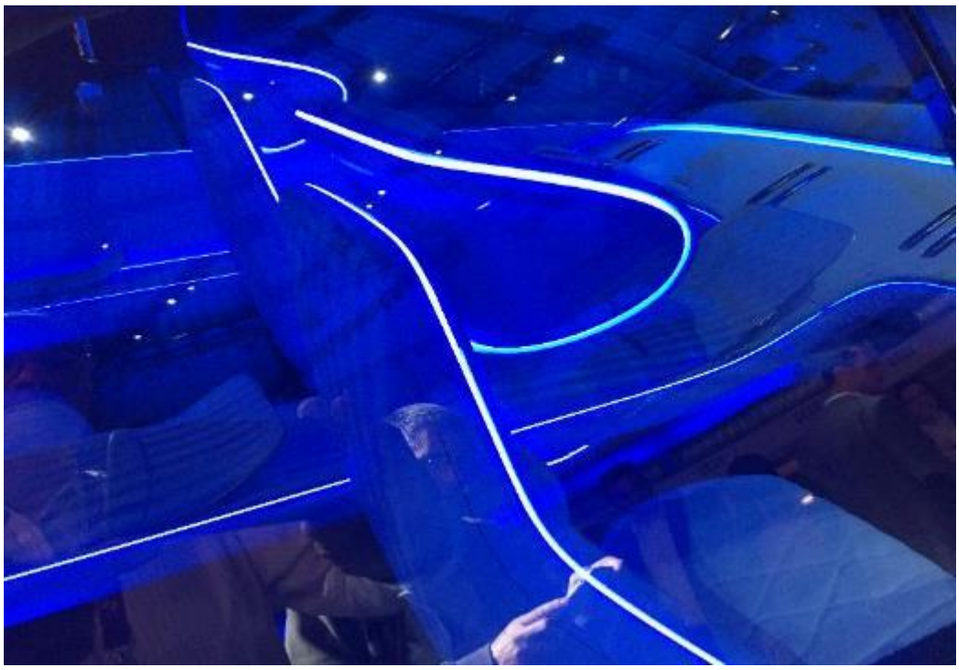
Interior Lighting

17 December 2019



DrivingVisionNews.com
automotive lighting and driver assistance technologies

Published by Driving Vision News · 3 rue Daumier · 75016 Paris · France
T: +33 (0)1 55 60 18 25 · F: +33 (0)1 55 60 18 39 · DrivingVisionNews.com

Table of contents

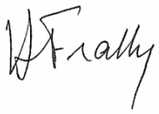
1 • Prefatory note

Few years ago, reading lights and ceiling lighting were the main sources of interior lighting. The type and color of light differed only slightly from model to model, mainly due to the limited possibilities of the classic light bulb.
Since then not only the shape, but also the function of the light in the interior has developed enormously. Light creates a recognition value, relaxes or activates, contributes to safety and entertains. The possibilities are limitless.
With the advent of LEDs, the type and location of their use in car interiors have expanded considerably. The design possibilities have also grown accordingly. Among other things, a light signature for manufacturers was able to establish itself, which made it possible to assign a cockpit to a brand beyond design.

In the Cockpit of the Future, beginning with a simple "Welcome DVN" on the console as a greeting, through the automatic adjustment of the light according to the passenger boarding the car, to complete light sequences tailored to individuals or a group of passengers, there are countless possibilities in the design of the car.
In semi-autonomous vehicles, light could take on additional safety functions. If the driver's attention at the wheel is required, running lights are conceivable that lead the driver's gaze back to precisely this point.
In autonomous vehicles, the application possibilities for the lighting will be significantly expanded once again. The interior is primarily used for comfort and entertainment. Light that adapts to the current film or enhances the gaming experience on the console also has an entertainment function at this stage.

For these reasons, I asked Jean-Paul Charret to build this new report on interior lighting while DVN published the last report on interior lighting around only three years ago. As vehicle illumination of all kinds grows smarter and more sophisticated, evolution is accelerating to speeds more in line with computer technology, and the value of the market is ballooning: from €2bn in 2019, the global market is on track to exceed €4bn by 2027.
Given the huge progress and changes in the field just in these last few years…it's time for a fresh report.
Have a look on the several interviews, from the most important experts on interior lighting, which emphasize the wonderful future of this field.

I thank Jean-Paul for his great job on this DVN Report. He explains very well the evolution in interior lighting and raises some interesting projections for the future. We at DVN trust you will find it worthy!



DVN President

2 • Executive Summary

The automotive market's evolution has really heated up lately, and there's a lot going on at the same time: powertrains going to electric, autonomous driving getting closer and closer, and more technology than ever before inside cars. All this has a significant impact on the interior of the vehicle. As Philippe Aumont described it on his DVN-Interior Report on the Automotive Interiors Expo Europe, the most prominently visible trends are in lighting: "Vehicle interior designer-specifiers have long had to work under very tight budget allotment, which historically reduced the offer to one dome light or two and maybe a couple of reading lights. But LED technology has opened new opportunities by dint of versatile lighting capabilities in small packaging at an affordable cost, while the functional role of lighting has evolved beyond just a glorified flashlight to help find things in the dark. Now lighting personalizes the interior, presents information, creates ambiance, conveys alerts, and more functions are being added to this list all the time".

Interior lighting, which was in the past purely functional, has become an important part of the style of the car, and stylists are the drivers to introduce new technologies in sync with fashion and major evolution trends of the society like ecology and veganism. ISELED, dedicated interior lighting controllers; luminous woods, textiles, and leathers; and illuminated panoramic roofs are some of the new technologies enabling these evolutionary trends, as exemplified by the Mercedes EQS concept car shown at the Frankfurt motor show (and on the front page of this report).

As new technologies arise, new suppliers become involved; partnerships are established between existing lighting suppliers and new luminous material suppliers. Customers expect to find in their car interior the same comfort levels they find in their own living room, facilitating cooling, re-energizing, and otherwise responding and adapting to the prevailing environment and conditions including the weather and the mood of the vehicle occupants.

Functional evolution is also needed. The first objective of lighting is to let us see what we're doing, naturally. Depending on automation scenario realization, occupants want to be able to control the lighting to make the interior of the vehicle a productive office…a living room on wheels…a place for a nap. The vehicle interior is the third living space, joining the home and the office. Now light is shaping the in-car environment, as it has for many years at home and work.

Interviews of major contributors in Interior Lighting from AUDI, BMW, PSA, HELLA, VALEO and others at the end of this report unanimously show that we are at the beginning of major evolutions on interior lighting.

3 • About the author

Jean-Paul Charret graduated as an Electronic Engineer in 1973. He worked first at two French companies: Thomson and then Alcatel. He joined GE Medical Systems in 1988, responsible for worldwide development of the vascular product range.
Then in 1995 he joined Valeo Lighting Systems, first as the Advanced Engineering Director based in Bobigny near Paris, then as R&D and Project Director for Valeo Sylvania based in Indiana, USA; in 2006 he replaced Hector Fratty as R&D Director of Valeo Lighting Systems. He retired in 2011 and now serves as a consultant for the automotive lighting community.

Important contributions to this report have also been provided by **Carsten Befelein**, CEO and Lighting Expert at CB-Lichtdesign.

4 • Introduction

Interior lighting was for many years the castoff, afterthought element in the greater field of vehicle lighting. Now autonomous driving is taking more importance, the trend towards transforming the car interior into a living space increases the importance of interior lighting. It is surely one of the major evolutions in car lighting as a whole.

For a long time, there wasn't much technology to the lights inside a car. That's changing fast, led by the introduction of LEDs in broad, but more specifically smart and matrix LEDs, mini- and micro-LEDs; technical evolutions in fiber optics and light guides, and with an infusion of design panache with new materials like luminous textiles, woods, and even stones.

For instance, a Scottish company—DesignLED—proposes integration of functional light for seats, center consoles, and doors with coupling to proximity sensors. Technical director Dr. James Gourlay says "Space constraints and complex curves make the backlighting of surfaces difficult. The joining or integration of surface materials such as cloth, wood, decorative foils, and metal, is challenging. Composite light guide technology allows LEDs and light intensity distribution optical features to be embedded inside and distributed throughout transparent films".

To fulfil new requests from stylists, traditional interior lighting suppliers establish partnerships of various kinds with new companies managing some of these new materials. For example, partnership between Faurecia and Hella, and partial acquisition of Walter Pack by Grupo Antolin.

We see four major evolutions in interior lighting:

• Ambient lighting becoming important, with surface and contour lighting facilitating adaptation to the overall environment of the weather outside as well as inside (mood and state of vehicle occupants)

• Smarter functionality: task lights directing light only where and when it is needed for reading or other work by dint of smart and matrix LEDs

• New functions like communication with exterior pedestrians and welcome/farewell lighting with small projectors

• Delivering safety information in case of danger

This report presents new applications, technologies, and materials, as well as interviews with well-positioned officers, technologists, and practitioners.

5 • Market Trends

Market Evaluation:

As we saw at this year's Frankfurt Motor Show, the global automotive market is evolving in two main directions: reduction of CO_2 with a switch to hybrid and electric powertrains, and autonomous driving. The interior lighting market is boosted by the autonomous vehicle advent, with a trend to transform the interior of the car into a living room, though extra lights mean more power consumption which goes against the lower-emissions trend. Nevertheless, the premium car market's interior lighting sector is still growing in a sky-is-the-limit manner. Interior lighting revenue will total up to about €2bn in 2019. This number will grow significantly in the future, certainly with the high-end cars but also with midrange cars and progressively with the arrival of L3, L4, and L5 AVs. We predict around €4bn revenue by 2027, with a CAGR of around 8% in the 2019–2027 period.

Dynamics:

Style, comfort, and technology will drive the growth of this market.

- **Style**: adapting the color to the ambient, and to the exterior, delivering brand signature and allowing customization with product differentiation.
- **Comfort**: to get closer to what is expected in a home living room.
- **Technology**: with a multiplicity of light sources inside the car thanks to electronics, LEDs and the introduction of ISELED, and even some pixel lighting to better direct the light for every passenger and increase the safety by illuminating vehicle interiors without driver distraction.

Market Segmentation:

We can divide the global interior lighting market into five segments:
• Traditional-functional with roof console, reading lights, trunk lights, carpet lights, map pocket lights, and switch lights
• Ambient lights
• Welcome lights, sometimes called "extraterior" lighting
• Decorative lights
• Safety information lights
Head-up displays could add another segment on this market, but they're more linked to instrument panel segment, so we consider them beyond the scope of this report.

Key vendor analysis:

Major global vendors in interior lighting include Draxlmaier, Faurecia, Grupo Antolin, Hella, and Valeo.
Tier-2 suppliers include the likes of Osram and Schott. And there are many regional vendors such as Changzhou Xingvu, EFI Lighting, Flex-N-Gate, Future Lighting Technologies, Oshino, Shangai Sunlight Enterprise, and Weidplas-Techniplas.

The global vendors are well positioned to make the investments warranted by the arrival of more technology on this market. But competition will still be tough, as cost remains a major driver. Moreover, as the decisions for interior lighting tend to be taken late in the development cycle, there's often less money left in the budget.

6 • Interior lighting today

Traditional interior lighting functions are still alive and doing fine:

Centre Console

Centre console lighting generally remain traditional, though LED light sources have taken over. The lights in center consoles are, so far, still primarily functional.

Roof console on Mercedes GLB 220

Glove Box and Cubby Bins

We're starting to see some decoration with contour light highlighting the glove box without disturbing the driver.

Cupholders

Cupholders are important, particularly in the American market. Light allows to better see the bottom of the cup holder, here with a blue contouring line:

Lighted cupholder in Ford Kuga

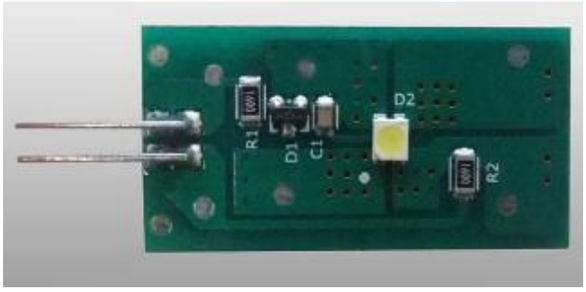
Ambient lighting in Peugeot 508

Footwell lights

Footwell lighting can be seen as ambient lights, used more and more to match the color of the car body or with changing color to adjust the ambiance. They are designed with LEDs.

BMW Alpina

Smart ForTwo EV



Audi Q3 seat foot Light Circuit Board

Reading Lights

This is where we are seeing the biggest technology evolution right now in functional lights. Traditional reading lamps are gradually giving way to more sophisticated lamps with matrix LEDs allowing to direct the light beam in different segments selected by the passengers.

Audi Q5 reading lights by Valeo

Cargo lights

Cargo compartment lighting is done with LEDs—purely functional.

Cargo light on Honda e

Cargo light on Mercedes GLC 300e

Interior decoration

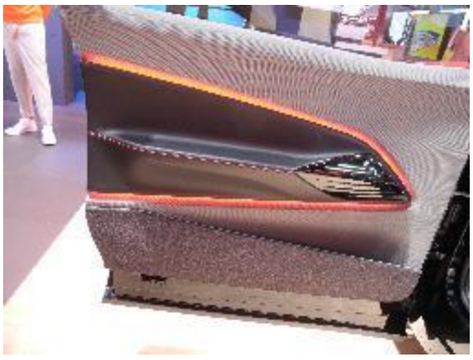
Beyond pure functionality, lighting becomes part of the interior styling of the car. It allows to highlight and decorate specific areas, items, and aspects of the vehicle interior—today this is mainly done with contouring concepts as shown here around the gearstick:

Smart ForTwo EV

Renault Clio

Door panels

Door panel lights are mainly for decoration, secondarily to give some ambient light. The design is mainly with lines, but can be designed either with direct contour light, with indirect reflective lights, or with light guides as we can see in these examples:



Audi

Audi

Line lighting by Schott on a door panel

Here we see contour lighting in an Audi Q3:

And more of a wash-light effect in the Volvo XC40

Volvo XC60 light guides by Valeo (alone above, installed below)

And a mix of linear and wash lighting in this BMW door panel:

Here's Daimler's corresponding design

Extraterior Lights

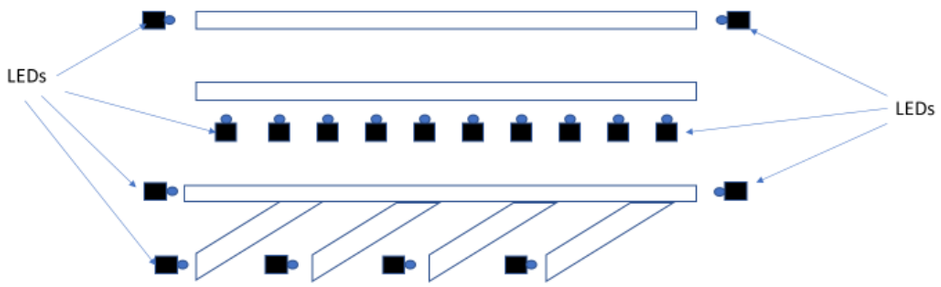
"Extraterior" lighting includes those lights that let us see where to put the feet when exiting or entering the car. It can be done with light guides, as shown here:

BMW Alpina

7 • New technologies

Stylists demand homogeneous linear lighting, and technology is evolving to meet this new demand. Examples:

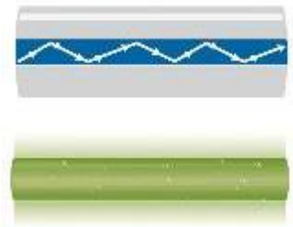
Light guides
We see a variety of light guide designs with different LED positions matched to the tasks that need to be accomplished. For example:



One LED on each side allows color mixing and mainly remains static. The LED array in the middle brings good homogeneity and allows for dynamic effects by driving each LED separately. The lowermost LEDs cater for segment-by-segment dynamic effects.


(here in lit seats)

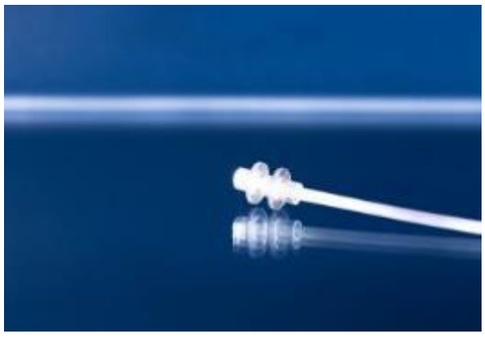
Other new technologies are coming with the help of fiber optics. An example is Corning's Fibrance light-diffusing fibers with inclusions called optical nanostructures to modify the refractive Index. Before fiber formation, the glass, is infused with optical nanostructures that emit or 'leak' light. This causes the resultant fiber to scatter light laterally rather than transmitting it all end-to-end (as is normally done with fiber optics). When light hits these nanostructures it evenly emits or diffuses the light out of the sides, but also down the length of the fiber.

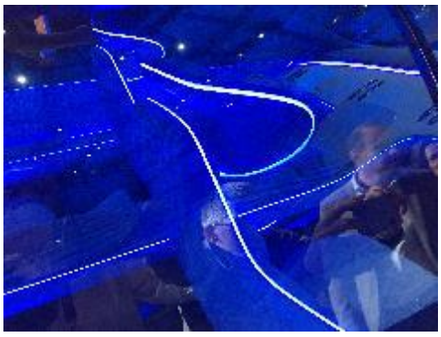


Top: Light is refracted and contained within a conventional fiber.
Bottom: Nanostructures within Fibrance fibers scatter and diffuse light.

Because the fiber is made of optically pure glass, it produces true, bright colors. The fiber must, of course, be connected to a light source. Corning recommend laser diodes. When a fiber is connected, for instance, to a blue laser on one end and a red laser on the other, the result is a striking purple with shades of electric blue and pink.

And here are Schott's Sidelight guides (with application on Mercedes EQC Concept)





Schott say their all-glass Sidelight guides offer a smaller diameter than plastic as well as much better temperature and chemical resistance. Other advantages include customizable diameters starting at 1.2 mm, tight bending radius of 6 mm, high color stability over lengths up to 3 m, highly uniform luminance, and compatibility with RGB LEDs or laser light sources.

ISELED

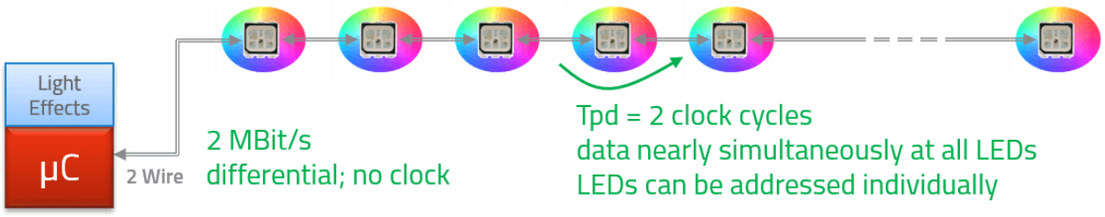
Today's and tomorrow's interior lighting needs a lot of light sources everywhere inside the car. Moreover, the evolution towards dynamic interior lighting requires all these light sources to work together with rapid communication and commands.

An open alliance called ISELED, founded in November 2016 in Munich, has the objective to provide a complete system solution for LED vehicle lighting. The ISELED Alliance unveiled a "digital LED" that delivers consistent colors and brightness without complex binning or recalibration. This new concept uses a tiny controller chip embedded in the LED package to control and address three RGB LEDs, enabling highly sophisticated lighting effects with several hundred LEDs.

ISELED's 28 current members. All major interior lighting suppliers are onboard.

The LED controller requires no calibration or external temperature compensation. It has a simple 2-wire interface, and supports daisy-chaining of up to 4,095 LEDs. It has full onboard diagnostics capable of monitoring individual LED temperatures, and has been designed and engineered for automotive service with an EMI-robust design based on 2 Mbit/sec communication—no dedicated clock needed.

Minimum system cost and maximum ease of integration are catered for by integration of LEDs, controller, and an advanced comms link supporting bidirectional talk with lowest latency, all in a single 3-mm package. Integration of LEDs, LED controller and advanced communication link in one small 3 mm package. Calibration is done during production, and there are no binning classes or bar coding required, as the calibration data is stored onboard, which also does away with the need for lookup tables. System assembly is direct-from-tape with guaranteed parameters.



Draxlmaier describe some of the applications these new kinds of lighting systems invite. They cite, for example, their LIN-RGB technology to facilitate color play on the car's headliner: Ted, green and blue can be individually controlled, resulting in an almost infinite range of color. The intelligent RGB LEDs are calibrated during their production for perfect color accuracy over the entire life of the car.

ASICs for LED controllers

An ASIC is an Application-Specific Integrated Circuit; basically, a chip designed to do a specific thing. ASIC specialist ELMOS are a 1,200-person company based in Dortmund, Germany. They provide automotive-dedicated ASICs, including LIN RGB controllers for LEDs as well as a range of products for ambient light and low- and medium-current interior lighting. Their customers include Daimler, BMW, and the Volkswagen Group.

Their products allow for light output independent of the temperature. Both static and dynamic controllers are offered. Static ones are for LIN RGB usage, while dynamic controllers are needed for use with CAN bus interfaces. One CAN controller can command up to four LEDs independently. Static controllers can command matrix LEDs to control every pixel with varying intensity. Dynamic controllers need to deliver speed and distance information with a high exchange of data working at 2 to 5 Mbit/sec.

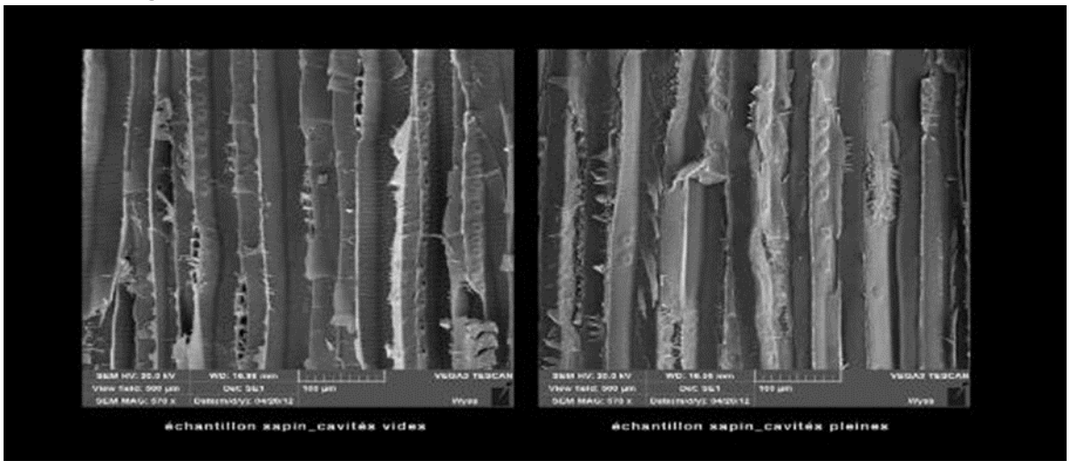
Elmos E521.3X controller

Materials

To provide innovative solutions stylists crave, new materials are being used in interior lighting. The association of these new materials with light provides innovative and interesting new design.

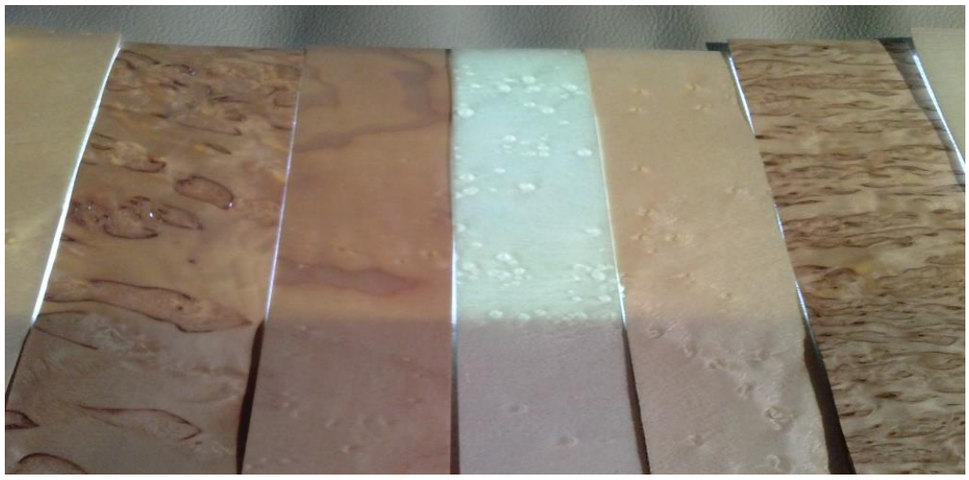
Wood

With the global trend to decrease the carbon footprint of cars and use more ecologically-friendly construction, one interesting material is wood. New kinds of wood are appearing on the market, such as a new product developed by Woodoo. It's translucent, rotproof, and has bolstered structural properties. A monomer matrix (i.e., plastic) is injected into a 7- to 10-mm-thick wooden board, to fill the microcavities. Depending on the species, wood comprises 60 to 70 per cent air. By filling the air voids with monomers that polymerize, the properties of the material change while respecting its micro-architecture. The wood becomes translucent because the cellulose is preserved, while the lignin is replaced by the monomer. Since cellulose is a crystalline material, light shines through.



Woodoo CEO Timothée Boitouzet says his company is building collaborations for wood elements in car interiors with certain German, French, and English premium-car brands.

Boitouzet with his translucent woods



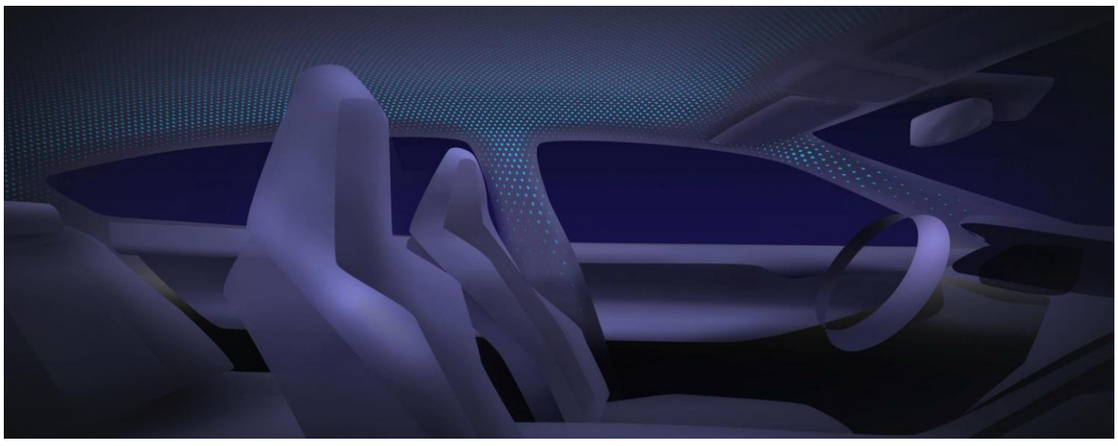
Translucent wood (image courtesy Future Lighting Technologies)

Textile

As the car interior comes to feel more and more like a living room, luminous textiles should appear in the near future. Here are some examples of suppliers and products we've got our eye on:

Luminous textile from Philips, for example, integrates multicolor LEDs within textile panels finished with Kvadrat textiles. They use Kvadrat Soft Cell acoustic panels to keep the fabric under constant tension within an aluminum frame. The integrated LEDs mean almost limitless "dynamic content" (i.e., light colors and intensities, images and animations, messages and alerts, etc.). The panels are not affected by humidity or temperature and look good for years.

Some other companies like DreamLux in China or Lumigram from DreamLux in Italy should be able to deliver similar products to equip the car interiors.



Rendering of luminous textile (above) and pictures of light fibers on Alcantara synthetic leather (below) courtesy Future Lighting Technologies

Leather

We're starting to see luminous leather, as on the images above and on these key fobs:

Hitsan luminous leather key fobs

No doubt we will see in the future different type of luminous materials used in interior lighting in the future including stone or marble materials.

8 • The future

Here's a look at how ambient lighting is taking on more importance, as seen in show cars on display at the Frankfurt motor show:

Pixel lighting atop the door on the SEAT Cupra Tavascan

Variable-pattern pixel lighting in the door panels of a VW show car

Futuristic lighting inside a Hella–Faurecia show car

Lighting used for color accents in a DS7

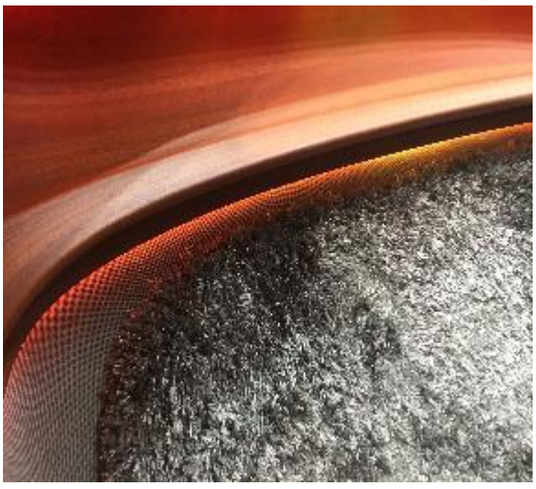
Dynamic lighting as proposed in the Hella–Faurecia car

Elmos' show car turns ambient light into a safety light by changing the color and blinking…

…or reassures with a cool blue ambiance.

The Hella–Faurecia car illuminates the interior and changes the ambiance with different colors in this dynamic roof liner:

Advanced lighting creating a living room atmosphere in a VW show car

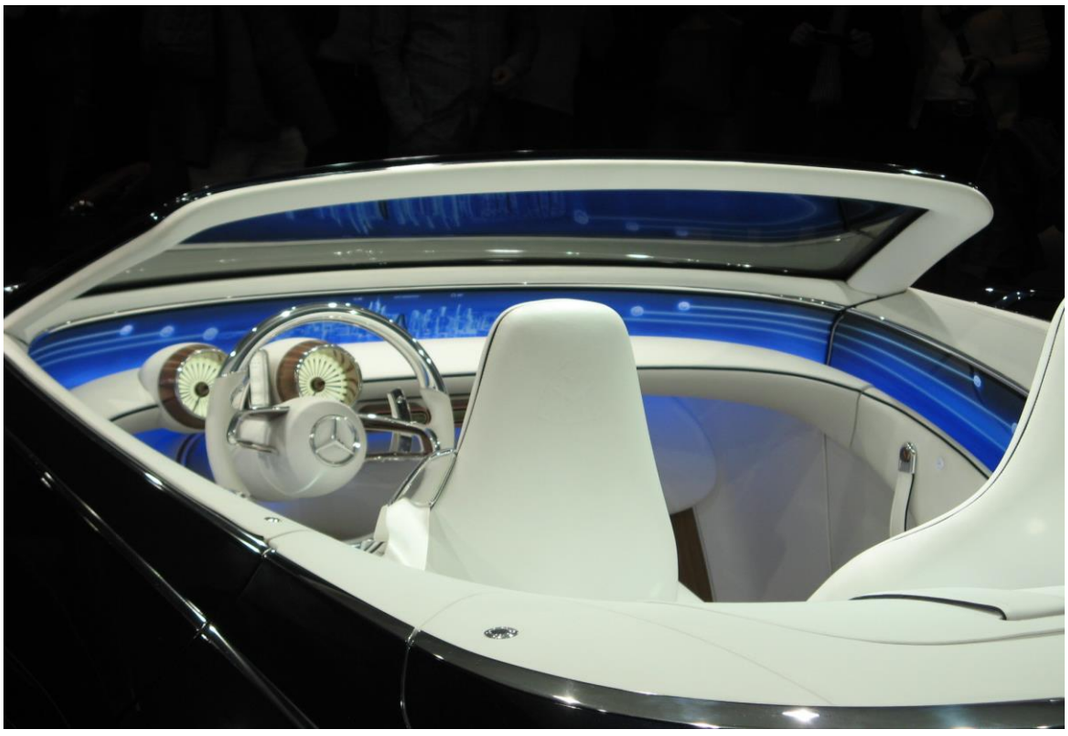


Footwells

Ambient Light

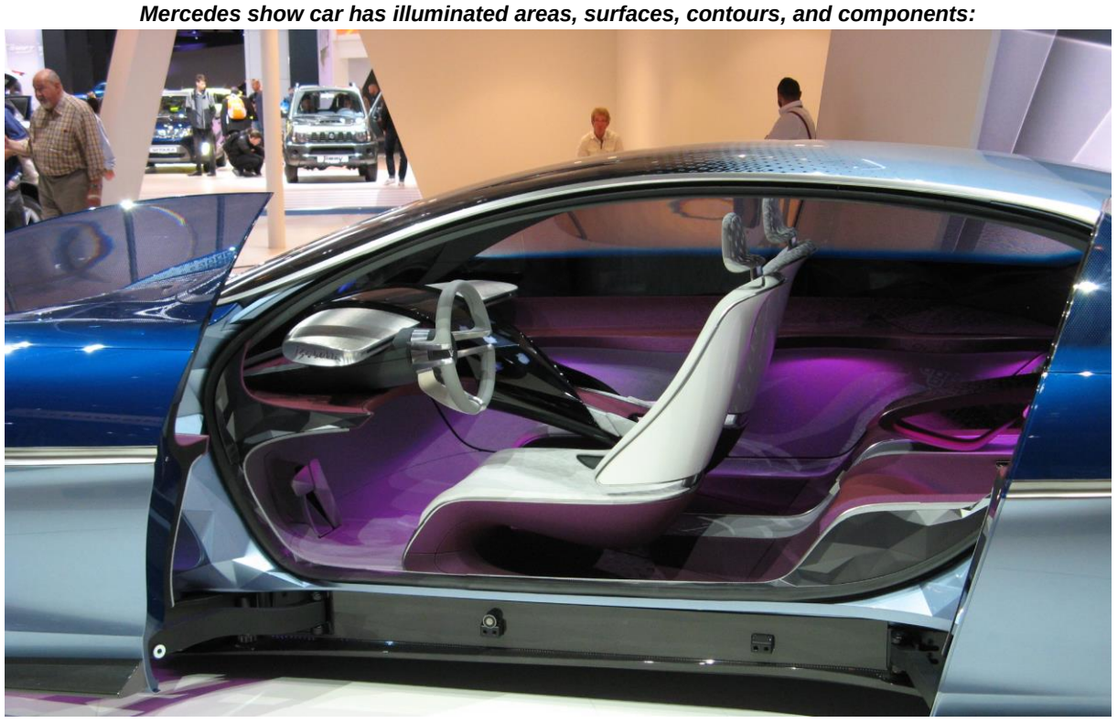
Light from LEDs creates an optical bar in this Hyundai show car

Hyundai show car with grand display of ambient lighting



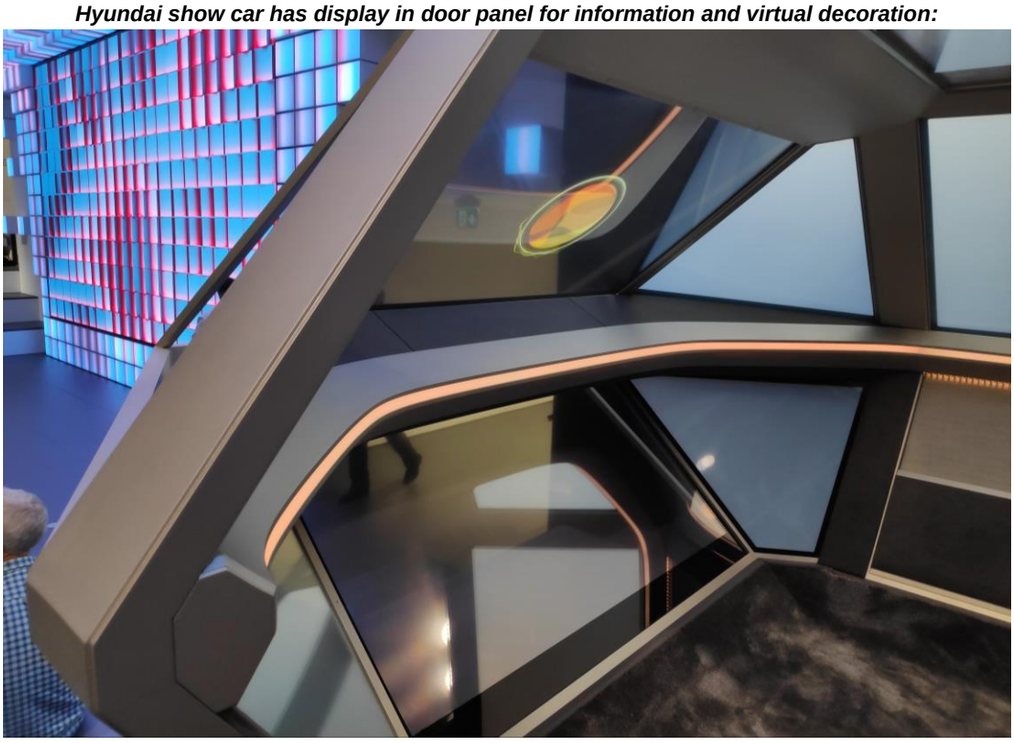
Mercedes show car with a mix of component, contour, indirect, and space lighting

Mercedes show car has illuminated areas, surfaces, contours, and components:



Renault show car with space and indirect lighting:

Hyundai show car has display in door panel for information and virtual decoration:



Shuttle with displays and ambient lighting like in a luxury office:

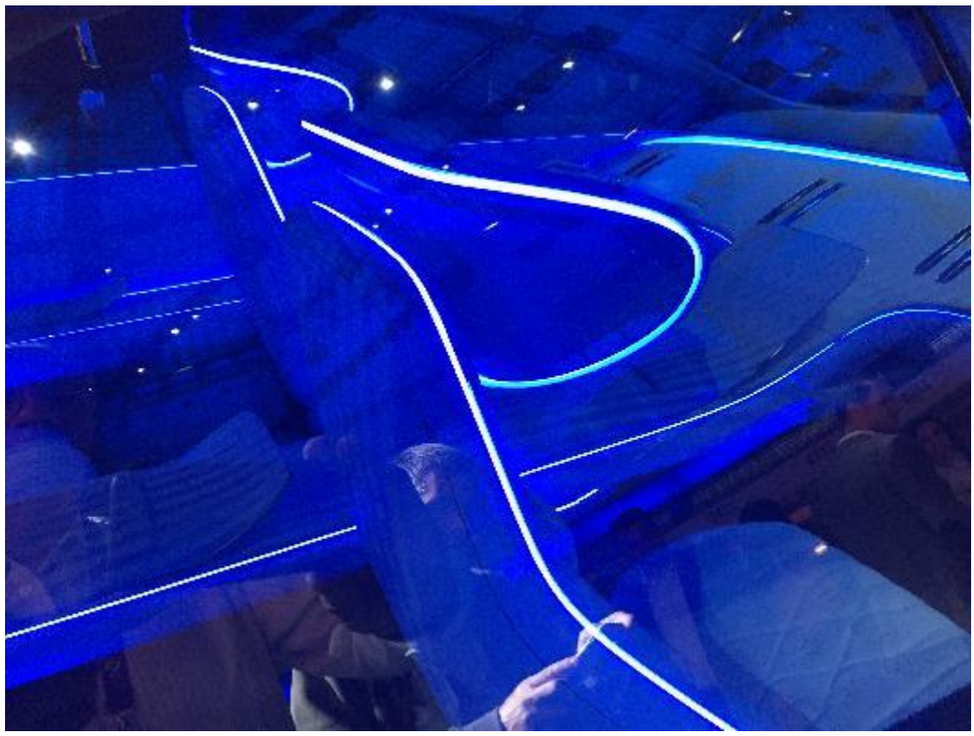
VW show car

The vehicle of tomorrow communicates with occupants using light signals on surfaces that are blank and invisible when the communications aren't required. Light is delivering a sophisticated environment with lit surface decoration putting emphasis for example on the VW Logo here:

Interior lighting can now complement the exterior design as well:

Mercedes EQS

Light contouring seats, doors, and floor with optical fibre in Mercedes EQS.



9 • Regulations

Today, vehicle interior lighting is almost entirely unregulated. The only existing regulations are FMVSS 101 in the USA and the closely similar CMVSS 101 in Canada. The lighting aspects of MVSS 101 are limited to requirements for certain controls to be lighted whenever the vehicle's headlamps are lit, and color requirements for certain indicators and telltales.

With increased capabilities and new usages in interior lighting we should start considering the need for appropriate regulation. Some new potential safety issues could appear, due to increased light distractions. According to a study done by Ansys' Victor Loya, certain aspects of interior lighting should be considered for regulation:

• Brightness, with a maximum illuminance value of 0.1 Cd/m2 and 35 Lux corresponding to a standard reading light with a target surrounded by low-reflective surfaces

• Color—perception of colors is impacted by reflections on surrounding interior materials

• Location; every light source in a cabin is reflected/refracted on the surrounding materials

• Activation, when and how; blind spot indicators and side mirror repeaters flash in the A-pillar zones with a predefined rate. Should we consider interior lighting?

Clearly, as interior lighting's capabilities increase, so do the potential for safety threats if the new capabilities are not appropriately constrained.

10 • Interviews

- Audi
- BMW
- PSA
- Hella
- Valeo
- Osram Opto Semiconductors
- CB-Lichtdesign
- Future Lighting Technologies
- Mentor Precision Components

Comments from Steffen Pietzonka, Hella's Global Marketing Director and Comments from Guillaume Basquin, Faurecia's Head of Innovation

AUDI AG
Riedmayr Florian, Leader of the interior lighting department

Interior and comfort become more and more important for cars, especially for autonomous driving, consequently interior lighting is taking more room.

DVN: What is in your mind the current Global market value for interior Lighting?
R.F.: In the future light is not only light, it will be a feature for communication and functional help for the customer. In addition to that the ability of changing the appearance of the interior by light is a comfort factor

DVN: How do you see the evolution in the next 5 years?
R.F.: new technologies will be emerging and the amount of lighting places will increase (dynamic light, surface light etc.)

DVN: What percentage value represents Interior Lighting versus the total amount value in a car for Lighting?
R.F.: At first, I think that it depends on the market. Concerning the percentage value of interior lighting versus the total amount value in a car for lighting will be approximately 50% in the future

DVN: Is there differences for interior Lighting in function of segment vehicle (SUV, Van, Cars, Luxury, Sport…)
R.F.: yes, interior lighting is individual for every customer need

DVN: Do you perceive styling trends influencing Interior Lighting?
R.F.: yes, surface light and projection will perceive

DVN: Do you see signatures in function of the brand as in Exterior Lighting?
R.F.: yes, the interior light will give the car an own character and their own brand identification.

DVN: Do you see new functions emerging in Interior Lighting?
R.F.: yes, for example human centric lighting

DVN: What are the dominant technologies in term of sources, material, optical guides, optical fiber, color variations?
R.F.: Full integration of light sources in trim-parts will offer new styling abilities to our designers. E.g. the combination of materials and light, and advantages for the packaging

DVN: More and larger displays: Supplement or replacement for interior lighting?
R.F.: Supplement

DVN: Do you envision an important evolution for Interior Lighting with semi-autonomous and autonomous cars?
R.F.: yes, the costumer will get more spare time in the car, and the use case will change: While self-driven, the cars main task is to support the specific driving-situation; autonomous cars will have the focus on support well-being, working atmosphere or entertainment use cases.

BMW
Robert Isele, Head of Interior Lighting

DVN: **What trends to you see happening now, and how do you see the evolution in the next five years?**
RI: We are still beginning to see more and more light functions in vehicles worldwide. After the premium brands have spearheaded the development also other car makers have started to use ambient light in the interior. In the premium and near premium segments I expect up to hundreds of light sources, additional new white light functions and more dynamic scenes.

DVN: **What fluctuations do you see in the value of interior lighting in today's and tomorrow's cars?**
RI: Interior lighting is valuing up but on the other side component prices are going down. The most influencing factor will eventually be the revolution of technology driving the LEDs. Traditional field bus systems are extremely robust but are both not able to drive hundreds of LEDs and far too expensive. The target must be to get more light with less effort.

DVN: **Are there differences for interior lighting depending on vehicle segment (SUV, van, cars, luxury, sport…)?**
RI: The functional level is almost the same, but the number and size of the light elements will vary. This is simply matched to package and design reasons.

DVN: **Do you perceive styling trends influencing interior lighting?**
RI: Of course, interiors are changing to match contemporary design language. Light is becoming a more and more important design element in the Interior. Especially the customer demand in Asian markets is driving this development.

DVN: **Do you perceive styling trends influencing interior lighting? Do you see signatures in service to the brand as we see it in exterior lighting?**
RI: One of these signatures are the contour lightings you can see in BMWs current vehicles. We are working on the next generations with continuous improvements and new designs.

DVN: **Do you see new functions emerging in interior lighting?**
RI: Yes, light and function will definitely merge more. Already in the current MINI there are several functions combined with driving and entertainment. The 2018 models offered warning and signaling functionality combined with interior lighting. In future, interior light will further be developed along with driver assistance and finally for highly automated driving.

DVN: **What are the dominant technologies for interior lighting?**
RI: Looking at the technology there are several major changes: white LEDs are moving into more CRI; LED driving changes from analogue to digital; LED arrays and stripes are used for many parts. Additional new technologies are emerging, for example logo projection and illuminated material and surfaces become interesting solutions for future cars. Last but not least, with more light sources it is possible to create entirely new scene settings and experiences with light in combination of other features.

DVN: **More and larger displays: Supplement or replacement for interior lighting?**
RI: I have worked in the field of display integration and development and would put it differently. Naturally, with cars getting smarter with every generation displays get more importance in the interior. However, displays only will not achieve a premium interior experience for our customers. Ambient light is very important for a premium interior experience. This means there will be both: Light will expand the display to the environment and functionality of both light and display will support each other. The major task is to bring both displays and light together in a way that they appear as one.

DVN: **Do you envision an important evolution for interior lighting with semi-autonomous and autonomous cars?**
RI: While driving autonomously the passengers have more time and room to enjoy the vehicle. This is an entirely new driving experience. The car becomes a favorite space like we showcase it in our Vision iNEXT [concept car]. The vehicle will become the living room for your journey, where you enjoy movies or have a nice conversation with some friends. This will require totally different light scenes, like the illumination of a stage in the theater.

PSA
Whilk Goncalves, Head of Innovation in Lighting and Signalization

DVN: **What do you reckon is the current global market value for interior lighting, and how do you see the evolution in the next five years? What percentage value does interior lighting comprise in context of the total lighting value in a car?**
WG: Interior lighting is still the poorest in lighting. Development for interior lighting starts very late in the development process of a new car and consequently is getting only the money remaining after painful decisions having been made for the other areas. On top of that, the requests for the new cars leave little extra time to allow innovative developments. Technology is not as important as front or even rear lighting. The main drivers are new materials and style.

DVN: **Do you perceive styling trends influencing interior lighting? Do you see signatures in service to the brand as we see it in exterior lighting?**
WG: PSA try to build relationships between suppliers which are not used to working together. For example, tier-1 lighting suppliers with specific interior material suppliers. The needs to send light in many different zones with color and intensity variation. As an example, the selection of colors allows brand differentiation inside PSA. Intensity of the light needs to be programmable to adapt to environment, to the context, to the driver or in function of the time during the day. We want to be able to configure the interior vehicle and consequently the light with our own smartphone.

DVN: **Are there differences for interior lighting depending on vehicle segment (SUV, van, cars, luxury, sport…)?**
WG: Segmentation for interior lighting doesn't come in function of the vehicle type (SUV, van, sports car, wagon…) but rather between entry-level or high range cars. Every brand has its personality—DS is French luxury, Opel is lighting performance, Citroën for youth, Peugeot for solidity, etc.

DVN: **Do you envision an important evolution for interior lighting with semi-autonomous and autonomous cars?**
WG: Autonomous vehicles will affect considerably the interior vehicle, which should evolve towards a living room.

DVN: **What are the dominant technologies in interior lighting?**
WG: We should see the application of ISELED modules where every smart LED can be addressed separately with a dedicated controller of interior lighting. We start seeing matrix LEDs able to direct the light spot in function of the place where the passenger is reading.
We envision micro-projectors to send any patterns or graphics on the ceiling, the seats, the windows or the ground. We should see new translucent materials with materials which are not usually translucent, like wood, stone, and textiles. OLEDs could be used for the light of the vanity mirror.

DVN: **Do you see new functions emerging in interior lighting?**
WG: Light stimulators to avoid driver falling asleep (with blue color). Light patterns to avoid car sickness. Light illumination in the walk-in phase. Safety alert (obstacle coming, vehicle detection, falling asleep perception…). Communication function towards the outside for a pedestrian to inform him that he has been seen.

DVN: **Do you anticipate any changes in the regulation for interior lighting?**
WG: The current regulation gives only few constraints today but could become more demanding in the future with the ratio of exterior lighting to interior lighting not to be overcome.

Hella
Dr. Herbert Wambsganß / R&D interior Lighting

DVN: What is in your mind the current Global market value for interior Lighting?
H.W.: Interior and comfort become more and more important for cars, especially for autonomous driving, consequently interior lighting is taking more room.

DVN: How do you see the evolution in the next 5 years?
H.W.: Beside traditional lighting applications as ambient and functional lighting, new applications like driver support and smart & lit surfaces will be introduced.

DVN: Is there differences for interior Lighting in function of segment vehicle (SUV, Van, Cars, Luxury, Sport…)
H.W.: Different segments deliver different driving experience and are therefore equipped with different illumination packages. Pure sports cars are and will continue to be less equipped with interior lighting e.g. ambient lighting compared to an SUV or a Limousine.

DVN: Do you perceive styling trends influencing Interior Lighting?
H.W.: As styling evolves, so does the design of light. Nowadays light is carefully integrated into the cockpit to complement the overall styling. Light enables OEMs to deliver a unique form and function during the day as well as in nighttime.

DVN: Do you see signatures in function of the brand as in Exterior Lighting?
H.W.: For sure: Sitting in a car, observing the design, craftmanship and experiencing the light signature, you are able to determinate the brand.

DVN: Do you see new functions emerging in Interior Lighting?
H.W.: Various topics are in discussion today, you may have seen some of the new functionalities in recent show cars: Dynamic lighting, surface lighting, circadian lighting, and finally matrix is everywhere.

DVN: What are the dominant technologies in term of sources, material, optical guides, optical fiber, color variations?
H.W.: In terms of technologies all is possible: light guide and optical fiber, white (warm & cold) and individual colors, lit lines and lit surfaces. However, most of the added value lies in enhanced driving experience and in the use cases that light supports.

DVN: More and larger displays: Supplement or replacement for interior lighting?
H.W.: Supplement. Large displays are an impressive product in the car, they cannot, however, create ambiance in the interior. Like in our living rooms, large TV and various luminaries build in the walls and ceiling works together to create a desired atmosphere.

DVN: Do you envision an important evolution for Interior Lighting with semi-autonomous and autonomous cars?
H.W.: All is open, especially when people give up the task of driving and have more time for other activities. In future car occupants will want to work, relax and play in the car. Complete interior including interior lighting is standing in front of a big evolution step.

Valeo
Benoist Fleury, Global Lighting Marketing Director
Sophie Porte, Interior Lighting Marketing

DVN: **What do you reckon is the current global market value for interior lighting, and how do you see the evolution in the next five years?**
Valeo: The global market exceeded €1bn in 2017 and it should be more than €4bn in 2027. These numbers only include the lighting parts, not the plastic parts for decoration or displays. On average interior lighting is about eight per cent of the total lighting in the car, but this ratio is expected to increase in the years to come.

DVN: **Do you see new functions emerging in interior lighting?**
Valeo: We split the market between the following functions:

- Traditional small lamps like reading lights, carpet lights, trunk lights;
- Interior lighting from static ambient lighting up to dynamic ambient lighting.
  We also consider "extraterior" lights such as welcome lights or brand signature lights—the on-board experience starts when the passengers are approaching the vehicle.

In addition to those pure lighting solution evolution, functions are merging to create new complete system combining light and other features. One may think of a higher integration of HMI and light in one sole component. These are competences that Valeo works on by combining the know-how of Visibility Systems and Comfort and Driving Assistance.

DVN: **Do you perceive styling trends influencing interior lighting? Do you see signatures in service to the brand as we see it in exterior lighting?**
Valeo: Interior lighting is clearly a major enabler for the brand signatures. This can be seen in new entrants like Nio and Byton, and also in established carmakers—mainly on high-end vehicles and concept cars. Interior lighting appears as a style differentiating factor.

DVN: **Are there differences for interior lighting depending on vehicle segment (SUV, van, cars, luxury, sport…)?**
Valeo: interior lighting is widely spread in automakers' model offer. They use several levers. Colors are one; it can be monochromatic or with a limited number of colors, or up to more than 60. Some brands will limit the number of colors, or the color itself, based on the type of vehicle, or the upgrading of the vehicle. Another lever is the amount and location of interior lighting features: front row or front and rear rows, etc. Dynamism (vs. static features) will be a differentiating element and therefore another lever. We can also observe that some makers develop a specific identity for their combustion-engine vehicles and a separate one for their EVs, and interior lighting reflects it.

DVN: **What are the dominant technologies?**
Valeo: LEDs were really key in the increase of interior lighting applications (consumption, lifetime, color capability with RGB). Today light intensity is a major characteristic for the light to be visible both in night and day conditions. Therefore, new electronic architectures are the next step needed to address not only this requirement but also to manage dynamic ambient lighting. This, of course, requires strong optics and electronics capabilities in hardware and software. An additional trend is to combine direct and indirect lighting, with a clear willingness to integrate backlit surfaces.

DVN: **Do you envision an important evolution for interior lighting with semi-autonomous and AV?**
Valeo: Interior lighting is already strongly evolving with carmakers anticipating the need for higher cockpit content for semi-autonomous and autonomous vehicles. In a highly competitive market, as already said, interior lighting is a differentiating factor, especially for the newcomers.

DVN: **Who are your main customers in interior lighting?**
Valeo: We are a global supplier with a strong European customer portfolio, and the share of Asian and North American customers is increasing.

Osram Opto Semiconductors, Automotive:
Dr. Markus Klein, General Manager for Interior
Dr. Stephan Hartmann, Global Head of Marketing

DVN: What do you reckon is the current global market value for interior lighting, and how do you see the evolution in the next five years?
MK: Current market value for interior lighting is estimated to be about €600m which is about 1/4 of the total automotive LED market. Looking forward, there will be a very dynamic development in the interior application split, whereas today about 50% of the value is in traditional applications like dash boards and switches, in five years the vast majority will be dominated by display applications (about half) and ambient lighting (about one quarter).

DVN: How do you see the evolution in the next five years?
MK: In fully autonomous vehicles, the driver or passenger does not necessarily have to sit at the wheel, causing significant changes to interior lighting once again. In addition, the expression of personality as a visual element of the vehicle transform the car into a comfort zone or an extension of the cozy, home-like environment enabling brand recognition, differentiation for privately owned cars but even more when offering mobility as a service. Already today we can address a wide area of automotive interior applications with our broad portfolio. During the next years the connection of those interior lighting applications will also get more important. We're convinced that year by year there will be more cars equipped with modern lighting solutions so the number of LED based applications per car increases.

DVN: What percentage value does interior lighting comprise in context of the total lighting value in a car?
SH: Today, about one quarter of the total LED value in the car is coming from interior applications. Trends in visualization (mainly displays) and sensing, next to more illumination related ones, likely shall impact this share towards a more balanced split between interior and exterior value in about 10 years from now.

DVN: Are there differences for interior lighting depending on vehicle segment (SUV, van, cars, luxury, sport…)?
MK: As in the past you will see new technologies entering higher class cars first. But interior lighting also shall be used to emphasize the characteristics of a car's function and their owners. Mobility as a service rather than privately owned cars might be another functional differentiator. Especially the interior will offer and therefore shall come with a high demand in various lighting scenarios, all built in the same vehicle.

DVN: Do you perceive styling trends influencing interior lighting?
MK: Users more and more expect the same amenities in their cars as they do e.g. at home or in the office. Therefore, it is not surprising to see similar styling trends as for example in the general lighting and furniture industry. Clean designs with aesthetic surfaces having controls only visible when in use for example. Those trends also are visible in cruise ship, airplane and other mobility areas. The already strong trend towards miniaturization of LEDs is particularly important here. The smaller the individual component, the greater the freedom to integrate it into new products and the greater the application possibilities for LEDs.

DVN: Do you see signatures in service to the brand as we see it in exterior lighting?
SH: Absolutely. Electric and/or autonomous cars will offer less and less traditional possibilities to distinguish (e.g. drive trains), pushing car brands to seek for other possibilities for differentiation. Comfort and well-being will attract more and more attention of car users, opening the stage for the interior to drive brand recognition and differentiation.

DVN: Do you see new functions emerging in interior lighting?
MK: It is the availability of new technologies that determines the functions which can be addressed and realized. Smaller and higher power LEDs with flexible binning enable functional yet ‘clean' surfaces. Rather than overwhelming with knobs and turns, the user experiences a clean design with functionalities only when in need. Enriching reality with additional information – augmented reality – depending on the availability of 5G and KI. Human centric lighting - scientifically proven that light affects people's wellbeing, health and productivity. But also, communication by light which takes advantage of human's sensitivity to peripheral cognition and could maybe even be used to ease motion sickness.

DVN: What are the dominant technologies?
SH: The requirements for those new interior functions and trends directly translates into the requirements for future technologies. Seamless is the magic word - seamless integration into building materials, i.e. a high tolerance of LED in regards with processability in conjunction with other interior materials. Seamless integration into the vehicle's board electronics including sensors and monitoring gear (LED fusion). And seamless integration into light guides offering completely new designs in linear as well as area lighting.

DVN: More and larger displays: Supplement or replacement for interior lighting?
MK: Both. In a first step, displays are replacing conventional systems like clusters and other controls. With technologies advancing, like mini- and micro-LED based solutions, new fields of application shall arise merging display, ambient and sensors.

DVN: Do you envision an important evolution for interior lighting with semi-autonomous and autonomous cars?
SH: Next to the vehicle becoming the third living space (next to home and office) and the related evolution and revolution described before, ease-of-use, efficiency and multi-functionality are key factors impacting Interior lighting. How the new spare time in detail will be spent during autonomous driving is not yet fully clear, generating the excitement to both understand this in detail and have the right products at the right time!

CB-Lichtdesign
Carsten Befelein, CEO and Lighting Expert

DVN: **What do you reckon is the current global market value for interior lighting?**
CB: Currently the market potential and value of automotive interior lighting is discovered especially by the premium car manufacturers in Europe top down in all car segments. The Asian and US car manufacturers are fast followers.

DVN: **How do you see the evolution in the next five years?**
CB: In the next five years the number of light sources and functions in the car interior will steadily increase; new, more and smart light functions will be created and integrated in interior components and surfaces for more cognitive and connected lighting combined with new materials and technologies.

DVN: **What percentage value does interior lighting comprise in context of the total lighting value in a car?**
CB: Currently exterior lighting dominates the light equipment of vehicles. In the next ten years, especially with the implementation of autonomous driving, the interior lighting will achieve the same value as exterior lighting.

DVN: **Are there differences for interior lighting depending on vehicle segment (SUV, van, cars, luxury, sport…)?**
CB: It's the strategy of carmakers to implement the interior lighting features top down. The vehicles in higher segments get the full extent of the latest interior lighting applications as series solution, in lower segments you can order a lot of interior lighting features as extras.

DVN: **Do you perceive styling trends influencing interior lighting?**
CB: Interior lighting is a very strong styling amplifier and more and more also a brand identifier. Meanwhile the stylists change the shapes and geometries of the car interior components and surfaces, to enable the integration of valent interior lighting features. Contour and indirect lighting are more and more supplemented by area lighting and dynamic light functions and animations.

DVN: **Do you see signatures in service to the brand as we see it in exterior lighting?**
CB: There is a trend, that the styling of interior lighting is becoming more adapted to the styling of the exterior lighting, so that interior lighting will also become a recognition feature and brand identifier of the vehicle.

DVN: **Do you see new functions emerging in interior lighting?**
CB: I see more and more dynamic, signaling and welcoming light features in the car interior. Contour and indirect lighting are complemented by area lighting in trim parts and on surfaces. The interior lighting becomes more and more smart and connected using the increasing number of sensors and electronics in the vehicle. Autonomous driving demands for of a lot of further new interior lighting applications to enable the vehicle as a rolling office, living and wellness room.

DVN: **What are the dominant technologies?**
CB: RGB or RGBW LEDs without or with processor (ISELED) are the standard light sources for package and energy optimized integration of ambient and functional interior lighting in many different colors. They are often combined with linear or area light guides, activated by new technologies. A very interesting light guide activation is realized by lasering microstructures into the volume of light guides, to create three dimensional light structures on free styling demands. Another example for interesting technologies is hidden until lit with e.g. black panel materials and area light guides with nearly invisible microstructures for many different interior lighting applications.

DVN: **More and larger displays: Supplement or replacement for interior lighting?**
CB: The increasing number and sizes of displays supplement the ambient and functional interior lighting. Beside operational and information tasks, the displays can also be used for light applications like ambient, decoration, signaling, welcome and functional lighting and can create many different virtual illuminated surfaces.

DVN: **Do you envision an important evolution for interior lighting with semi-autonomous and autonomous cars?**
CB: Rolling offices, living and recreation rooms in the autonomous driving mode demand for a lot of new interior lighting features as we know them from our (smart) homes and offices. Beside the functional lighting for the office mode there is also a market for stylish lamps with magic and emotional effects for the living rooms and recreation modes. Using the existing electronics and sensors of the vehicle, a smart lighting will be realized much earlier in vehicles than at home or in our offices.

Future Lighting Technologies:
Björn Sobischek, Founder and CEO

DVN: What do you reckon is the current global market value for interior lighting, and how do you see the evolution in the next five years?
B. Sobischek: From my point of view this value will significantly change in high level cars because more lighting functions have to be installed. Not only on/off interior lighting, but more maker and brand specific welcome scenarios and brand identification lighting. Furthermore, while driving autonomously you need different lighting versus today while driving for yourself.

DVN: **How do you see the evolution in the next five years?**
B. Sobischek: Today even cheap cars have some ambient lighting, even when on a low level. But this will change to more lighting. Also, those type of cars do not have brand identification light. This will constantly raise. Exclusive SUVs will continue display new technologies available and the best brand identification possible. E-mobiles and cars for car-sharing have a different group of users and will be “different” from normal cars with petrol engines. So, we will see a lot of different approaches of lighting integration.

DVN: **Are there differences for interior lighting depending on vehicle segment?**
B. Sobischek: The higher the total value of the car, the higher valuable the total amount of extras, and this includes interior lighting. Actually, SUVs need more light and light with a higher light output, because the cars are bigger and the distance from lamp to reading surface is bigger. Sport cars actually less, because the interior is much smaller. Furthermore, in an SUV sometimes you spend many hours while comfortable driving from Hamburg to Munich, while in a sports car you only sit for racing the highway to the next cinema. So, I say yes, there should be a difference.

DVN: **Do you perceive styling trends influencing interior lighting?**
B. Sobischek: The branding of lighting is getting more important. Contour lighting is implemented to show with the very cheapest solution and increase in spacious feeling inside the car. Since some years the trend is moving a bit to illuminated larger surfaces.

DVN: **Do you see signatures in service to the brand as we see it in exterior lighting?**
B. Sobischek: In show cars I see the efforts of stylists to create brand identifiers with lighting in the car interior like they do it with the DRL in the headlamps or the 3D-effects or light bodies in the tail lamp.

DVN: **Do you see new functions emerging in interior lighting?**
B. Sobischek: New technologies allow bringing light into surfaces. This means you can hide the light, without seeing it at daytime and without cutting the design lines. Furthermore, when autonomous driving finally is implanted, much nicer light functions have to be developed for the car interior.

DVN: **What are the dominant technologies?**
B. Sobischek: For the past it was clearly RGB LED modules and PMMA light guides—that's finished. For the future I wish to add smart textiles and functional surfaces to that list.

DVN: **Do you envision an important evolution for interior lighting with semi-autonomous and autonomous cars?**
B. Sobischek: Definitely a clear yes. While driving your car for yourself you need other lighting functions and different ambient lighting areas, versus when you sit in the car being driven, and you can read a book without having to take care of the traffic.

Mentor Precision Components:
Wolfgang Mursch, CTO and Executive Board Member

DVN: What do you reckon is the current global market value for interior lighting?
WM: Even though there are no reliable figures regarding the growth of ambient and interior lighting in cars, we know from many discussions with the premium OEMs in Germany, but also with international suppliers, that the demand for interior lighting is increasing rapidly and disproportionately high. Smart and dynamic light will be more widely implemented. An illustrative example for this is that dynamic lighting sequences can be used to signal to the driver that he should take control of the steering wheel.

DVN: How do you see the evolution in the next five years?
WM: If in former times functional aspects such as good orientation were the focus of automotive interior lighting, today the role has rather been taken over by emotional aspects such as atmosphere, feelgood factors and value, or by the desire for individually styled lighting that is adapted to the preferences of the drivers or is regulated according to their moods. We believe that this trend will continue and intensify. In the process, light inside the vehicle will increasingly also fulfill other functions. Function and emotion are combined more strongly

DVN: What percentage value represents Interior Lighting versus the total amount value in a car for Lighting?
We have no reliable information on this either. However, we assume that the share will increase due to the increasing significance of interior lighting.

DVN: Are there differences for interior lighting depending on vehicle segment (SUV, van, cars, luxury, sport…)?
WM: We see that interior lighting is gaining importance in all segments. We expect that new solutions and functions will spread from top to bottom, starting with the luxury segment via trend vehicles and the middle class into the volume models and into the base segment, as was already the case with other technologies.

DVN: Do you perceive styling trends influencing interior lighting?
WM: Colored light solutions for sophisticated interior lighting are almost standard today. This will continue. We also expect the interior lighting to become much more dynamic. It is used in areas where it hardly occurs today, like in textiles. Also, on the stronger integration into different applications, like behind foils and in direct combination with controls.

DVN: Do you see new functions emerging in interior lighting?
WM: In addition to identity-shaping, atmosphere-creating and emotionalizing aspects—and from our point of view, these are certainly relevant aspects of benefit, for example, safety, comfort, and interaction-promoting functions will become increasingly important.

DVN: What are the dominant technologies?
WM: In the field of light sources, microcontroller-controlled RGB LEDs will dominate. To the extent that the lighting applications in the interior become more diverse, the technology portfolio required for guiding and emitting the light will also have to become wider. We at MENTOR react to this by expanding our technology portfolio to include fiber optic technology

and textile lighting systems in addition to our expertise in today's dominant technologies for injection molded light guides.

DVN: More and larger displays: Supplement or replacement for interior lighting?
WM: We also see the importance of displays growing. However, they will certainly complement rather than replace interior lighting solutions and both will certainly be used in combination.

DVN: Do you envision an important evolution for Interior Lighting with semi-autonomous and autonomous cars?
WM: Specific autonomous driving-oriented new functions have not yet emerged, but are conceivable in the near future, e.g. the indicator of the indicator by an internal running light as in the tail lights on the Audi. We are very sure that this megatrend will increase the importance of interior lighting even further. In the future, light will certainly take on new and completely new functions. We are very excited about what is developing here.

Comments from Steffen Pietzonka
Hella's Global Marketing Director

Hella have a partnership strategy with Faurecia for autonomous vehicles and with Plastic Omnium for front-end assemblies. With this approach we can optimize the design and gain expertise, cost, weight and development time. We presented a Renault Espace demonstration vehicle at Frankfurt made with Faurecia, showing the interior concepts for a Level-4 autonomous vehicle. Interesting points of this demonstration vehicle:

• Welcome procedure with an optical image projected by a DLP on the driver's seat
• Ambient lighting with door and instrument panel lighting, made with combinations of RGB LEDs positioned at the end of the light guide and behind. Lighting therefore programmable in color and intensity
• Ceiling fully illuminated by other RGB LEDs
• Driver recognition with a map
• Seats released for better seating, then automatically adjusting to previous driver settings
• Retractable steering wheel at Level 4
• Large screen moving mechanically from the area behind the steering wheel to the centre in Level-4 mode to view a movie

Comments from Guillaume Basquin
Faurecia's Head of Innovation

Four Divisions inside FAURECIA
- Interior
- Seats
- Exhausts/composites
- Electronics (incl Clarion)

In Interior, Faurecia has been mainly an integrator. Interior lighting is reinforcing what can be done in interior lighting. The market is moving from platform allocation to more dedicated interior lighting to a car. Differentiation is key for the future and this can be done with the help of lighting, both functional and ambient
One axis of development is back lighting with skin effect. They moved from linear to surface light. Material association in these developments is important. Very thin, slides of wood leaving pass the light (transparency). They look at materials with optical properties: transparent, translucent, or opaque.
China is making innovative proposals and US consider this as a "Wow!" effect. Lighted seams are another axis of development with Light moving along the seams. The market is moving from static lights to dynamics. There is a trend to remove switches going to capacitive switches for the remaining ones.

Segmentation of interior lighting according to Faurecia:
• Traditional
• Welcome
• Safety
• Communication
• Decoration

11 • Conclusion

Having now read this report, you've probably got a clearer image of the huge evolution we're in the middle of in interior lighting, and the speed and degree to which it will continue to increase in the near future.
Style will be the primary driver of the evolution, while technology will meanwhile grow to satisfy the new demands. Light sources, electronics, and new materials will provide the innovative solutions progressively transforming the vehicle interior into a third living space along with the home and the office. New technologies and new suppliers will be needed, and integration of traditional lighting suppliers with these new suppliers will help meet that need.

It seems there is consensus in the lighting community on the increasing importance of interior lighting, and broad agreement that we'll likely see global market revenue double in the next eight years.

We hope you had fun reading this report, and that it has given you food for thought and conversation to discuss and propel the progress within the lighting community.

Jean-Paul Charret and the DVN team

I would like to thank all the participants who gave input and interviews for this report—Sophie Porte and Benoist Fleury for their availability, Whilk Goncalves for his lighting expertise, Michael Brandl, Guillaume Basquin, Steffen Pietzonka, and Jatin Thaker for the time spent with me to initiate me on some new concepts; Riedmayr Florian, Robert Isele, Bjorn Sobischek, Wolfgang Mursch, Herbert Wambsganß, Stephan Hartmann and Markus Klein, for their involvement answering the interviews, and a special thanks to Carstein Befelein pour his important contribution to this report.

List of DVN Gold Members

Car Makers

Aston Martin, UK
Audi, Germany
Bentley, UK
BMW, Germany
Daimler, Germany
FCA, USA
Ford, Germany
Geely, Germany
GM, USA
Honda, Japan, USA
Hyundai Motor, Korea, Eu
Jaguar-Land Rover, UK
Nio, China
Nissan, Japan, Europe, USA
Opel, Germany
Porsche, Germany
PSA, France
Renault, France
S-Volkswagen, China
Seat, Spain
Skoda, Czech Republic
Toyota, Japan, Europe, USA
Volkswagen, Germany
Volvo Cars, Sweden

DVN-Interior
Faurecia, France
Coindu, Portugal
Marelli, Japan
NBHX Trim, Germany
Novem, Germany
Osram, Germany
Preh, Germany
Recticel, Germany
Sensata, UK, Frane
Valeo, France, Spain, China
ZKW, Austria

Set Makers, Tier 1s

Bee Liging, UK
Elba, Romania
Farba, Turkey
Flex'N'gate, USA
Grakon, USA,
Grote, USA
Hascovision, China
Hella, Germany
Ichikoh, Japan
J.W. Speaker, USA
Koito, J, Eu, USA
Lear, USA, Europe
Magna, USA, Au, It
Marelli, Germany, USA
Mind Opto China
Mobis, Korea
NAL, USA
Neolite ZKW, India
Nordic Lights, Finland
Odelo, Germany
Plastic Omnium, Fr
Peterson, USA
Rebo Lighting, Ch, Ge
SL Corporation, Korea
Stanley, Japan
Valeo, Fr, Sp, China
Varroc, Ge, Czech R.
Xingyu, China
ZKW, Austria
Zodiac, France

Light Source Suppliers

Anrui Opto, China
Cree, USA
Diodes Dynamics, USA
Dominant Opto Tech.,
Everlight, Taiwan, Germ.
Excellence Opto, USA, Tai
LG Innotek, South Korea
Lumileds, NL
Nichia, Japan
Osram, Germany
Samsung Electronics, Kor
Seoul Semiconductor, Kor
Soraa Laser Diode, USA
Tungsram, Hungary

Univ., labs, Consultants

Andaltec, Spain
Darmstadt university, Germany
DEKRA laboratory, Nederland
FEP, Franhaufer, Germany
Fudan university, China
GranStudio, Italy
Hannover Leibniz Univ.(HOT), Germ.
Institut d'Optique, Fr.
Karlsruhe Lighting Institute, Germany
LAB, France
Light Sight Safety, Belgium
Nuremberg university, Germany
Pacific Insight, USA
Parma university, Italy
Rensselaer university, USA
SLD Laser—formerly SoraaLaser
UMTRI, USA
University of California, Santa Barbara
YoungNam University, South Korea
Mr Shunxing Wang, China

Lighting Suppliers

3M, USA
A2Mac1, France
AML Systems, France
Aspöck Systems, Germany
ASYST Technologies, USA
Auer-Lighting, Germany
Bicomoptics, China
Bühler Alzenau, Germany
Covestro, US, China, Eu
Dajac, USA
DBM Reflex, Canada
Delvis, Germany
DesignLED, UK
Docter Optics, Germany
EcoGlass, Czech Republic
Elmos, Germany
Enmech-Mektec, Germany
GXC Coatings, Germany
Holophane, France
IMS, Netherland
Infineon, Germany
Instrument Systems, Ge
Jenoptik, Germany
Keboda, China
Less, Switzerland
LMT, Germany, China
Luminit, USA
Luminus, USA
Lumitex, USA
Maxell Joei Tech, Japan
Mentor Graphics, Eu, USA
Mitsubishi Electric, Ge, J
Myotek Industries, USA
Nalux, Japan
NXP, UK
ON Semiconductor, Europe, Asia, US
Optoflux, Germany
Panasonic, Japan
Proper Group, USA
Red Spot, USA
Sabic, USA
Sapphire, USA
Sea Link, USA
Synopsys, USA, Germany
TechnoTeam, Germany
Texas Instruments, USA
TQ Technology, Taiwan
Weidplas CH, Switzerland
WL Gore, USA
Zollner, Germany

All past DVN Reports are permanently available for indefinite download by DVN Gold Members at the DVN website, www.drivingvisionnews.com