Automotive matrix systems with improved efficiency

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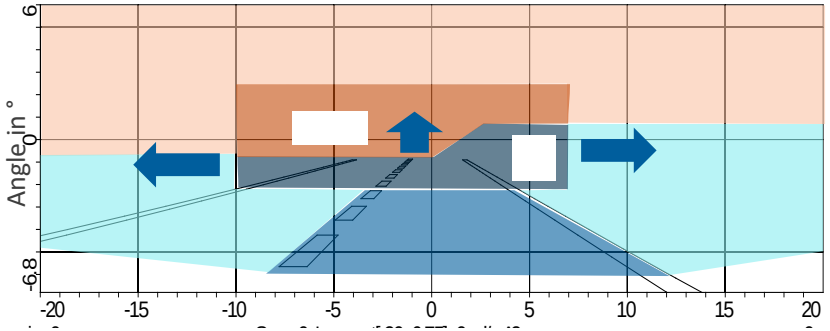
Overview

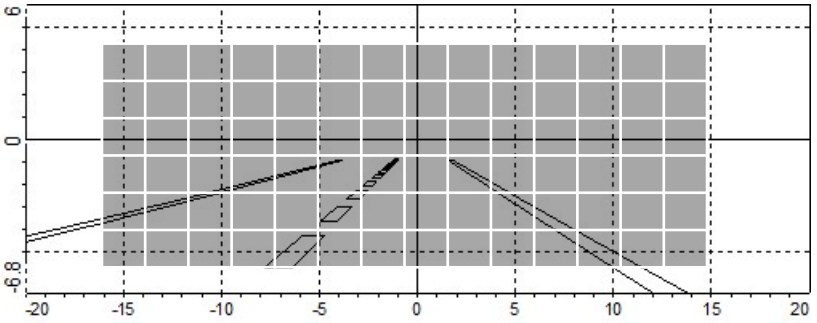
- Application Requirements: Matrix Headlamp
- Direct projection of Light source
- Pre-collimation for higher system efficiency
- Direct integration to LED surface

Adaptive Driving Beam / Matrix: Application Overview

- AFS (Adaptive Front lighting System): beam adaption according driving situation (ECE R123) + swiveling Low Beam
- ADB (Adaptive Driving Beam): Glare free High Beam – selectively block light in direction of oncoming cars
- Marking Light: high light selective areas if there is a potential risk
- Automatic Levelling: adjustment of beam according to load and acceleration of car and slope of road



Basic Idea: switch an LED Matrix



Direct Projection of LED

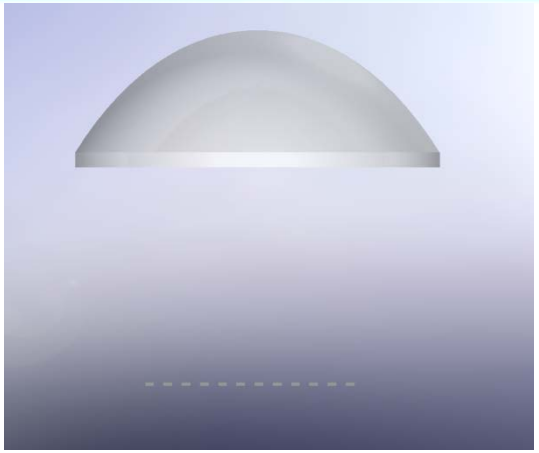
- Use a simple (aspherical) lens or a reflector
- Cost efficient system optic

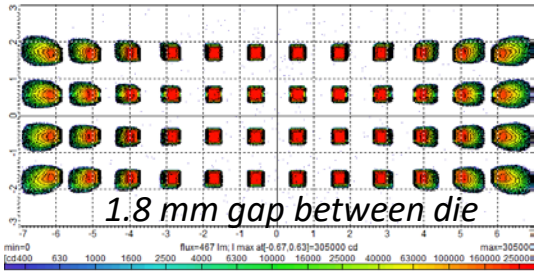
But:

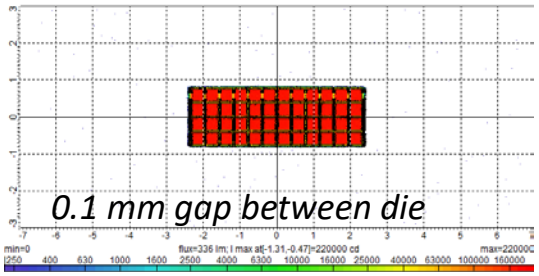
- Close placement of LED is required
- Compromise between Lens aberrations and collection efficacy – typically only 20-30% collected
- Contrast in beam is generated by contrast in light source

Alternative:

- Combination of two or more systems: the overlap can fill the area between pixel
- Structure on lens surface to smear out the images

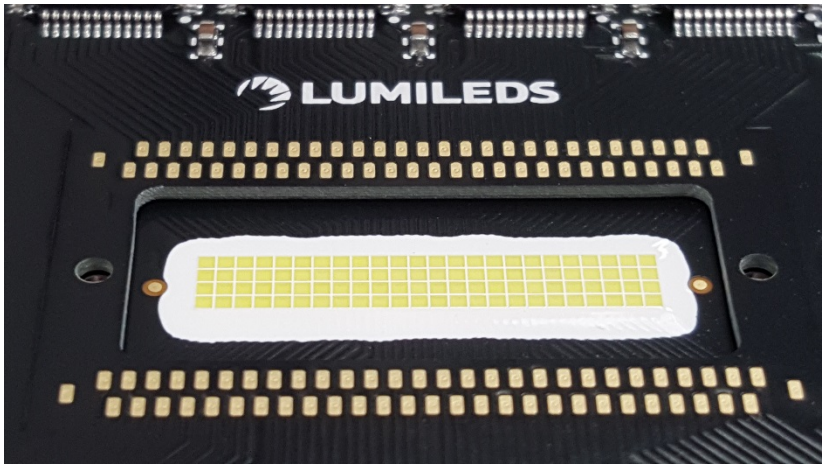


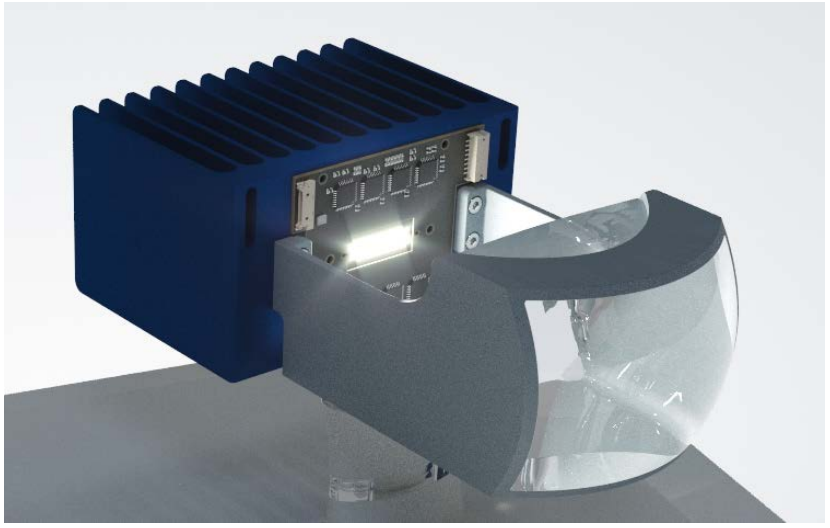




Example System

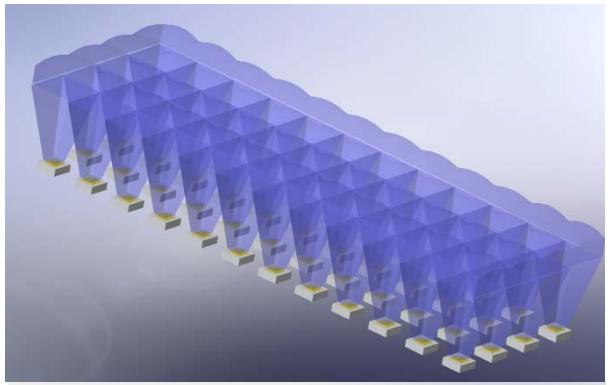
- 4x24 LEDs
- 90 µm gap between the LEDs
- White side coating is filling the gap: contrast pixel to pixel need to be 200:1
- Each LED can be addressed individually
- Dimming via plus width modulation
- High LED luminance is required – up to 100 MNIT
- >10000 installed Lumen, but only 25% will be used at the same time
- System efficiency: 20% - 40% of the generated light will reach the road

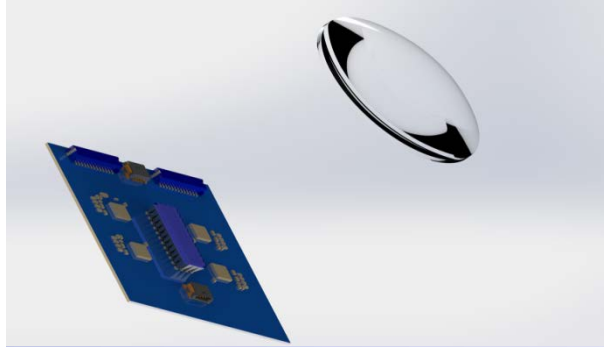


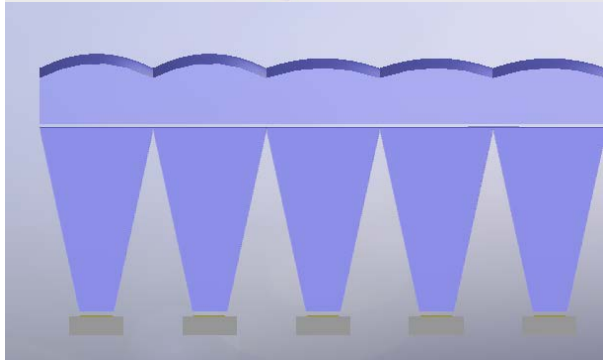


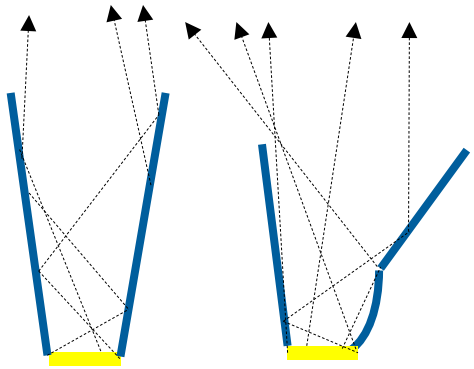
Indirect Projection - Imaging the exit plane of a pre-collimator

- Collimator needs to be designed to generate desired illuminance distribution at exit :
  - Uniformity: e.g. CPC or simple cone
  - Gradient: asymmetric
- Additional elements can be used or integrated to improve collection efficiency or correct for lens aberrations
- Alignment – especially in z-direction is very critical





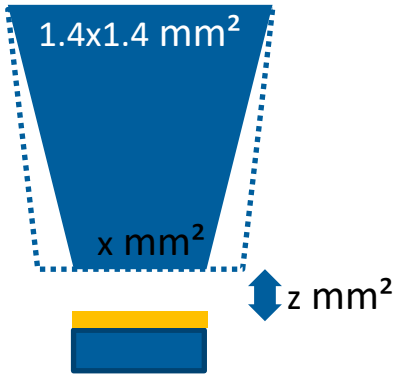




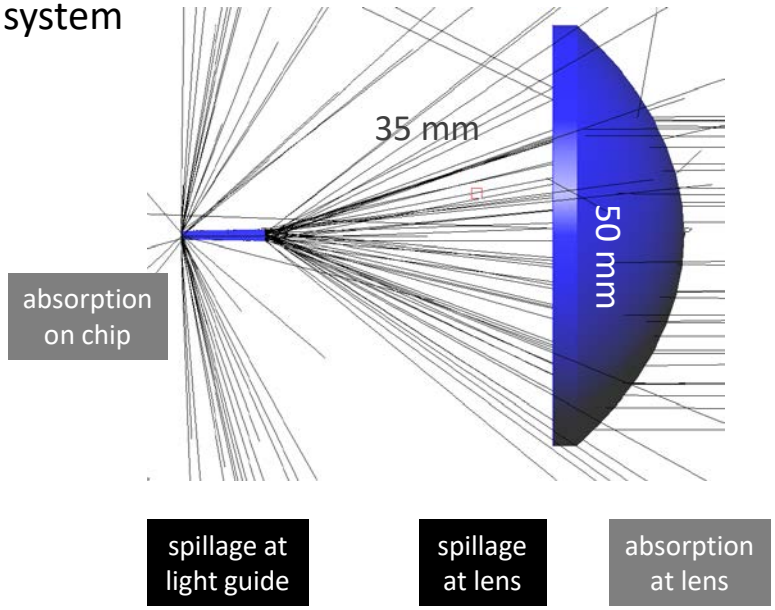
Design rules for pre-collimator: optimize system flux

- Simulation of optical system flux
- based on TIR optic attached to the LED, but with air gap

LED with TIR optic attached with air gap



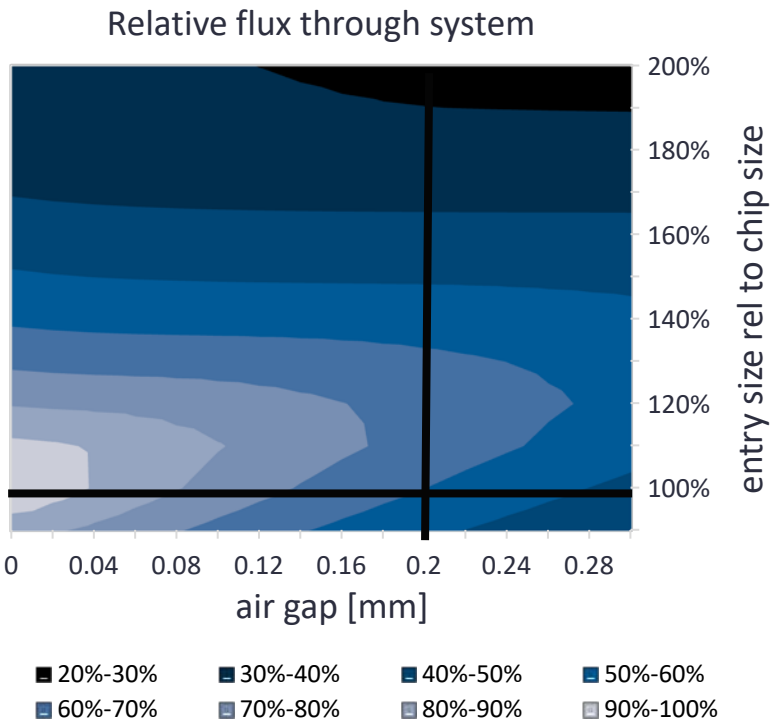
Projection system

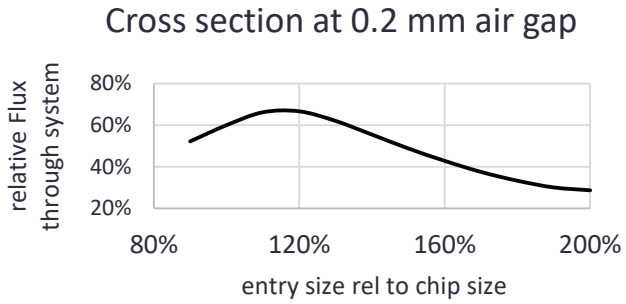


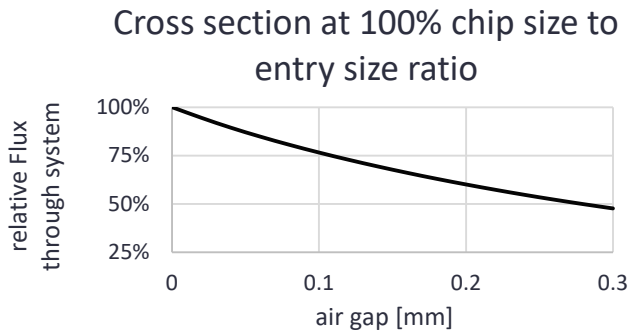
Maximum system flux by optimized entry size and distance chip to entry

**TIR = Total Internal Reflection*

Design rules for pre-collimator: optimize system flux



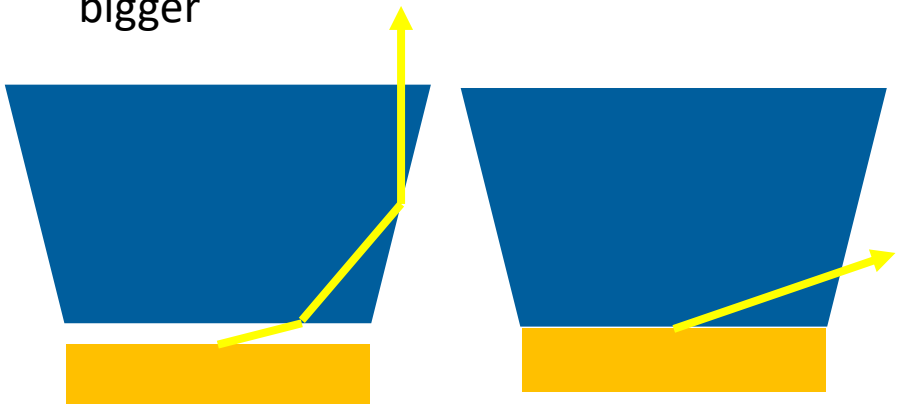


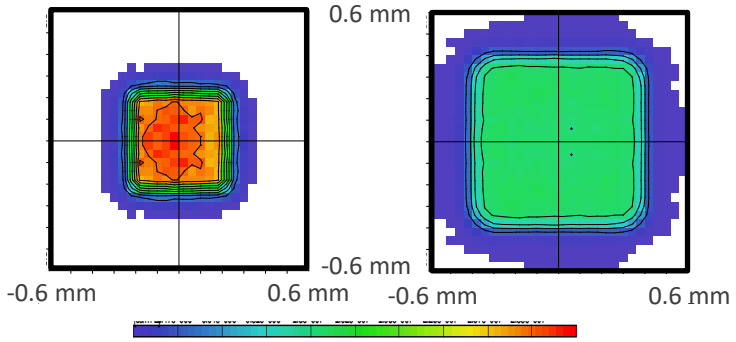


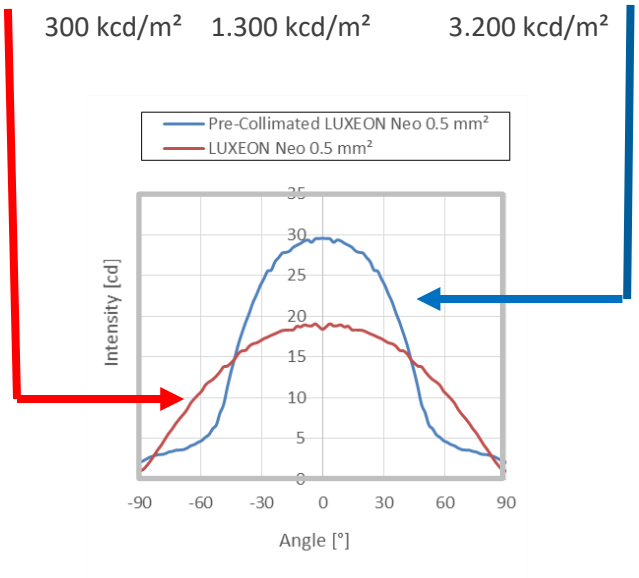
- If entry is bigger than chip, light is lost at lens
- For maximum flux through system air gap should be minimal

Gluing collimator directly to the LED surface

- Index match of collimator and converter
- Light extraction can be increased
- Up to 15% more power can be extracted
- But the collimator exit is significantly increased in lateral direction and so the pixel
- Luminance is lower – final optic needs to be bigger





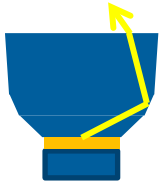


Conclusion and outlook

- Automotive headlamps optic will become smaller
- The luminance of light source needs to increase

Direct imaging

Systems cost



direct attached

Flux extraction

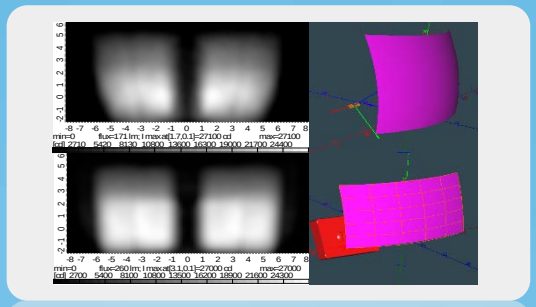
attached with air gap

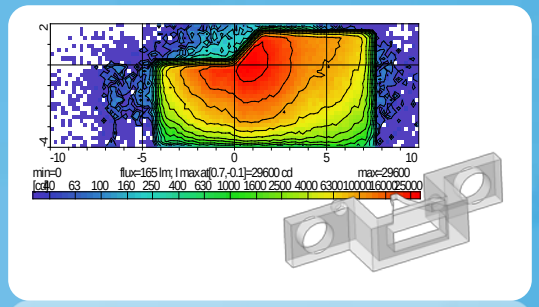
Flux on the road

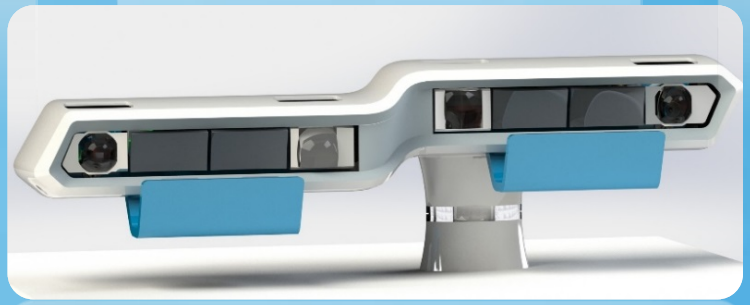
- The same concepts can also be transferred to other pixel shapes e.g. to form a complete low beam

Thank you for your attention!

... please be invited for further discussions





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