AUTOMOTIVE ADVANCED FRONT-LIGHTING SYSTEMS 2019

Market & Technology Report - November 2019

Headlamp digitalization is driving automotive lighting's growth and technological evolution.

WHAT'S NEW

- Automotive exterior front lighting system - Design and manufacturing
- LED technology miniaturization approach - Enabling slim headlight design
- Technology roadmaps for light sources - LEDs and lasers
- Building blocks of advanced front-lighting system (AFLS) architecture - Including lighting, sensing, computing, and software control
- AFLS lighting technologies - Efficacy aspects, FOV, accuracy, and ADB lighting scenes as a function of resolution
- AFLS penetration into different car segments
- LED-based headlamps - Pricing and cost breakdown

KEY FEATURES

- Automotive lighting - Market analysis
- Automotive lighting - Industry analysis, including Tier-1 players
- Automotive lighting - Technology analysis, including LEDs and lasers
- Automotive lighting - System development and manufacturing analysis
- Automotive AFLS - Roadmap analysis

DIGITAL LIGHTING WILL CONTINUE TO TRANSFORM AUTOMOTIVE LIGHTING

The digitalization of cars is a megatrend in the automotive industry, moving towards electric and autonomous vehicles. The developments related to this trend facilitate new approaches in safety, comfort, and information services. Exterior lighting is gaining significance because automated driving advancements have illustrated the importance of communication between all road users.

Today, digital lighting is a key area of investigation for the automotive lighting supply chain, since it enables smarter lighting functionalities, safer adaptive-driving beam (ADB) designs with cameras, and artificial intelligence (AI) in the loop.

Two approaches are being investigated for image generation: additive and subtractive. Images from DMD, LCDs, and liquid crystal-on-silicon (LCoS) are formed with illumining optics to ensure precise illumination of the corresponding spatial light modulator (SLM). The micro-structured adaptive front-lighting system (or µAFS) forms the light distribution by projecting the light-emitting surface of each LED pixel onto the road. Pixel LED itself is a novel technology, consisting of more than 1,000 pixel points per chip, with tiny pitch.

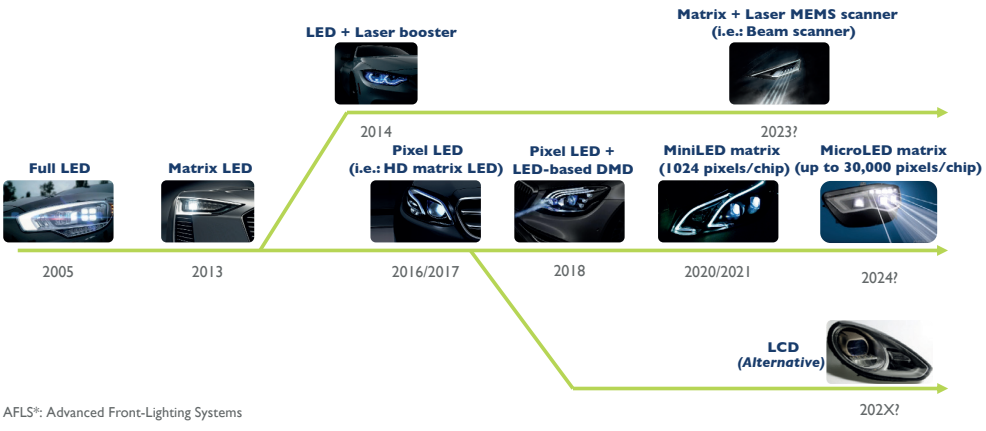
Additionally, the advanced front lighting system (AFLS) architecture integrates other inevitable building blocks. These include cameras and sensors enabling detection and identification of objects, electronic control units (ECUs) for fast computing of information, and software for effective image processing and automation of functions. Based on image processing functions and intelligent settings in the projection module, critical areas of oncoming traffic that might face glare are removed from the high-beam's distribution, with the rest of the high-beam field remaining intact for the driver's convenience. With these new digital headlight technologies, light distribution must be reinvented. High resolution, combined with flexible software and wide-ranging sensor integration, creates options that were once inconceivable.

HD light-enabling technologies are still emerging. DMD has only appeared in small volume as an additional module in the 2018 Mercedes-Benz S-Class Maybach. The preferred technology among car makers is matrix LED array, evolving to micro pixel LED technology. Today we can see full-LED matrix headlights with up to 128 LEDs per cluster in the VW Touareg. In 2020 true micro pixel LED technology, containing thousands of LED dies, will be implemented for the first time. An interesting fact is that such lighting systems generate ever more synergy with projection systems, since their function is evolving towards communication - for example, projecting information onto the road.

However, several barriers still must be overcome in areas such as technology, manufacturing, and regulation. These challenges will be reinforced as digital light further strengthens the relationship between lighting, automotive sensors, and data processing.

This report presents a complete overview of new lighting technologies and AFLS, including details regarding benefits and drawbacks, integration status, and development roadmaps. Insights into the future of automotive lighting, with particular analysis of synergies with ADAS, are also provided.

AFLS* roadmap - In the future, different technologies will co-exist



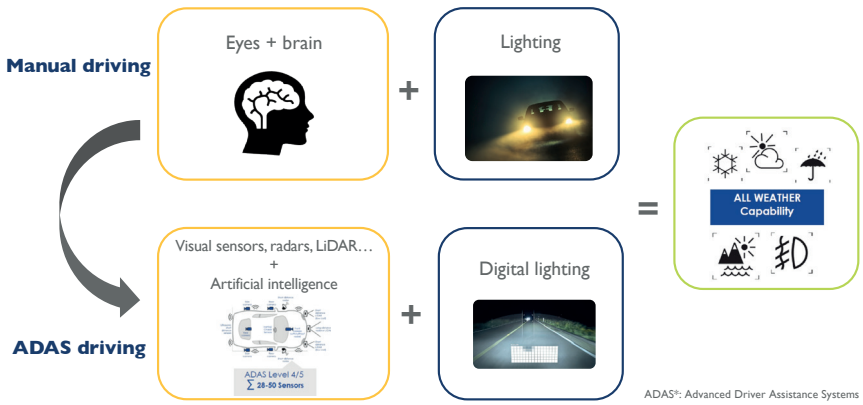
AFLS*: Advanced Front-Lighting Systems

(Yole Développement, November 2019)

AUTOMOTIVE LIGHTING INDUSTRY: POSITIONING TOWARD ADAS

The market is already transforming, and now automotive lighting is becoming a potential critical node for automated driving. This is because lighting systems could represent a key opportunity for integrating sensors like local cameras, radar, and LiDAR systems. Furthermore, technology and application evolution brings more complex systems, more components, and more subassemblies, while maintaining quality. This requires new strategies - particularly for cost reduction. Implementing costly AFLS that includes intelligent lighting, precise sensing, fast computing, and software control requires standardization - creating a platform and architecture that can be used in a variety of cars.

Driving architecture: Manual vs. ADAS*



(Yole Développement, November 2019)

Different business strategies are being adopted by the top-7 Tier-1s. The first group is focused on developing more high-end AFLS technologies. The second strategy is to increase the global footprint of basic LED headlights, and the third strategy is ADAS development along with lighting technologies. Industry leaders have already begun presenting their future headlight (and even car) concepts.

New engineering and manufacturing methods enable additional integration and thus create new modules. More integrated components enhance the functional content of headlamps, supporting freedom of design while simultaneously reducing the number of interfaces, which improves reliability. However, miniaturization and new-component integration is not enough in the automotive industry. Increased sensor competence will be essential.

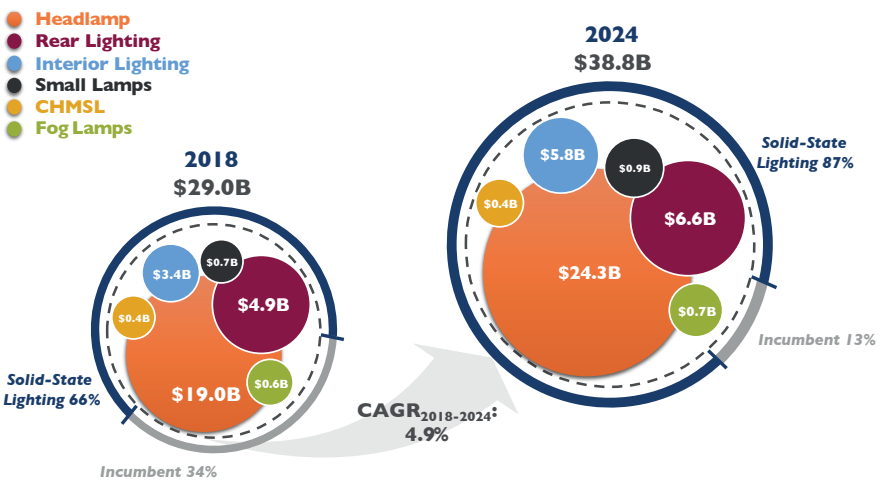
This industry's evolution is likely to continue as solid-state lighting technologies are integrated. The rapid evolution of these technologies, coupled with the AFLS trend and increased use of non-visible lighting systems like LiDAR, radar, and cameras, might bring further change to an industry that's already transforming.

This report analyzes the automotive lighting industry, with details concerning the top 15 suppliers' revenue and market share, in total and by region. A focus on the value chain and non-visible lighting applications in automotive is also included, along with an in-depth analysis of automotive lighting system development and manufacturing.

DESPITE THE AUTO INDUSTRY'S OVERALL SLOWDOWN, THE LIGHTING MARKET LOOKS BRIGHT OVER THE NEXT DECADE

The period following the 2008/2009 global economic crisis was the auto industry's longest-ever growth phase. But after eight productive years, in 2018 we observed a modest decrease in vehicle sales. The drivers of this recent downturn are global trade uncertainty due to U.S. tariffs, and increasing trade restrictions that threaten to destabilize economies worldwide. OEMs and suppliers now must face industry disruption of a traditional model.

2018-2024 Automotive lighting market forecast



(Yole Développement, November 2019)

New mobility and digital transformation are the key trends that will directly impact the automotive lighting industry.

LEDs are rapidly gaining popularity as their cost decreases and efficiency, luminance, and package size improves. Full LED headlamps are now being commercialized in emerging markets, and nearly all car makers and Tier-1 parts suppliers have developed full LED-based headlamp systems. Such technology is a must-have in the C and also the D (large vehicle) automotive segments, with implementation continuing in the lower B (small car segment). For example the Renault Clio and Opel Corsa are equipped with full-LED lighting, either as standard on the base model, or as optional LED matrix headlights in the Corsa's case. Today's moderate market growth is mostly related to the strategies of light source suppliers - "LEDification" – implementing lower-cost solutions for emerging markets.

Advanced LED matrix headlights, with more than 50 LEDs per vehicle, have been implemented in premium car segments. These attractive headlamps provide different lighting scenarios and are

frequently selected by new-car buyers. As a result, styling and technological advances have also contributed to the market's growth.

In this context, the automotive lighting market totaled $29B in 2018 and is expected to reach $38.8B in 2024, at a compound annual growth rate (CAGR) of 4.9% for 2018-2024. This growth is driven by natural LED cost erosion, coupled with standardization and optimization of LED modules, resulting in more vehicles equipped with this technology.

This report presents all AFLS applications and their associated market revenue for the period 2019 - 2024, with details concerning the integration status of different lighting technologies and systems, recent trends, and market size by application.

REPORT OBJECTIVES

- Analyze the current status and future trends related to automotive front-lighting market applications
- Review the automotive lighting industry's structure and future trends
- Examine the AFLS used for automotive applications, and the associated roadmaps
- Provide market insights for 2015 - 2024 regarding automotive lighting applications

COMPANIES CITED IN THE REPORT (non exhaustive list)

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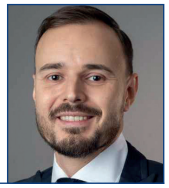

AUTHORS

Martin Vallo, PhD is serves as a Technology & Market Analyst specialized in solid-state lighting technologies, within the Photonics, Sensing & Display division at Yole Développement (Yole). With 9 years' experience within semiconductor technology, Martin is involved today in the development of technology & market reports as well as the production of custom consulting projects at Yole. Prior his mission at Yole, he worked at CEA (Grenoble, France), with a mission focused on the epitaxial growth of InGaN/GaN core-shell nanowire LEDs by MOCVD and their characterization for highly flexible photonic devices. Martin graduated from Academy of Sciences, Institute of Electrical Engineering (Slovakia) with an engineering degree in III-nitride semiconductors.

As part of the Photonics, Sensing & Display division at Yole Développement (Yole), **Pierrick Boulay** works as Market and Technology Analyst in the fields of Solid State Lighting and Lighting Systems to carry out technical, economic and marketing analysis. Pierrick has authored several reports and custom analysis dedicated to topics such as general lighting, automotive lighting, LiDAR, IR LEDs, UV LEDs and VCSELs. Prior to Yole, Pierrick has worked in several companies where he developed his knowledge on general lighting and on automotive lighting. In the past, he has mostly worked in R&D department for LED lighting applications. Pierrick holds a master degree in Electronics (ESEO – Angers, France).

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9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract/orders entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.