From illumination to communication

Ricardo Plöger

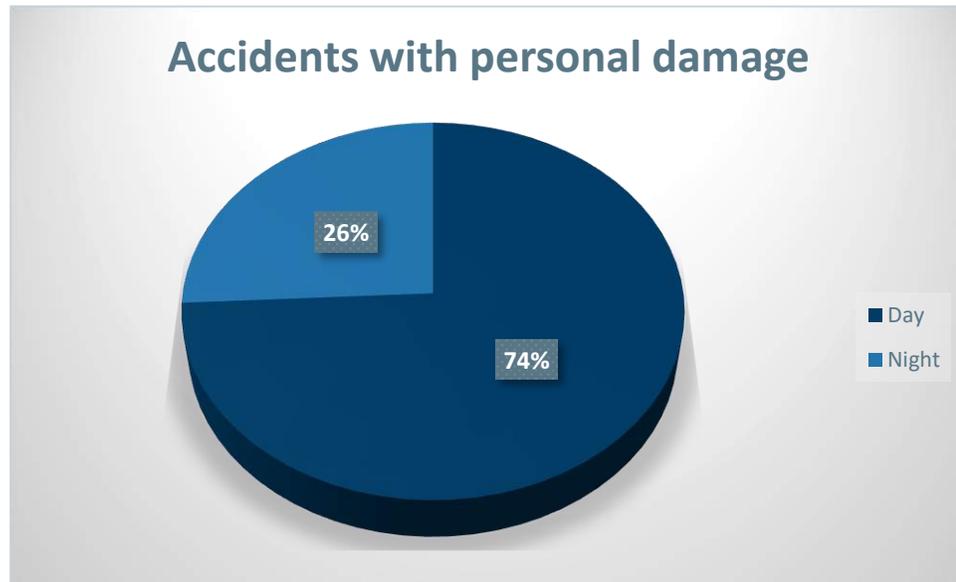Head of Lighting and Vision

Agenda

1. Motivation

2. Democratization of Lighting Technology

3. Enhancement of Lighting Features

4. Future Lighting Technologies and Challenges

5. User Studies on New Lighting Features
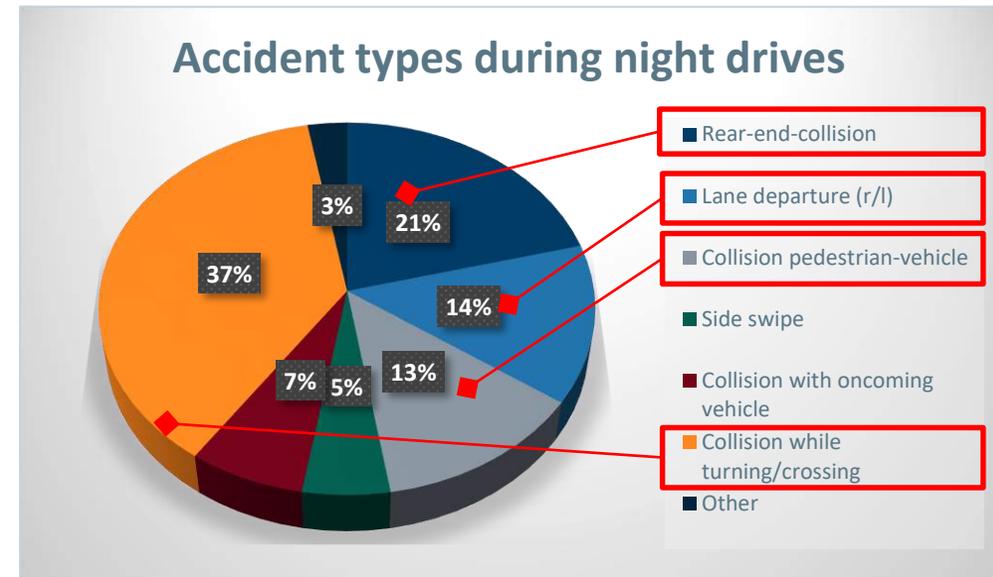
6. Conclusion and Outlook

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Motivation

Road Accident Statistics

Accidents with personal damage

- 26% — Night
- 74% — Day

Legend:
- Day
- Night

Accident types during night drives

- 3%
- 21%
- 14%
- 13%
- 5%
- 7%
- 37%

Legend:
- Rear-end-collision
- Lane departure (r/l)
- Collision pedestrian-vehicle
- Side swipe
- Collision with oncoming vehicle
- Collision while turning/crossing
- Other

Based on GIDAS aquired accidents from 2000-2018

Democratization of Lighting Technology – Dynamic Light Assist

Rolling Out of the Dynamic Light Assist into the Volume Segment

Dynamic Light Assist

Touareg 2010

Passat 2011

Golf 2013

Democratization of Lighting Technology – Matrix Technology

13% Collision pedestrian-vehicle

Example Volkswagen Touareg

Currently in market		Coming soon...

Technology (each headlight)
- 128 LEDs
- Low beam 1150lm@55lx
- High beam 2150lm@210lx

Features
- 13 adapted light distributions (e.g. for cities, country roads and highways)
- **Marking light with night vision**
- Masked high beam
- Sequential turning light
- Adverse weather light
- Offroad light

Democratization of Lighting Technology – Click-Clack Stop Light

21% Rear-end-collision

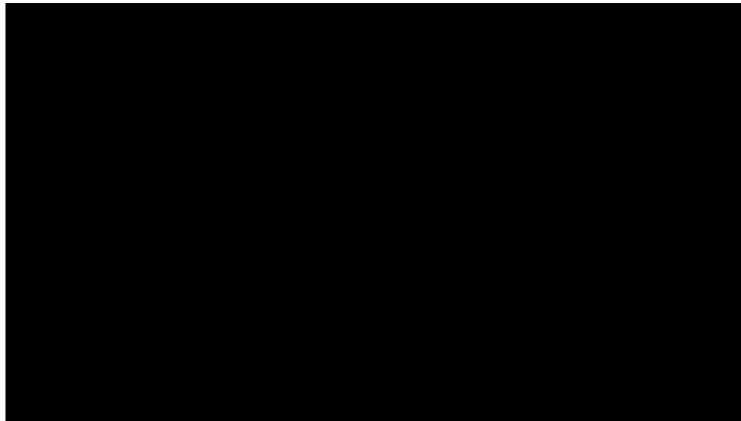## Unique Design and Safety Feature

Passat 2014

Tiguan 2016

Golf 2017

Touareg 2018

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Enhancement of Lighting Features

Examples of Lighting Features for High Resolution Headlights

Optical Crossing Assist

Optical Lane Assist

Pedestrian Safety Zone

37% Collision while turning/crossig

14% Lane departure

13% Collision pedestrian-vehicle

Enhancement of Lighting Features

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Enhancement of Lighting Features

Examples of Lighting Features for Matrix Taillights

Individual signature/animations
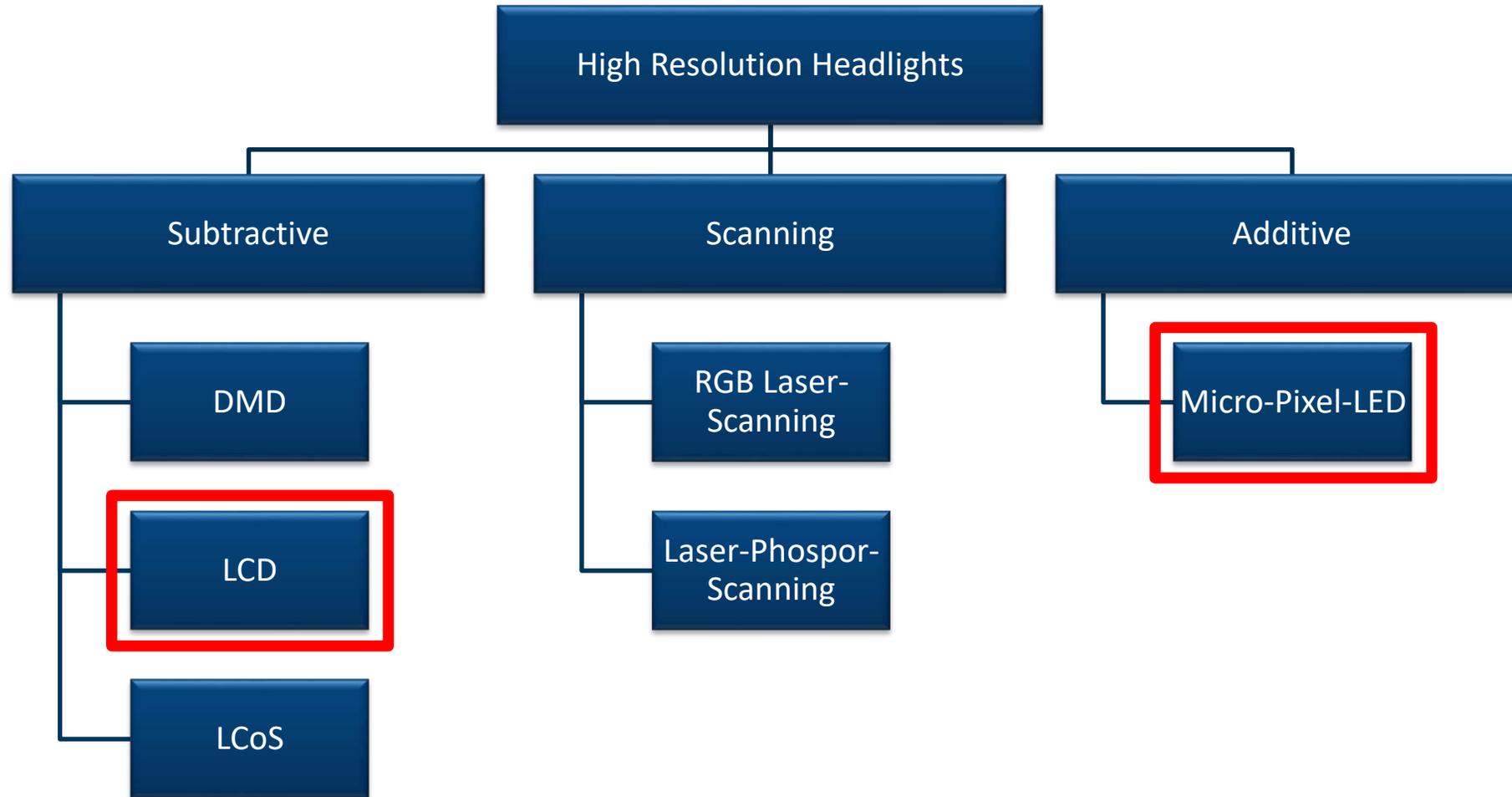
Function on demand

Safety functions

21% Rear-end-collision

Enhancement of Lighting Features

Examples of Lighting Features for Matrix Taillights

Individual signature/animations

Function on demand

Safety functions

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Future Lighting Technologies and Challenges
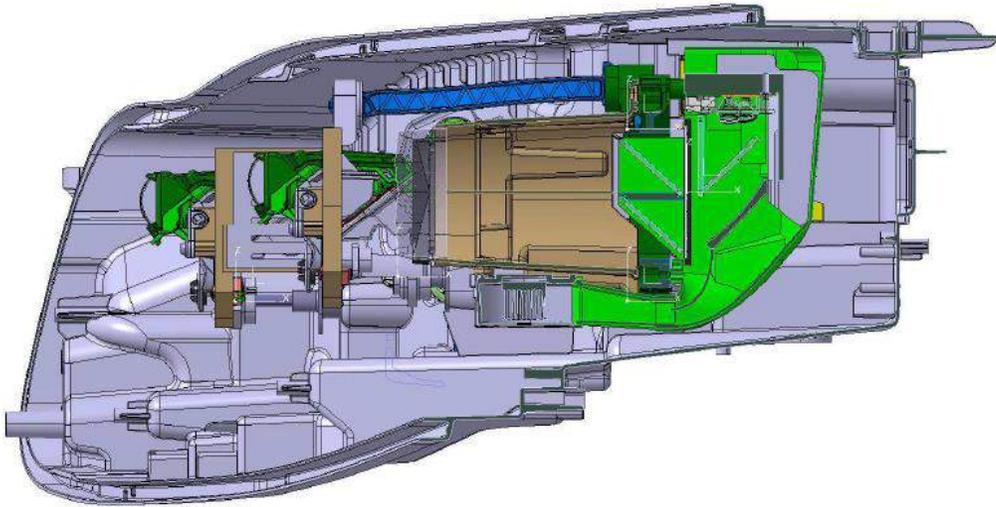
High Resolution Headlight - Overview

15.01.2019 | Ricardo Plöger, Mathias Thamm, Dr. Joscha Roth, Christian Studeny

Future Lighting Technologies and Challenges

High Resolution Headlight – LCD-Headlights

- 30.000 pixels in each headlight

- Testcar allows dynamic evaluation of new light based driver assistance systems
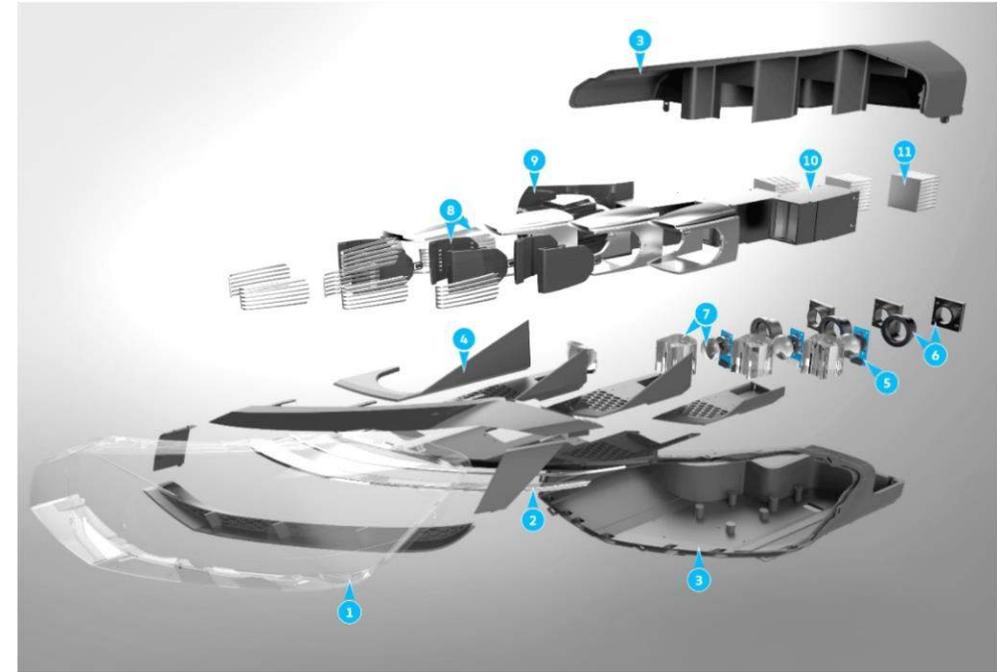
Future Lighting Technologies and Challenges

High Resolution Headlight – Micro-Pixel-LED-Headlights

- Currently over 3000 Pixels in a pre-development headlight

- Up to 25.000 pixels in serial applications

Future Lighting Technologies and Challenges

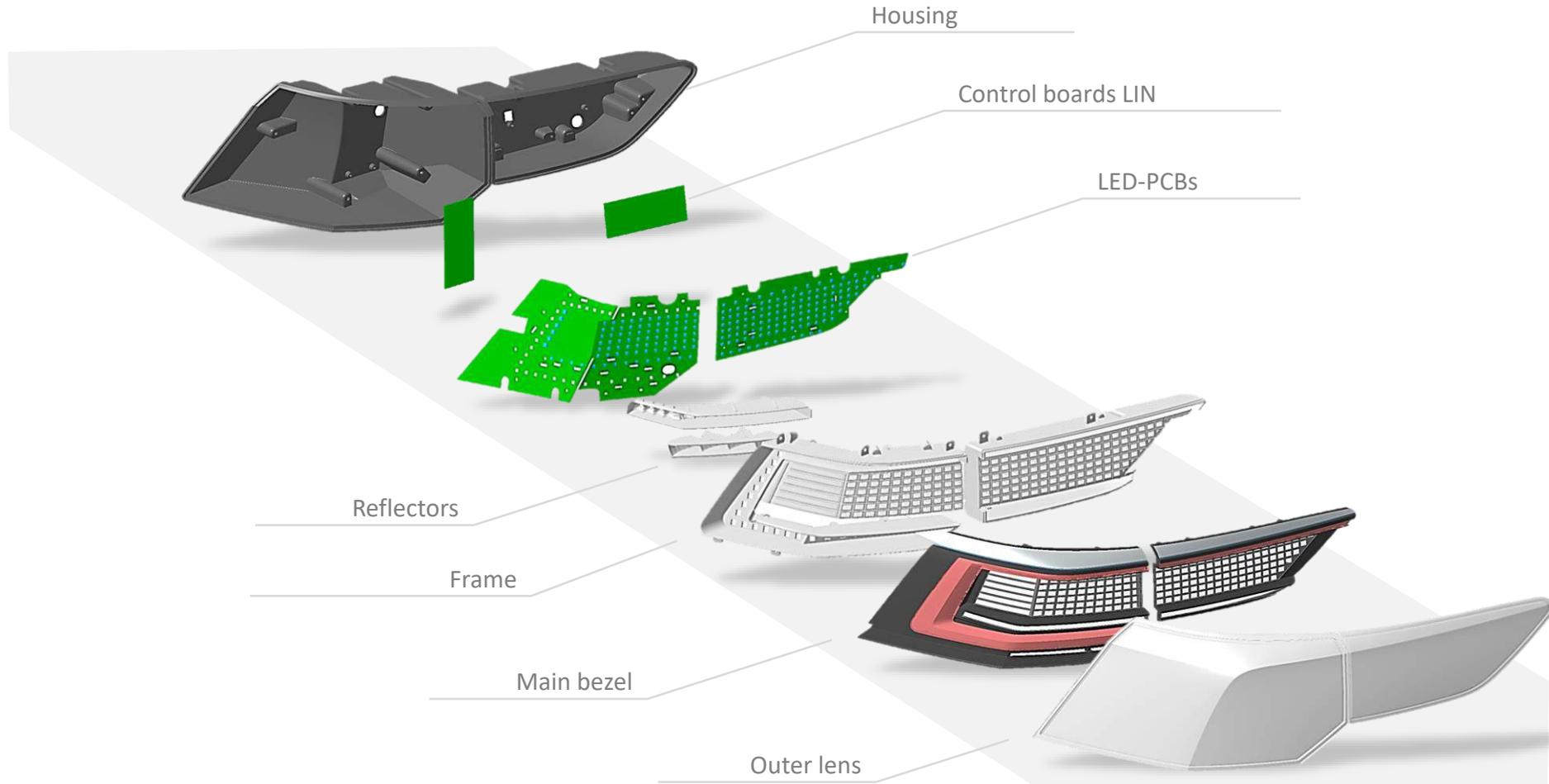## Challenges – Micro-Pixel-LED

- High efficiency required for usage in electric cars (<60W in high beam per headlight)

- Modularization important to adress all car segments

- Legal changes required to introduce new lighting function for safety enhancement

- Costs should be less than current matrix systems (<200€ per headlight)

- Compact package size to follow future design requirements

Future Lighting Technologies and Challenges

Matrix Taillight – 260 Individually Addressable LEDs per Taillight

Housing

Control boards LIN

LED-PCBs

Reflectors

Frame

Main bezel

Outer lens

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Future Lighting Technologies and Challenges

Matrix Taillight - Challenges

- International comprehensive symbols

- Legal changes required to introduce new lighting function for safety enhancement

- Electronic concepts and architecture

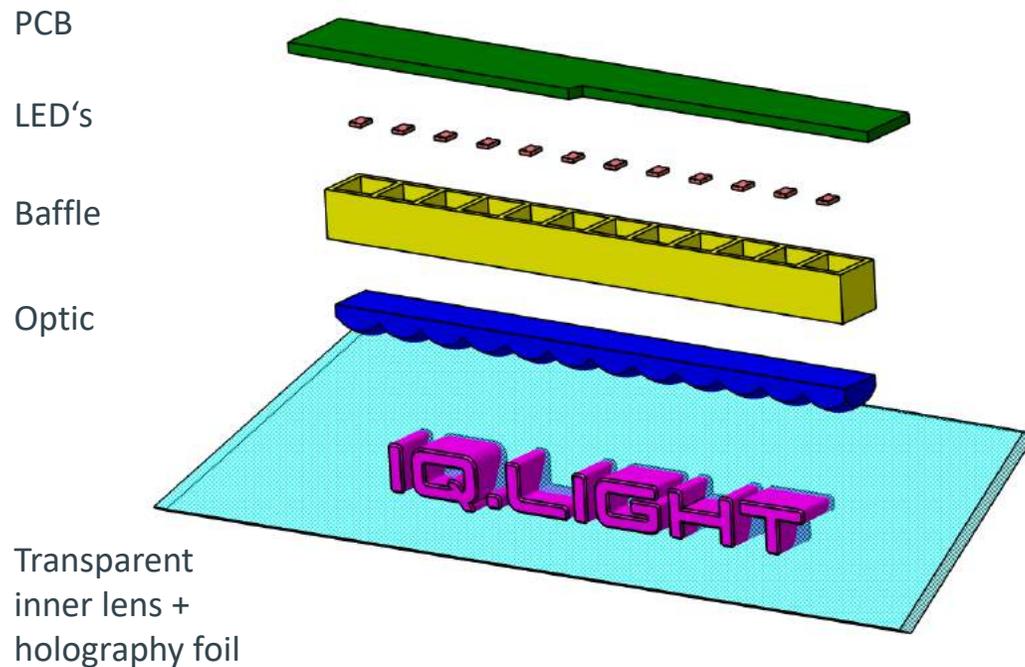- High number of LEDs in limitied package

- Costs <100 € per taillight

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Future Lighting Technologies and Challenges

Holography

- Allows a 3D effect that can be used in light functions to enhance road safety

PCB

LED's

Baffle

Optic

Transparent
inner lens +
holography foil

Future Lighting Technologies and Challenges

Holography - Challenges

Provide a completely new design and functional spectrum

- New places for light functions

Challenges

- Industrialization (complete new process)

- Quality (homogeneity lit and unlit appearance)

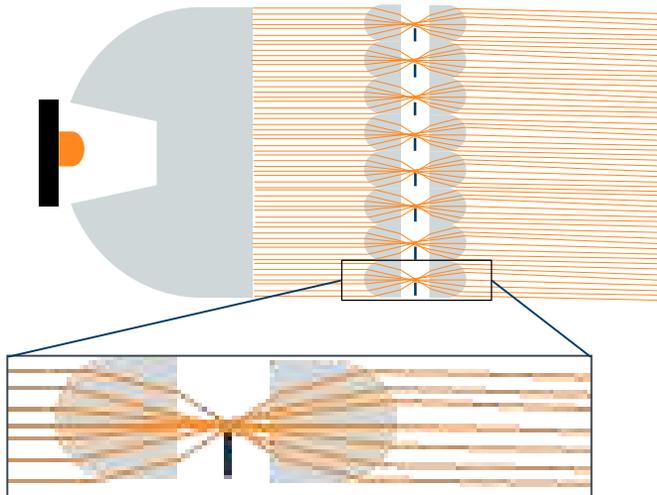- Automotive specification (temperature, humidity & UV stability)

Future Lighting Technologies and Challenges

Micro Lens Array (MLA)

Allows compact modules and precise projections

Challenges

- Installation space

- Costs

- High efficiency

User Studies on New Lighting Features

Evaluations on Optical Lane Assist

- 85% wishing for an assistance in narrow lanes and road works

- Subjective: With light stripes driving is more comfortable

- Wide Light stripes achieved best ratings

- 83% prefer dynamically bending light stripes

- No expected influence on other traffic participants
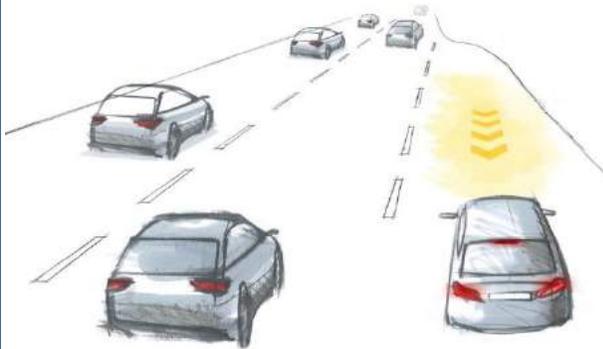
- Contrast (Weber) should be between 2,4 und 5,6

Study type	Number of test persons	Age of test persons
Pre study	20	
Real driving study	29	
Simulator study	32	25-45
Expert study	10	
Contrast study	28	

User Studies on New Lighting Features

Evaluations on Merging Assist

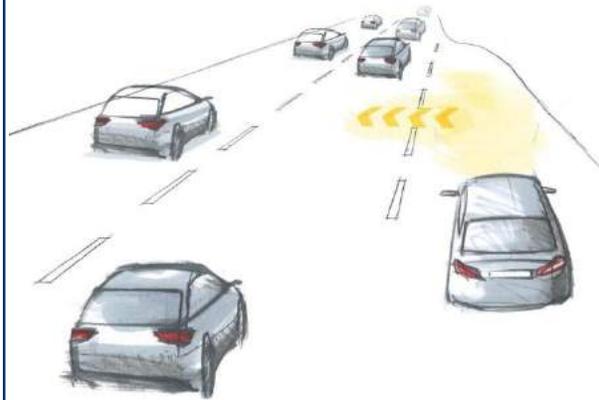### Merging Assist with longitudinal animation

Positive rating
- Acceptance evaluation
- Subjective evaluation

Rating 1
Combination of longitudinal animation and call to action → Best driver assistance
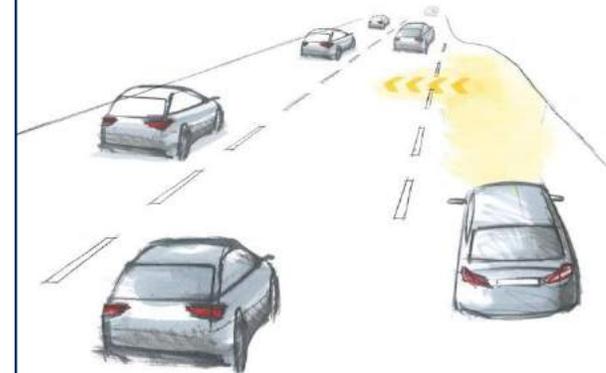
Simple Merging Assist

Positive rating
- Acceptance evaluation
- Subjective evaluation

Rating 2
Rated as intuitive, comprehensive and helpful function

Stationary Merging Assist

Poor rating compared to vehicle related projections

Rating 3
Stationary projection not favored in this particular use case

PHD Thesis Anna Zoé Krahnstöver, 2017, Licht führt!? Konzeption und Evaluation von Fahrmanöverunterstützung durch lichtbasierte Fahrerassistenzsysteme

Ricardo Plöger, Mathias Thamm, Dr. Joscha Roth, Christian Studeny

Conclusion and Outlook

- Headlights and taillights will have more functionality and complexity in future

- New electronic interfaces are required to handle increasing amount of data

- We need to adapt the legal requirements to allow for new safety lighting functions