14th International Symposium on Automotive Lighting

Darmstadt
April 4–6, 2022

TECHNISCHE
UNIVERSITÄT
DARMSTADT

ISAL 2021

Tran Quoc Khanh (Hrsg.)

14th International Symposium on Automotive Lighting – ISAL 2021 – Proceedings of the Conference

Volume 19

utzverlag · München 2022

Darmstädter Lichttechnik

Ebook (PDF)-Ausgabe:
ISBN 978-3-8316-7712-2 Version: 1 vom 28.04.2022

Alternative Ausgabe: Hardcover
ISBN 978-3-8316-4953-2

ISAL 2021

Proceedings

of the

14th International Symposium on Automotive Lighting

Technical University of Darmstadt

Laboratory of Adaptive Lighting Systems and Visual Processing

Published by

Prof. Dr.-Ing. habil. Tran Quoc Khanh

in the series

Darmstädter Lichttechnik

Volume 19

ISAL 2021: Volume 19

ISBN 978-3-8316-4953-2

Bibliografische Information der Deutschen Bibliothek:

Die Deutsche Bibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.ddb.de abrufbar.

Printed in Germany

utzverlag GmbH, München
089-277791-00 · www.utzverlag.de

14th International Symposium
on Automotive Lighting

Foreword

It is a pleasure to present you the proceedings of the 14^{th} International Symposium on Automotive Lighting, which takes place in Darmstadt on April, 4-6, 2022. Caused by the global Covid19-pandemic, this conference had to be shifted to 2022. This conference is the document of a series of successful conferences since the first PAL-conference in 1995 and shows the latest innovative potentials of the automotive lighting technologies, together with the sensor technology and AI (Artificial Intelligence).

These proceedings result from the work of a lot of experts in the automotive and optical industry, administrative bodies, research institutes and universities. It summarizes the findings of more than 200 authors and co-authors and gives a scope of their expectations for the future. In 2021, the ISAL Steering Board could identify the following focus topics:

- Headlamp Rating Systems and their practical relevance for a global use
- High Resolution Headlamps and Digital Light, not only for high beam but also for low-beam range in the cities in the context of an international urbanization
- Road Projections (Front field and near-field)
- Communication between automated vehicles and other road users
- Light source technology generally with the innovations in Laser and LED-OLED
- Simulations as promising test environments

While in the last couple of years, focus was placed on high-resolution headlamps and this topic still remains relevant today, the most pressing topic for this year's ISAL is the evaluation of headlamp light distributions on the road. The main influencing parameters are the visibility (object detection probability), the homogeneous illumination and the effective lateral width of the light distribution. A key factor for an optimal illumination on the road is the correct adjustment of the headlamps in the system of the vehicle. Another strong topic for this year's symposium is the ongoing investigation on road projection and its benefit for the driver. What kind of symbols should be projected onto the road in front of the driver and what benefit do they lead to?

Similar to ISAL 2019, ISAL 2021 will host a podium discussion on the latest research and international opinions regarding the evaluation methods for headlamp lighting distributions and on how these methods can find the way into international regulations.

We wish you a very informative and successful ISAL 2021 in Darmstadt. We hope that this year's event and these proceedings will give you inspiration and motivation for your work during the next months and years.

Yours sincerely,

Prof. Dr.-Ing. habil. Tran Quoc Khanh

Contents

I. Light Sources

III. High Resolution Headlamps

IV. ADAS and Headlamp Cleaning

V. Rating

VI. Visual Performance

VII. Signalling and Communication

VIII. Road Projections

IX. Simulation and Virtual Reality (VR)

I. Light Sources

Amazing Backup Lamp – how to get white light out of a rear lamp with a red covered lens/glass

H.P. Schiffert, Mercedes-Benz AG, Germany

Keywords: Light Source, LED Rear Lamp, Backup Lamp, Light Color Conversion, Design Freedom, Improve Appearance Of Rear Lamps

1 Abstract

In this abstract, we would like to show the development, the principle and implementation of a backup lamp through a red outer lens, without additional color filter elements and optics, realized with a specifically developed light source. The innovation aims to provide more creative freedom in the design for the appearance of rear lamps and to simplify the production process of the lamps.

The elaboration shows a solution that can emit white light color from a rear lamp with a red cover, taking into account legal color requirements and light values for a backup lamp. It describes the examination and selection of suitable materials and plastics, the properties and definition of a specific LED light source, as well as test results according to the legal requirements of the first prototypes. A comparison with conventional backup lamps as well as the advantages and disadvantages of the application are developed. In the last step, we would like to go into the necessary steps for solution approaches from the first simulations, the achievement of a high degree of maturity and to get ready for a successful implementation in series production.

2 Introduction and Motivation

One of the most crucial and challenging necessities for the development of rear lamps in modern luxury cars for the premium segment is firstly to find the optimum for the safety-relevant functions, secondly a technology that is high innovative as possible and thirdly has the maximum design freedom in the division of the lighting function areas. Under these three conditions, we get the option for rear lights, which are best integrated into the appearance of the entire vehicle.

One part of a seamless design is a clear, uniform and clean appearance of the rear lamps. Provided that the rear lamps should be implemented uniformly with a red appearance, we were unable to implement a purely red outer lens due to the legal color requirements for lighting functions. Two light functions, the direction indicator and the reversing light, have limited these requirements of our design wish. Figure 1 shows the two clear backup function areas left/right, which do not allow us a uniform red appearance for the rear lamps. The turn indicator areas left and right already implemented in red.

Figure 1: Appearance of the rear lamps with clear functional fields for the reversing light on the vehicle [4]

Thus, the question for the solution of the task is clear. How can we transform the clear transparent functional field in an equally red appearance with innovative LED-Systems?

For the turn indicator, a solution for yellow emitting light through a bright red outer lens was found. We know bulb lamp systems from the past, which have also enabled a red appearance of the light function through an additional filter lens between the light source and the bright red outer lens. Nevertheless, the current challenges for very small optical systems in LED technology and its spectral power distribution characteristics, provide more difficult conditions for systems that can be implemented in series.

In Figure 2, the clear transparent functional field for the reversing light can be seen based on a current series car lamp. However, as can be seen in Figure 3, the desired appearance is a completely red-looking rear light without visible separated functional areas. Figure 3 shows the goal of the content of this article.

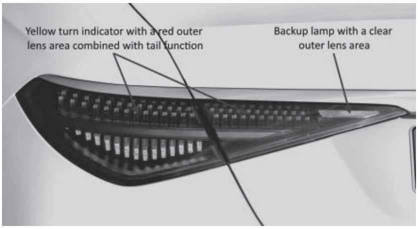

Figure 2: Rear lamp with clear backup function area in a red covered outer lens [4]

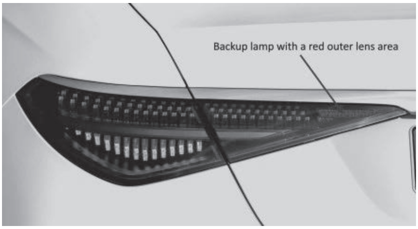

Figure 3: Rear lamp with a seamless red covered outer lens without clear function area

3 State of the art and basic parameters

In the first steps, we have to evaluate the existing parameters and requirements in order to achieve the necessary characteristics for a suitable definition of an optical unit.

Light color:

The light color and thus the target range of the color mixture after transmission through the outer lens must be within the valid legal regulations e.g. UNECE [5]. A specific color range within the legal regulations with corresponding tolerances is therefore required to ensure all operating states and environmental influences such as temperature, geometric tolerances, manufacturing tolerances, degradation of luminous flux, color shift over temperature, color binning’s, etc.. In the CIE 1931 Chromaticity Diagram (Figure 4), taking into account previous reversing lights according to the manufacturer's specifications or according to the state of the art of reversing lights, a specific area is defined as a possible target window.

Filter properties:

As an outer lens/glass of the lamp, we used the existing material with the known specific spectral transmission properties of the material. In this example, we use the polymer from Röhm 8N red [3]. The specific color of the materials used for the outer lens is shown in Figure 4 in the CIE 1931-Diagram with the corresponding (x,y) coordinates from the manufacturer datasheet and corresponding material thickness of the lens.

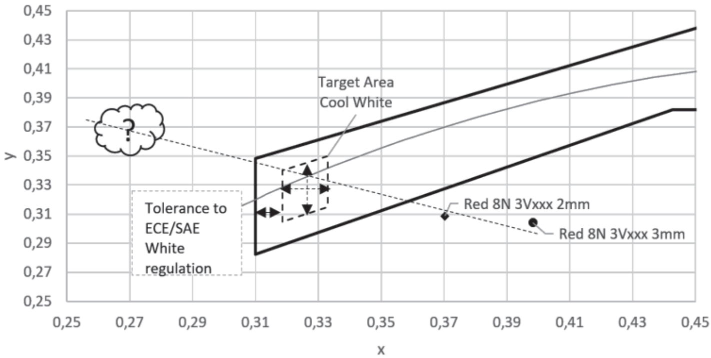

Figure 4: Chromaticity coordinates (x,y) CIE 1931 Color ECE White with an example of a target area for backup lamp and outer lens material color coordinates

In Figure 4 and 5 we can see the dependence of the thickness of the lens material with the corresponding color code 8N 3Vxxx. Because the outer lens also acts as a color-mixing filter, the definition and tolerance of the thickness of the lens is crucial for defining the spectral color distribution of the light source. Compared to transparent clear lenses, the efficiency of the optical unit should not be ignored, as transmission and color mixing through the lens result in significant losses.

Figure 5: Dependences thickness (left) and color grade (right) of the outer lens

In the summary of the existing parameters of the optical unit of the lamp, we were able to determine the material specifications and to meet the legally required light color. Since no further filter level is provided, the light color must be generated for transmission through the red outer lens by the light source itself. The light color mixed with the transmission properties of the red outer lens should give mathematically a white spectral power distribution, which is suitable for the backup function.

4 LED – Simulation and Characterization of the light source

After initial investigations of the idea with filter plates made of different materials and colors, already existing light sources and optical prototypes, the analysis for finding a solution was carried out with parallel using lighting simulation tools.

As a next step, after ensuring that technical feasibility is very likely to be possible, we were able to include further support for technical elaboration with the idea. Together with Lumileds Germany GmbH, we were able to find an experienced light source manufacturer to achieve products suitable for series production. Thus, we had a partner with all the necessary knowledge and influencing variables for the characterization of a suitable light source to “integrate” the color filter into the light source in order to avoid additional filter plates or complex optical units. Together we analyzed all technical conditions such as optical requirements, materials and the basic idea in order to find an efficient and as fast as possible a solution suitable for series production.

The basis of the filter material was given, it is the same material which is already used for the turn-indicator function in the cover lens of the rear lamp. This gives us the opportunity not to have a separate production cycle for the creation of the cover lens and thus to have a flexible and cost point taken into account. The second question was, does the transmission curve in Figure 6 allow a corresponding transmission without high losses in the necessary wavelength ranges of spectral absorptivity?

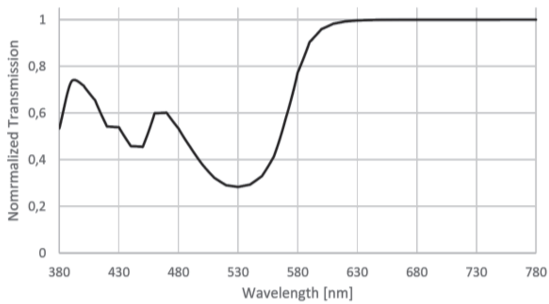

Figure 6: Spectral Absorptivity data from Roehm for Plexiglas 8N red [3]

In the third step, it was important to validate the requirements for a high quality reversing light. This results in the properties of the optical system and the necessary performance parameters. The power parameters are decisive for the choice of the package of the LED, the operating range for all electrical, optical and thermal characteristics such as minimum/maximum forward current, forward voltage, luminous flux, viewing angle, thermal resistance, degradation, etc.. As a suitable starting point for all the mentioned and required parameters, the selection fell on the existing LUXEON Versat 3030 350 package. It is a packaged LED with a blue die and phosphor converted, has a flexible operating range and a suitable package size.

In several simulation steps, the task was to determine the appropriate color characteristic, more precisely the corresponding phosphor conversion adjusted to the cover glass. As a result, the spectral characteristic can be seen in the Figure 7, which acts on a green appearance in the light color.

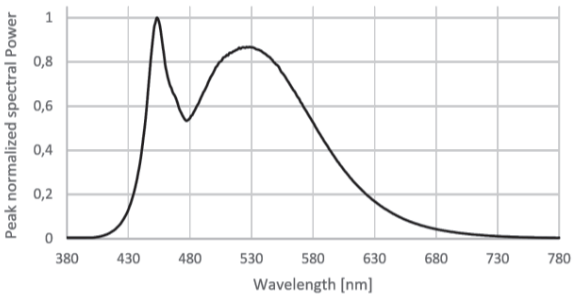

Figure 7: LUXEON Versat 3030 350 green spectral power distribution [2]

As the result of the simulation, assuming all defined input parameters, Figure 8 shows the spectral intensity curve after transmission through the red Plexiglas 8N outer lens.

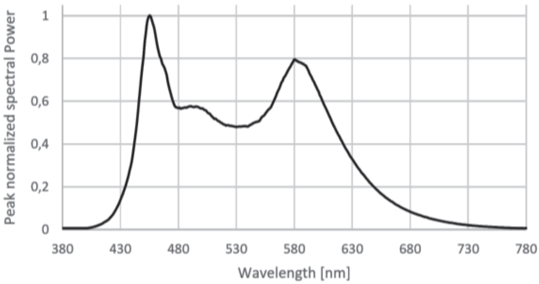

Figure 8: Spectral density after transmission through red outer lens [2]