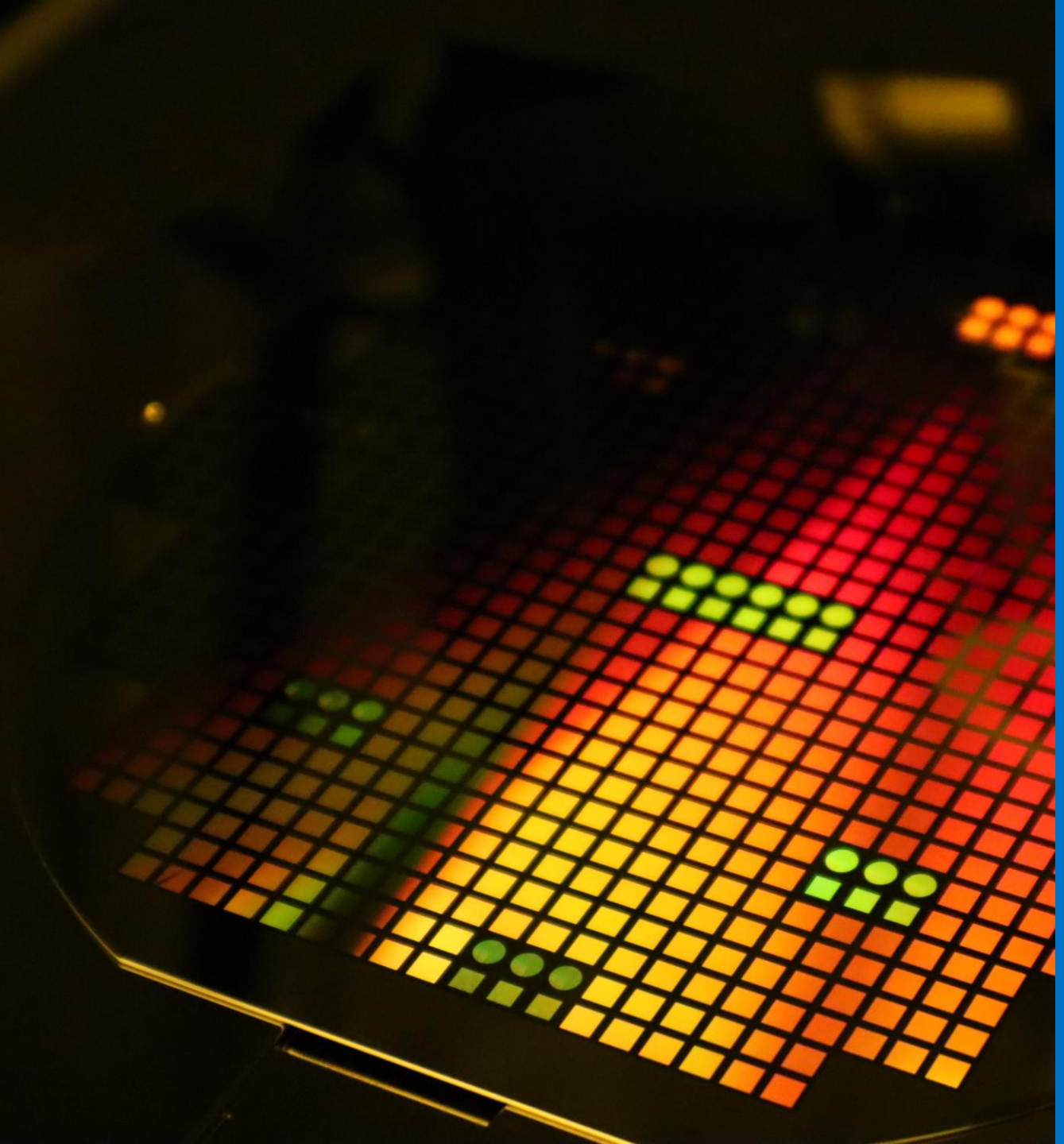

NIL TECHNOLOGY

NILT's single lens MOE camera

EPIC Online Technology meeting on metalenses and metamaterials
09 Jan 2023

Niklas Hansson, Head of Application Engineering
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Video captured with single lens MOE camera

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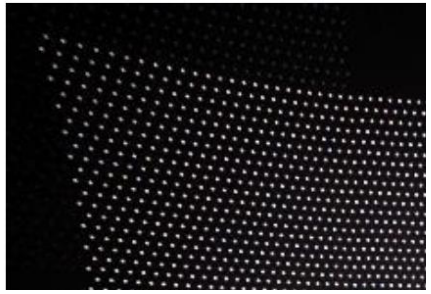
Applications for MOE (Meta Optical Elements)

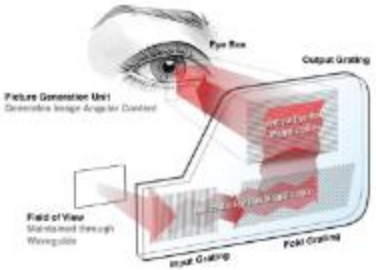
Time of Flight Depth sensors, Presence detect, Eye-tracking, Driver monitoring, LiDAR, IoT sensing, SWIR imaging, Medical imaging, Waveguides

Flood illuminators



Dot projectors

Compact Cameras



XR Waveguides

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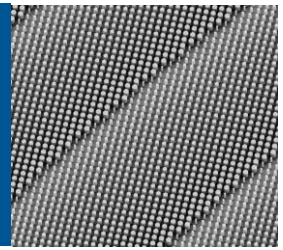
Products | Elements/components and AR waveguides

Meta Optical Elements (MOEs)



Illumination and receiver optics for
ToF, LiDAR, Driver monitoring and Eye Tracking

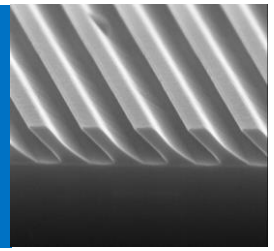
→ Emitter optics (dot projection, flood illumination)

→ Lenses (collimators, focusing lenses)

→ Receiver modules
One Metasurface lens (1M) camera module
Two Metasurface cameras (2M)
Hybrid cameras (1M3P, 2M2P,…)

Fast prototyping & Mass production

Masters for Displays (AR/MR)



Input-, expander-, and output gratings for waveguides in AR/MR and auto HUDs

→ Slanted Gratings

→ Large Area Gratings

→ Blazed/Binary Gratings

All grating types can be combined, in any relative placement and orientation

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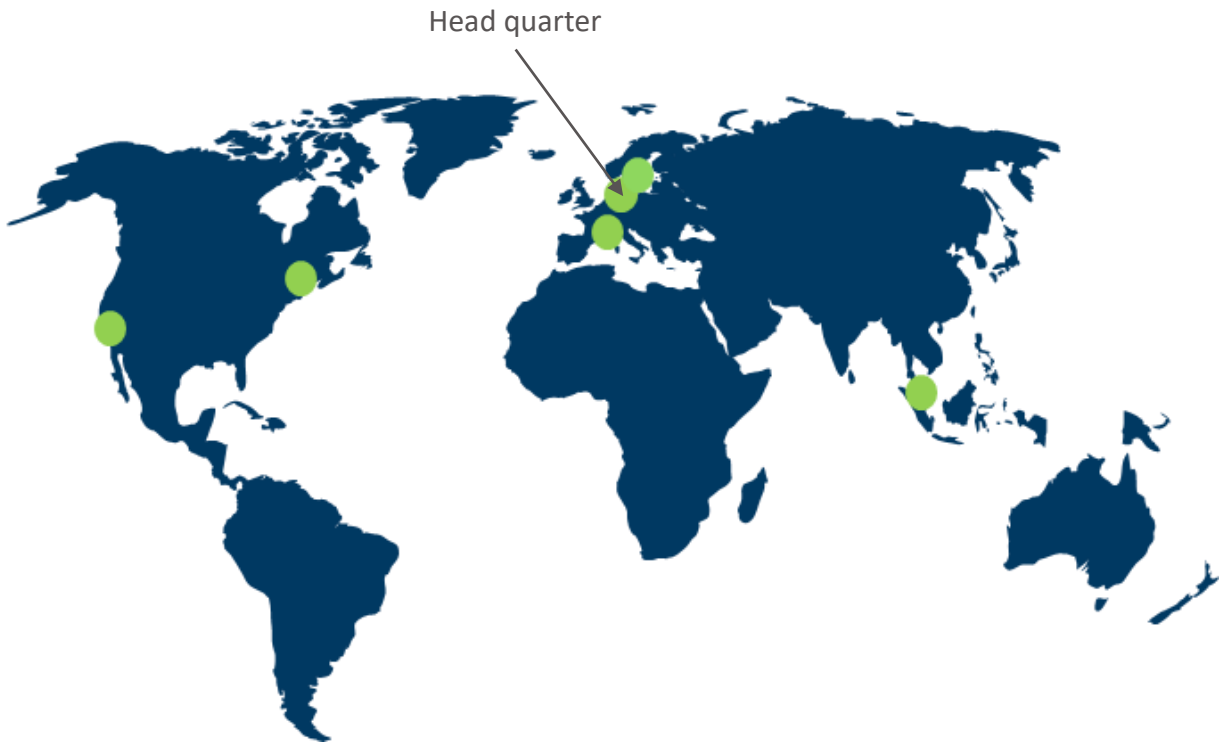
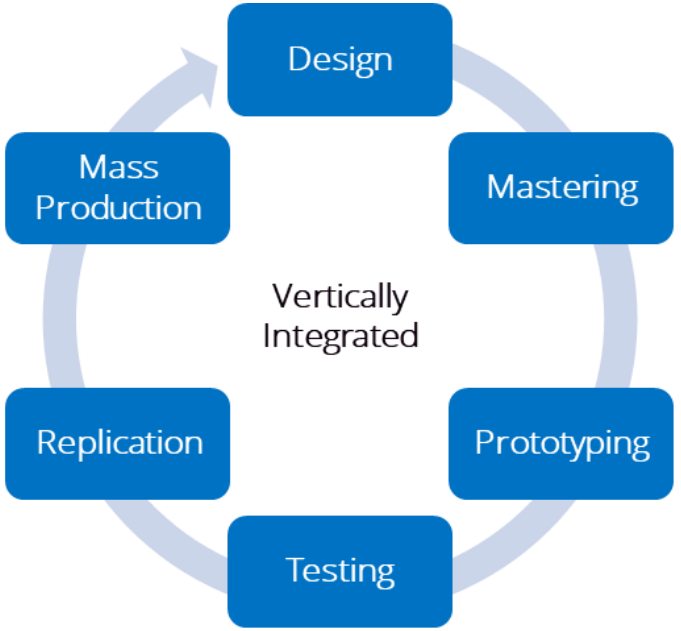


70+ employees
20+ nationalities
≈50% w PhD degree

Production
Six class 10-100 cleanrooms
Unique lithography machines
In-house etching + EBL Q4-22

IPR
>70 registered inventions



=

Fast prototyping
+
Design for manufacturing
+
One company, full solution!

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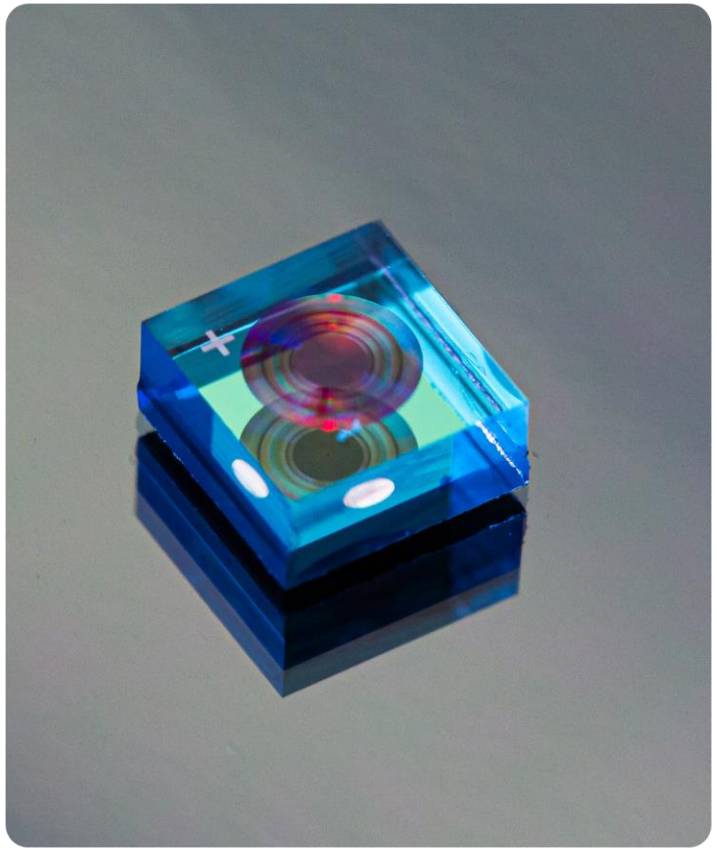
MOE (Meta Optical Elements)| Introduction

A lens technology with potential to disrupt optics used for sensing and imaging

- Examples of advantages with MOE:
  - Reduction of number of lens elements
  - Multi-functional performance
  - Polarization control
  - Ultra-compactness and flatness
  - Reduced BOM and integration complexity

- NILT provides custom-made solutions with MOE, ranging from pure MOE to hybrid solutions

- NILT is leveraging its long experience from nanostructured mastering and fast prototyping turnaround to leading mass production solutions



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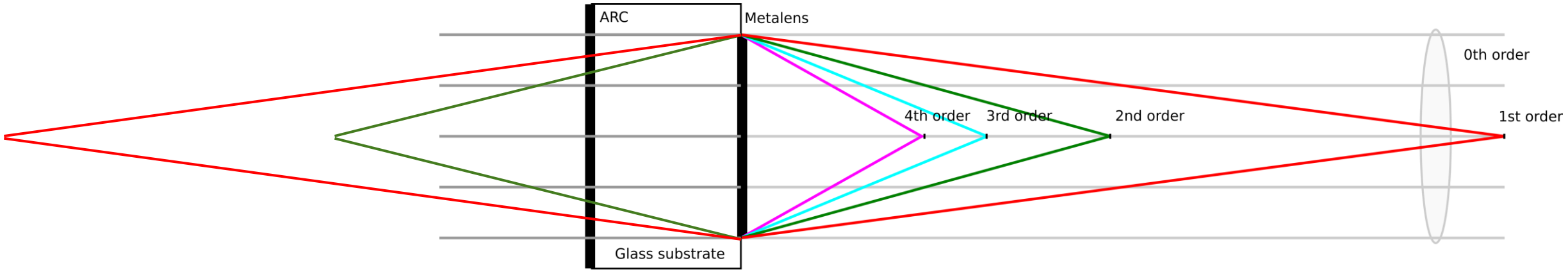
MOE | Where does the light go?

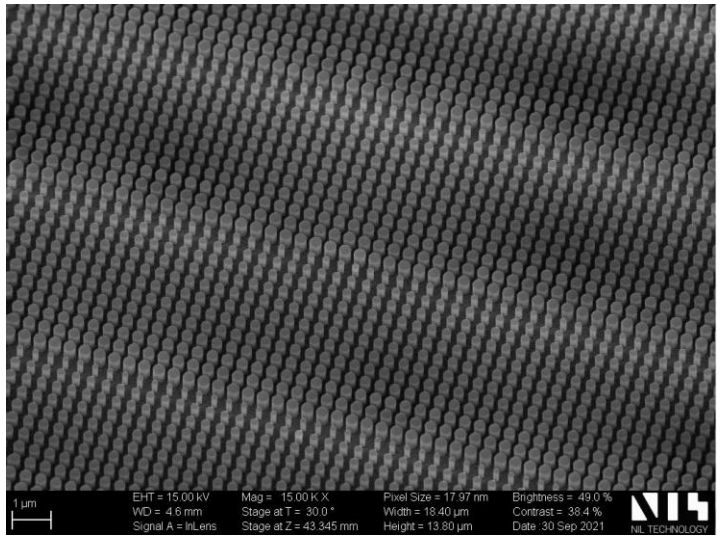
Reflected orders: 0, 1st, 2nd, 3rd, ……

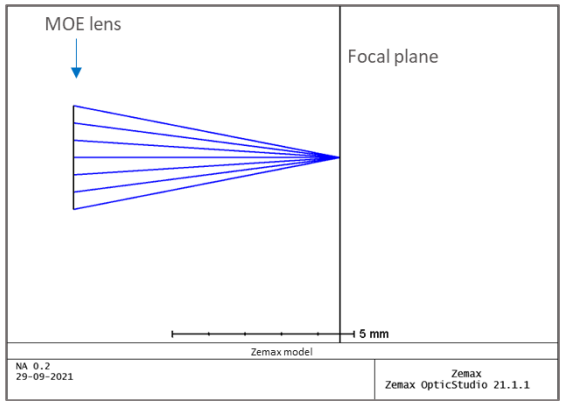
Transmitted orders: 0, 1st, 2nd, 3rd, ……

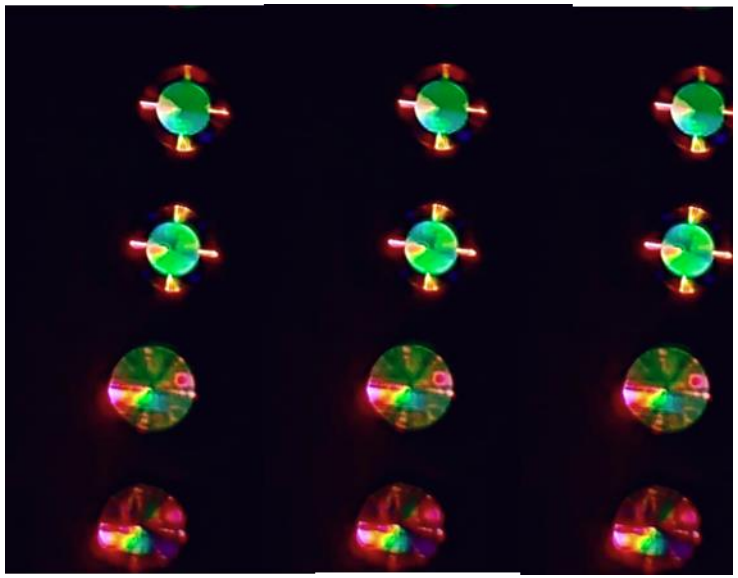


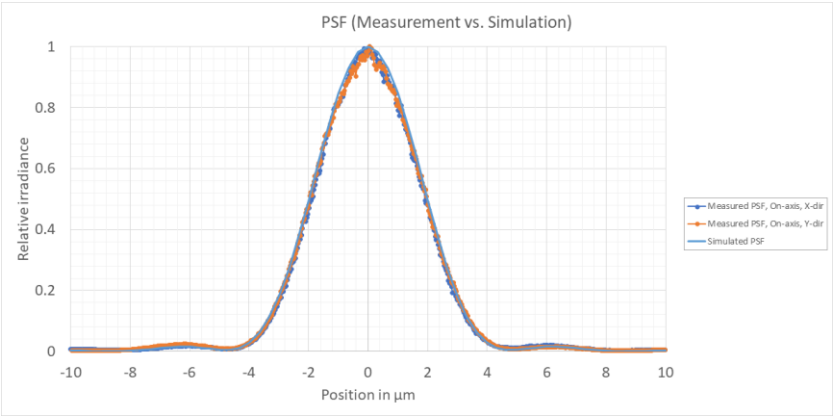
Diverging orders
Diffuse scattered light
Absorption

MOE | High efficiency









Parameter	Units	Specifications	Note
Numerical aperture		**0.2**	
Wavelength	[nm]	940	
Effective focal length	[mm]	7.35	
Lens diameter	[mm]	3.0	
Absolute focusing efficiency	[%]	**94**	Relative to incident intensity, on axis
Relative focusing efficiency	[%]	98	Relative to transmitted intensity, on axis
Thickness (wafer)	[mm]	1.1	
Material		Si/Glass	AR coating on non-structured side
AR coating, transmission	[%]	>99	Transmission through AR coated surface

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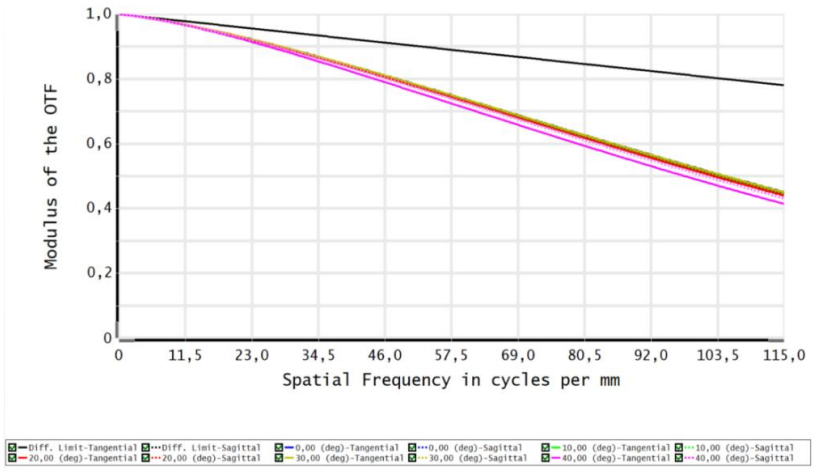
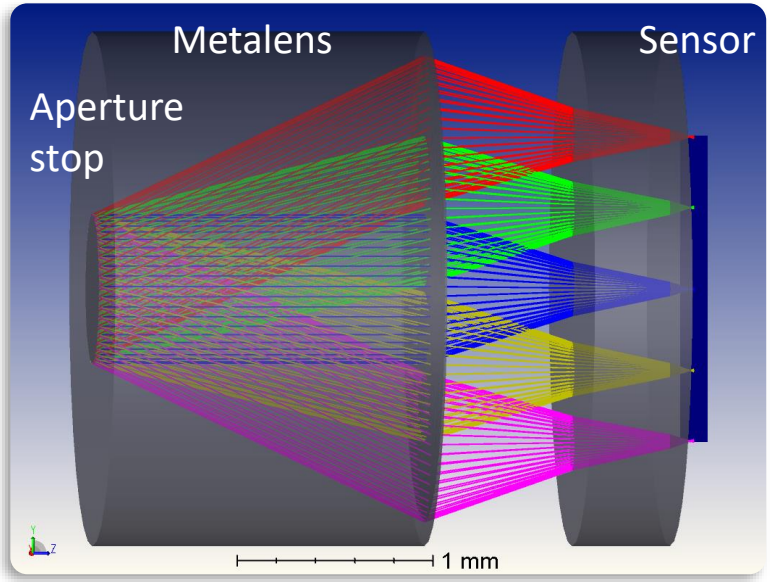
Single lens MOE camera | Design

- Eliminate aberrations, field curvature, astigmatism
- Low F-number
- Easy assembly
- High relative illumination
- Stable to temperature change (focal length)
- Less tolerances than refractive lens

Parameter	Specifications		
Wavelength	940 nm		
EFL	1.24 mm		
TTL	3.1		
FOV, diagonal	80°		
F/#	1.6		
CRA	<1.5°		
Distortion	23%	**Lens MTF**	
Aperture Diameter	0.78 mm	0.0 F (Ny/2: 114 cc/mm)	45%
Lens Diameter	Ø 2.50 mm	0.5 F (Ny/2: 114 cc/mm)	44%
BFL	1.213 mm	1.0F (Ny/2: 114 cc/mm)	42%

The performance of the 1M shown below as Modulation Transfer Function [MTF]. The MTF shows good contrast for all field points (up to full field). The MTF as function of spatial frequency is plotted in the graph below.





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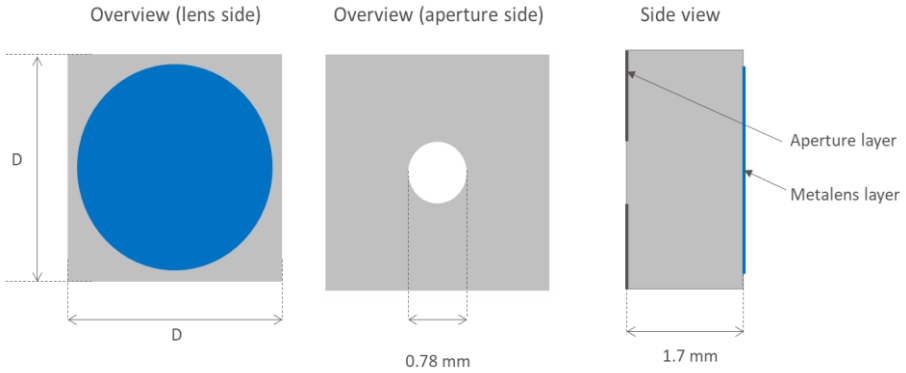
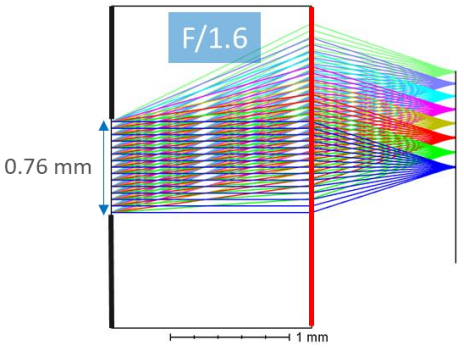
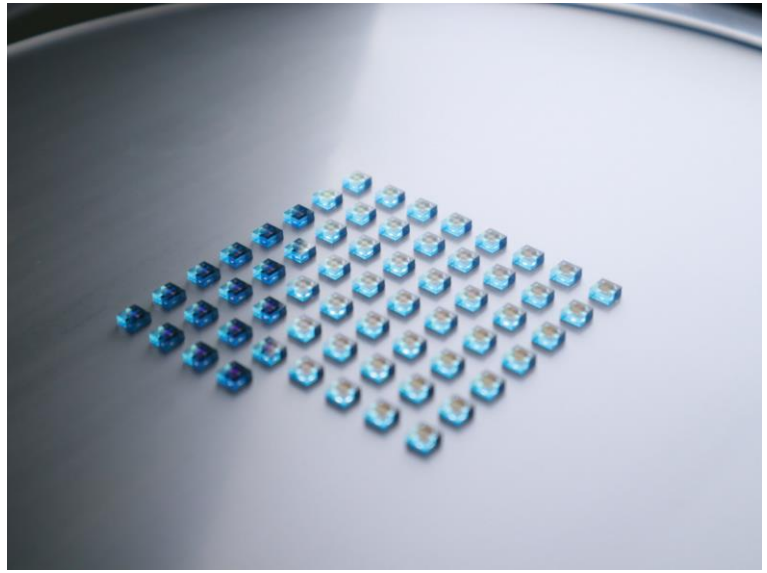
Single lens MOE camera | Implementation

Live demo at Photonics West 2023





- 1M, FOV 80°, λ 940±2.5 nm, Sensor Size 1.6 mm
- Telecentric: High signal to noise ratio
- High RI



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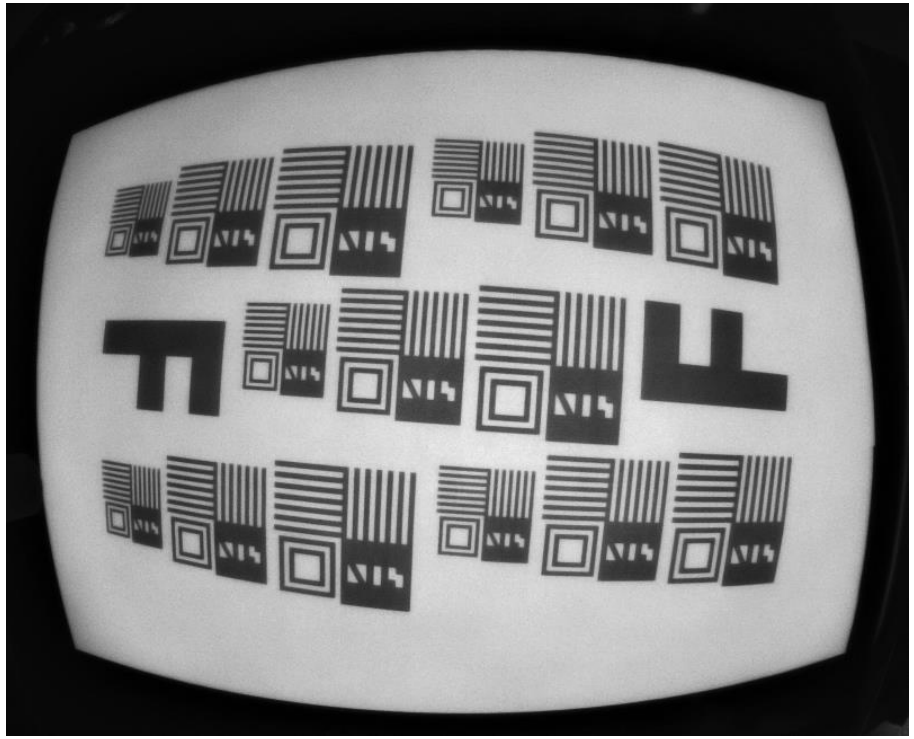

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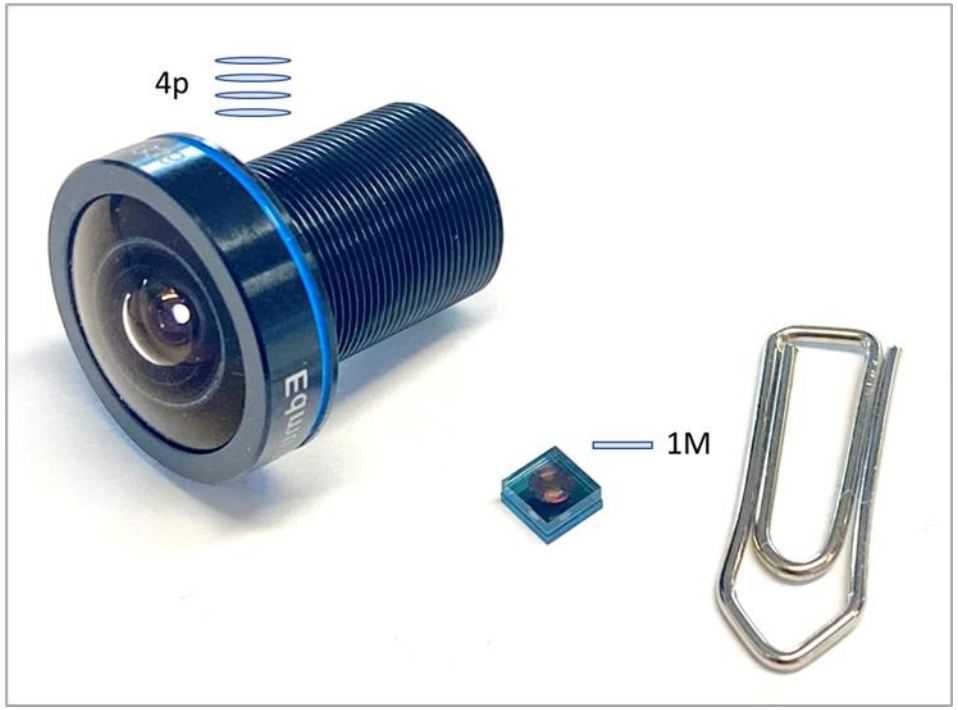
Summary

- Camera with single lens (MOE) surface
- Matching form factor with sensor (sensor is flat, optic is flat)
- Eliminate field curvature, coma and astigmatism
- Performance similar to refractive camera with 3-4 lenses with VCSEL illumination 940 nm

- NILT also makes systems with multiple MOE lenses or hybrid stacks

- Lens prototyping by EBL – fast turnaround
- Lens manufacturing by NIL – cost effective



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Thank you for your attention. Any questions?

NIL TECHNOLOGY

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