New PZT MEMS Tunable Optics Technology & Solutions

MEMS & Sensors Technical Congress-MSTC 2022 April 27, 2022

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Executive summary

- poLight, a global tunable optics company, has developed an Optical MEMS product, as well as a technology platform, which enables new solutions where electronic tuning of an optical function is required. poLight's Auto Focus (AF) TLens® PZT MEMS and Driver offer fastest focus speed, lowest power consumption, ultra-compact design and with no gravity sensitivity for AF or focusing functions that fit smartphone applications, AR, other wearable and consumer devices, and industrial as well medical applications.
- poLight will present the piezo MEMS structure and performances of the TLens® AF products, and advanced concepts such as wide FOV optics, Optical Image Stabilization (OIS) beam steering, and tunable wedge ultra-resolution components based on the same technology platform. Commercially available products using TLens® will also be presented.

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Today’s agenda

- poLight Introduction
- TLens® Technology & Products
- Optics Design Examples
- MEMS and Polymer Technology Roadmap
- Q&A

Presenting

Pierre Craen

Chief Technology Officer

Pierre Craen is a senior executive with more than 30 years’ experience in opto-mechanical system engineering. Prior to joining poLight, he has managed product development and teams in different companies, Spacebel Instrumentation (Belgium), BARCO (Belgium-USA),Zebra (former Motorola/Symbol) (USA), Sagem-Reosc (France), Varioptic (France). poLight (Norway). Pierre Craen Educational background includes M.Sc. degree in optical engineering from Institute d’ Optique Graduate school of Paris-France, M.Sc. Degree in Optoelectronic from University of Liege-Belgium. M.Sc. Applied Physics from University of Liege-Belgium.

Tristan Joo

VP or N. America Business Development & Corporate Marketing

Tristan is a 27-year veteran business executive with extensive experiences in business development, marketing and general management in mobile, consumer, industrial and XR markets, and across imaging/optical sensors semiconductor and OEM devices, while scaling the businesses to industry's #1 positions. Prior to joining poLight ASA in June 2021, he was at Ofilm as VP of N. America Market Development for compact camera/3D sensing modules, at ams AG as Sr. Director & GM building up its ToF/3D Sensors PL, at Maxim Integrated starting up its Optical Sensors PL incl. P&L ownership, as well as at LensVector, a solid-state optical actuator startup. Tristan started his career as a founding Product Manager at Samsung Mobile, then moved into semiconductors at IBM Microelectronics, marketing RF/MS & image sensor ASIC/foundry technologies. Tristan holds an MBA from Darden School (UVA) and a BSEE degree, and is based in W. San Jose, CA.

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poLight at a glance

Background and description

- Global player in tunable optics with 1st TLens® products used in the mobile, consumer, barcode, industrial, augmented reality and other markets
- Founded in 2005 and has since developed state-of-the-art expertise in tunable optics, polymers, MEMS technology and image applications and processing
- Holds 16 worldwide patents families, 10 pending applications and 3 registered trademarks
- 35 employees (incl. consultants), actively expanding
- Headquartered in Horten, Norway, with offices in Finland and China with representation in France, UK, USA, Taiwan, Russia, Korea and Japan
- Listed company since 1st October 2018 on Oslo Stock Exchange

Geographical footprint

poLight enables unique use cases

Instant focus

Small real estate

Constant field of view

Extremely low power consumption

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poLight products & technology well-suited for several applications

Smartphones and wearables

- Large addressable market for which billions of cameras are produced for the each year
- 1,5 billion phones per year with 1 front camera and an average of 3 back cameras
- Increasing demands on both camera functionality and battery life
- Potential addressable market for TLens®/poLight technology estimated at 3 billion units per year

Barcode/Industrial

- Evolving from 1D laser to 2D imaging barcode readers
- Lasers replaced by camera systems, where autofocus will improve efficiency in scanning and portfolio
- Barcode technology is spreading to new industries
- OEM scan engine vendors today are increasingly looking to enable machine vision capabilities on their current offerings

Augmented Reality (AR)

- AR is expected to to grow significantly as the technology is rapidly expanding beyond entertainment and gaming to an increasing number of industrial, commercial, educational applications and later become a consumer device

Other

- New opportunities are emerging that could represent significant potential
- Video conferencing and endoscopy are just two examples of new opportunities for poLight technology

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TLens® customer-wins

XIAOMI Mi Bunny 4 Pro smart watch

xiaomi

MAXHUB UC W20

MAXHUB®

XUN Smartwatch Max Pro

XUN小寻

Honeywell EX 30 barcode scanner

Honeywell

Augmented reality
– world-facing camera

Machine Vision
– direct marking reading

Barcode reader
– assembly line

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TLens® Technology & Products

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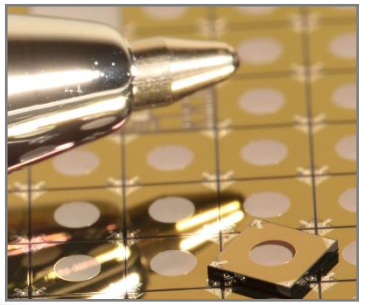
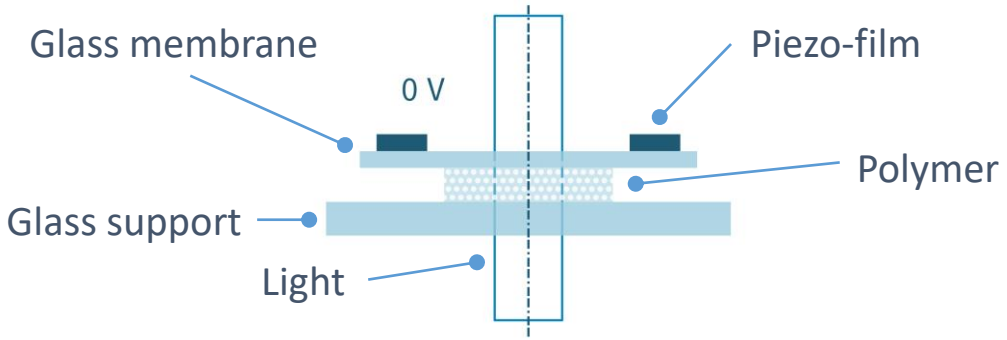
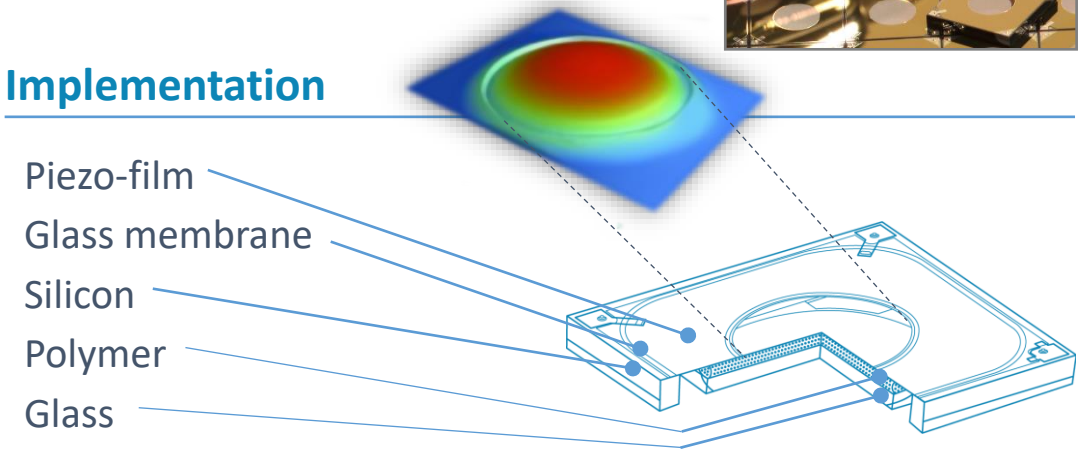
TLens® Actuator: Enabling Smallest, Lowest Power, Fastest AF Cameras and Projectors



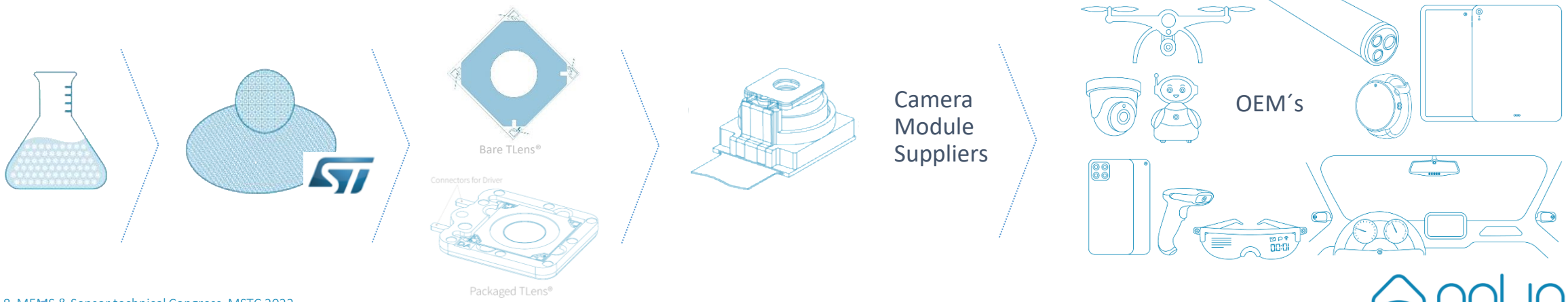
Principle of operation



Implementation



From Polymer Gel > MEMS Wafer > TLens® > Camera Modules > OEM



TLens® AF product family in numbers: Typical values

	Unit	Silver	Silver Premium	Platinum
TLens® AF Front Aperture Diameter	mm	1.55	1.90	>2.20
TLens® AF Back Window Aperture Diameter	mm	2.0	2.25	>2.55
TLens® AF size	mm	3.2 x 3.2 x 0.4	3.2 x 3.2 x 0.4	3.75 x 3.75 x 0.4
TLens® AF size with Package (incl. light baffle)	mm	4.4 x 4.9 x 0.55	4.4 x 4.9 x 0.55	4.9 x 6.1 x 0.55
Maximum Optical power (@47V)	dpt	14	9	7
Wavefront Error (RMS WFE) over useful aperture	nm	30	35	45
Transmittance in visible spectrum	%	94%	94%	94%
Response time	ms	1	1	2
CM: 1/4”, 8M and over, 82° FOV	F#	> 2.0	> 1.5	> 1.3
CM: 1/3”, 13M and over, 82° FOV	F#	> 2.3	> 1.8	> 1.6
CM: 1/2.8”, 16M and over, 82° FOV	F#	> 2.4	> 1.9	> 1.7
Commercial availability		Now	Now	TBD
TLens® Operating Temperature*	°C	-20 to +85	-20 to +85	-20 to +85
Driver ASIC		PD50 (50V)	PD50 (50V)	PD50 (50V)

* *CM with TLens® operating temperature range will be limited by CM thermal stability*

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poLight TLens® offers the most to the user and OEM's

Technological advantages

- Small real estate
- Extremely low power consumption
- Constant field of view
- High speed
- Low test & calibration cost
- No gravity impact
- High optical axis stability
- No magnetic interference
- 10 cm to ∞

Supported by top Camera Module makers

User advantages

- Touch & re-focus
- All in focus
- AF to the selfie camera @ no screen size penalty
- Bokeh using one camera only
- Instant focus
- All in Focus Video
- Constant field of view

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TLens® Demo: Fast AF @ 120 fps AF Hill Climbing search, 16M pixel

Optics Designs with Add-In TLens® AF

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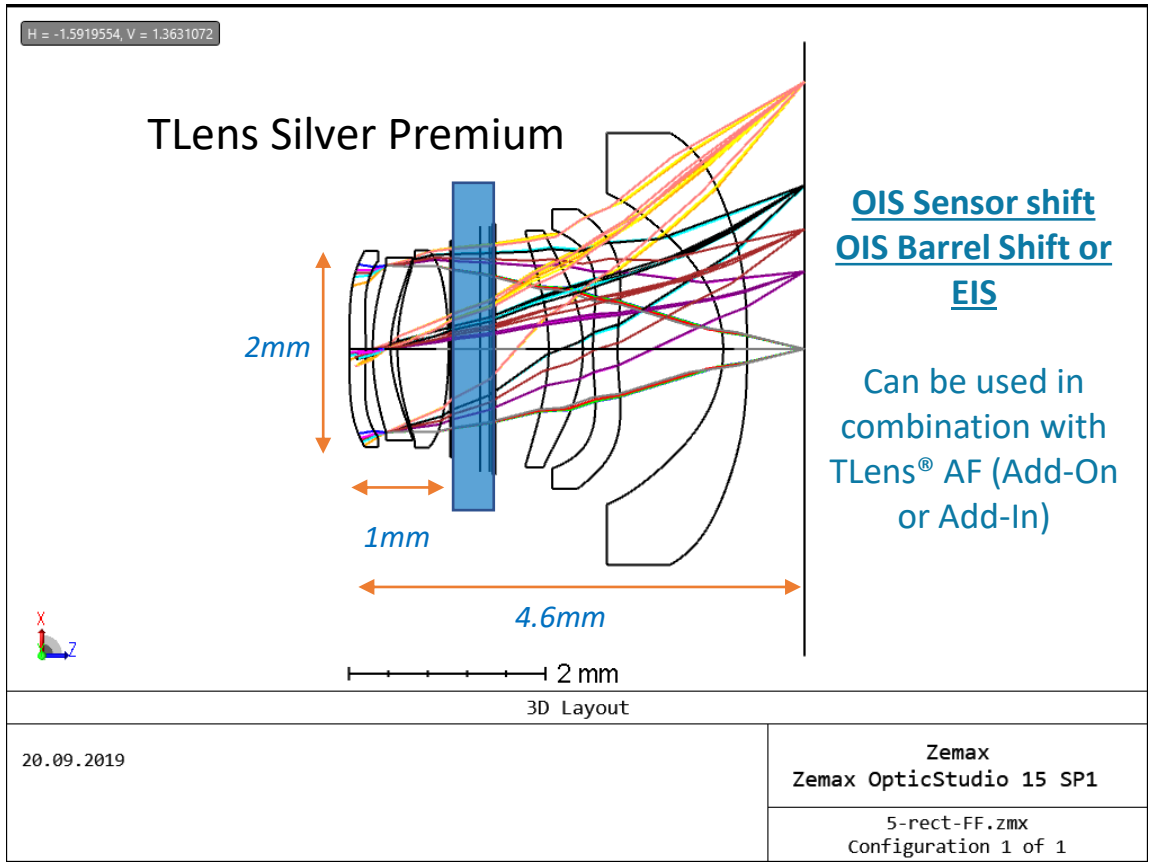
TLens® Add-In design for Hybrid OIS camera

Performances table			
Item	**Design values**		
Lens Module Nose Diameter	2.0 mm (optical)		
Lens Module Nose Length	1.0 mm		
CMOS Size	1/3″ (D=6.475 mm)		
CMOS Pixel Size	1 µm × 1 µm		
CMOS Image Size	6.2 mm diagonal		
EFL	3.78 mm		
IR Filter thickness			
F/#	2.2		
Optical Total Track	4.6 mm		
Back Focal Length (optical)	0.6 mm		
FOV (Degree)	Diagonal	77	
	Vertical	42.6	
	Horizontal	69.4	
MTF		S	T
On Axis	500 cyc/mm	23%	23%
	250 cyc/mm	48%	48%
	125 cyc/mm	73%	73%
80% Field	500 cyc/mm	3%	17%
	250 cyc/mm	36%	49%
	125 cyc/mm	65%	73%
Max Optical / TV Distortion	2.43/0.7%		
Illumination (0.7 /1.0 field)	35%		
Chief Ray Angle	< 40.1 deg		
Lens Component	6P + T-Lens		



OIS Sensor shift
OIS Barrel Shift or EIS

Can be used in combination with TLens® AF (Add-On or Add-In)

Last free form *lens* helps to reduce thickness or front nose diameter
while keeping good optical quality; IR cut filter integrated onto bottom of TLens®

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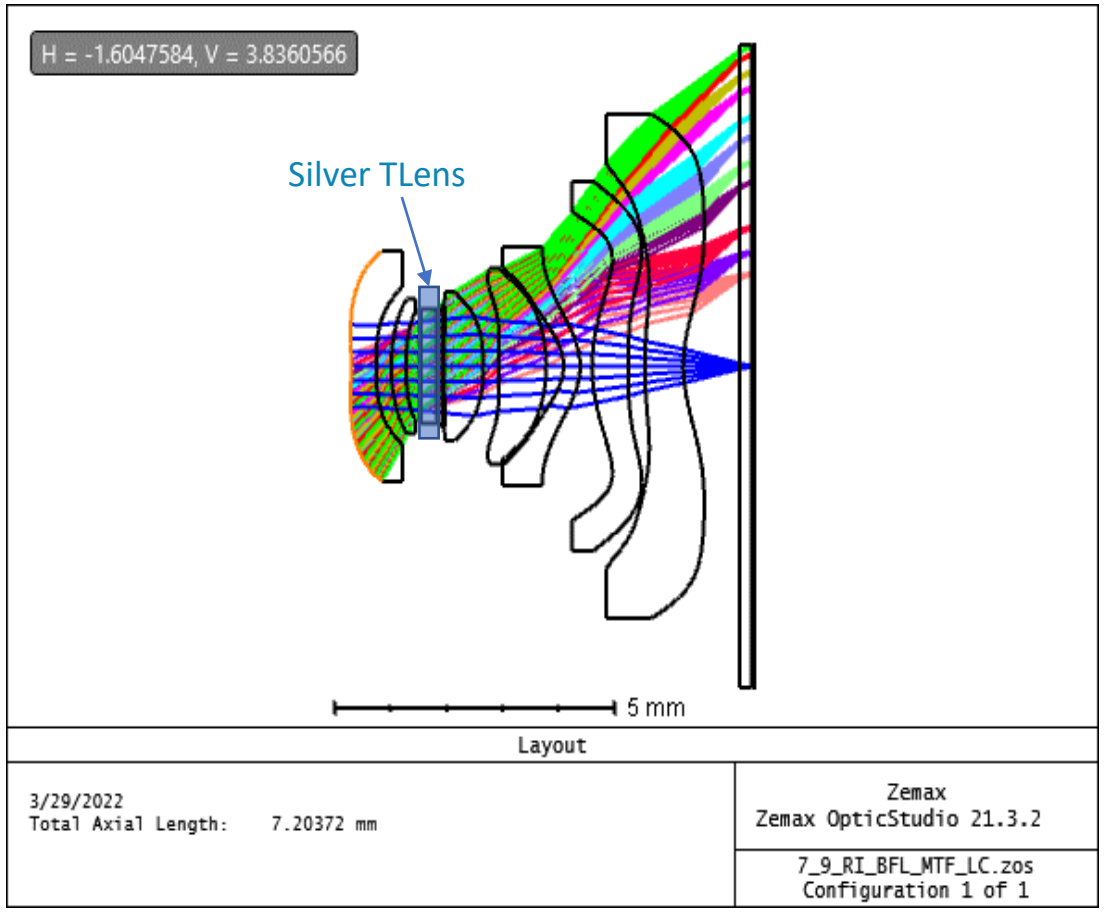
Wide FOV TLens® Add-In design (big format sensor)

Performances

Parameters		Information	Performances	
Construction		7P		
TLens® type		Silver		
Sensor Format		Over 40Mpixel		
Sensor Pixel size		1/1.5'' sensor		
Wavelenght range		400 - 700		
F.No		2.2		
Total Track length		7.2 mm		
EFL		2.96 mm		
View Angle	Horizontal (deg)	108		
	Vertical (deg)	93		
	Diagonal (deg)	120		
MTF	On Axis	500 lp/mm	24%	
		250 lp/mm	55%	
		125 lp/mm	74%	
	80% Field (T/S)	500 lp/mm	1%	0%
		250 lp/mm	37%	0%
		125 lp/mm	65%	34%
Distortion	Optical distortion	2%		
	TV distortion	1.2%		
Relative Illumination (Ref. IH=1)		@inf	14.6%	
Chief Ray Angle Deviation limit		38 deg max		
Maximum Image Circle (MIC)		10.48 (122 deg)		
IR filter thickness		0.21 mm		
Focusing range of using silver TLens®		INF…10 cm		

Principal Layout



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MEMS & Polymer Technology Roadmap

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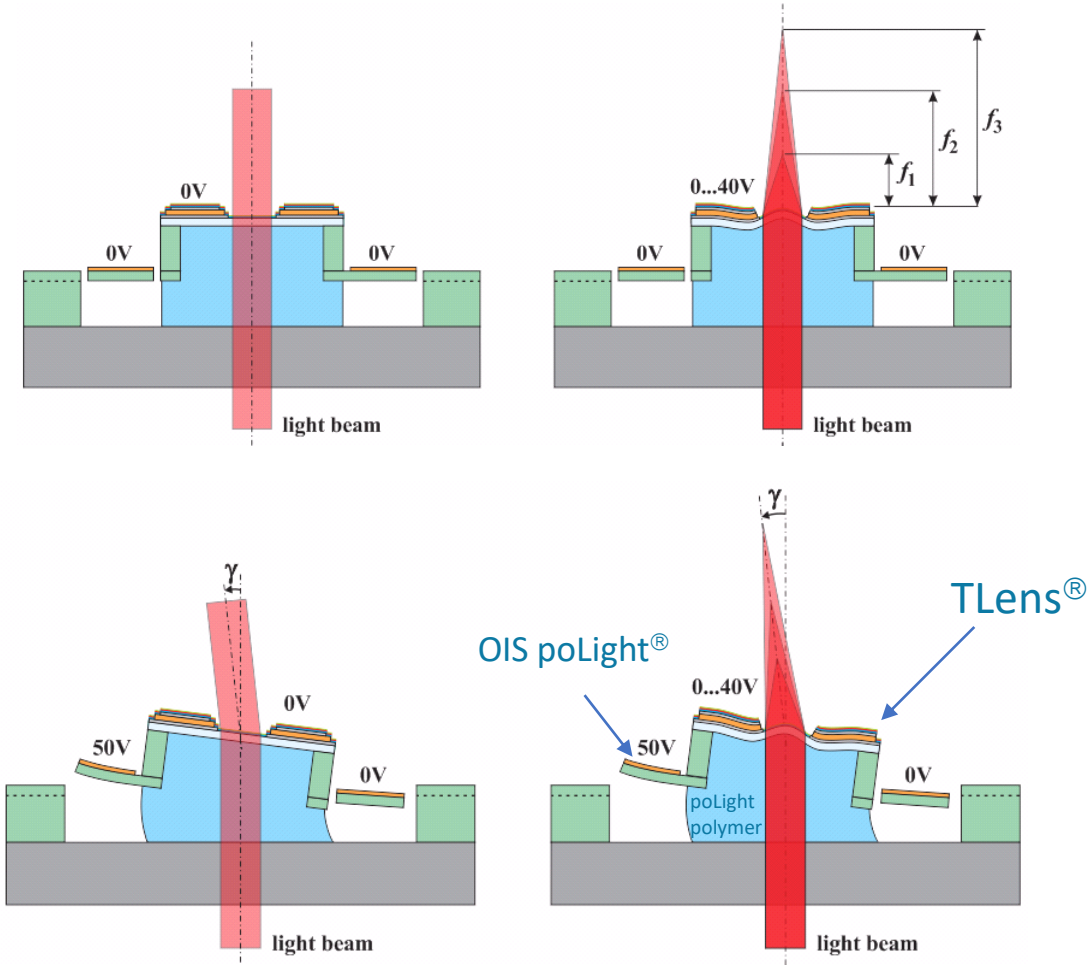
poLight® OIS-AF solution



Optical power [dpt]		Voltage on the TLens® [V]	
		0	40
Voltage on the OIS [V]	0	-3.22	13.01
	50	-3.23	13.01
Deflection angle [degrees]		Voltage on the TLens® [V]	
		0	40
Voltage on the OIS [V]	0	0	0
	50	1.1	1.1

Size < 7 x 7 mm and 0.8 mm thickness

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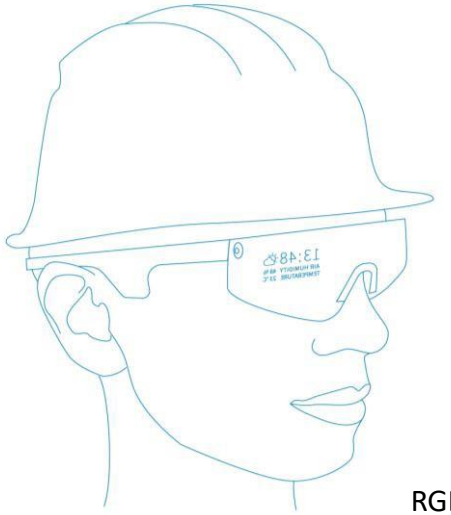
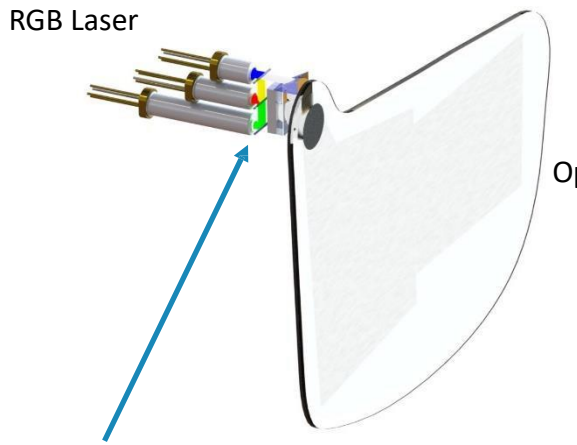
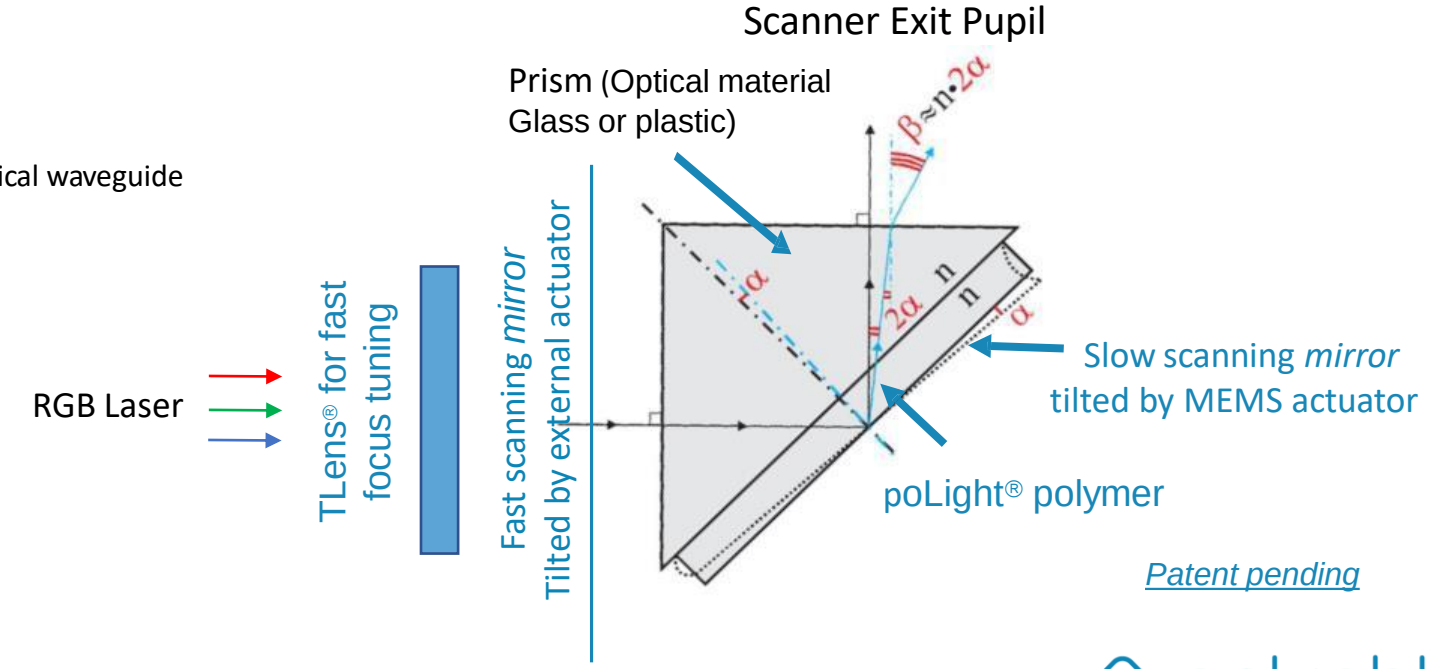
Projection laser display focusing concept



- Ultra compact RGB lasers with TLens® focus tuning
- 1 fast scanning x-axis: Small 1D scanning mirror with external actuator
- 1 slow scanning y-axis: Large 1D scanning mirror with poLight® polymer & MEMS actuator
- Usable with different Waveguide types (SRG or VHG, i.e. holographic mirror)





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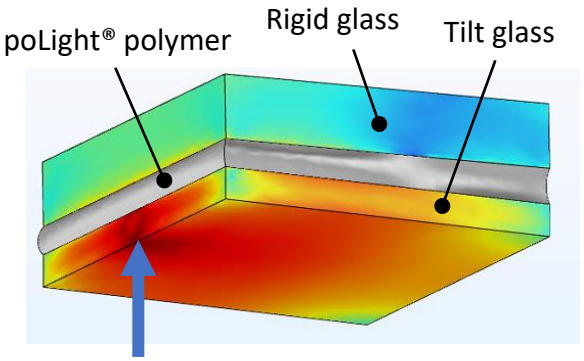
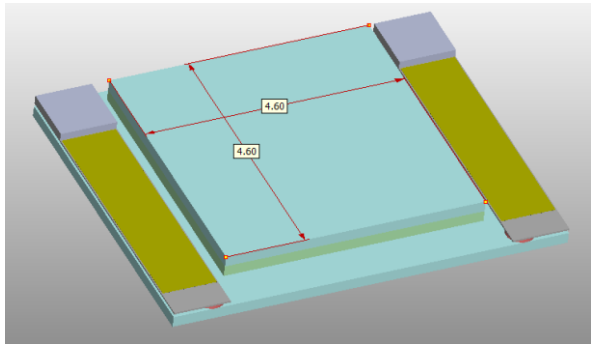
Tunable wedge concept for supra resolution



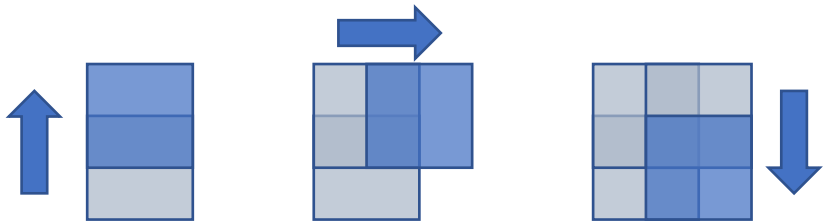
Actuation force at edge of tilt glass



- Target Application: Higher (supra) resolution scaling from a low resolution µLED display
- Key dimensions of simulation example:
  - ✓ Polymer thickness 200um
  - ✓ Tilt glass thickness 200um
  - ✓ Glass size 4.6x4.6mm
  - ✓ Useful aperture 4.0mm

Further optimisation of dimensions is possible, according to actuation force and stroke.
Based on below table, actuation force and stroke should be within reach of piezo technology.

Force (N)	Mechanical tilt in deg	Optical ray tilt in deg	WFE	Stroke um
0	0.000	0.000	0.00	0.0
0.001	0.003	0.002	0.84	0.1
0.002	0.005	0.003	1.69	0.3
0.01	0.027	0.015	8.40	1.4
0.02	0.054	0.030	16.74	2.7
0.03	0.081	0.045	25.03	4.1



Projected pixel

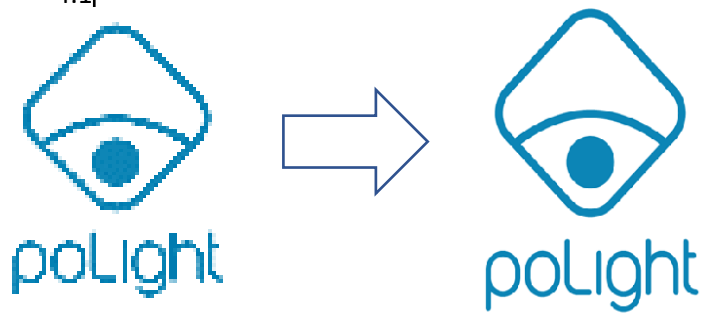


Image perceived by user

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