

# PUR FOR EXTERIOR LIGHTING APPLICATIONS

CHALLENGES AND THE INFLUENCE OF PROCESSING

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**FORVIA**



# AGENDA

## Company Forvia



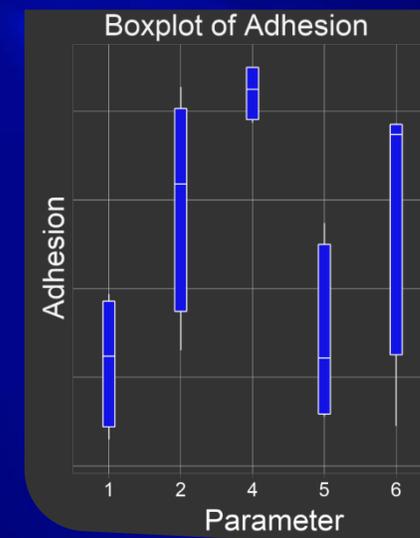
## Lighting Challenges



## PUR Lighting



## Influence of processing



## Summary and Outlook



# AGENDA

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## Summary and Outlook



# FORVIA: A GLOBAL AUTOMOTIVE TECHNOLOGY SUPPLIER

**6**

Business Groups

**€27bn**

sales

**12,900**

patents

**40**

countries

**150,000**

employees

**€31bn**

order intake

**≈ 900**

programs in 2024

**1 in 2**

vehicles worldwide  
equipped with FORVIA  
products

**15,000**

R&D engineers

Including

**400+**

new launches

# FORVIA

Powerful combination of 2 automotive technology suppliers

## faurecia

Founded in 1914 by Bertrand Faure, Faurecia became one of the world's top automotive suppliers. After Groupe PSA merged with Fiat Chrysler to form Stellantis in 2021, Faurecia became independent and, in 2022, acquired a controlling interest in HELLA.



Founded in Germany in 1899, HELLA has remained at the forefront of the industry ever since. It is a listed company in which the Hueck and Roepke families held the majority stake prior to Faurecia.



**FORVIA**  
Inspiring mobility

In 2022, two of the world's leading automotive suppliers joined forces: Faurecia and HELLA became FORVIA.



# A COMPREHENSIVE PORTFOLIO

Six international business groups with differentiating product lines



## Seating

- > Seat structures
- > Complete seats

**46,000+**  
employees



## Interiors

- > Instrument panels
- > Door panels
- > Center consoles
- > Sustainable materials
- > Technology integration

**32,000+**  
employees



## Clean Mobility

- > Ultra-low emission solutions depolluting thermal vehicles
- > Hydrogen storage solutions for both automotive and non-automotive applications

**17,000+**  
employees



## Electronics

- > Sensors & actuators
- > Auto parking systems
- > Lighting/body electronics
- > Energy management
- > Cockpit electronics
- > Cockpit experiences

**6,000+**  
employees

**12,000+**  
employees



## Lighting

- > Headlamps
- > Rear lamps
- > Interior lighting
- > Car body lighting

**22,000+**  
employees



## Lifecycle Solutions

- > Independent aftermarket
- > Workshop solutions
- > Special original equipment

**4,500+**  
employees

**FORVIA Faurecia**

**FORVIA HELLA**

**FORVIA Faurecia & FORVIA HELLA**

**FORVIA**  
**HELLA**

# LIGHTING

## High-end lighting solutions for enhanced vehicle signature & road safety

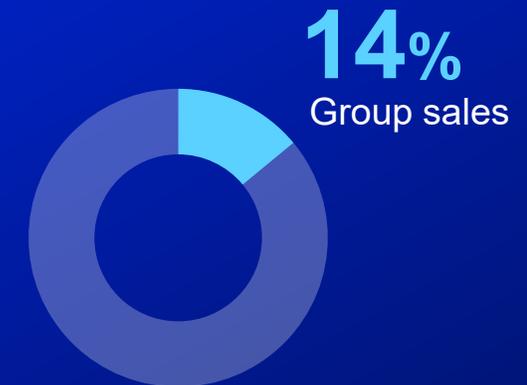
- > Headlamps (including high-resolution headlamp systems)
- > Rear combination lamps
- > Car body lighting (including radomes, illuminated logos and front pygital shields)
- > Interior lighting

**#3**

in global lighting supply



**22,000+**  
employees



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## Lighting Challenges



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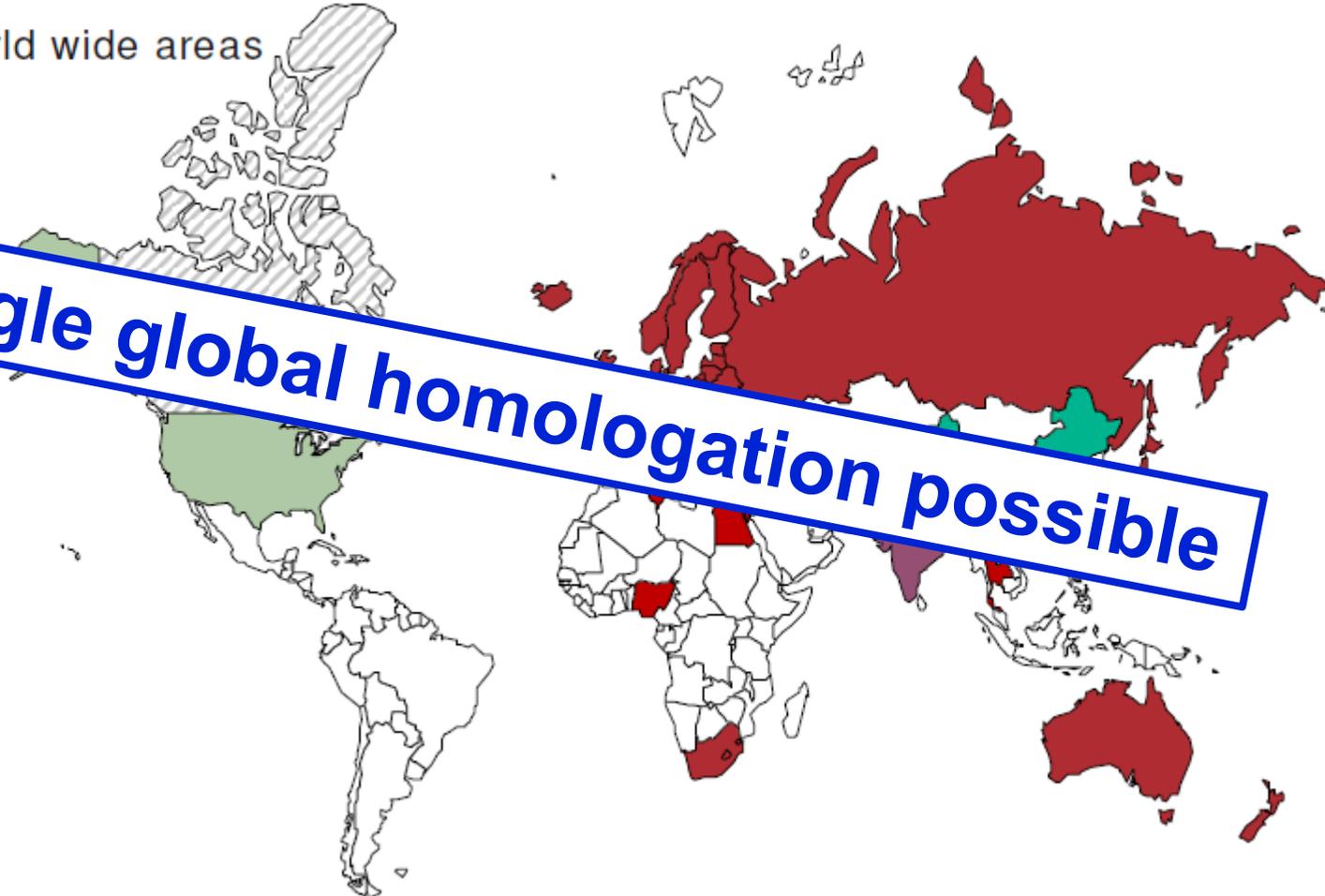
# LIGHTING CHALLENGES

A ton of legal functions and testing

Homologation – important world wide areas

**No single global homologation possible**

-  USA DOT / FMVSS
-  Canada DOT / CMVSS
-  UN-Regulations
-  CCC / GB (~UNECE)
-  India (~UNECE)
-  Korea KMVSS (~UNECE)
-  Taiwan (~UNECE)
-  National / Regional (i.e. GCC)



**ECE**  
Economic commission for Europe

**FMVSS108**  
Federal Motor Vehicle Safety Standard

**CCC**  
China Compulsory Certificate

**VSCC**  
Vehicle Safety Certification Center

**INDIA**  
AUTOMOTIVE INDUSTRY STANDARD

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## Company Forvia



## Lighting Challenges



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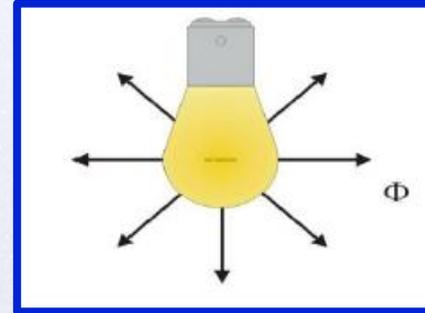
## Summary and Outlook



# PUR LIGHTING

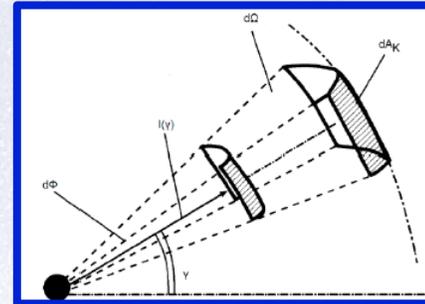
What is lighting? Fundamentals of light.

**Luminous flux (Lichtstrom) [ lm ] is the total amount of light released into the whole space.**



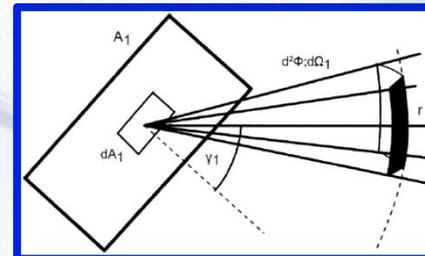
Lightsource	Luminous flux in lm
Halogen H4 low beam	350 ... 700
Halogen H4 high beam	350 ... 1000
Halogen H7	1100 ... 1200
Xenon	3200
Automotive white LED	200 ... 450
15 mW green laser (532 nm)	8,4
Sun	$3,7 \cdot 10^{28}$

**Luminous intensity (Lichtstärke) [ cd ] characterizes the luminous flux in a certain solid angle.**



Lightsource	Luminous intensity in cd
Candle	approx. 1
Filament bulb 100 W	110
Automotive white LED	30...70
High pressure sodium lamp 70 W	500
15 mW green laser (532 nm) 1 mrad divergence	$3,8 \cdot 10^6$
Sun	$3 \cdot 10^{27}$

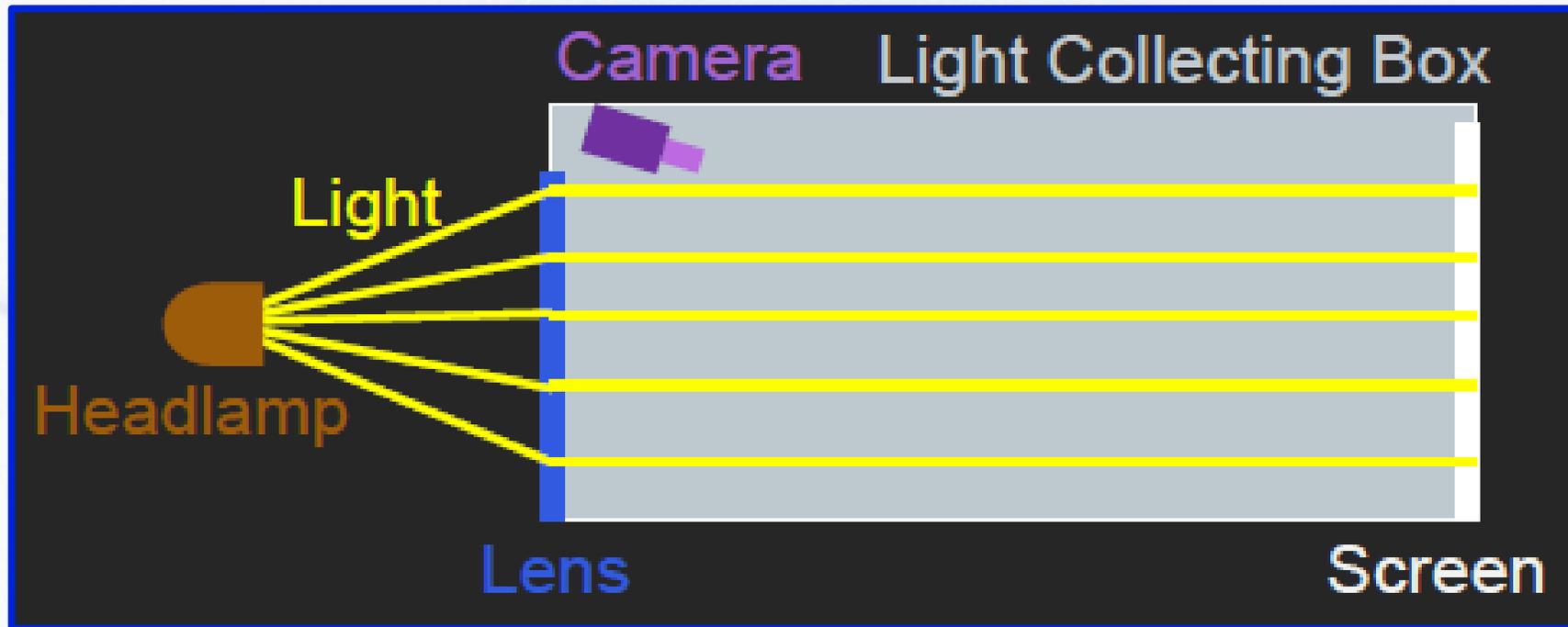
**Luminance (Leuchtdichte) [ cd/m<sup>2</sup> ] describes the luminous flux in a solid angle per projected part of surface in one direction. It is the closest way to match the human perception of brightness.**



Lightsource	luminance (Mcd/m <sup>2</sup> )
High Power LED	4 ... 14
Halogen H7	20 ... 30
Xenon	90

# PUR LIGHTING

Measurement concept - Lighting measurements of different PURs



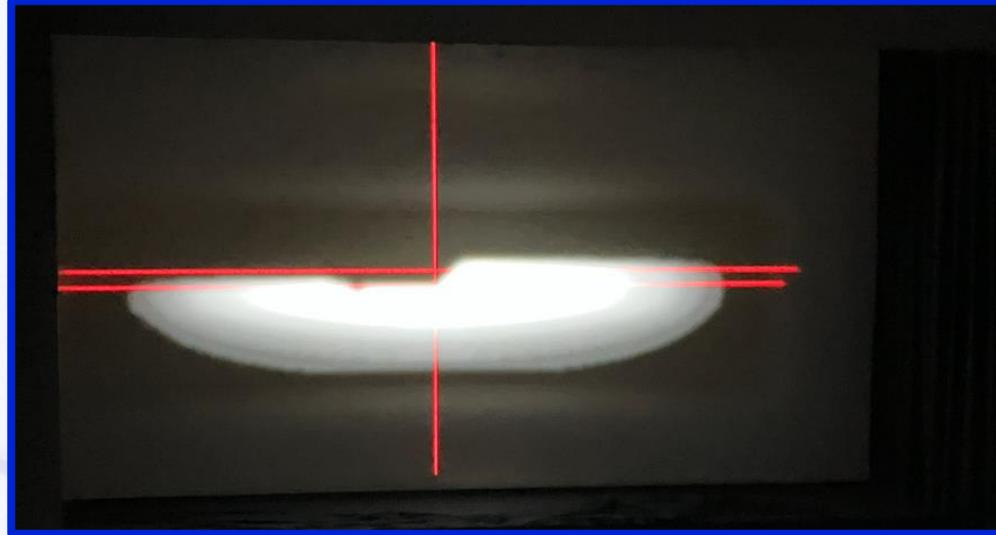
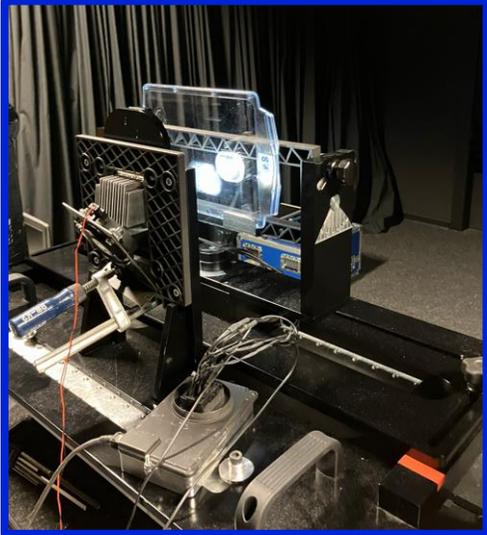
# PUR LIGHTING

Measurement concept - Lighting measurements of different PURs: Mainlight

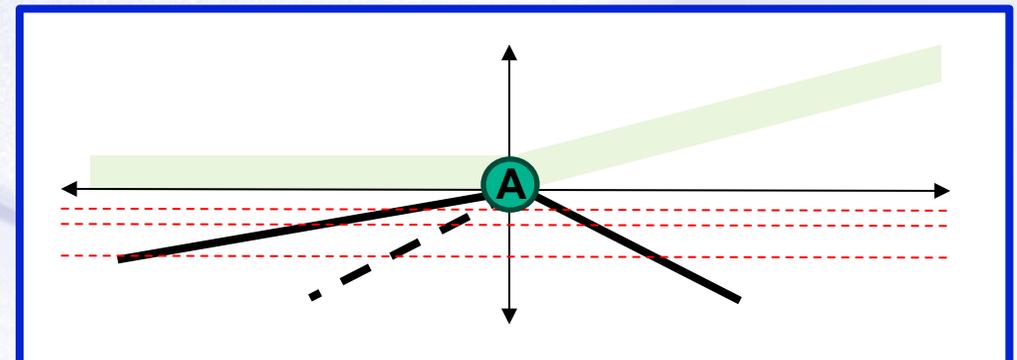
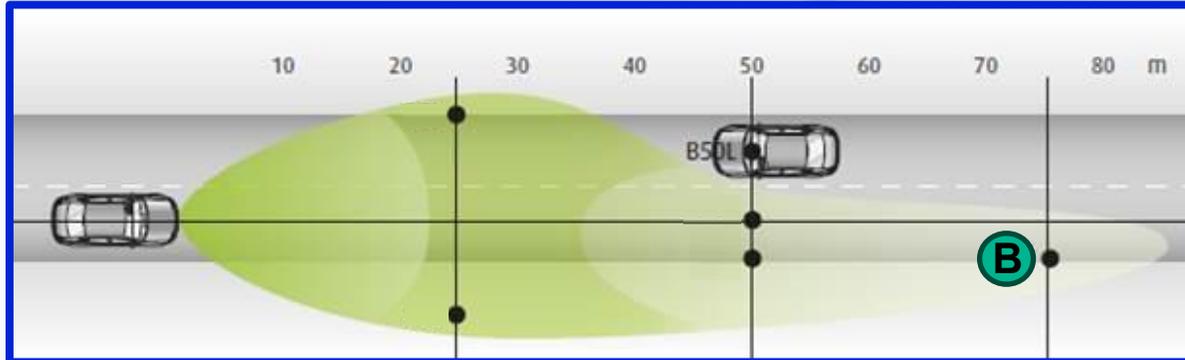
Headlamp

Sample

Screen

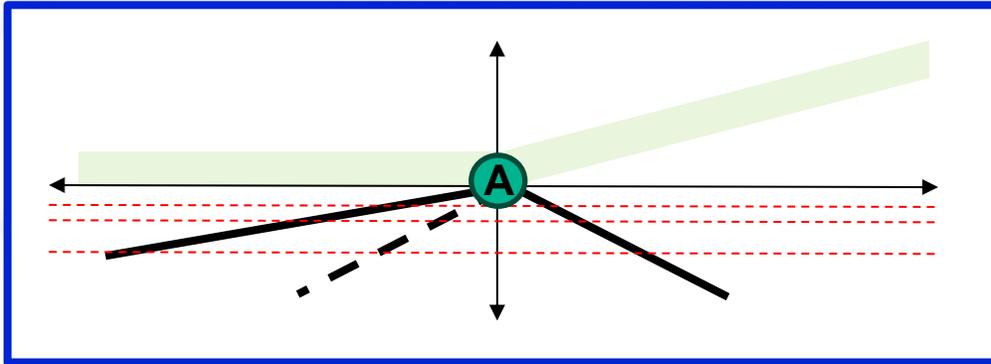


- Measuring of sample plaques
- Testing of:  
PC+PUR vs PC+HC
- Testing at nominated points
- Testing after loading

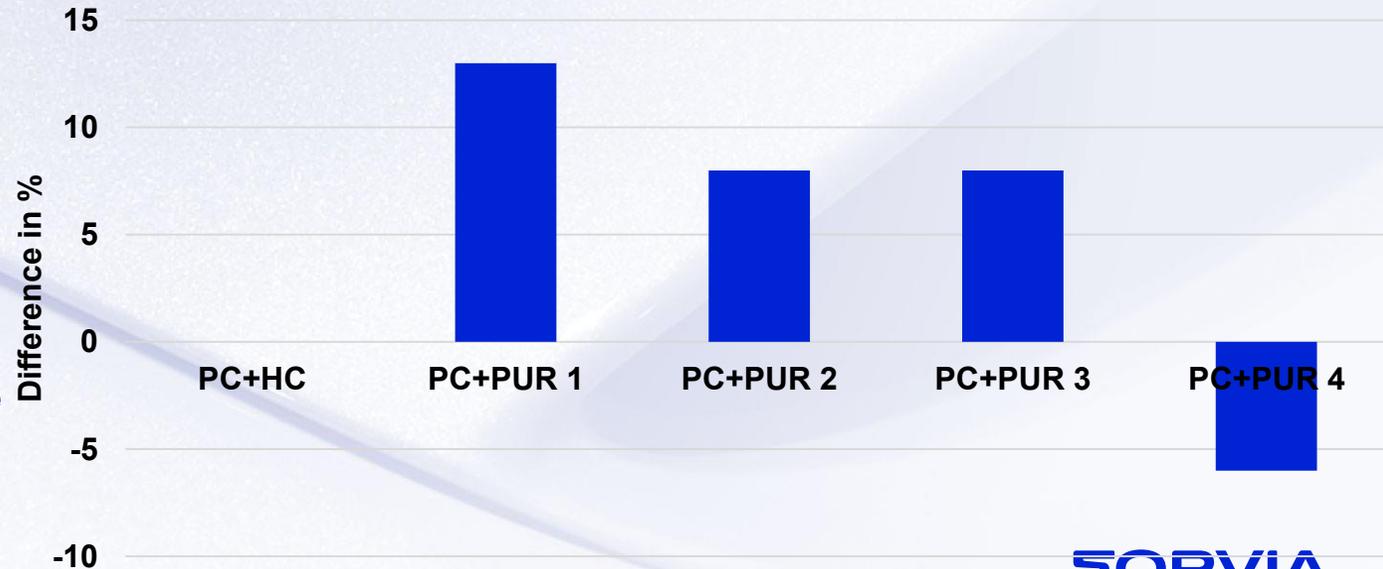
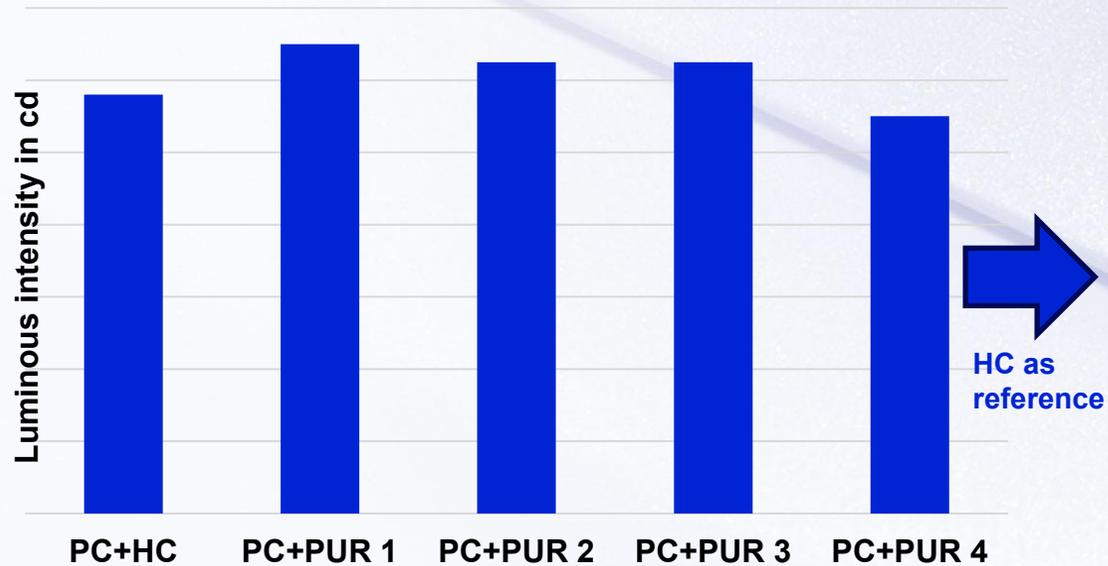


# PUR LIGHTING

Results - Lighting measurements of different PURs



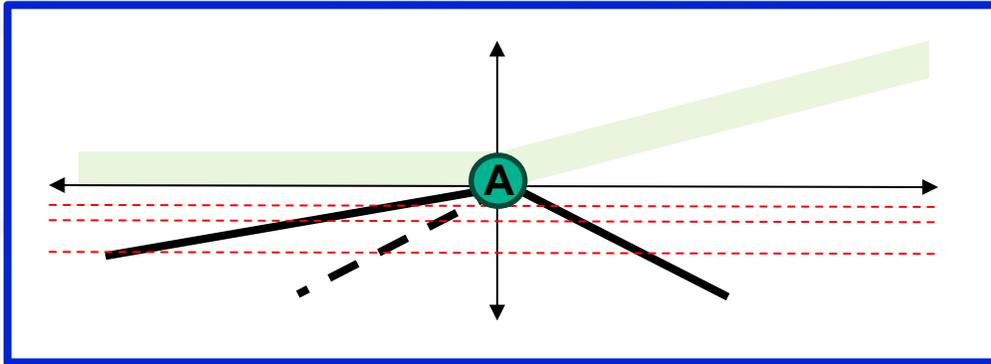
Point A



- Hardcoated PC as a reference
- Differences in PUR systems
- PUR tends to dazzle

# PUR LIGHTING

## Results - Lighting measurements of different PURs

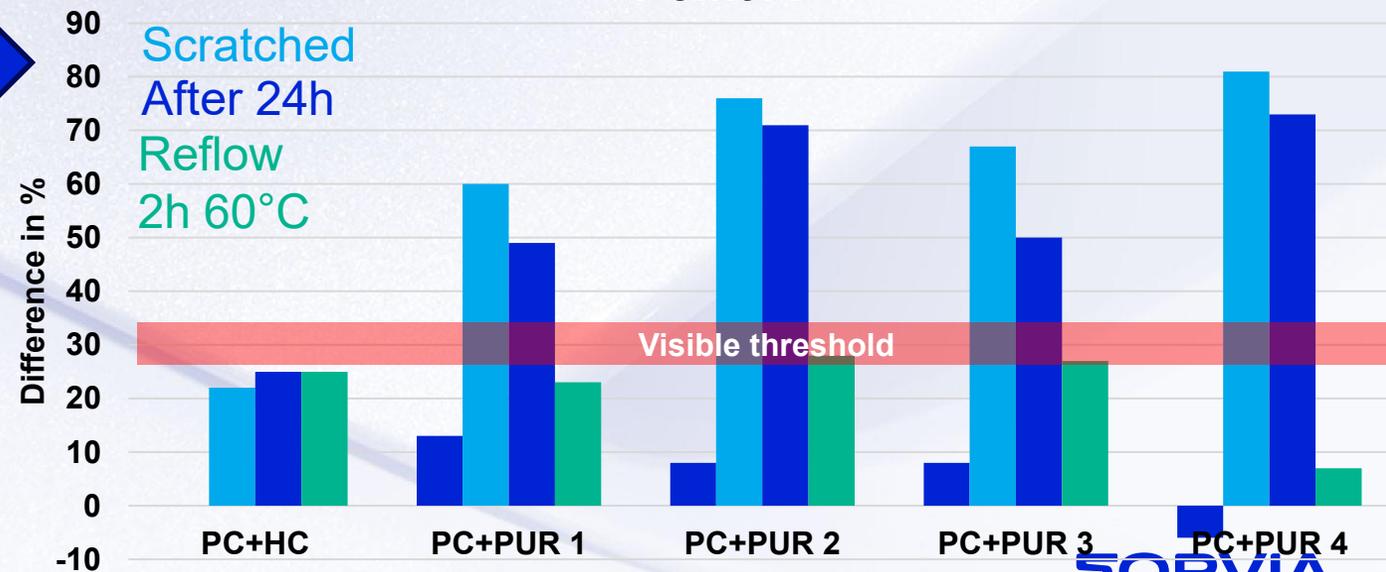
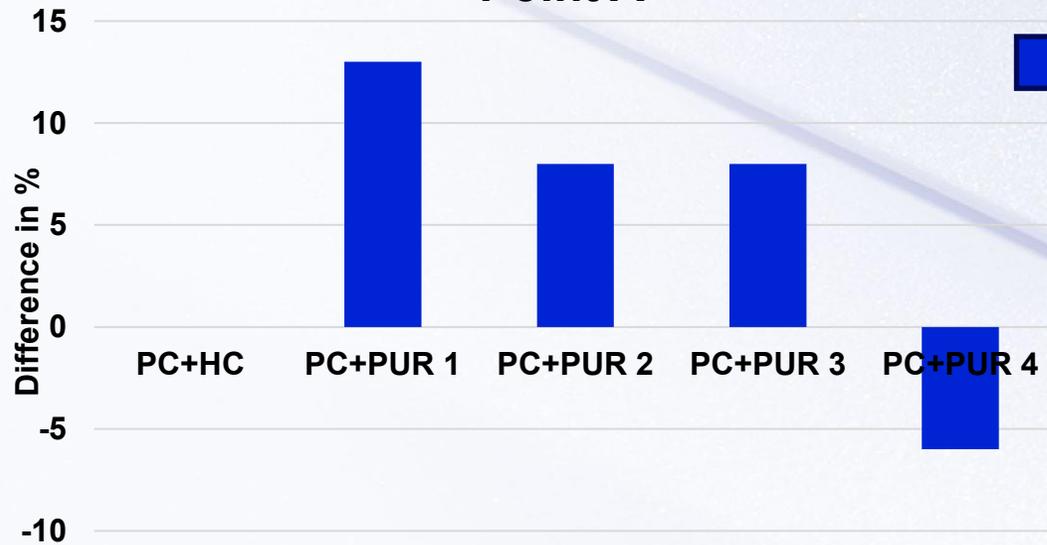


- High changes in luminous intensity
- PUR dazzles a lot after brushing
- Reflow reduces the dazzling below HC level

Point A

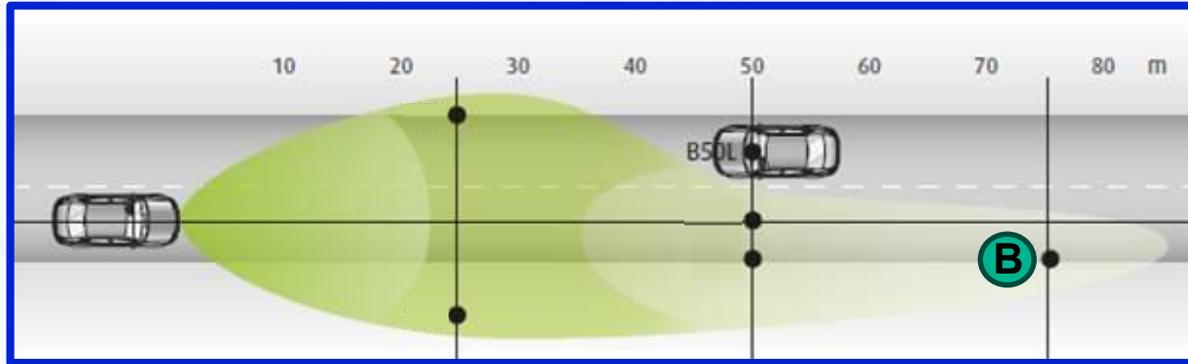
Brush test acc. FMVSS108

Point A



# PUR LIGHTING

## Results - Lighting measurements of different PURs

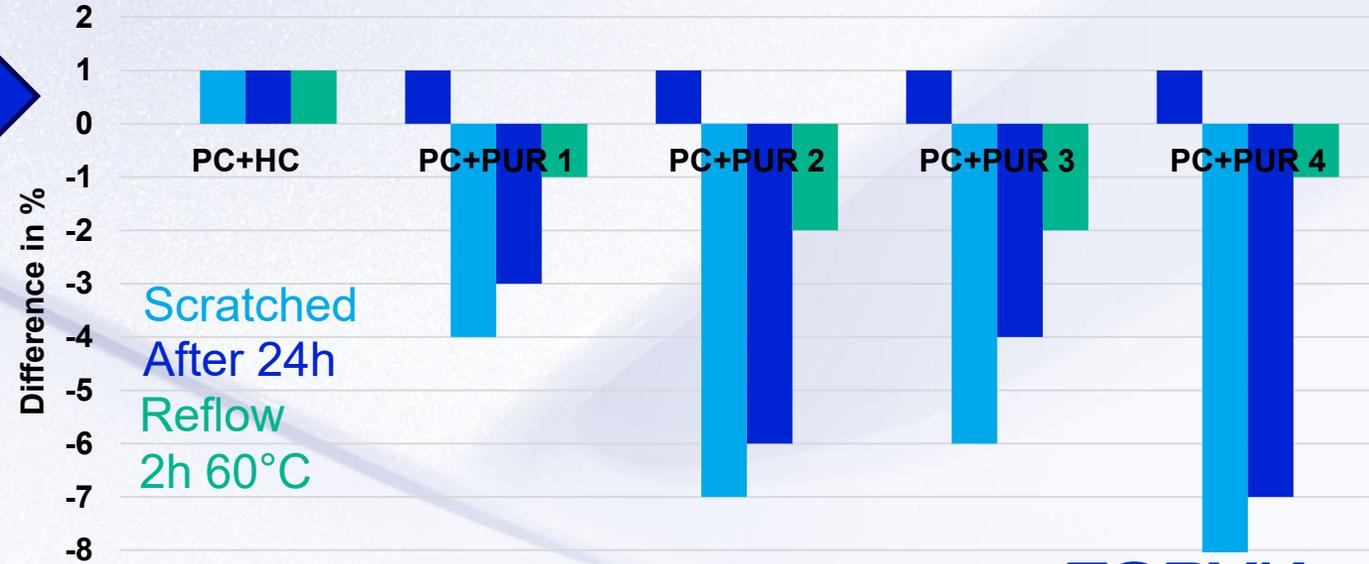
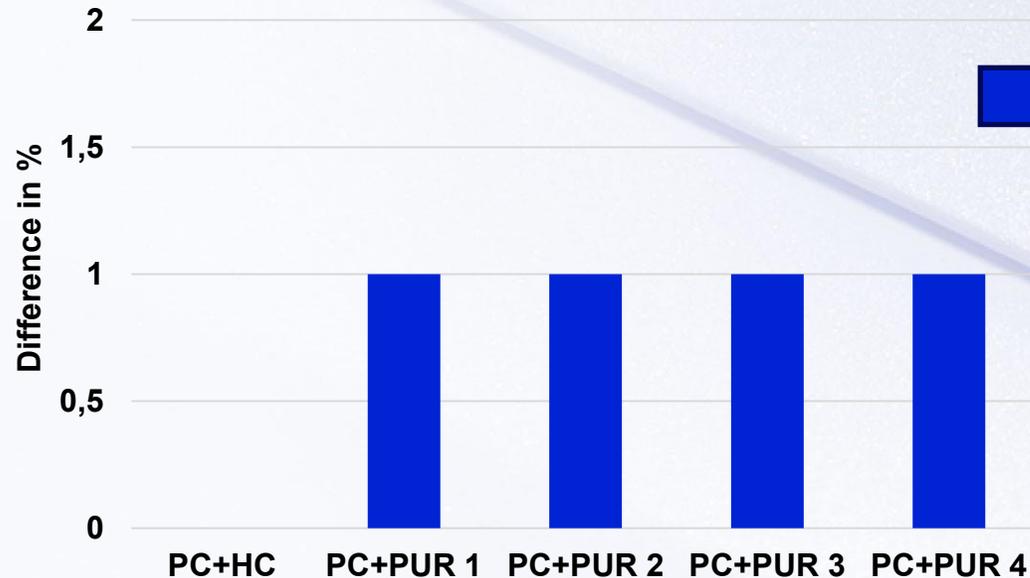


- Less differences at far sight compared to point A
- Luminous intensity of PUR is reduced after brushing
- Reflow almost eliminates differences to HC

Point B

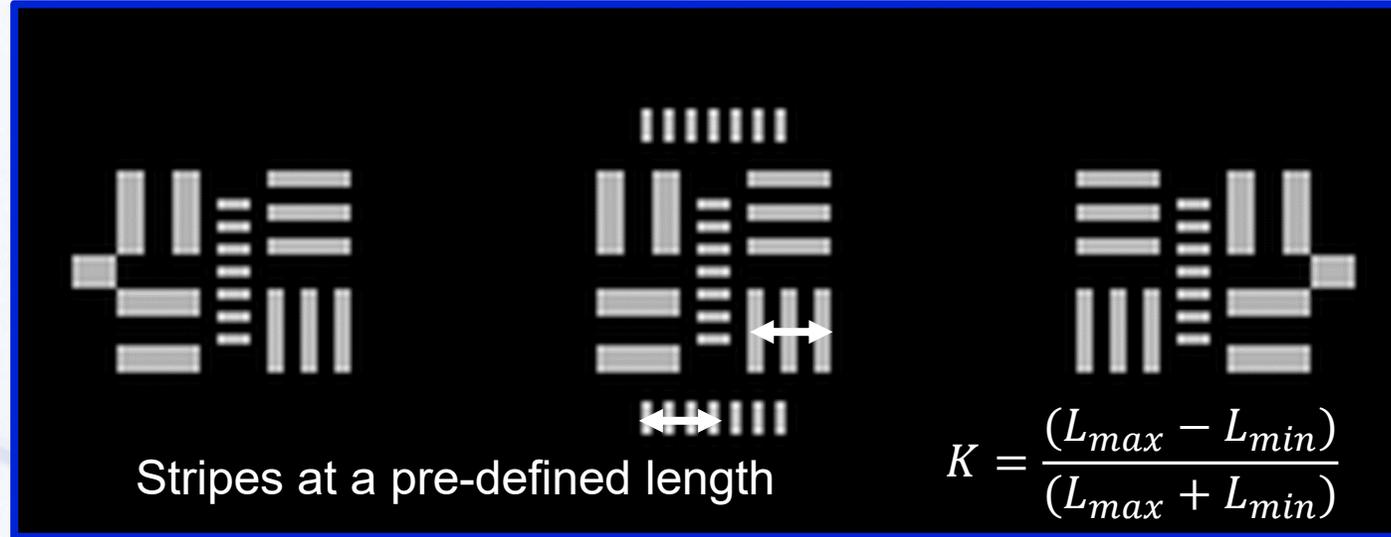
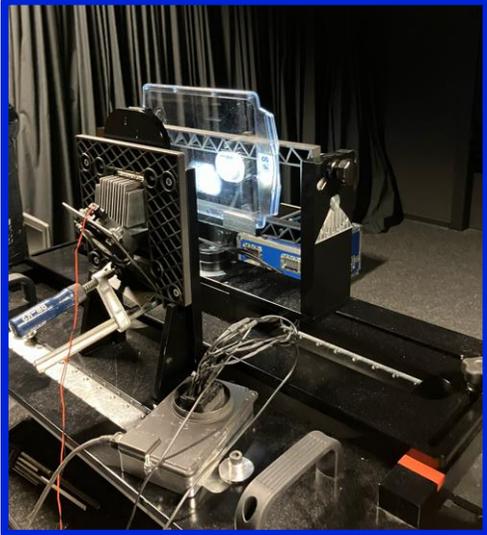
Brush test acc. FMVSS108

Point B



# PUR LIGHTING

Measurement concept - Lighting measurements of different PURs: Contrast



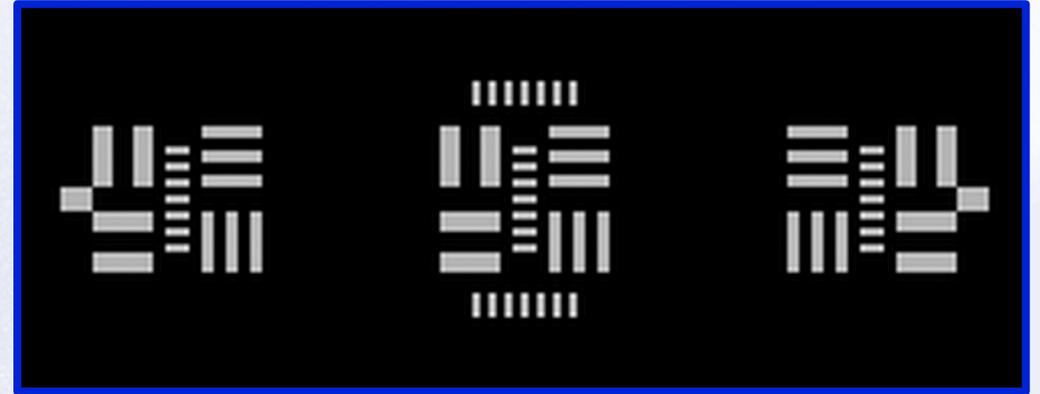
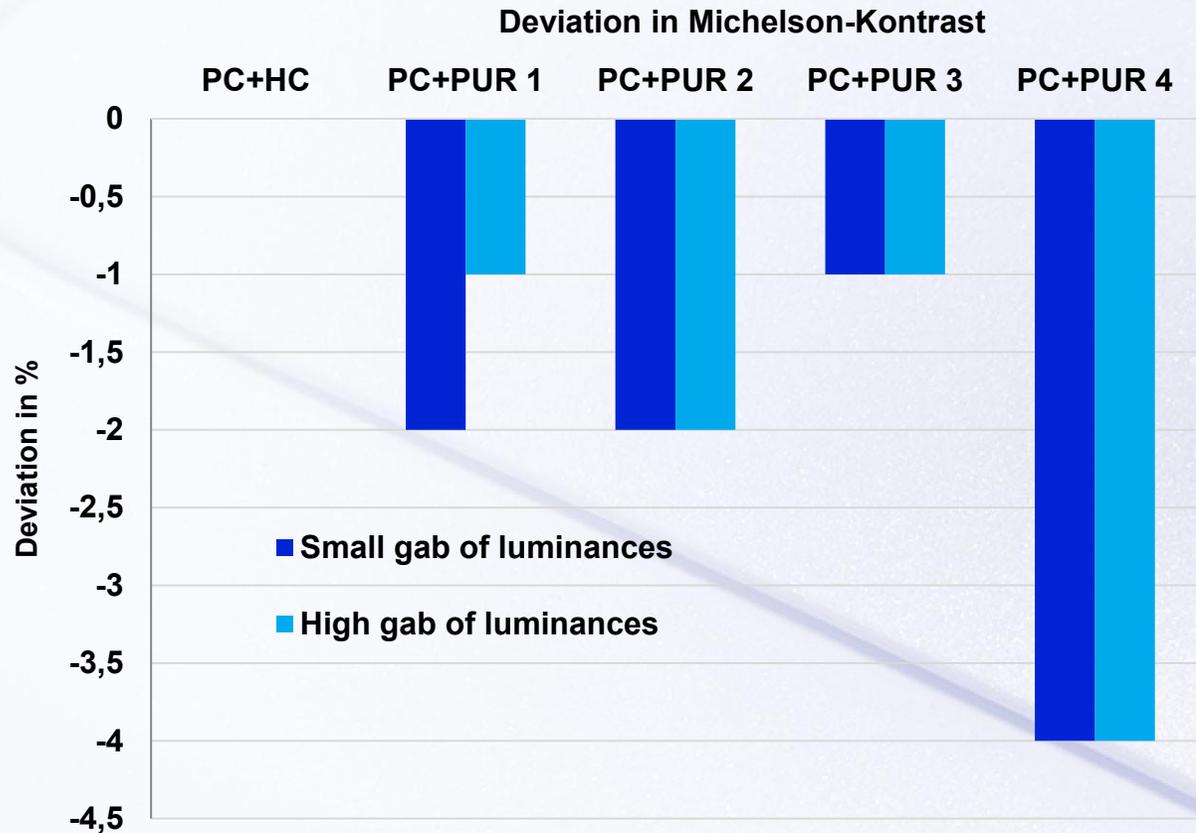
Michelson-Kontrast [ K ]

Is the **ratio between the spread and the sum of the two luminances**. This definition is commonly used in signal processing, where it helps determine the signal quality relative to the background noise. **In a visual context, such noise could be caused by scattered light**, which partially obscures the scene behind it when viewed through a translucent element.

Luminance (Leuchtdichte) [ cd/m<sup>2</sup> ] describes the **luminous flux** in a **solid angle** per projected part of **surface** in one direction. It is the closest way to match the human perception of brightness.

# PUR LIGHTING

Measurement concept - Lighting measurements of different PURs: Contrast



- Low differences in contrast between HC and PUR
- PUR got a slightly lower contrast than HC
- The contrast of polyurethanes differs
- No problem for headlamp applications so far

# AGENDA

## Company Forvia



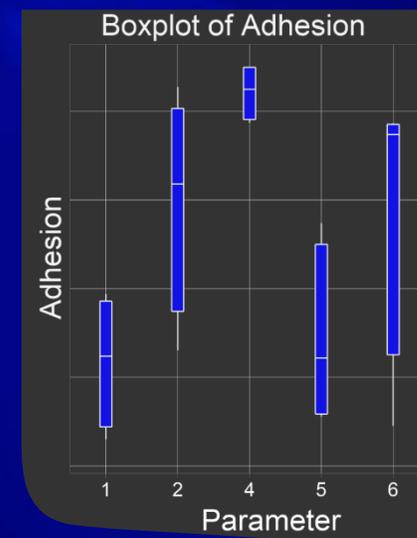
## Lighting Challenges



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# INFLUENCE OF PROCESSING

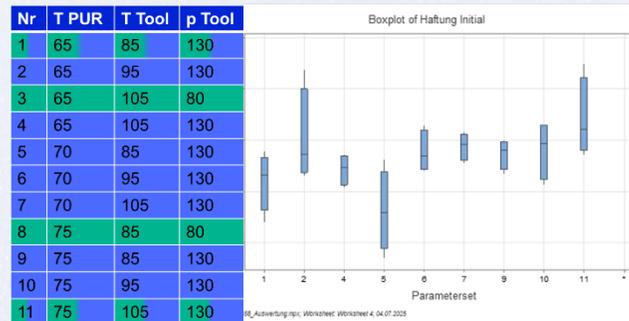
## The overview

### Machinery



- > Injection Molding Machine: Arburg Allrounder 720 S
- > Polyurethane Dosing Unit: Kraussmaffei RimStar 4/4

### Processing



- > Process variation of 11 parameters
- > Use of puroclear 4358 IT
- > Use of Makrolon IMC2477

### Sampling



- > Plaque design as shown
- > Almost 500 Plaques have been manufactured

# INFLUENCE OF PROCESSING

## Adhesion testing

### Test device



### Fracture description

**A:** Cohesion fracture in the PC substrate

**A/B:** Adhesion fracture between PC and PUR

**B:** Cohesion Fracture in the PUR coating

**Y:** Cohesion fracture in the glue

**Y/Z:** Adhesion Fracture between glue and dolly

**X:** Adhesive fracture during drilling

### Glue



### Dolly



Figure 4

a) A: Cohesion fracture in the substrate leading to a cohesive failure in the glue

b) A/B: Adhesive failure between the first coating and the substrate

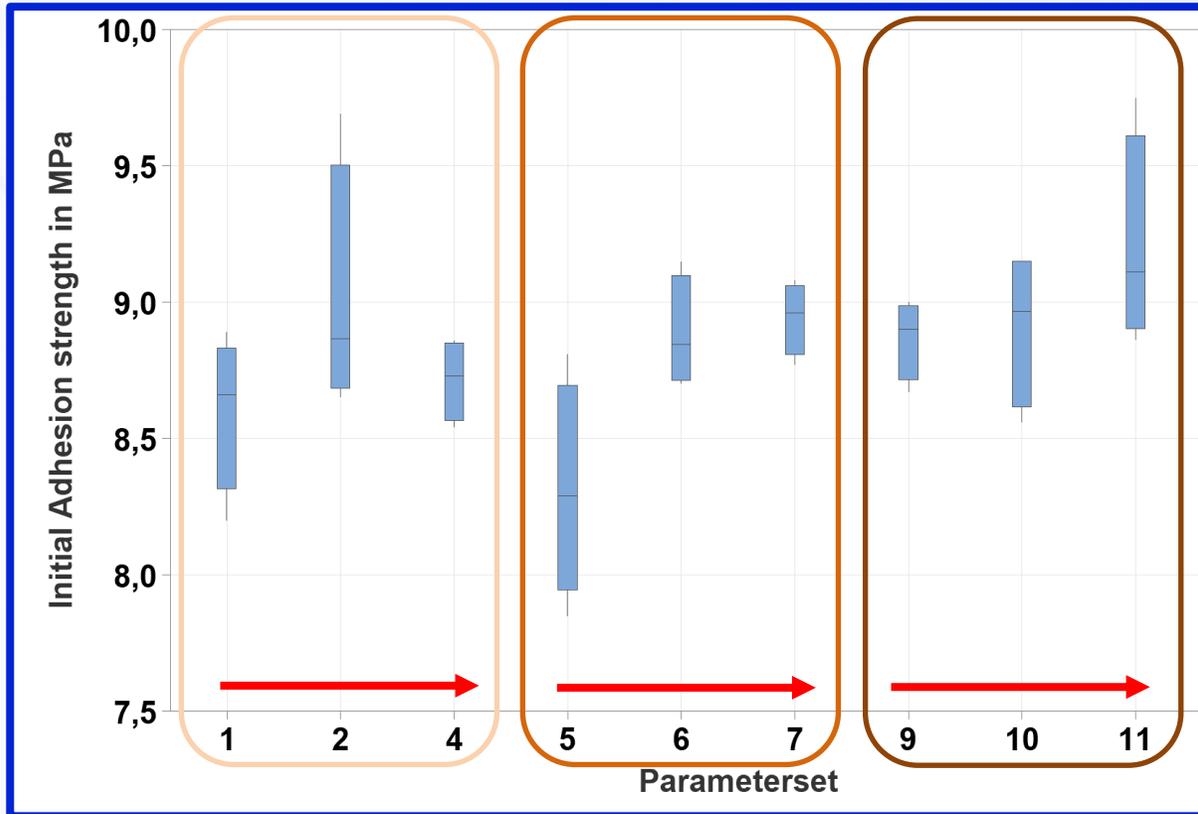
c) Y: Cohesive fracture in the adhesive

d) X: Adhesive fracture after the drilling

# INFLUENCE OF PROCESSING

## Adhesion results

### Initial testing



- Testing of five samples for each parameter set
- High levels of adhesion strength
- Every sample was above the needed threshold of adhesion strength
- All samples failed with a fracture in the PC substrate (Fracture A)

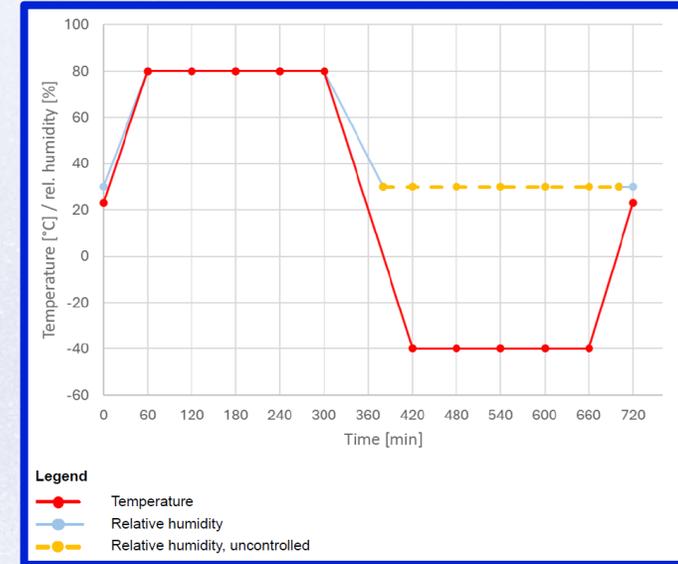
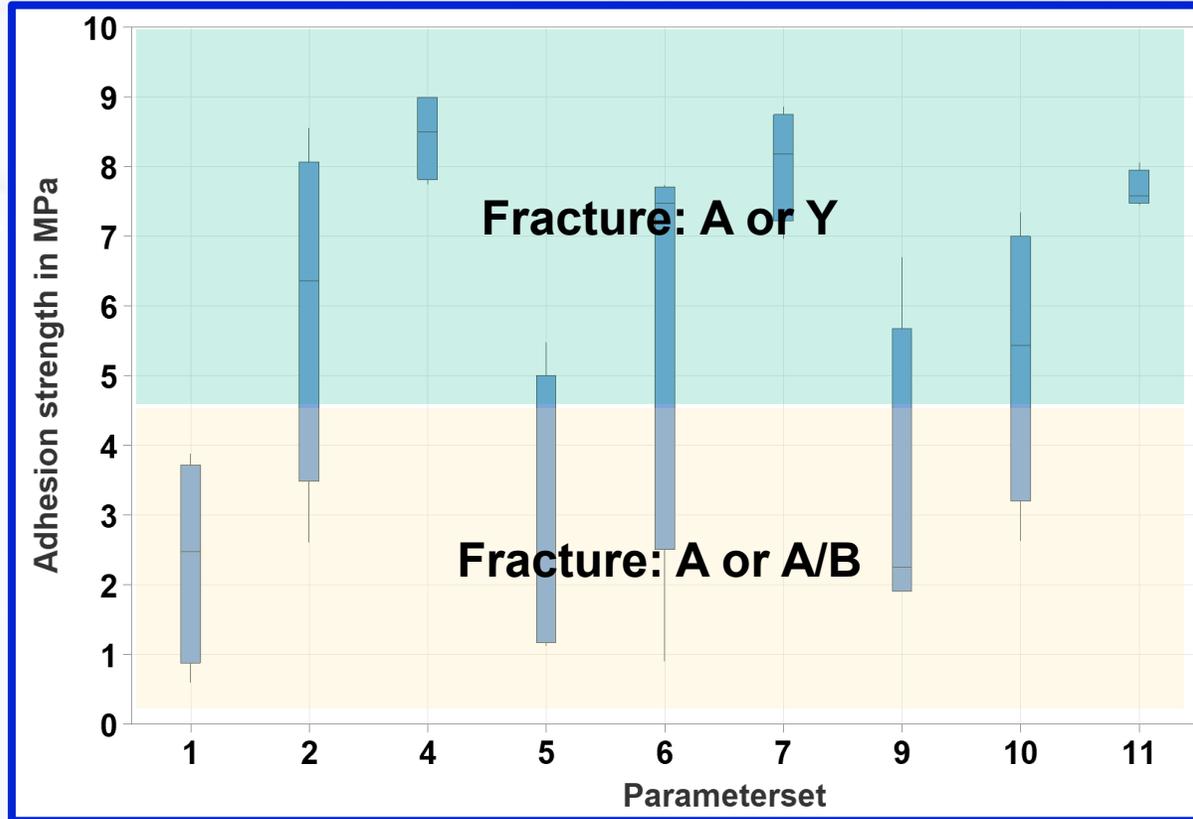
→ Rise in tool temperature 85 / 95 / 105 °C

□ □ □ Rise in component temperature 65 / 70 / 75 °C

# INFLUENCE OF PROCESSING

## Adhesion results

### Testing after climate change test



- Highest adhesion strength at high tool temperatures including small deviation
- Adhesion strength drops at low tool temperatures, which can be compensated by increasing the component temperature
- High deviation at lower temperatures

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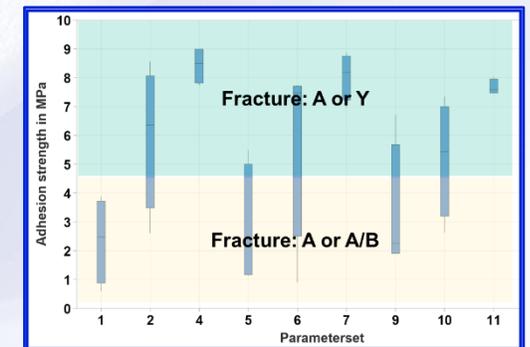
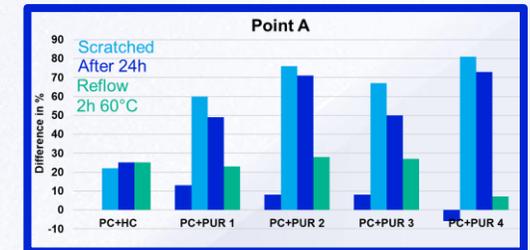


## Summary and Outlook



# SUMMARY

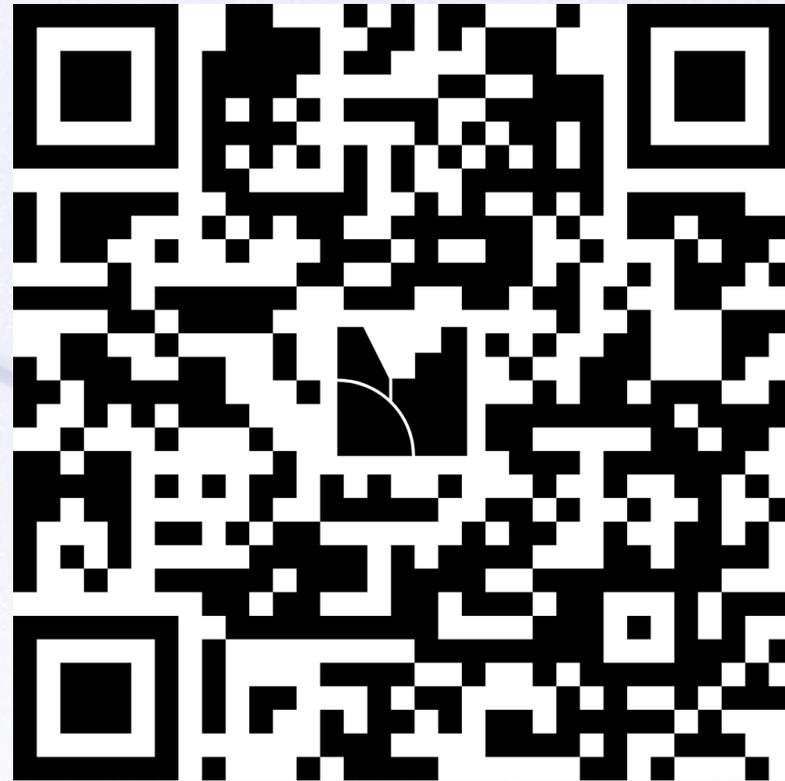
- Light properties of PUR and HC are comparable
- PUR is less resistant against surface abrasion
- The healing properties of PUR are great and can bring the lighting properties back to HC level
- Adhesion of PUR depends on the processing parameters
- Huge potential for PUR at exterior applications



# OUTLOOK

- **Light properties of PUR and HC will be compared after weathering**
- **Differences in wallthickness need to be investigated**
- **Final feasibility of PUR for headlamp applications**
- **Results of tests for legal requirements are on the way**
- **A lot of interesting investigations are planned**

# YEAR OF FIRST HEADLAMP WITH PUR ON THE STREET?



**FORVIA**

