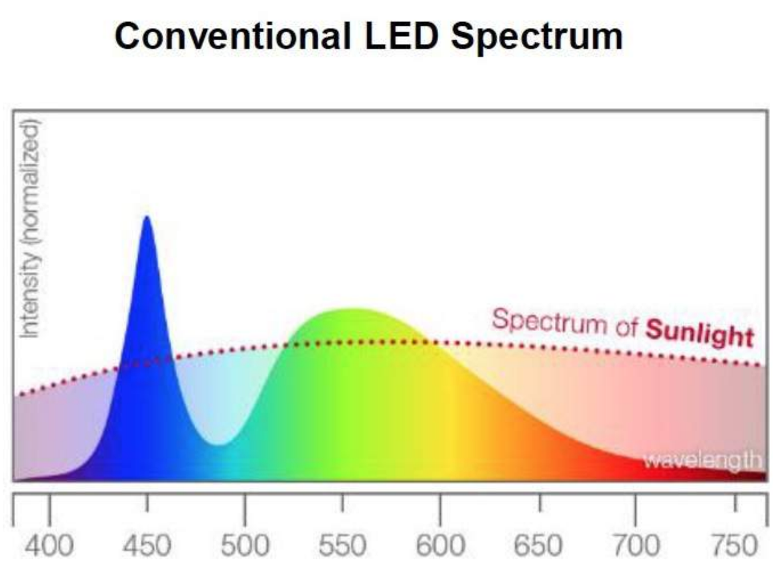
Dr. Chai Won Kwon, Seoul Semiconductor (Director, Automotive R&D Centre)

The speaker started by presenting the benefits of digital lighting: exploiting the advancement of information and telecommunication technologies, time resolution with pulse control, energy efficiency, spatial resolution, local dimming, design flexibility, colour control, etc.

He pointed out that the next generation technology of digital lighting is the combination of human-centric functionality, smart connectivity, and digital IT technology to deliver a better customer experience

With that stated, he described Seoul Semiconductor's SunLike white LED technology: departing from conventional white LED technology which pumps a yellow/red phosphor with a blue LED and then admixes the output to get a white-appearing light, SunLike uses a purple LED to excite red, green, and blue phosphors. All colour is generated through the controlled phosphor colour conversion. The result is a broader spectrum much closer to that of sunlight, without the high blue spike or severe violet-red-cyan deficiencies of conventional white LED light.





This outcome is important because the spectrum of sun is intimately linked to human circadian rhythm. Excessive blue light at night suppresses melatonin production and disturbs our circadian rhythm.

So, natural colour spectrum delivers 3 key benefits:

• Wellbeing (fit to circadian rhythm and better sleeping quality)
• True colour (natural colour sense and accordance with real colour)
• Better visiion (less glare and dazzle)

Dr. Chai pointed out that SunLike is beneficial to automotive interior applications and can be a solution to "winter blues" (seasonal affective disorder, SAD; according to researchers in Canada, light therapy is effective in 60% to 90% of cases) .

DVN Comment

The technology described appears technically disruptive (purple chip rather than blue as the basis for white light from LEDs) as well as potentially groundbreaking in quality-of-light terms. Although the presentation focused primarily on interior lighting where quality of light is directly appreciated by vehicle occupants, it is intriguing to ponder what improvements in real and perceived headlighting might be possible by improving the colour rendition of headlamps and attenuating the high blue spike in most present LED headlamp SPDs.

Session 6:
Electronics, Simulation, Tools, Condensation Management

View lectures

Session 6 Q & A

• **Cross Carline Electronics Applicable Even for µAFS High Resolution Lighting Technology**
Gerhard Fleischmann, Lear (Director of Engineering)

• **High Resolution Digital Lighting and Safety—a Semiconductor Tier 2 Perspective**
Jatin Thaker, NXP (Segment Manager, Solid State Lighting)

• **Managing Condensation in LED Headlamps, and Considerations for CFD Design**
Dr. Ulrike Geissler, WL Gore (Product Manager, Automotive Lighting & Powertrain)

• **Frontloading Thermal Management for Faster Design and Cost Efficient Development**
Thomas Schultz, Mentor Graphics (Application Engineering Manager)

• **Software Approach for Construction, Simulation, and Optimisation of Light Guide DRL**
Dr. Thomas L.R. Davenport, Synopsys (System Engineer)

Cross Carline Electronics Applicable Even for µAFS High Resolution Lighting Technology

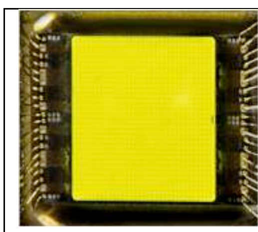
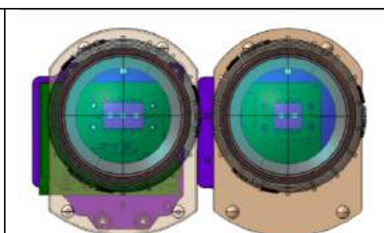
Gerhard Fleischmann, Lear (Director of Engineering)

View presentation

Gerhard Fleischmann's presentation was about applying lessons learned from Daimler E-Class 84-pixel approach to minimise the risk to introduce a µAFS light engine as a standardised and cost efficient cross-carline system solution based on the Osram Eviyos chip.

A µAFS light engine allows an increase of resolution from 84 pixels to 4,000 or 5,000 pixels with better low beam appearance, improved marking, smaller glare-free zones, increased possibilities for light distributions, and signatures and signals on the road (lane marking, snowflake, etc).

To meet customer requirements for introducing µAFS micro matrix LED modules, technical investigations have been conducted by Lear: setup of hardware, system performance, electrical performance, thermal performance and cooling, optical concepts, packaging , scalability, etc. The results of these investigations were carried over to an engineering prototype which main purpose was to prove the robust design of the electrical performance. This prototype was on display at Lear's exhibition booth.

		
Osram µAFS	Optical system:master @ slave	Lear Prototype FOV 4° × 20°

Conclusions: LED micro matrix systems don't need any additional light sources beside the base light to fulfill the light requirements. They offer good opportunities for scalability over carlines or within the carline. They're highly efficient, with no energy waste or discarded light if light is not needed at a particular location. And they provide very good diagnostic capabilities of any single pixel via serial interface.

DVN Comment

The fancy lights themselves usually take most of the attention. It's good and valuable to get such a close look at the behind-the-scenes components and the electrics and electronics that make it all work effectively. We are eager to see the predicted improvements in resolution and FOV come real!

High Resolution Digital Lighting and Safety—a Semiconductor Tier 2 Perspective

Jatin Thaker, NXP (Segment Manager, Solid State Lighting)

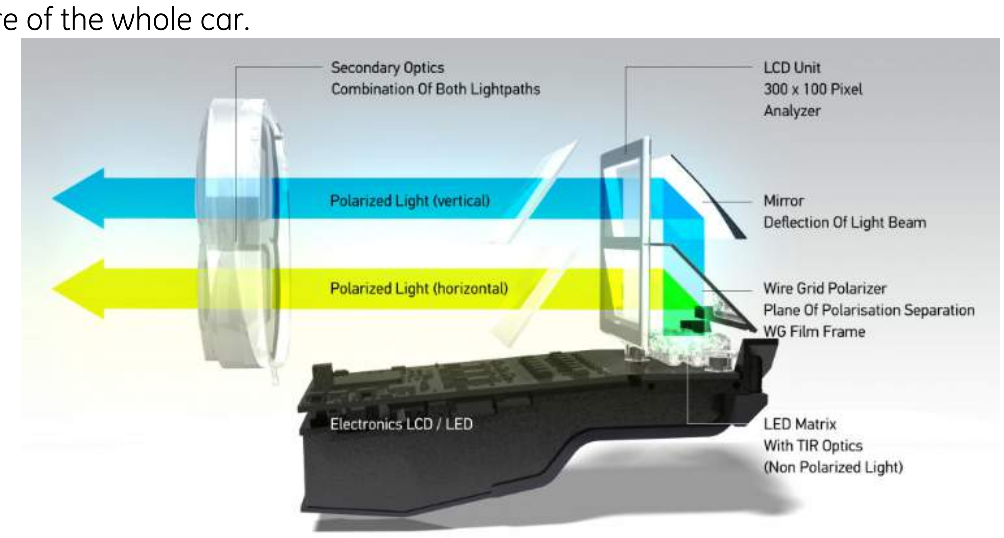
View presentation

In his presentation, NXP's Jatin Thaker developed his view about what makes LCD a better fit to affordable Semi IC solutions for high resolution digital lighting, altogether robust in harsh automotive environment and affordable vs. other digital light alternatives.

LCDs require backlighting with some key characteristics:
• High contrast resolution and dimming
• High Current handling capability enabling brightness
• Robust Communication interface, high bandwidth and bit rate
• Full Diagnostics to prevent backlighting malfunction.

The NXP matrix LED controller enables high contrast resolution, dimming, and handling of the high current required, while ensuring robustness and high bandwidth and bit rates as well as full diagnostics for ultimate performance control.

LED driver platforms are also available from NXP systems solutions for MCU and LED drivers.
NXP have leveraged their wide lighting application expertise and technology to deliver a total system solution for LCD backlighting using their matrix controller, MCU, and LED drivers, demonstrating that their HD light solution are adapted to increasing performance and diagnostics, for a smooth integration in the electrical-electronics architecture of the whole car.



DVN Comment

The twin-axis polarisation aspect of Hella's LED matrix unit is particularly interesting, with the horizontally- and vertically-polarised light blended by dint of secondary optics. It appears to be a highly versatile basis for a highly-versatile vehicle front lighting system that could well bring LCDs onto the menu of serious contenders for digital lighting technological wins.

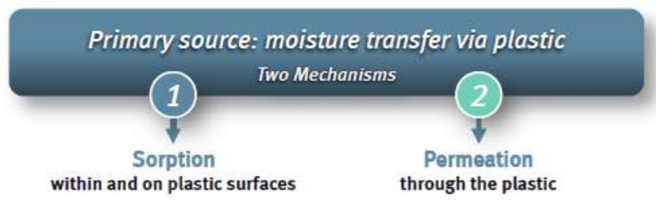
Managing Condensation in LED Headlamps, and Considerations for CFD Design

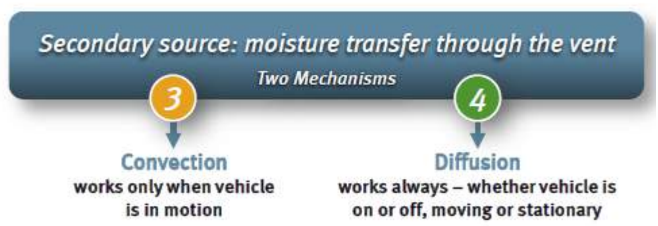
Dr. Ulrike Geissler, WL Gore (Product Manager, Automotive Lighting & Powertrain)

View presentation

Front lighting systems have made fantastic progress in the recent years, but condensation is still an issue during the development to ensure a good quality, and this problem is even today more critical with LED headlamp as the dissipated heat is reduced.

Dr. Ulrike Geissler has presented a very good synthesis of the phenomena involved for this issue, due to the moisture transfer via plastic by sorption and permeation and the moisture transfer through the vent by convection and diffusion.





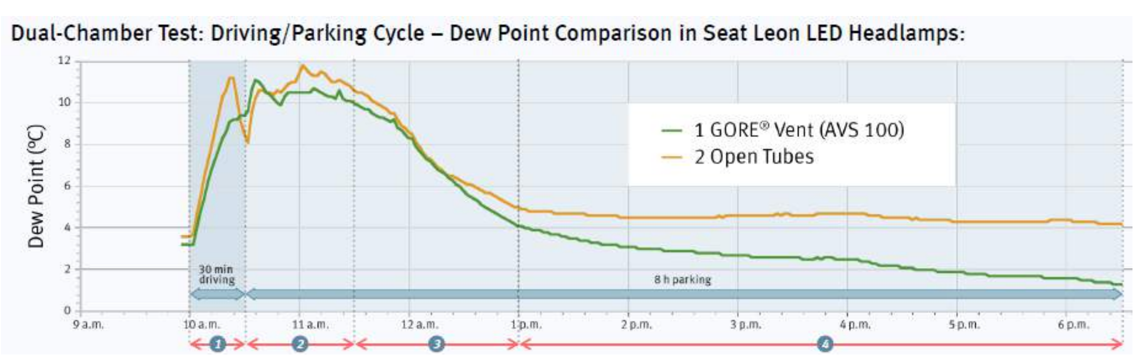
It is essential to select the right plastics and the best venting solutions.

It is well known that some plastics like polyamide (Nylon) have very high water absorption/desorption, and must be carefully used. For water vapor permeation, PMMA and PC have high coefficient, PMMA being even at 30 g/m^2/day.

As for venting: convective solutions can be effective when the car is in motion, but the efficacy disappears when the vehicle is stopped. So diffusion remains the main solution to compensate the moisture level.

And to have a good diffusion through the vent, a large surface and a reduced depth is better.

Gore presented a comparison between a Gore vent and traditional open tubes, showing the quicker compensation and more stable equilibrium with Gore vents.



DVN Comment

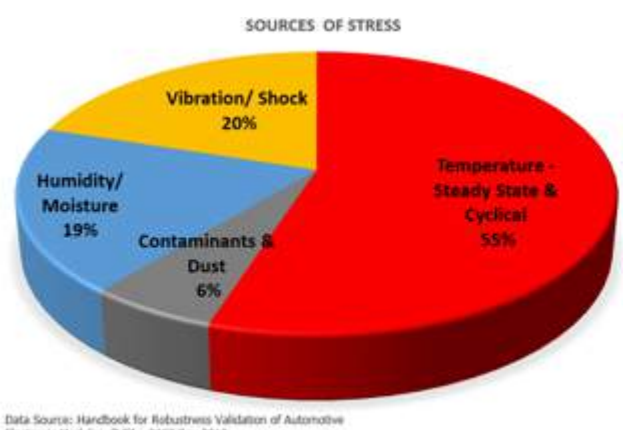
In addition to the stopped car vs moving car issue, Dr. Geissler made some very interesting points, particularly about the sorption characteristics of commonly-used plastics, the more critical need for appropriate air exchange in LED headlamps (versus older technologies) to avoid condensation, the greater consequences of condensation in LED headlamps (destroyed electronics, etc) and the packaging reasons why ultralow-profile vent solutions such as Gore membranes are preferable to vent caps and tubes.

Frontloading Thermal Management for Faster Design and Cost Efficient Development

Thomas Schultz, Mentor Graphics (Application Engineering Manager)

View presentation

In today's advanced car lights, each LED might have its own lens, while light guides with textures and structures are increasingly used to direct the light as needed. All these new structural changes and components mean today's lamps are vastly more complex than yesterdays. And that's without even mentioning cars with multiple choices of headlight systems—full LED, matrix LED, or HID, in the case of the Audi TT, for example—which increase the variety of systems even more. Constant across all the variants is the need for thermal management to assure the performance and reliability of the lighting system. This task has to be handled with CFD (Computational Fluid Dynamics), as making prototypes for each change to each variant would be inefficient and costly. In general CFD tools require a mesh in order to discretise the geometry in small elements which will then be calculated by the solver. Such a mesh generation in the new lighting systems becomes very time consuming and often even before the mesh in generated a CAD model preparation is required to simplify the geometry for the mesh generation. When taking a closer look at the actual geometry of a headlight, one can see a lot of fine details such as the sawtooth structure of the light guides or small ribs on the reflector or bezels for directing low beam light upward onto overhead road signs, or the small facetted surfaces of the orange plastic of the turn signal. Such small structures are difficult to model in every traditional meshing process. But the worst part of it is when the mesh is finally completed after several hours or days of manual work and then the design has changed slightly and the first simulation hasn't even run. With the automotive lighting industry being so strongly linked to design, a better solution is required that is much more upfront in the design process and automates laborious task such as meshing and eliminates the geometry simplification.



Such a frontloading approach to automatically create a highly accurate mesh directly on the native CAD geometry is the approach pursued by Mentor Graphics' FloEFD and its integration in Catia V5, ProE/Creo and Siemens NX. This enables engineers to always be up-to-date with the simulation on the latest design and automatic meshing reduces the manual workload for the user who can rather take care of other things in his schedule.

Of course, fast simulations mustn't come at the price of accuracy. The corresponding physics should be represented in the simulation and result in high result accuracy. When talking about simulation tasks in the automotive lighting industry, there are some critical criteria the design has to fulfill. Thermal management is crucial; the whole system should work within its operating limits even in worst-case, hot-as-Hell scenarios such as a car parked in Dubai with the engine running, lights switched on and the sun shining into the lens, potentially creating a focused solar hot spot on a plastic component with several hundred degrees Celsius. Such tasks have to be resolved in order to not burn holes in parts. There is also the other extreme to consider, wherein a car leaves a relatively humid warm garage after a rainy day into the cold outside world and a condensation film starts building on the front lens of the lighting system. This is not desired by the OEMs, who want no condensation (or at least fast dissipation). These simulation tasks require certain capabilities in the software such as Monte Carlo radiation model with refraction capabilities or condensation calculation where a transient simulation can provide information on how fast and in which areas the condensation disappears the fastest in order to maybe even improve the evaporation by specific design changes.

DVN Comment:

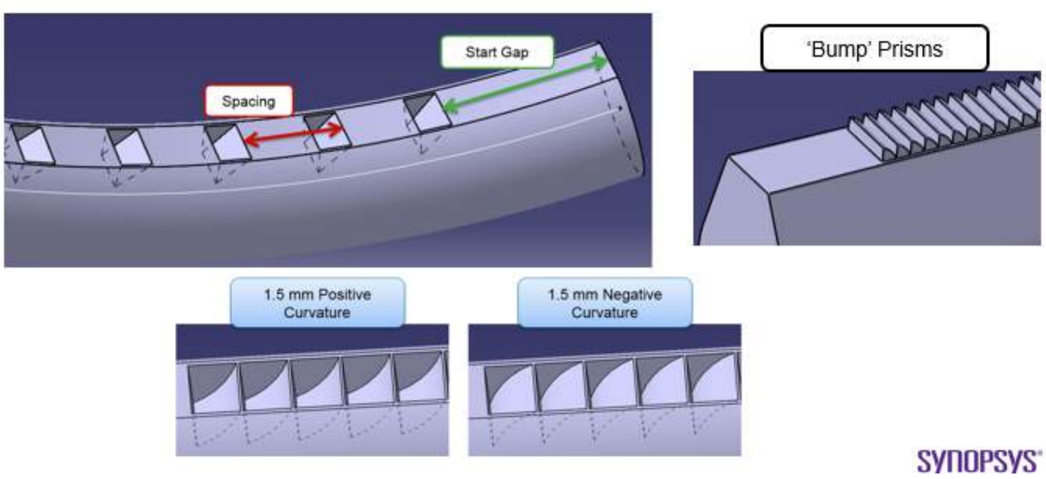
With increasingly complex and intricate lamps come the necessity of increasingly sophisticated test and development methods; this frontloading concept appears to be a good one for optimising decisions and costs. Thermal management is seeing a higher priority within the development cycle, and process-oriented workflows, such as frontloading, are more and more dominating the CAE environment.

Software Approach for Construction, Simulation, and Optimisation of Light Guide DRL

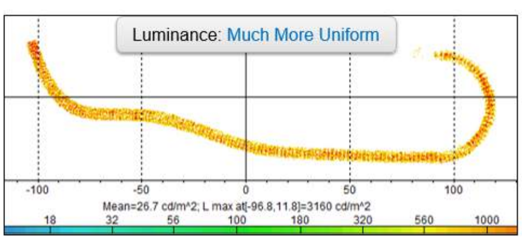
Dr. Thomas L.R. Davenport, Synopsys (System Engineer)

View presentation

Synopsys' Dr. Davenport described their new tool for the quick design and optimisation of light guides.
The goal of the work is to start with a provided path curve, create a light-guide DRL in the CATIA V5 environment, then optimise the luminance uniformity of the lamp by automatically adjusting prism sizes, optimising the direction that the light points in by automatically adjusting the prism face angle, and finally examine and compensate for material losses and fillet radii. Davenport walked the audience through the process step by step, starting with a path curve from the design and with a CATIA spline curve. Then a profile shape type is chosen, then profiles orientated according to light direction and the light guide surface, and finally the solid light guide is tuned with addition or subtraction of prisms.



The optical simulation uses a complete ray file sensor records with all the rays and colour information used for optimisation.
Some complementary operations are done for the optimisation, and a very uniform light guide is the end result.



The simulation can also account for the real dispersion and absorption of the material of the light guide. Other improvements can be made by adding fillets on the prisms to smooth the spatial performance.

DVN Comment

This was a fun presentation to see in person, with the light guide's performance and luminance uniformity improving visibly as each step in the process was carried out. As it happens, light guides that look as though they have simple transverse striations, all alike along the length of the guide, in fact are very much more intricate than they look.

Session 7:
Digital Light—Views From Research Institutes

View lectures

Session 7: Capacity Crowd

• LiFi Technology for Vehicle Communication—Opportunities & Challenges
Prof. Dr. Suat Topsu, University of Versailles (Founder of OLEDCOMM)

• From ADAS to Automated Driving—Challenges & Research Needs
Dr. Ing. Adrian Zlocki, Automotive Research Institute Aachen (Senior Manager, Driver Assistance)

• Micro-Optics for Automotive Lighting
Dr. Peter Schreiber, Fraunhofer IOF Jena (Head of Illumination & Projection)

• Disruption in Action; the Future of Mobility
Dr. Ir. Carlo JT van de Weijer, TU Eindhoven (Director, Strategic Area Smart Mobility)

LiFi Technology for Vehicle Communication—Opportunities & Challenges

Prof. Dr. Suat Topsu, University of Versailles (Founder of OLEDCOMM)

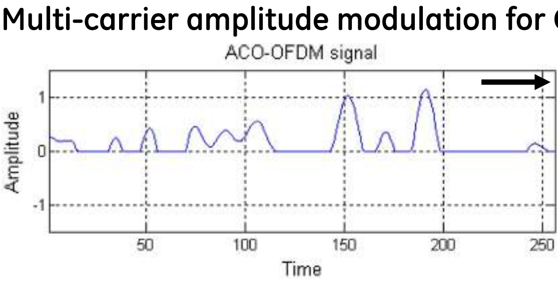
View presentation

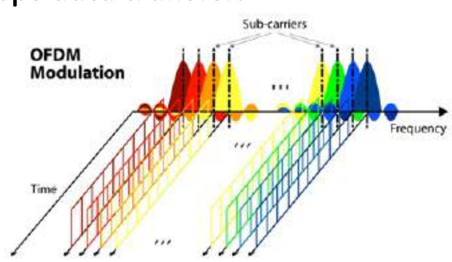
Professor Dr. Suat Topsu presented the state of the art and the bright future of LIFI in the automotive Lighting filed. Using light instead of radio waves to communicate allows 80% energy savings and increased communication speed by a factor of 200.

LIFI is the wireless transmission of data via visible light. Two methods are presently considered: pulsewidth modulation of an LED or laser diode, which can provide data transfer rates in the Mbps range, and multi-carrier amplitude modulation for Gbps data transfer rates.

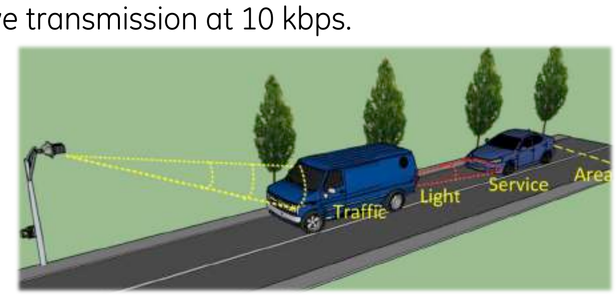
PWM for Mbps data transfer:

Multi-carrier amplitude modulation for Gbps data transfer:





Topsu described examples of LIFI use cases in transport: airplane LIFI for infotainment and internet onboard, and V2I and V2V communications in traffic to facilitate platooning as demonstrated by Valeo at Versailles University with error-insensitive transmission at 10 kbps.



More recent results in automotive LIFI:

• National Taiwan/Versailles University and Ford (2017) :

Error-insensitive transmission at 100 kbps from a leading vehicle to a following vehicle over 30 m, even in highway curves.

• Nagoya/Shizuoka University and Toyota (2014) :

Error-insensitive transmission over 7 m at 10 Mbps.

• Example of OLEDCOMM results for Automotive: University of Versailles (2016):Entertainment content transmission from the ceiling light to a laptop.

• Error-insensitive transmission at 1 Mbps over the front seats of a Nissan Leaf.

DVN Comment

LIFI looks to be a highly promising addition to the ways and means of shuffling increasing amounts of data necessary to keep up with advances in transport and infotainment technology. The modulation is invisible to humans, which should make for good public acceptance, but will there be privacy and security concerns…?

View presentation

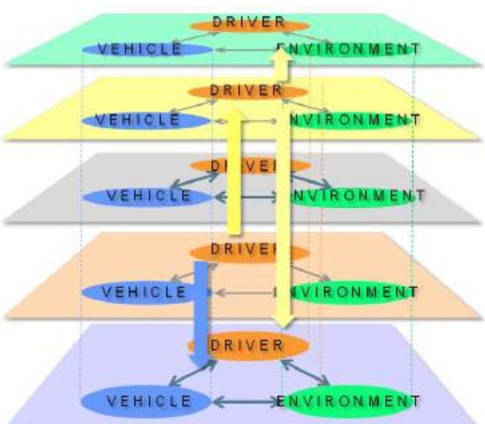
From ADAS to Automated Driving—Challenges & Research Needs

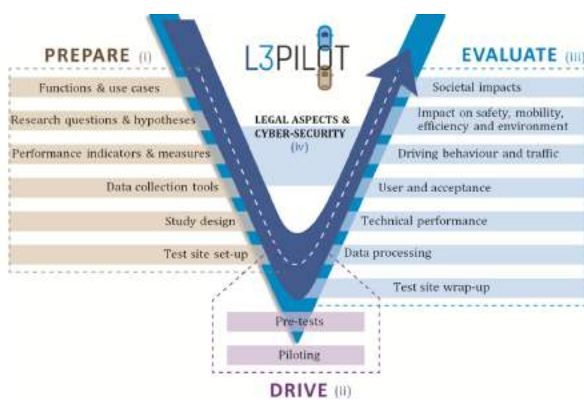
Dr. Ing. Adrian Zlocki, Automotive Research Institute Aachen (Senior Manager, Driver Assistance)

Dr. ing. Adrian Zlocki detailed the challenges and research needs to succeed in the transition from ADAS to automated driving. Vehicle intelligence needs to be designed in a holistic way: automated driving poses challenges. These can be structured according to the 5-level model, with a method covering through a holistic approach five different levels: technical, vehicle-driver-environment interaction, economic and legal levels, and finally the acceptance level by different social groups.

Research activities on automated driving have started, yet many research areas require new methods and solutions for design, development and evaluation. By analogy with human cognition, an "automotive brain" concept proposal has been described, with three levels of increasing intelligence: the skill-based level generating automatic actions according to perceived situations, the rules-based level applying rules based on a recognition process, and the knowledge-based level able to understand and solve problems. AI methods (e.g., deep learning) from the IT field will incur in the automotive value chain; meanwhile, creating the database of relevant situations offers an efficient and valid evaluation procedure.

These kinds of challenges will require close coöperation among all practitioners from science, industry, and government.





DVN Comment

This high-level lecture shone an unusual light on the challenges put forth by the onset of autonomous driving and truly advanced, intelligent assistants for human drivers. Controlling it in a thoughtful, scientifically valid manner will surely improve the uptake of these new technologies in terms of speed and freedom from problems and drawbacks.

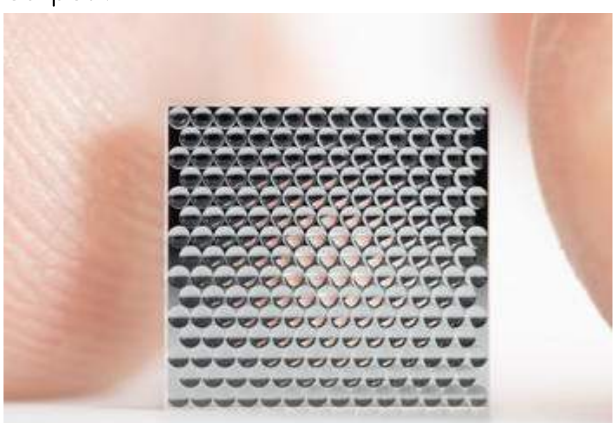
View presentation

Micro-Optics for Automotive Lighting

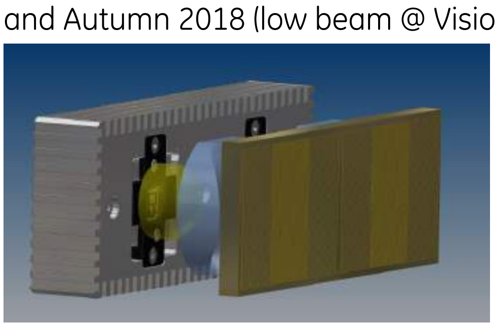
Dr. Peter Schreiber, Fraunhofer IOF Jena (Head of Illumination & Projection)

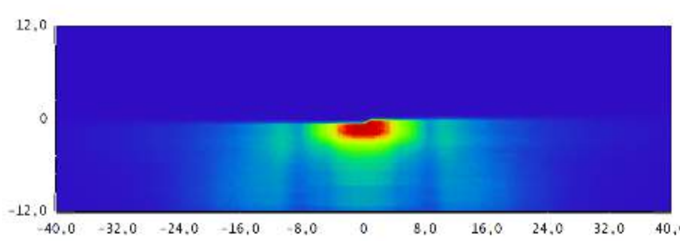
Dr. Peter Schreiber presented the current state of the art of micro-optics and its future outlook. He summarised micro-optics scaling laws and the new perspectives offered by chirped arrays (with continual variation of lenslet parameters like f/number, orientation, astigmatism correction, etc), tailored diffusers, and stacked arrays. He described application examples for interior and exterior lighting and information displays, as well as the different manufacturing technologies now available: lithography, UHP diamond shaping, and UV molding replication.

The key is the "homogeniser", which improves over a diffuser and works like an insect's compound eye: monolithic micro-optical tandem lens arrays produce sharp edges, acceptable luminance, and homogeneous light distribution. Application example: the 2015 BMW "Welcome Light Carpet":



What about using an array projector as headlight? It presents challenges, but these can be overcome. For example, the mismatch between square LEDs and round lenslets is fixed by changing to square lenslets. Fraunhofer's concept SSL ("Structured Spot Light") prototype provides low beam and segmented high beam. Demonstrator hardware is planned for presentation in Spring (high beam @ OptaTec, Frankfurt) and Autumn 2018 (low beam @ Vision, Paris). Very compact packaging is promised.





DVN Comment

This is a very intriguing optical technique that seems highly adaptable to whatever needs might present. The progress from an array of uniform round lenslets to a more intricate array of lenslets of various sizes and shapes seems poised to unlock new possibilities, including very small and performant headlamps. We look forward to seeing the hardware demonstrations planned for later this year!

View presentation

Disruption in Action; the Future of Mobility

Dr. Ir. Carlo JT van de Weijer, TU Eindhoven (Director, Strategic Area Smart Mobility)

Dr. ir. Carlo Jt van de Weijer's presentation was a delightful mix of unusual perspectives and tantalising predictions of disruption in action. Here are a few of his best statements:

"A city doesn't need driverless cars, a city needs carless drivers."

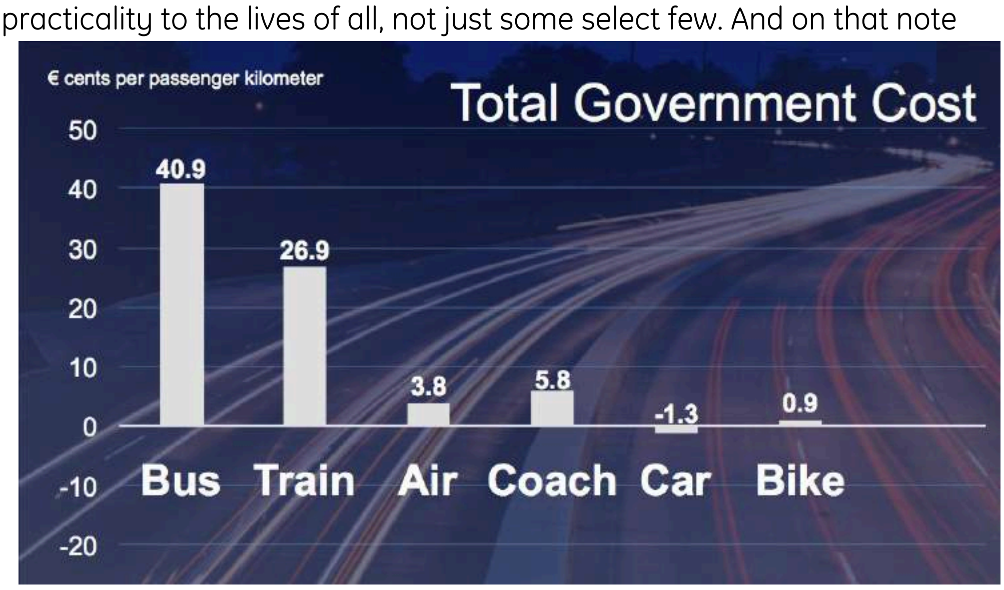
"Don't fear demonetisation; you are about experience all over (which you will pay for!)."

"Car sharing requires recognisable personal ambience."

"Smart mobility = smart cars on stupid infrastructure."

"Traffic is chaos by definition; it mainly functions outside the official rules and regulations. Robots should never be allowed to do so." In conjunction with this assertion, van de Weijer showed a simple yet common example: a city junction with a signalised pedestrian crossing and stop-and-go lights, populated with cars, pedestrians, and bicyclists. The rules describe who has priority for right of way, but the actual interactions of the various road users deviate from these rules in ways that run the gamut from carelessness and selfishness all the way to what might be called duelling altruism through hand and face signs: "Go ahead". "No, please, after you." "No, I'm stopped and waiting; you go ahead". These usually resolve quickly when the communication is human-to-human, but a difficulty with autonomous vehicles: at least in the way they are presently conceived, they will tend to slavishly adhere to the rules. The result could be an awkward nuisance if self-driving cars and pedestrians get in endless games of no-you-first.

That's a way in which disruption can give a negative result. Van de Weijer discussed how disruption can be positive if it is appropriately managed. He said the six main characteristics of effective disruption are that it is **d**igitised, **d**eceptive, truly **d**isruptive, **d**ematerialised, **d**emonetised, and **d**emocratised such that it adds pleasure, fun, convenience, and practicality to the lives of all, not just some select few. And on that note another topic discussed was cost, with the government cost per passenger-kilometre compared for various modes of transport. The results look bad for public transit; can the good result for cars be preserved and enhanced as we move from private car ownership to shared car usage, turning the car into a new mode of public transit? Perhaps it is possible. He gave the example of a mobility startup called Amber that seeks to provide guaranteed car availability eveywhere for €33 per week, all inclusive. That's a big improvement over the present model, wherein the average private car is parked and unused a staggering 96% of the time (but its costs don't stop while it's not in use). Good compliance with the six D's of effective disruption, too.



Finally, van de Weijer advised not to fear demonetisation and gave vivid examples of vehicle customisation and new prospects for light in what he called the disruption era.

DVN Comment

Surely this was one of the best lectures of the Workshop. Van de Weijer's perfect mix of precaution and exuberance over the onset of the new technologies—AV, V2x, and all the rest—gave a clear, sharp picture of the amazing things that can be done and obtained if we exercise thought and care in how we channel and harness the disruption.

Session 8:
Panel Discussion: Performance vs. Efficiency

View pictures online >

Huhn chairing the round table with Allgeier, Matha, Evrard, Kleinkes, Neumann, Larsen, Yamamura

The panel discussion set up as Session № 8 at the DVN Munich Workshop gathered top minds in the field to grapple in real time with some dificult, thorny questions.

About weight and consumption:
Probably foremost among these was the matter of what happened to early promises that LED headlamps would dramatically cut the power consumption and mass of vehicle lighting systems.
Examples were provided of production LED headlamp systems heavier and with higher power consumption than their halogen predecessors. The panelists' opinions seemed to converge on realism: Yes, it would be lovely if power consumption and lamp mass could be kept down. But automakers will carry on asking tier-1s for whatever they will ask tier-1s for, and it is not really feasible for a tier-1 to refuse to provide the functions and performance requested on grounds of unnecessarily high weight or power draw.

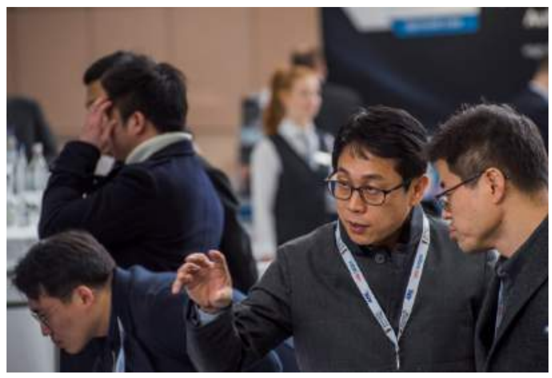
About regulations:
You must have regulations concerning new technologies with lights on AVs, with light markings on the road, with communication to pedestrians and the environment. The US regulatory process requires proof of cost-benefit before a mandate can even be considered.

About integration of sensors in the head/rear lamps :
New technologies are invested to integrate sensors. We also have to be able to do it without interfering with styling and design.

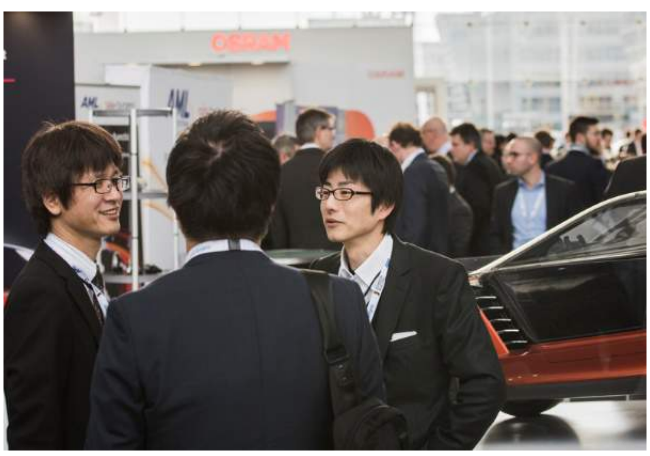
About new technologies:
They are accelerating because automakers—so far mostly premium makers—want to show innovative functions, performance, and design.

DVN Comment
This is really quite a conundrum: we were all so sure that LED headlamps would mean a real breakthrough in terms of low-mass, low-power headlamps. Apparently we were so busy focusing on those rosy goals that we didn't pay enough attention to the fine print: how do we define "headlamp"? Legal-minimum performance is easy to achieve with a lightweight, low-power headlamp. But we've also apparently forgot to be careful what we wish for; customers and automakers are demanding highly performant lighting with all the fancy functions, and that adds up to heavy headlamps that consume a great deal of power. Perhaps increases in LED efficiency and stricter rules about CO_2 emissions will help mitigate the trend.

Networking



Networking, cont'd



Demonstrator Cars

Osram Smartrix HD modules,
µLARP Gen 2 + SRS Laser module

Pixel modules and laser; first micro LARP in mass production vehicle

Full LED, LED glass total reflection, laser, OLED, animation

Full LED headlamps and rear lamps, ADB

Full LED headlamp with rotating modules
Full AFS, RGB welcome and bye-bye modes

Full LED adaptive headlight, ADB, dynamic and static bending light

Digital Light
test vehicle based on DMD technology

Matrix technology, first in segment
8 segments per headlamp

Award Ceremony

Ingolf Schneider (Opel)
Generalist OEM Lighting Award
Advanced Functionalities

Paul-Henri Matha (Renault)
Generalist OEM Lighting Award
Cost Optimisation

Carlos Elvira (SEAT)
Generalist OEM Lighting Award
Styling Innovations

Michael Larsen (General Motors)
OEM Lighting Award
Technical Standards Development

Award Ceremony, cont'd

Rainer Neumann (Varroc)
Special Award
Lighting Community Promoter

Jan Hamkens (Docter Optics)
Special Award
Innovative Lighting Supplier

Uwe Kostanzer (Mercedes-Benz)
OEM Lighting Award
Performance-orientated Innovation

Exhibition

Everlight

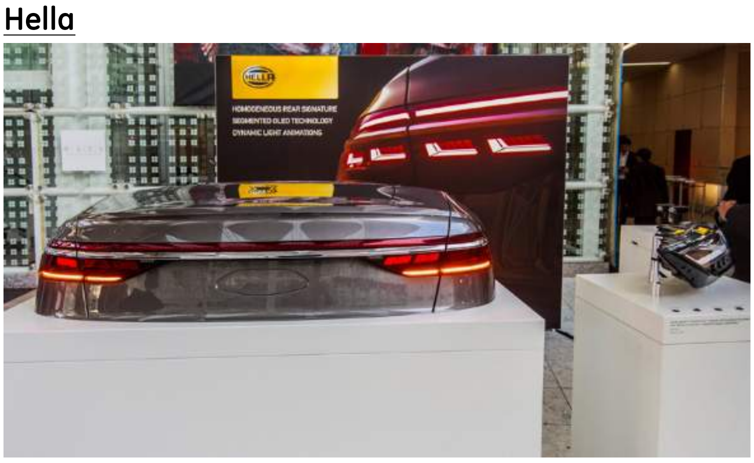
Everlight demonstrated their Smart Multi-LED rear lamp concept.

Thanks to the IC intergrated in the LED package, different light functions can be easily realised in a small module.

W. L. Gore

Gore's portfolio includes venting products that manage moisture and condensation, to protect todays more complex lamp designs and LED technology from failure or damage.
Products for EMI grounding and shielding, for data, power, and sensing applications.

Hella



Hella's booth included Audi A8 OLED rear lighting and LED matrix headlamp with dynamic laser spot; high-efficiency new optical lens systems, and LED matrix headlamp modules.

Exhibition, cont'd

Instrument Systems

Instrument Systems' DSP 200 photometer gives fast "on-the-fly"scanning in combination with the goniophotometers of the AMS line. And their 4th-generation CAS 140D spectroradiometer brings accuracy, reliability, repeatability and stability in lab and production

Lear

Lear's booth included their latest reference product, launched in E-Class. There was also a prototype for µLED matrix based on Osram's Eviyos; Lear applied 5 Eviyos chips on a PCB, and a 2-lens optics with a 4° × 20° FOV and a Power ECU to control all 1024 LEDs separately.
A demo software was running on both systems to show the differences caused by the different resolutions.

Myotek

Myotek's exhibit featured their current and concept offerings of high performance LED fog lamps, fog/cornering lamps, stop lamps, and CHMSLs as well as existing OE and prototype combination lamps featuring fog, cornering, DRL, and sequential turn functions. All demonstrated Myotek's commitment to cost-effective new technology and revolutionary LED lighting designs.

Exhibition, cont'd

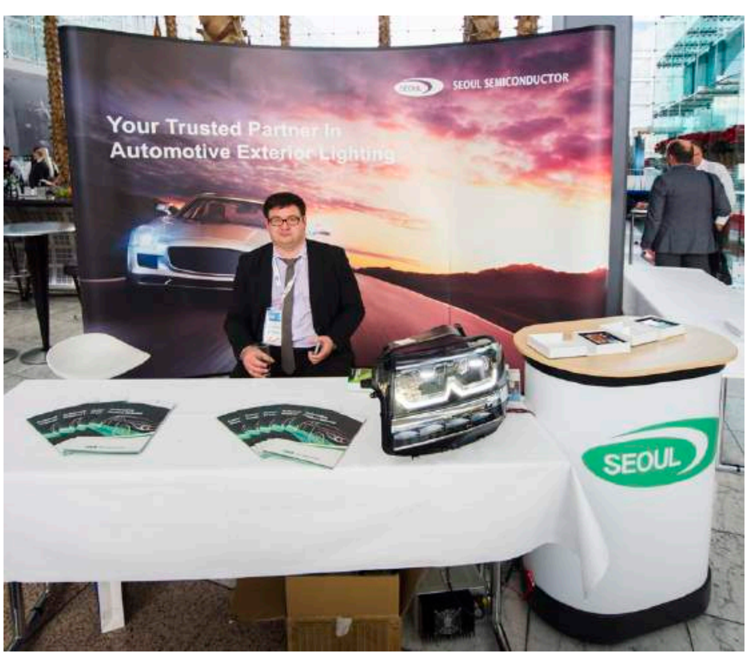
Optis

Optis showed their full software suite to develop virtual vehicle lights: VRX for headlamp simulation, and their night drive simulator with a driving seat to test digital lighting of every kind. In addition to optical assessment and measurement, their real time rendering solution is helpful to test embedded software using Matlab Simulink or C++. Lidar simulation was demonstrated with SPEOS and VRX for ADAS.

Osram

At the Osram booth and show car, visitors could experience adaptive front lighting systems and laser light, and autonomous driving technologies based on lidar. “Digital and efficient: the future of front lighting” was also the leading theme of the presentation by Dr. Claus Allgeier, VP Business & Technology Development Automotive OEM.

Seoul Semiconductor

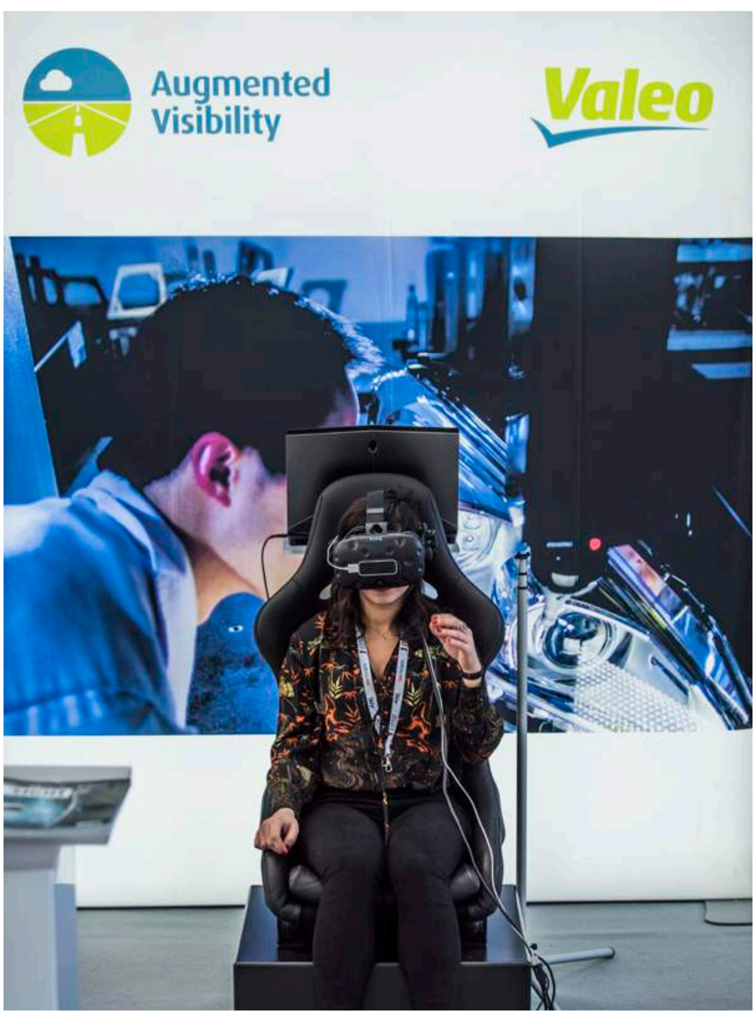


Seoul Semiconductor's booth described their broad automotive LED portfolio, with cutting edge technology and excellent quality, for interior and exterior lighting applications. We could have wished for more hardware demonstrations, particularly of the fascinating purple-chip-based SunLike technology presented in their lecture.

Synopsys

Light Tec are the European distributer for Synopsys. Displayed were software packages LightTools, Lucidshape, CODE V and RSoft. They also showed and demonstrated their newest scattering measurement equipment: the MiniDiff V2.

Valeo



Valeo's booth centred round a virtual-reality demonstrator, and showed off solutions and innovations catering to the new needs of using cars emerging among the drivers of partially autonomous vehicles. On display:

- LED ADB headlight with BiLED 2.5 G. which is a swiveling bi-function module which holds the same benefits and characteristics as the BiLED 2.5 with the addition of ADB function;

- Thin Lens Matrix Beam module which is a unique technology with one light output and one lens. Thanks to the number of segments, the module can replace a high beam classical Thin Lens module;

- Laser Spot headlamp, one of the first laser modules on the market. It has a very intense light range thanks to the super high brightness of the laser diode;

- Full LED rear lamp with 3D homogeneous tail or graphic light, or 3D effect.

Varroc Lighting Systems

Varroc's showspace included LED pixel headlamps with styling bezels; an LED pixel headlamp with laser high beam booster; a drivable demonstrator headlamp with DMD Full ADB functionality, with projections on the road and many other functionalities; another drivable demo lamp with latest state of the art MEMS mirror for combined low beam/ADB/high beam; and a whole portfolio of LED projector units.

XingYu

XingYu's booth showed a range of complete vehicle lamps for Audi, Toyota, and PSA models. These included high/low beam headlamps with multiple LED modules or with D5S HID, and rear lamps with LED and light guides or inner lenses to provide the tail lamp function with good homogeneity and styling.

List of DVN Gold Members

27 Car Makers
Audi, Germany
Bentley, UK
BMW, Germany
Changan Design Center, Italy
FCA, USA
Daimler, Germany
Ford, Germany
GM, USA
Great Wall, China
Harley-Davidson, USA
Honda, Japan, USA
Hyundai, Korea, Europe
Jaguar-Land Rover, UK
Mahindra Mahindra, India
Nio, China
Nissan, Japan, Europe, USA
Opel, Germany
Porsche, Germany
PSA, France
Renault, France
SAIC TC UK
Shanghai-Volkswagen, China
Seat, Spain
Skoda, Czech Republic
Toyota, Japan, Europe, USA
Volkswagen, Germany
Volvo Cars, Sweden

19 Univ., labs, Consultants
FEP, Franhaufer, Germany
Darmstadt university, Germany
DEKRA laboratory, Nederland
Fudan university, China
GranStudio, Italy
Hannover Leibniz Univ.(HOT), Germ.
Institut d'Optique Graduate School, Fr.
Karlsruhe Lighting Institute, Germany
LAB, France
Light Sight Safety, Belgium
Nuremberg university, Germany
Pacific Insight, USA
Parma university, Italy
Rensselaer university, USA
UMTRI, USA
University of California, Santa Barbara
YoungNam University, South Korea
Mr Shunxing Wang, China
John Peek- Soraa

38 Set Makers
AL, Germany, USA
Auer Lighting, Germany
Denso, Japan
Elba, Romania
Farba, Turkey
FIEM Industries, India
Flex'N'gate, USA
Grote, USA
Harbin Good Time, China
Hella, Germany
Hyundai IHL, Korea
Ichikoh, Japan
J.W. Speaker, USA
Koito, Japan, Europe
Lear, USA, Europe
Lite-On, Taiwan
Lumax, India
Magna, USA, Austria
Microlight Auto Parts, Taiwan
Mobis, Korea
NAL, USA
Neolite ZKW, India
Nordic Lights, Finland
Odelo, Germany
Olsa, Italy
Plastic Omnium, France
Peterson, USA
Shanghai Koito, China
SL Corporation, Korea
Stanley, Japan
Truck-Lite, USA
Valeo, France, Spain, China
Varroc, Germany
Wipac, UK
Xingyu, China
ZF-TRW
ZKW, Austria
Zodiac, France

51 Lighting Suppliers
A2Mac1, France
AML Systems, France
Anrui Opto, China
Astron-Fiamm, France
Auer-lighting, Germany
Bicomoptics, China
Bühler Alzenau, Germany
Covestro, US, China, Europe
DBM Reflex, Canada
Delvis, Germany
Docter Optics, Germany
Elmos, Germany
Enmech-Mektec, Germany
Everlight Electronic, Taiwan, Germany
GXC Coatings, Germany
Hitachi, Japan
Holophane, France
IAV, Germany, USA
Infineon, Germany
Innotec Group, USA
Instrument Systems, Germany
Jenoptik, Germany
Keboda, China
LG Innotek, South Korea
LG Electronics, South Korea
LMT, Germany, China
Lumileds, Nederlands
Merck, Germany
Mentor Graphics, Europe, USA
Myotek Industries, USA
Nalux, Japan
Nichia, Japan
NXP, UK
ON Semiconductor, Europe, Asia, USA
Optis, France
Optoflux, Germany
Osram, Germany
Oxyphen, Switzerland
Panasonic, Japan
Proper Group, USA
Sabic, USA
Samsung LED, Germany
Sapphire, USA
Sea Link International, USA
Segula Technologies, France
Seoul Semiconductor, Korea
Synopsys, USA, Germany
Texas Instruments, USA
TQ Technology, Taiwan
Vosla, Germany
WL Gore, USA
Zollner, Germany

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