DVN Workshop

21-22 September 2021

Precision Molded Glass Lenses with Application to Automotive HD-Pixel Light Systems

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DOCTER® OPTICS

AGENDA

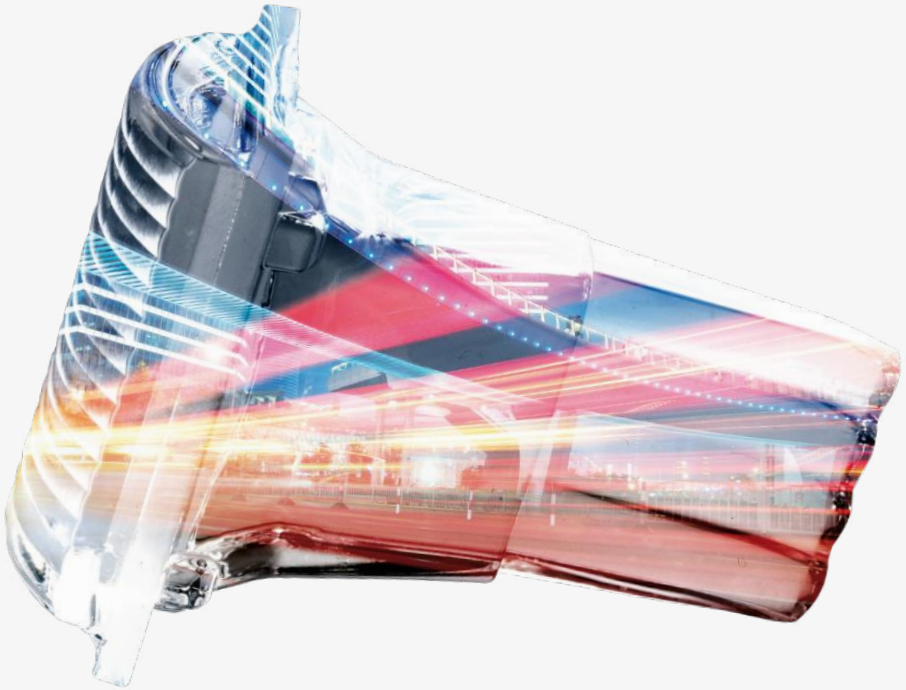
1 Introduction into Classic Head Lighting Systems and LED Matrix Light

2 Pixel Light System

3 Precision Ready Molded Glass Lenses DOCµTEC®

4 Future HD Pixel Light Systems Hybrid Aspheres

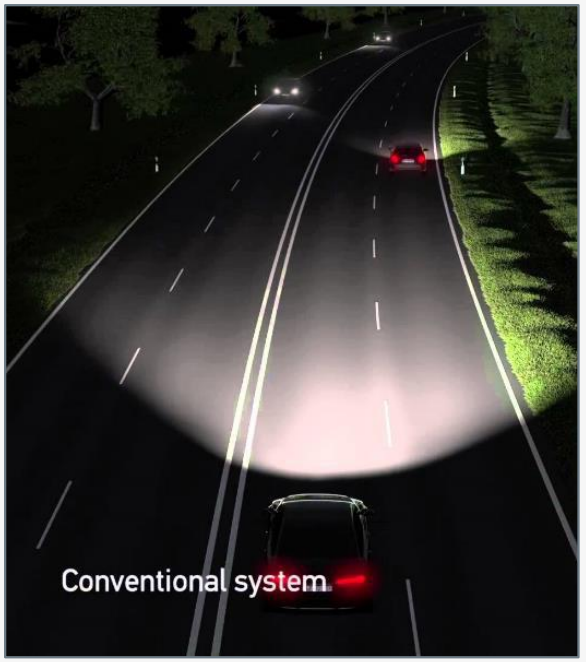
5 Summary



1 INTRODUCTION

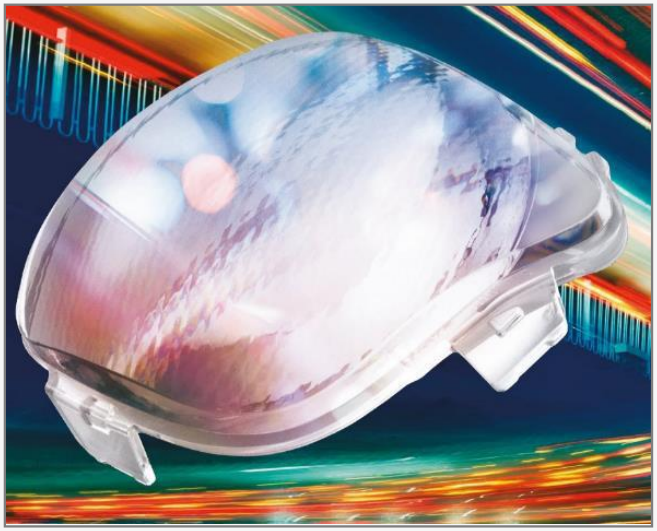
INTRODUCTION
Classic Headlights

- Classic headlights generate static light distributions
- Optical systems/ illumination unit for specific scene illumination:
  - Low beam
  - high beam
  - Fog light
- Additional function, as for example, sign illumination can be included in lenses



Source: Docter Optics SE

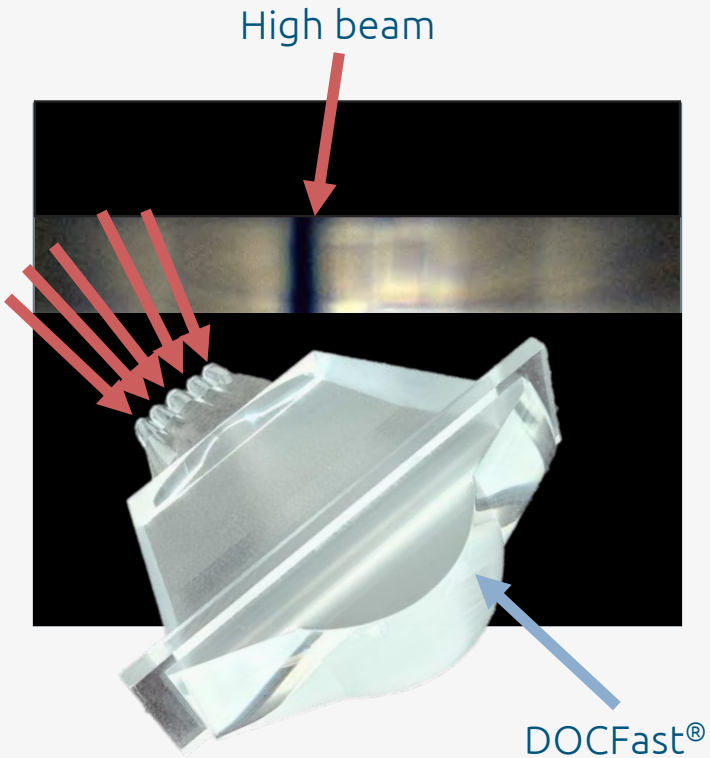
INTRODUCTION
Classic Headlights



- Illumination unit uses single aspherical glass or polymer lenses
- Typically, shapes are round, rectangular or customized
- Typically, accuracy is low for the optical surface requirement

  → deviation of surface form: 200µm Peak to Valley (±100µm)

INTRODUCTION
LED Matrix Light

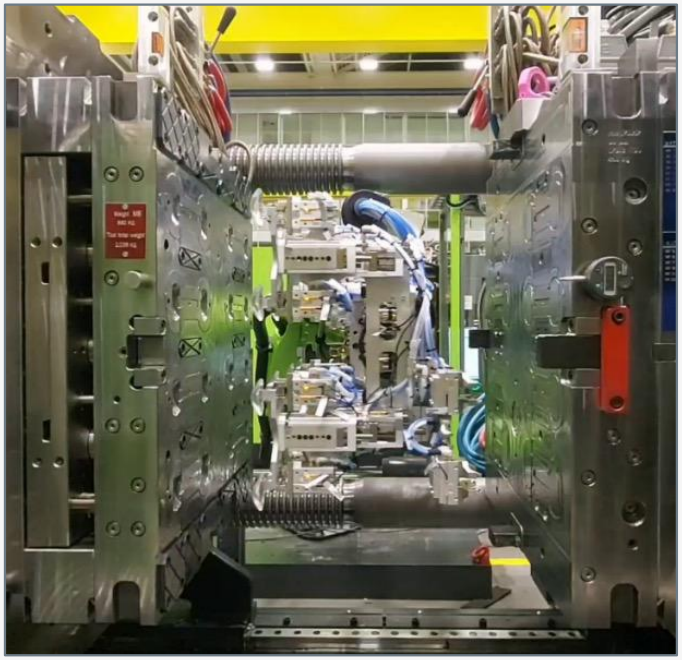


Dynamical switching between different light sheets

- LED Matrix Light
- Multi channel lenses made of polymer or glass
- One pcs lens generates multiple light sheets (patterns)
- Single LED per light channel
- Dynamic switching of light sheets by switching LEDs on and off

INTRODUCTION
Injection molding

- Manufacturing of aspherical lenses and multichannel lenses at Docter Optics
- Manufacturing includes
  - Polymer injection molding (see figure)
  - Ready molded aspherical glass lenses
- Ready molded aspherical glass lenses enables high volume at reasonable costs
  - No grinding required
  - No polishing required



Source: Docter Optics SE

INTRODUCTION
In-House Glass Production

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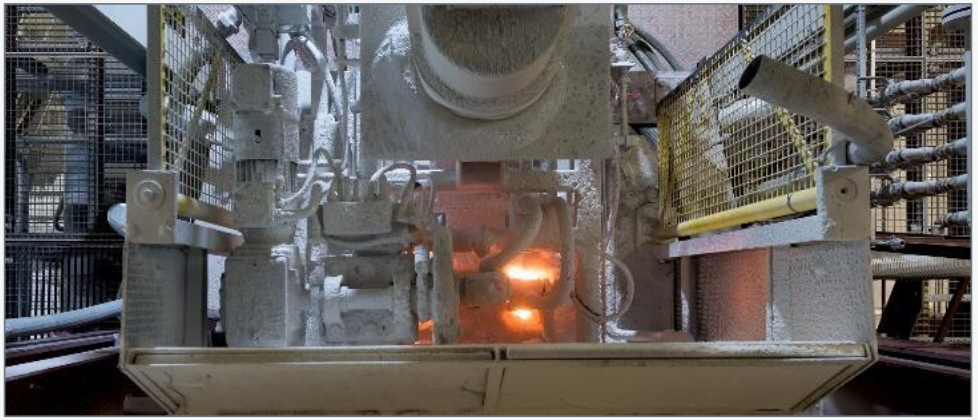
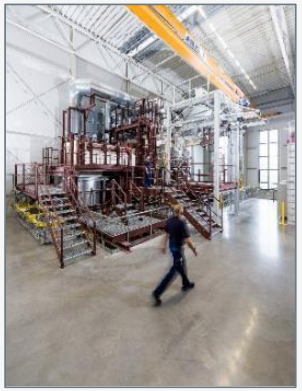



2 PIXEL LIGHT SYSTEM

PIXEL LIGHT SYSTEM

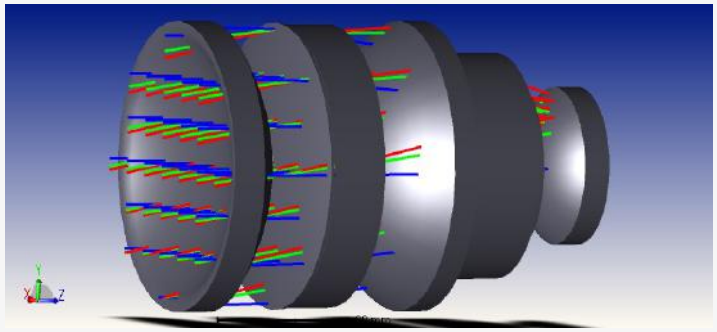
- Dynamic scene illumination
- Used for low and high beam
- Dynamic line and pattern projection

  → requires pixel light with several 1000 -10000 of individual pixels

- Pixel sources as for example as LED pixel matrix, DMD

Source: Mercedes Benz

PIXEL LIGHT SYSTEM

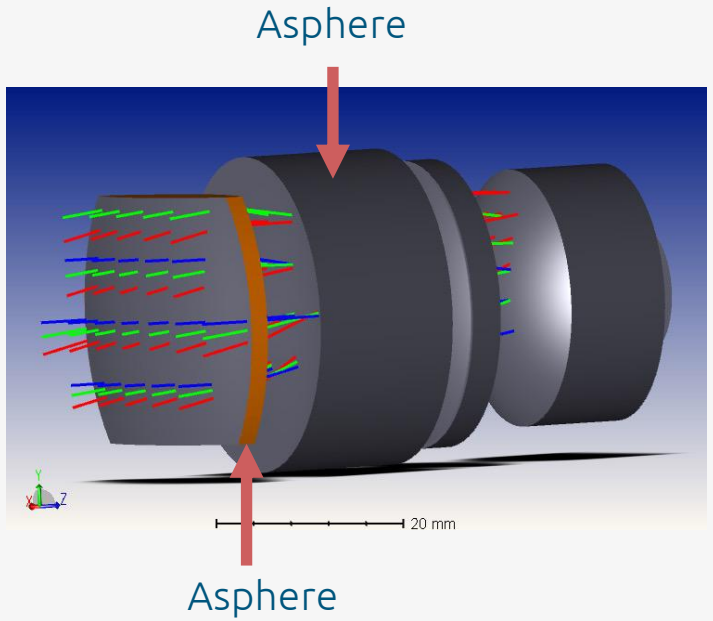


Optical design of headlights with spherical lenses

- HD Pixel light requires objective lenses with high efficiency (low F#)
- Standard for automotive lens systems (camera, LIDAR) are objectives with spherical lenses
- Requires up to 7 spherical lenses depending on optical performances and resolution
- Optical systems with only spherical lenses are quite bulky
- Not appropriate for headlights

PIXEL LIGHT SYSTEM

- Aspherical polymer and glass lenses allow reduction of number of lenses (7 to 4 lenses depending on required optical resolution and performance)
- Molded aspherical glass and polymer lenses enable customized geometries of front lenses
- This presentation focuses on molded aspherical glass lenses
- Optical surface accuracy of aspherical lenses must be increased by factor 10 compared to classic headlighting systems
  - → therefore, surface form deviations must be reduced from 200µm to 20µm peak to valley



PIXEL LIGHT SYSTEM
Simulated Test Image with 20 µm PV (±10µm)

Simulated test image of pixel light with 160 x 80 pixels

Smallest test structures
partially resolved

3 PRECISION READY MOLDED GLASS LENSES

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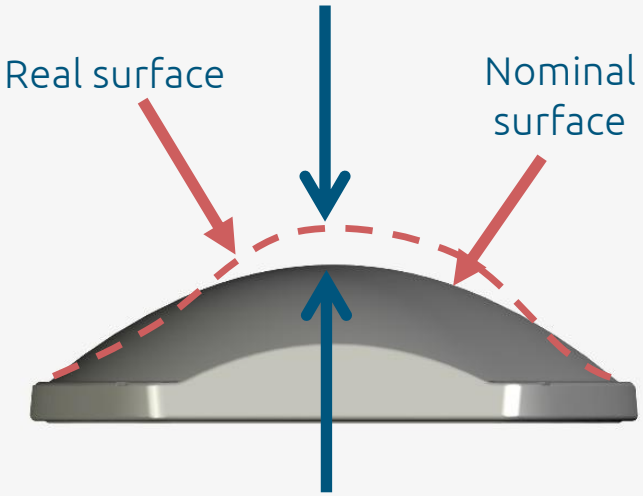
PRECISION READY MOLDED GLASS LENSES



Surface form deviation is the difference between nominal and real surface. The maximum deviation is called Peak to Valley.

- Optical lens surfaces must be accurate to have a good optical performance and resolution
- Precision ready molded aspherical lenses means
  - Optical surface accuracy must be increased by factor 10
  - Surface form deviations must be reduced from 200µm to 20µm (±100µm to ±10µm)
  - customized mechanical shapes to the front lens
  - without any further rework as grinding or polishing
  - high volume products at reasonable costs
  - Improvement of patented molding process
  - Good temperature stability

PRECISION READY MOLDED GLASS LENSES
Production Process

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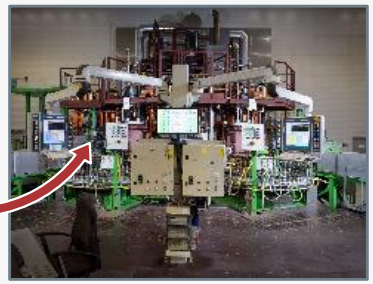
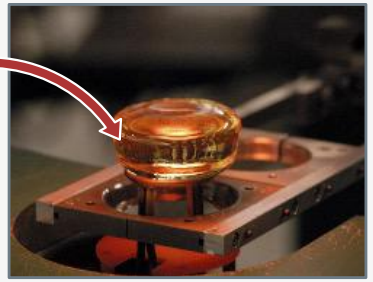
Shaping Preform



Molded Preform

Pickup Preform

Heating Preform



Double Side Precision Molding

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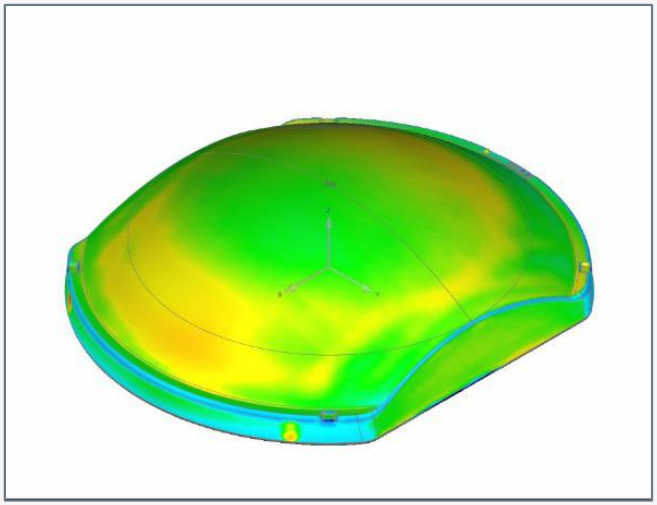
Ready Molded Lens

PRECISION READY MOLDED GLASS LENSES
Production results



- Colors indicates surface form deviations
- Measured surface form deviation of molded lens PV ≤ 20µm (±10µm)

  → Pixel Light Ready Component by Doctor Optics

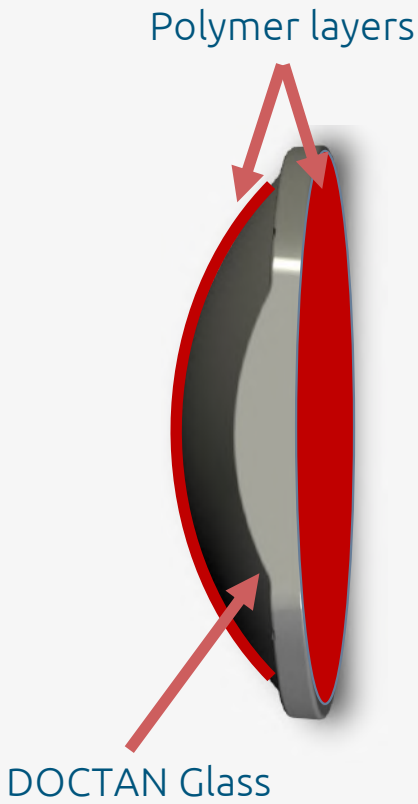
4 FUTURE HD PIXEL LIGHT SYSTEM HYBRID ASPHERES

FUTURE HD PIXEL LIGHT SYSTEM

- requires a further significant increase in optical performance in:
  - Resolution
  - MTF (Modulation Transfer Function)
- Several 10.000 individual pixels required
- Increase of optical performance requires an increase of surface accuracy by around factor 100
  - → Surface form deviation must be reduced from 200µm to 3 µm Peak to Valley
- Further reduction of number of optical and mechanical components desired

Source: Mercedes Benz

FUTURE HD PIXEL LIGHT SYSTEM
Hybrid aspheres



- Aspherical molded lens with polymer layers ➔ currently under development
- Polymer layer used for compensation of surface deviations for example caused by shrinking after cooling:
  - further increase of precision regarding surface form deviation in high volume processes
  - Reduction of time to market
- Polymer layer enables integration of additional optical functions, as for example:
  - diffractive lenses for reduction of color shift
  - micro structured diffusers
  - anti-reflection nano-structures
- Additional optical functions allow reduction of optical components in system

FUTURE HD PIXEL LIGHT SYSTEM

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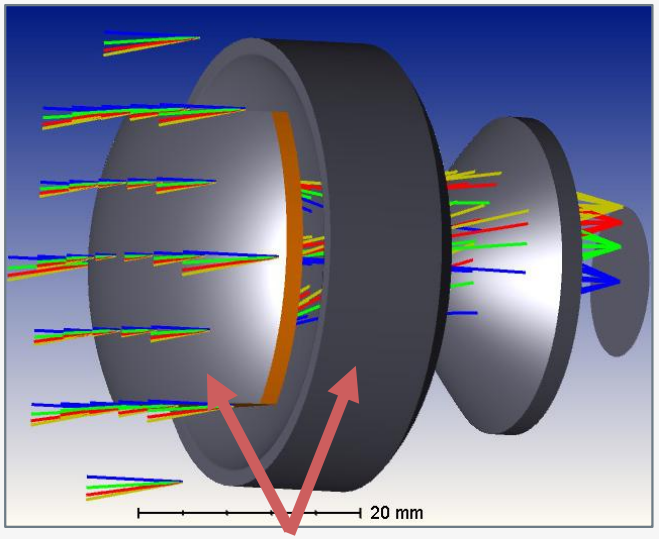
Lens System with increased performance and micro structured surface

- Optical system with doubled resolution (320 x 80 pixels) and reduced number of lenses, enabled by
  - Optical design with 3 molded Hybrid aspheres with polymer layers.
  - Two surfaces contain diffractive lens microstructures for color shift corrections
- Increase of optical surface accuracy by factor 100

  → This means surface form deviations have to be reduced compared to classic headlights from 200µm to 3µm



Aspheres with diffractive surface

FUTURE HD PIXEL LIGHT SYSTEM
Simulated Test Image with 3 µm PV (±1.5µm)

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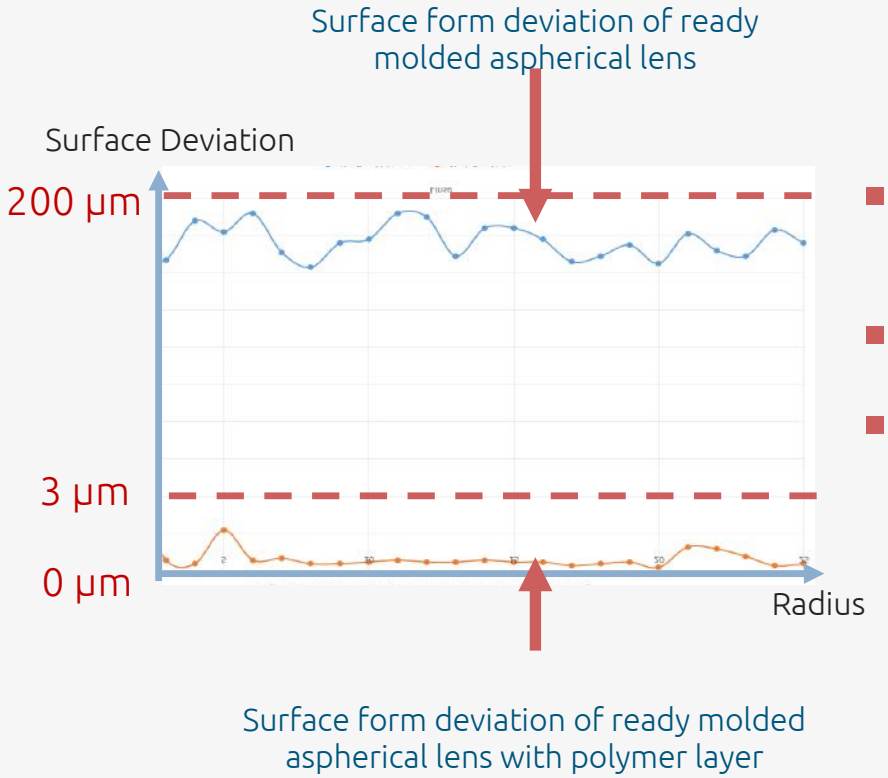
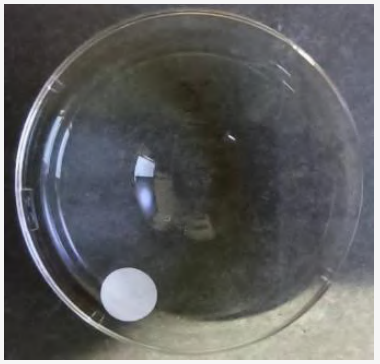
Simulated test image of pixel light with 320 x 80 pixels

Smallest test structures
fully resolved

FUTURE HD PIXEL LIGHT SYSTEM
Production results



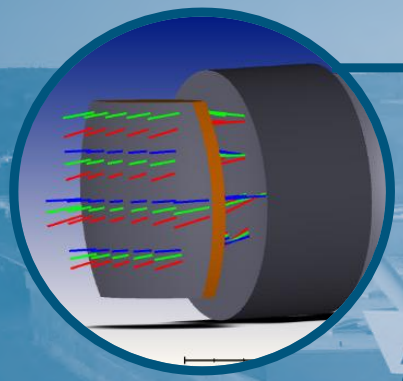
- Molded aspherical lens with OrmoComp polymer layer for shrinking compensation
- Reduction of surface form deviation from 180µm to 3 µm
- Left figure: Measured surface form deviation of polymer surface



5 SUMMARY

SUMMARY

- HD Pixel headlighting can more than 10.000 individual pixels
- Optical systems for the projection of the pixel matrix require precision aspheres for
  - Reducing number of optical components in system
  - Getting compact optical systems non-bulky
  - Very good optical performance and very good temperature stability
- Precision ready molded aspheres enable high volume production at reasonable cost
- Hybrid aspherical lenses with polymer layers enable an increase of surface accuracy and allow often a reduction of optical components.



- Optical and Mechanical Design

- Ready Molded of Polymer- and Glass Lenses

- Assembly of Optical Systems

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