

Latest LED light source solutions, driving enhanced safety for all

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Lumileds Headlighting source solutions, enhancing safety for all !

❖ Digital Beam



❖ Premium ADB

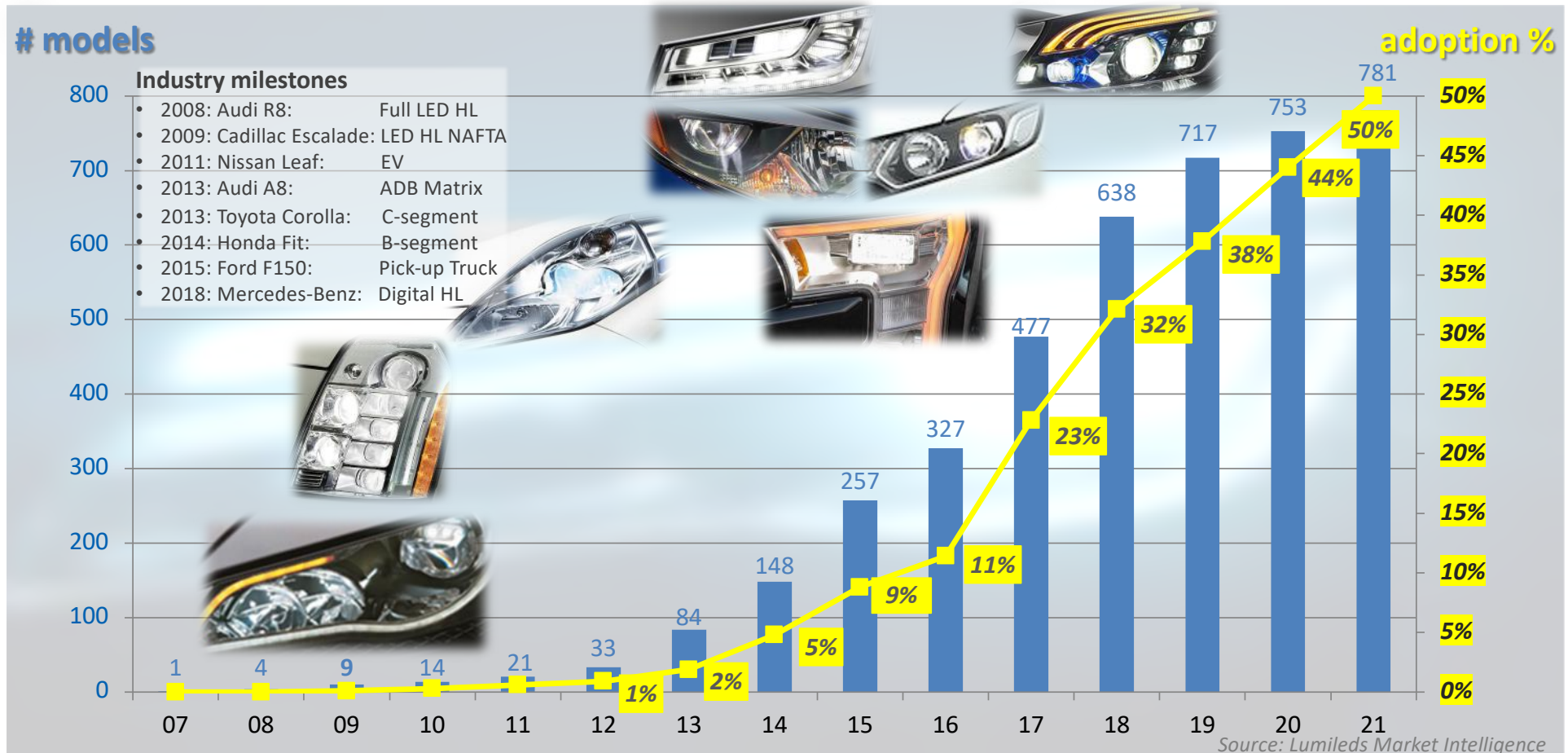


❖ Mainstream ADB

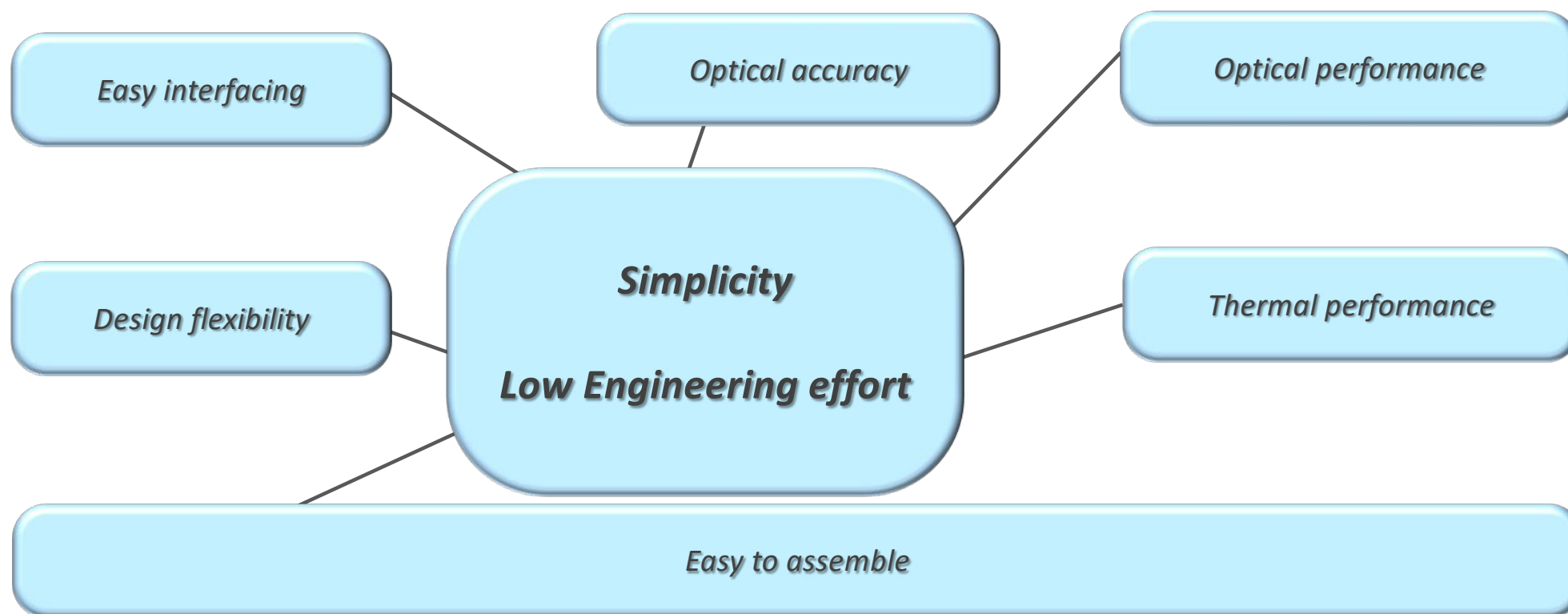


❖ Cost effective Mainstream LED Headlighting

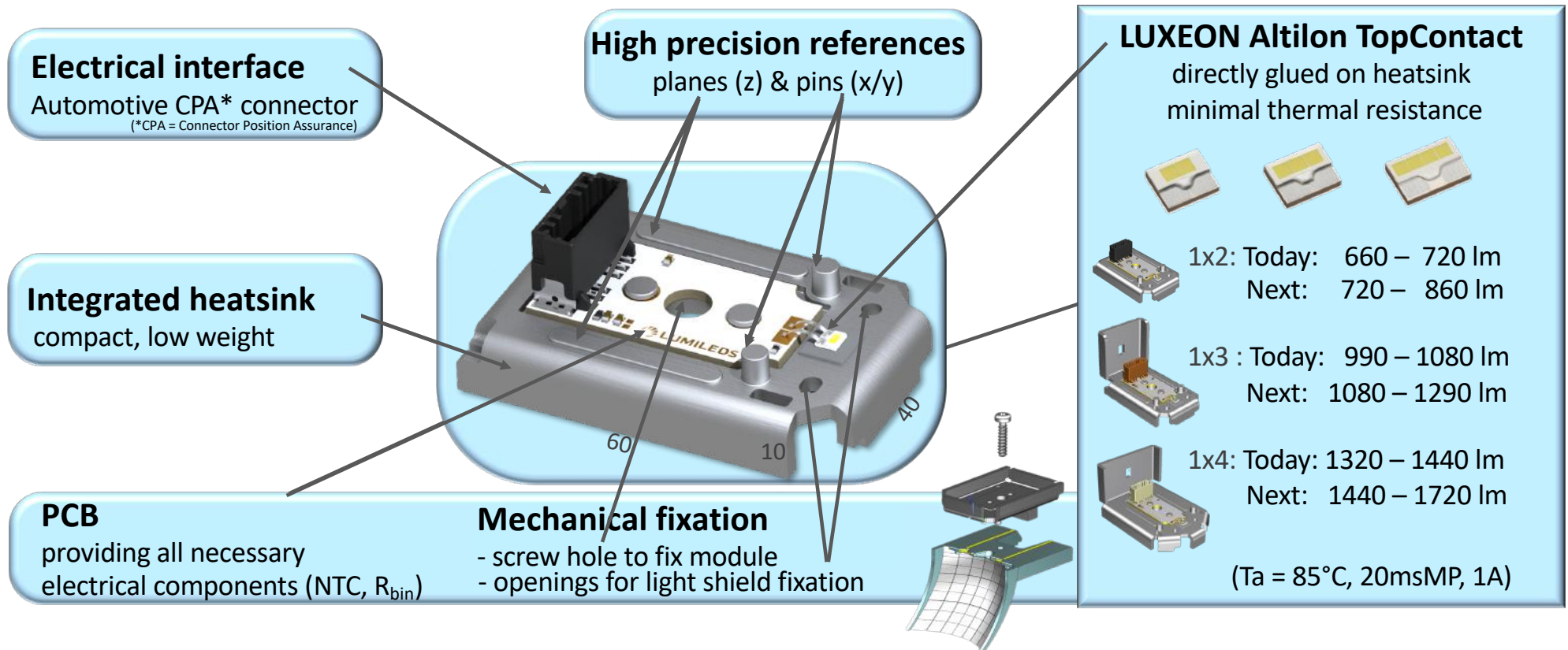
LED Headlighting has reached global market majority adoption



Mainstream adoption: realizing fast Time-to-Market, Cross Platform roll-out



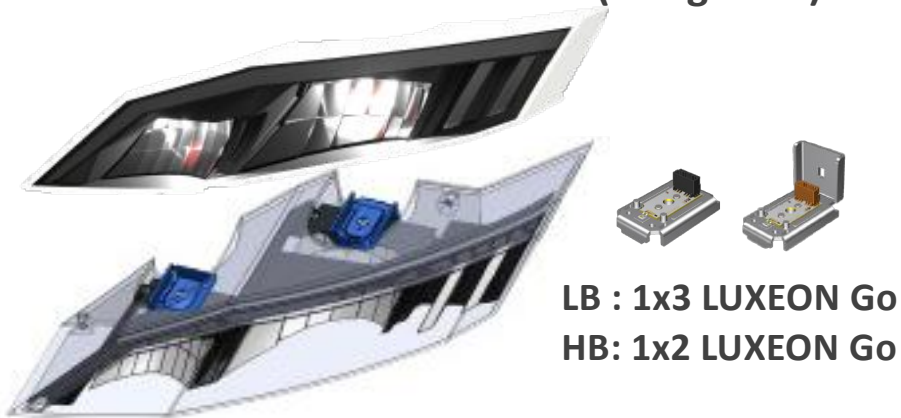
LUXEON Go, Standardized LED Headlighting module solutions



Application case examples

breakthrough in total system weight reduction

Case 1: Lower Mainstream Car (B segment)



Low beam

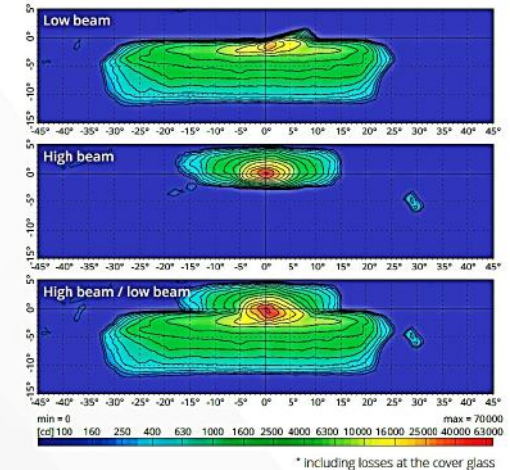
- 1 × LUXEON Go 1x3 at 1 A, 1000 lm @ $T_a = 25^\circ\text{C}$
- Flux in beam*: 472 lm
- Optical efficiency*: 47%
- Meets ECE requirements

High beam

- 1 × LUXEON Go 1x2 at 1 A, 667 lm @ $T_a = 25^\circ\text{C}$
- Flux in beam*: 297 lm
- $I_{\text{max}}^* = 64000\text{ cd}$
- Optical efficiency*: 45%
- Meets ECE requirements

Combined high beam / low beam

- Flux in beam*: 769 lm
- $I_{\text{max}}^* = 66000\text{ cd}$
- Optical efficiency*: 46%



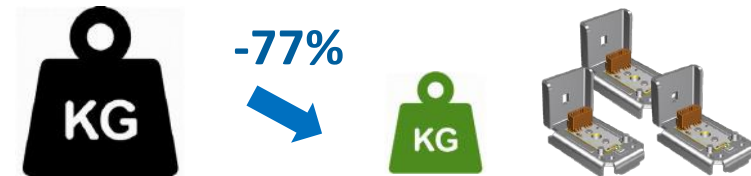
Case 2 : Mainstream Car (C/D segment)

- Die-casted aluminium heatsink, metal core boards
- Low beam: three 1x3 LEDs / High beam: two 1x3 LED
- Retrofitted with five 1x3 LUXEON Go modules



Example 3 : Two-Wheeler

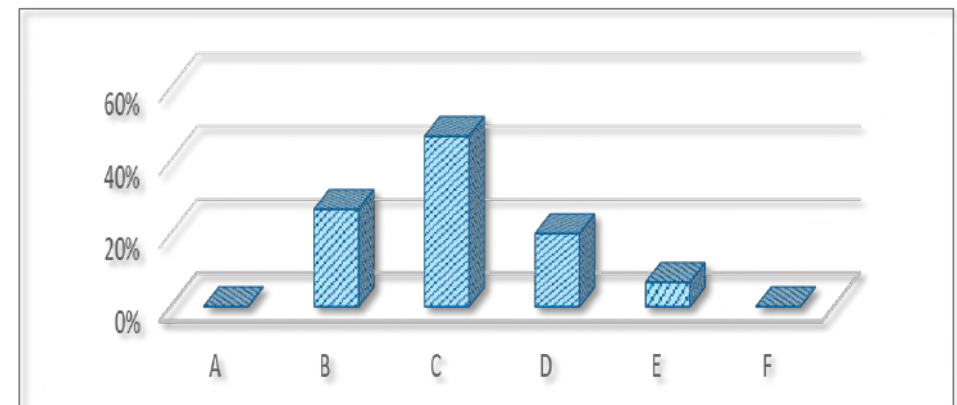
- Die-casted aluminium heatsink, metal core boards
- Low beam: Two 1x3 LEDs / High beam: One 1x3 LED
- Retrofitted with three 1x3 LUXEON Go modules



LUXEON Go: Ready to Go!

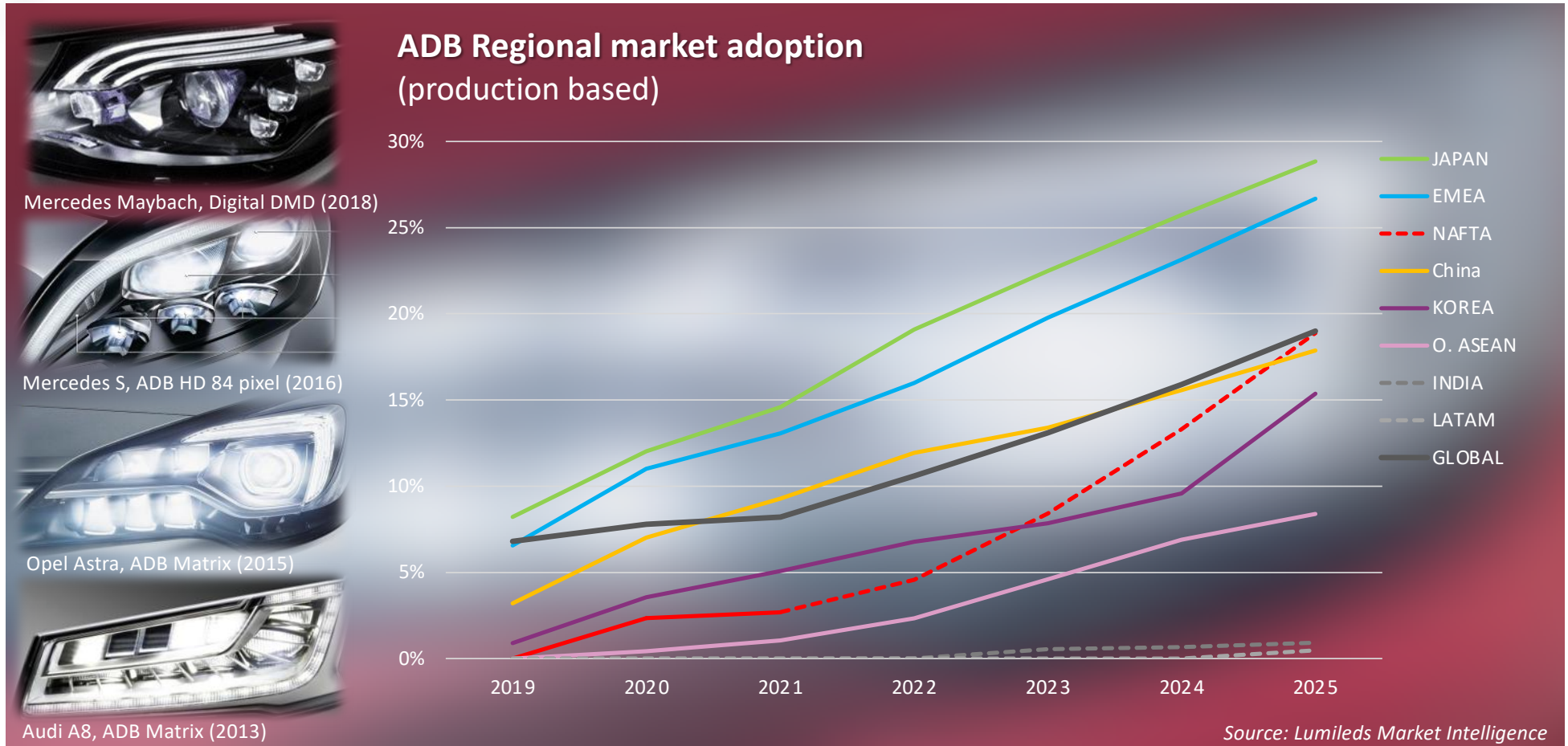
Design-in platforms all over the globe...

and across all mainstream car segments



... more to come !

ADB function adoption is expanding quickly and globally!



System Optimization for ADB Mass Market Solutions

Key drivers to enable ADB volume growth in mass market:

- System simplification
- Compactness
- Robustness against assembly tolerances
- Reduced Engineering complexity, reduced costs and short Time-to-Market

One path to achieve above requirements is to adapt the optical system of ABD solutions:

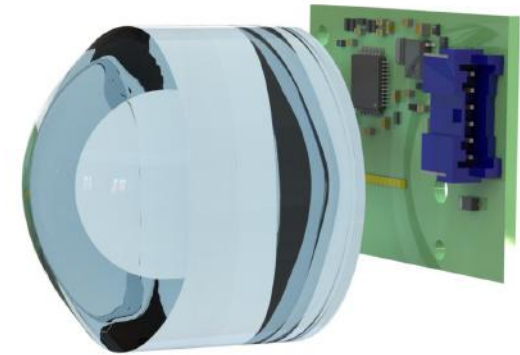
- Today's ADB matrix systems often use primary / collimating optics and a secondary lens.
- Primary optics can be complex and need to be aligned well with the LEDs.



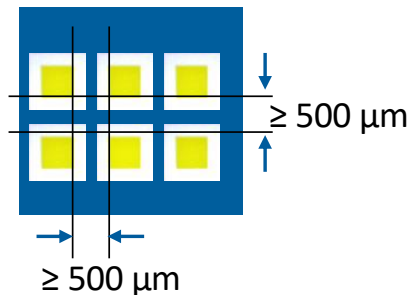
System Optimization for ADB Mass Market Solutions

Possible way to simplify the optical system:

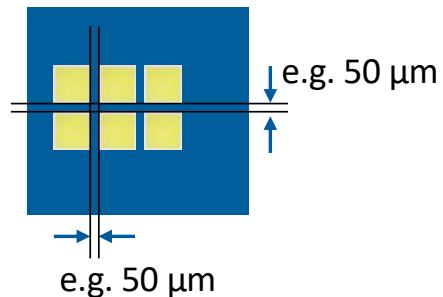
- Single-cavity ADB system with **Direct Imaging** of LEDs to the road
- Hence, **elimination of the primary optics**; just a secondary optics is used!
- Requires **very narrow placement** of LEDs



Conventional Spacing
(primary optics required)

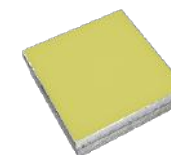
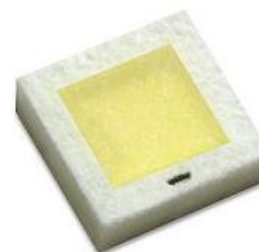
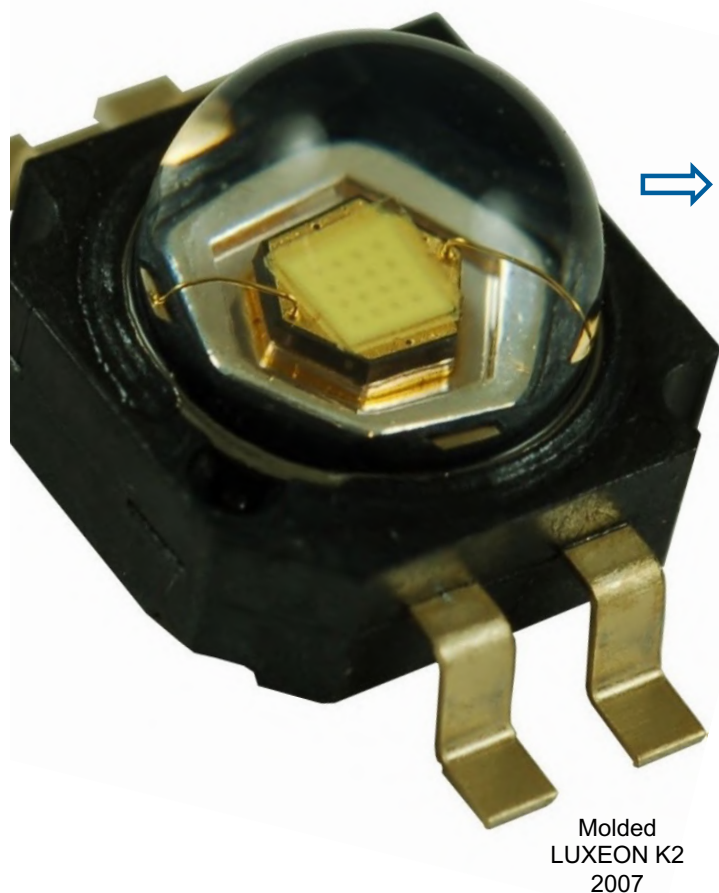


Narrow Spacing
for Direct Imaging



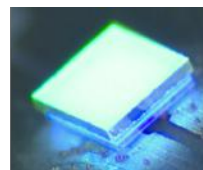
Direct Imaging Solutions require LED sources allowing for narrow spacing.

Need for LED Miniaturization; Technology evolution



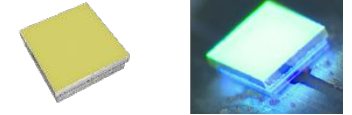
Thin-Film-Side-Coating (TFSC)

creates the smallest possible package.



Light emitting area (LEA) same as package size.
Available as 1.0 mm² or 0.5 mm².

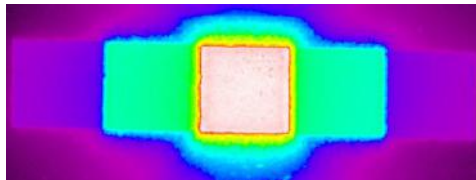
Improved Cross Talk and Contrast with LUXEON NeoExact



Lab prototype LED:
conventional side coated

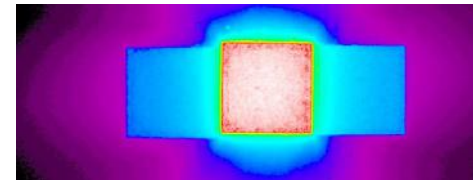


linear arrays
50 µm gaps



cross talk $\approx 1/40$

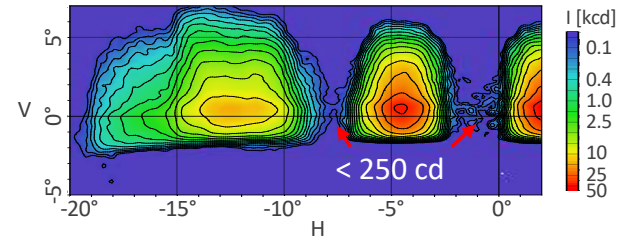
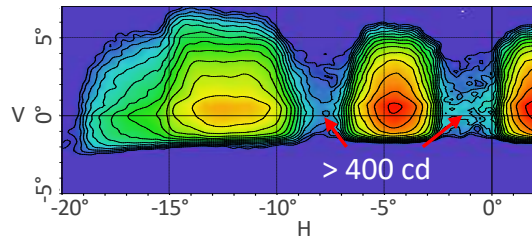
LUXEON NeoExact with
Thin-Film-Side-Coating



cross talk $\approx 1/200$

$$\text{cross talk} = \frac{L_{80\% \text{ OFF}}}{L_{80\% \text{ ON}}}$$

→ Cross Talk ~5x lower!



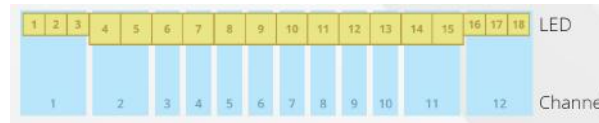
→ Contrast in Beam improved by 60%!

Application Demo : Compact ADB system with Direct Imaging Optics

12 Segmented Single-Row solution, using LUXEON NeoExact 12 x 1.0mm² & 6 x 0.5mm²

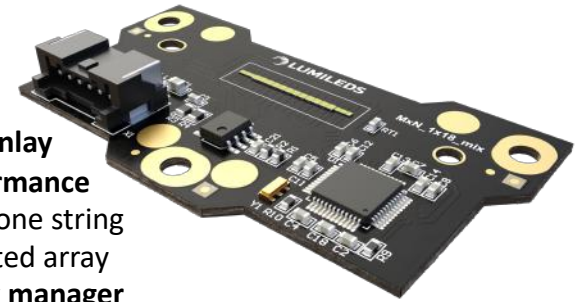
LED arrangement

- **One row of 18 LUXEON NeoExact**
 - 12 x LUXEON NeoExact 1.0 mm²
 - 6 x LUXEON NeoExact 0.5 mm²
- LED combination optimizes cost, FoV, and performance
- LED gap of 70 µm ; LED pitch of 1.116 mm



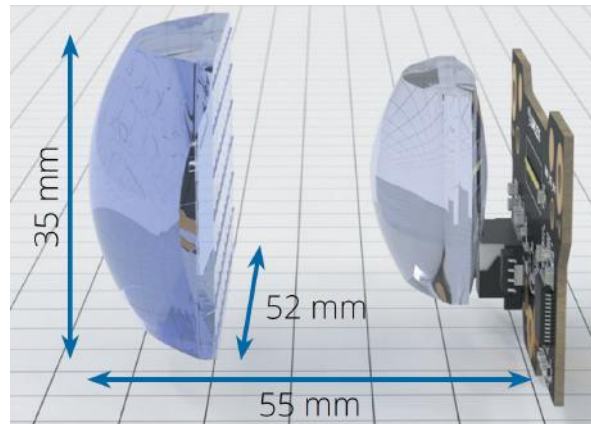
PCB Solution

- single FR4 PCB with AlN inlay offers **best thermal performance**
- 18 LEDs are connected in one string
 - grouped in a 12-segmented array
 - controlled by **one matrix manager**
 - supplied by one LDM power channel with intelligent PWM control

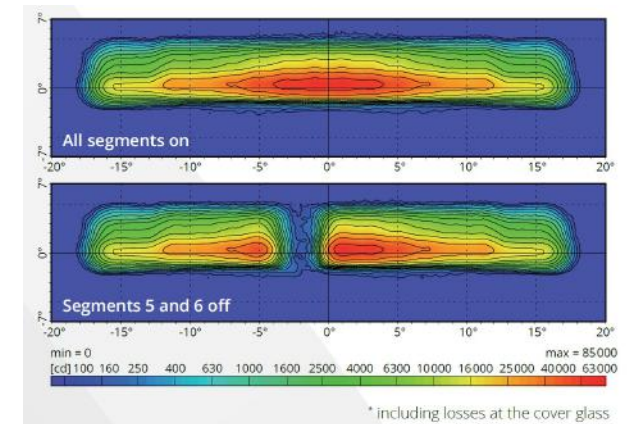


Lens System and Optical Performance

- **Doublet PMMA projection lens of**
 - 52 mm x **35 mm**
 - focal length of 55 mm
 - respecting molding manuf. design rules
- **Flux of 300 lm from the LEDs in center**
 - Flux in beam: **1090lm**
 - I_{max} = 84300 cd, E_{max} = 135 lx
 - Optical efficiency: **41%**
 - Field of view: +/-17° H, -2°/+5° V
 - Resolution of 2° at center pixel



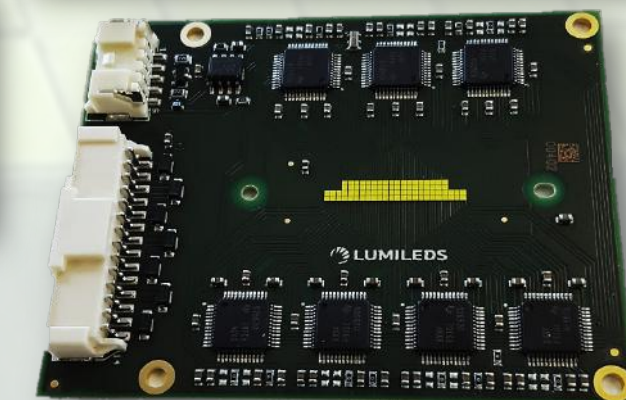
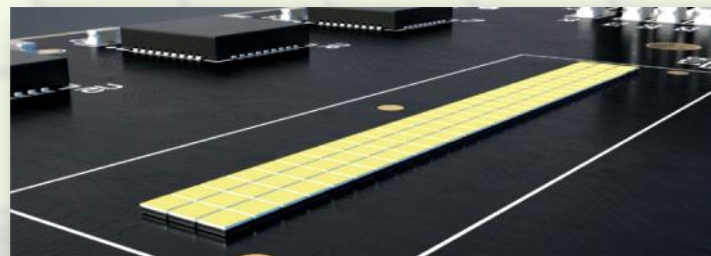
Doublet direct imaging lens



ADB Beam Performance

LUXEON NeoExact on Custom Board ADB solutions

- **Customized pixel count and flexible LED arrangement**
single & multi row arrays
- **High precision LED placement**
min. pixel gap of 50 μm
- **PCB technology**
FR4 with AlN inlay
- **ESD protection on board**
switching electronics, EMC measures



From AFS/ADB to High Resolution Digital Beam

AFS Basic ADB



- Conventional LB / AFS
- Basic ADB (5° to 1.5° angular resolution)
- Glare Free (horizontal) segmented High Beam

Higher Segmented ADB Matrix



- Smooth Beam (1° to 0.5° angular resolution)
- Basic LB for high angles / foreground
- Swiveling HB/LB Spot
- Vertical segmented ADB
- Marker Light

High Resolution Digital Beam



- Smooth Beam (0.25° to 0.1° angular resolution)
- Digital AFS LB
- Electronic Predictive Leveling
- Road Marking: Symbol projection and lane marking
- Customization in Software

Micro-LED Light Source Requirements for a Digital Beam

Derived from Application

Source: Driving Vision News



ADB

$I_{\max} > 70\,000\text{ cd}$

Field-of-View:

H: $> \pm 10.5^\circ$

V: $+3^\circ/-4^\circ$

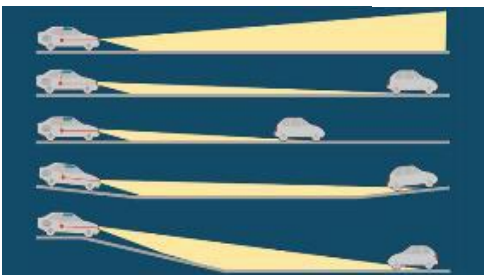
Source: Gommelblog.it



Lane Marking Resolution

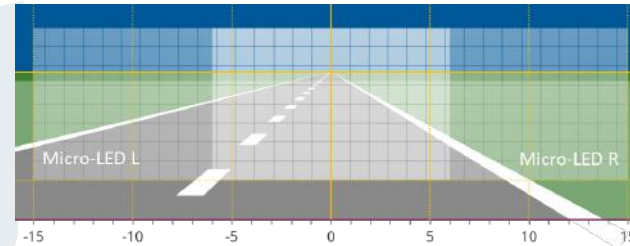
$< 7.5\text{ cm in } 50\text{ m}$
 $= 0.085^\circ$

Source: Driving Vision News



Dynamic Leveling Resolution

$< 12\text{ m in } 75\text{ m}$
 $= 0.085^\circ$



Key Application Requirements

Full Beam Width [°]	21
Full Beam Height [°]	7
Angular Resolution	0.085
I_{\max} [cd]	70 000



Micro-LED Device Solution

Pixel Matrix	20k (82 x 246)
Luminance	$> 80\text{ cd/mm}^2$
Flux (Light Source) for Full HB Drive	$> 2400\text{ lm}$

Full Field-of-View Demonstrator Design

Utilizing One Single Micro-LED per Headlamp

Foreground Module

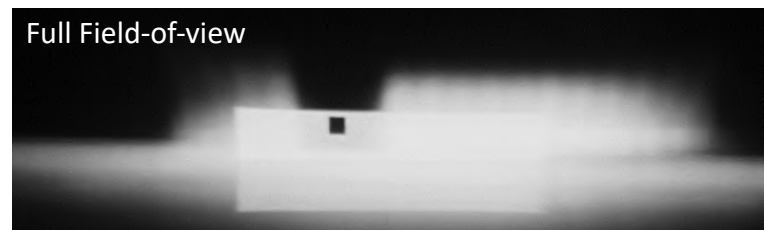
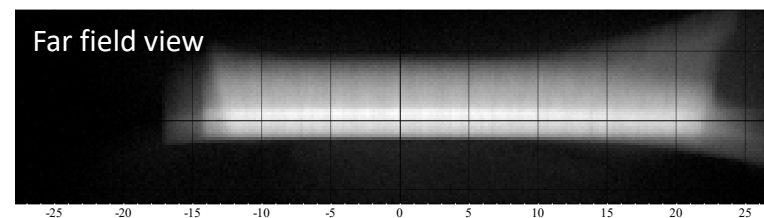
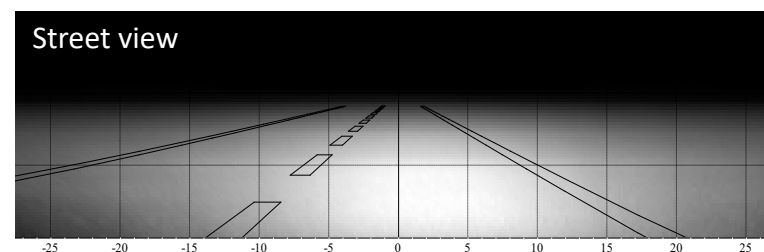
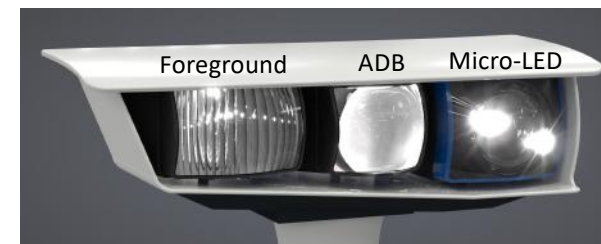
- Horizontal range: $\pm 40^\circ$
- LED product: LUXEON NeoExact
- Light-emitting area: 4 mm^2
- Optical concept: Direct image
- Optic size: $60 \text{ mm} \times 40 \text{ mm}$

ADB Module

- Field-of-View: $6^\circ \times 40^\circ$
- LED product: LUXEON NeoExact
- Light-emitting area: 18 mm^2
- Optical concept: Direct image
- Optic size: $43 \text{ mm} \times 40 \text{ mm}$

Micro-LED Module

- Field-of-View: $7^\circ \times 21^\circ$
- LED product: Micro-LED
- Light-emitting area: 32 mm^2
- Optical concept: Direct image
- Lens diameter: 40 mm



Full Field-of-View Demonstrator Design

LUXEON NeoExact & Micro-LED

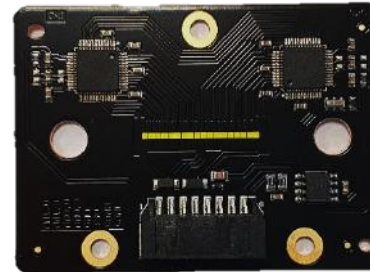
Foreground Module

- 3 x LUXEON NeoExact 1.0 mm²
- 2 x LUXEON NeoExact 0.5 mm²
- LED gap: 60 µm



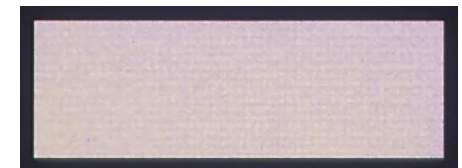
ADB Module

- 18 x LUXEON NeoExact 1.0 mm² LEDs in a single row
- LED gap: 60 µm



Micro LED Module

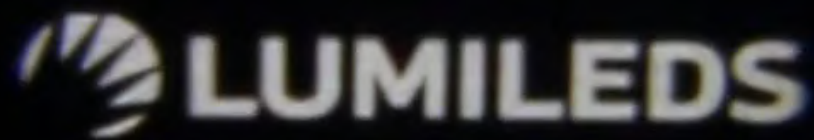
- High Resolution pixel array: 82 x 246 > 20k pixels
- Pixel pitch: 40 µm
- Target flux: 0.4 lm/px @ 85 °C, DC operation



*Micro-LED true-color image
taken with luminance camera*

Video of the Demonstrator Beam

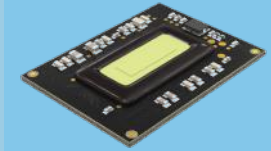
To a Test Wall



Lumileds Headlighting source solutions, enhancing safety for all !

❖ Digital Beam

High Resolution
Micro-LED



❖ Premium ADB

Compact Multi-Row
LED Matrix



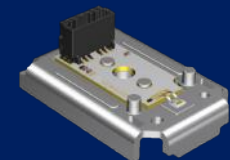
❖ Mainstream ADB

Single-Row
LED Array



❖ Cost effective Mainstream LED Headlighting

Standardized
Headlighting Module





Pushing
the Boundaries
of Light

Thank you for your attention!





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