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Laser Beam Scanning for Augmented Reality Wearable Applications

12th October 2022, ST Developers Conference

MEMS Product Marketing

Nicolò BONI

20 Years and 26 Billion of MEMS at ST

Products

Markets

Consumer

Computing

Automotive

Industrial and Medical

Leadership

ST MEMS Sensors shipped 21 BILLION

#1 50% Market Share** in Motion MEMS in Personal Electronics & Automotive telematics

ST Microactuators shipped 5 BILLION

#1 Micromachined actuators For ink-jet printing and micromirrors**

Sensors

Actuators

**Source: OMDIA

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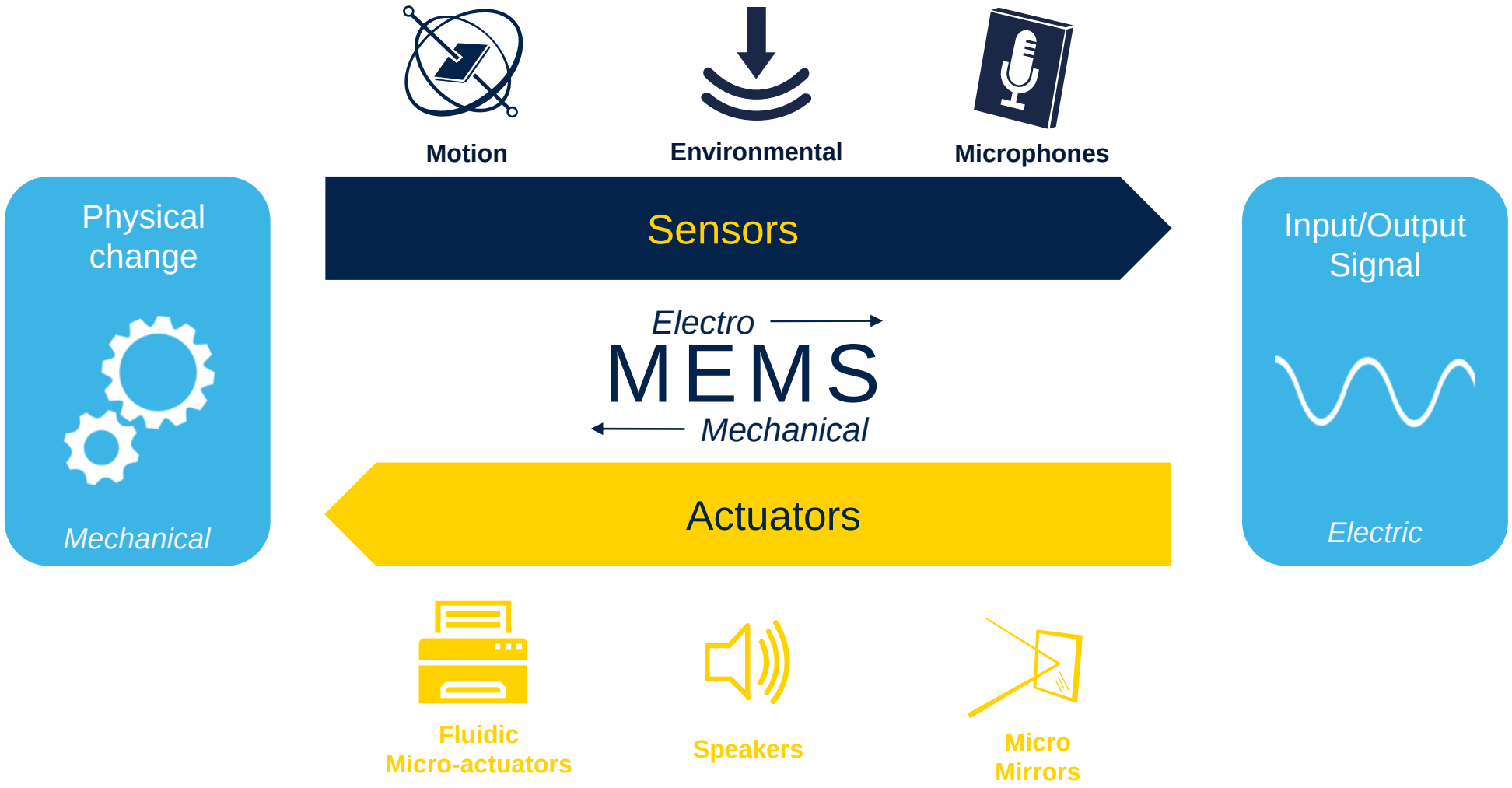
Sensing and Actuating



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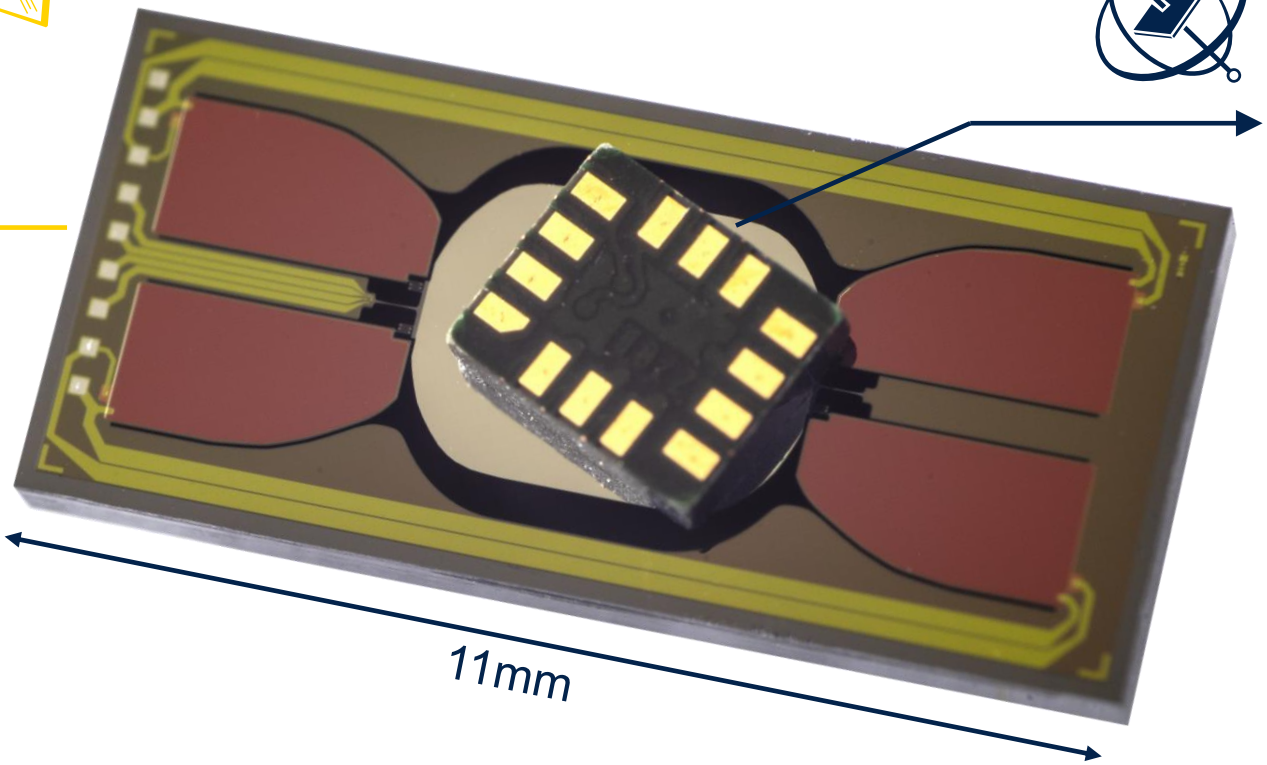
Sensors vs Actuators

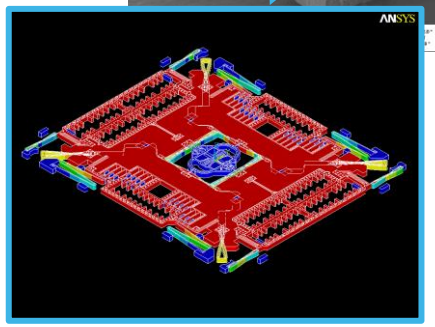
Actuators needs to “change” the external environment:

Large force needed → actuators are typically larger than sensors

ACTUATOR
MEMS only
⇩
11 x 5 x 1mm



SENSOR
2xMEMS + ASIC
In package
⇩
3 x 3 x 1mm



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Microactuators Technologies and Lab-in-Fab

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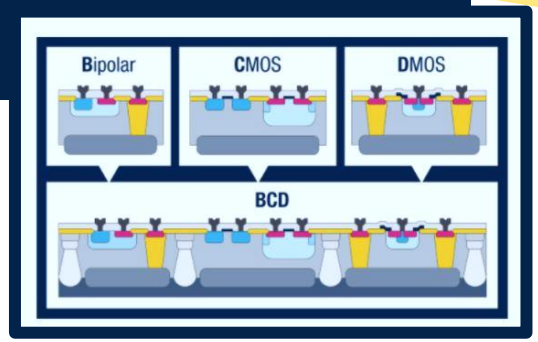
Micro-actuators: Technologies and Products

Different technologies for MEMS actuators

Thermal | **Electrostatic** | **Electro-magnetic** | **Piezo-Electric**

BCD



Design flexibility

- PMUT
- Speaker
- Valves
- Mirrors
- Printheads
- Autofocus
- Atomizer/ Vaporizer
- Custom Development

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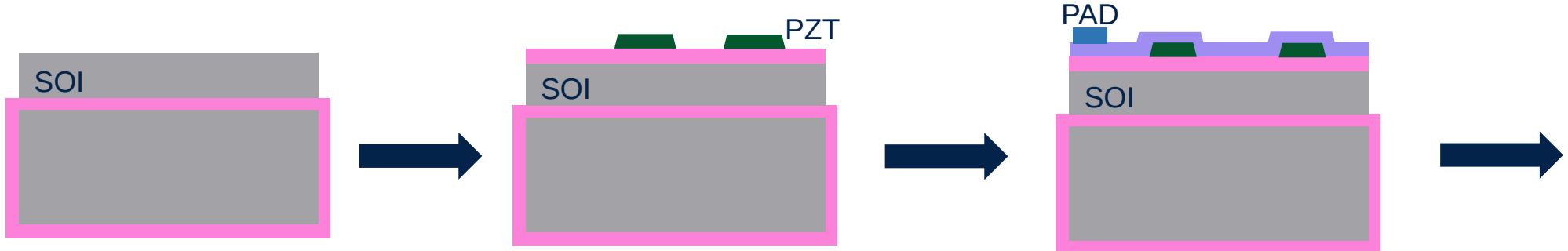
PεTRA Technology

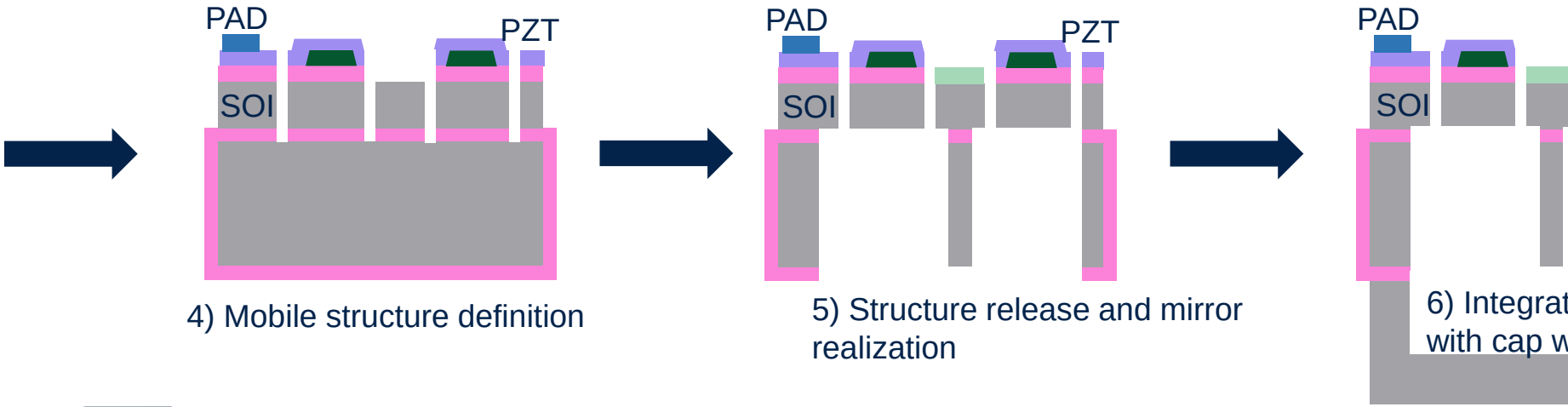
- ST developed **PεTRA** technology platform to create PZT-based MEMS actuators



1) Starting material SOI

2) PZR sensor and thin film piezo capacitor realization

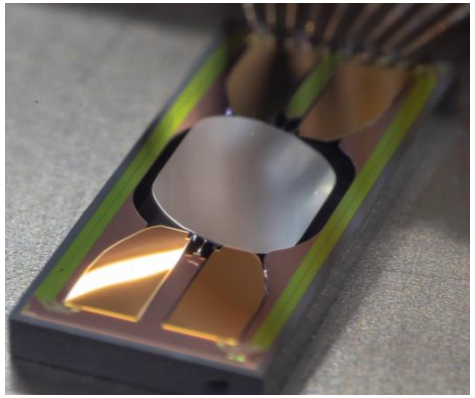
3) Passivation and pad realization



4) Mobile structure definition

5) Structure release and mirror realization

6) Integration with cap wafer



Legend: Si Oxide PZT + electrodes Passivation Pad Mirror metal

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World’s first “Lab-in-Fab” on Piezo MEMS

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Institute of Microelectronics
IME

ULVAC

New MEMS R&D line hosted at ST’s Singapore campus

R&D tools and engineers co-located by the participating parties

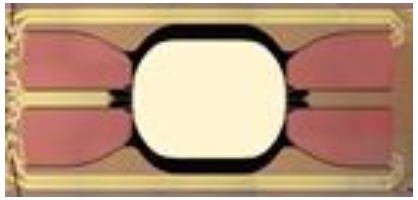
Embedded in ST’s Fab to enable fast time to volume

Mission: become the world's leading R&D center for Piezo MEMS, from fast POC to manufacturing

PεTRA Technology - Roadmap

Sol-Gel

2018 Mass production 8'' sol-gel PZT process



First fully industrialized process for multiple applications

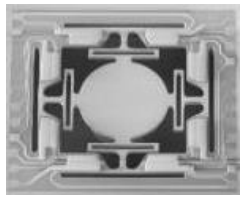
STAR1 – MEMS mirrors

2021 Improved doped PZT process (e31f ↑)

Doped PZT to improve actuation force

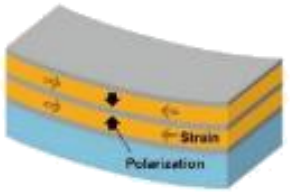
PVD

2022 PVD PZT (e31f ↑ ↑)



Optimal flexibility and lower manufacturing cost

2024 Multilayer PVD PZT



Actuation force increase by layer stacking for power and area reduction

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MEMS Micromirrors

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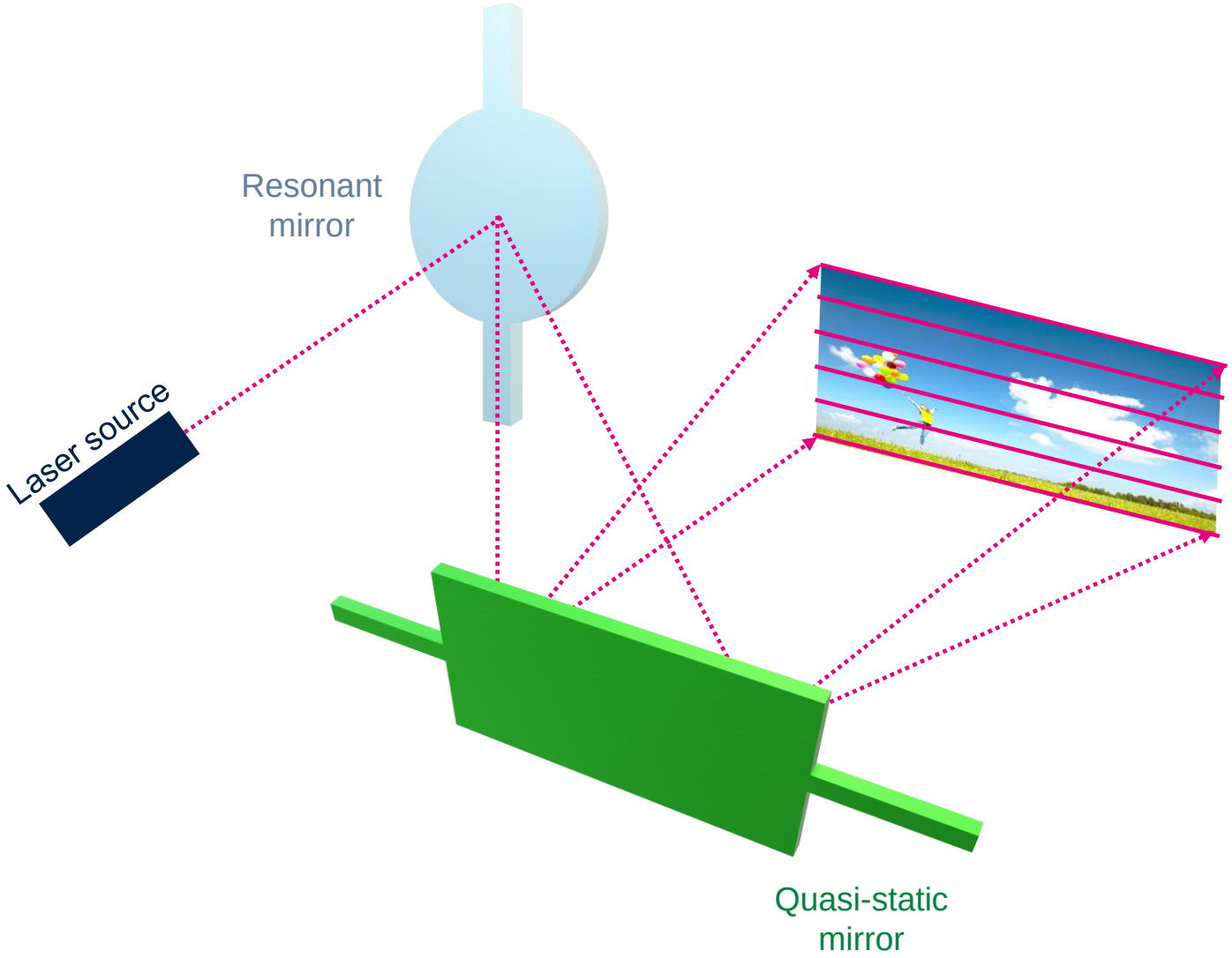
MEMS Mirrors: Laser Beam Scanning

Principles:

- Light from one/multiple **lasers** is combined into a single beam
- Beam is relayed onto **MEMS scanning mirror(s)**
- Mirror(s) scan the beam in a **raster** pattern



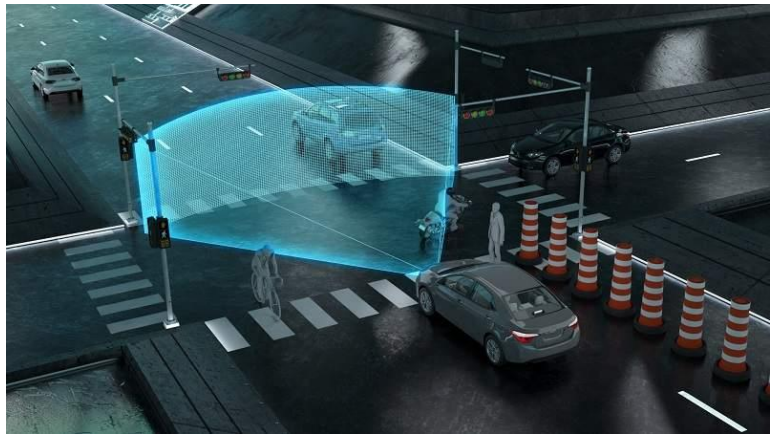
Micro Mirrors: Laser Beam Scanning Applications

Projection (visible light):

Smart Glasses and **Augmented/Mixed Reality** (xR)

Sensing (typically infrared light):

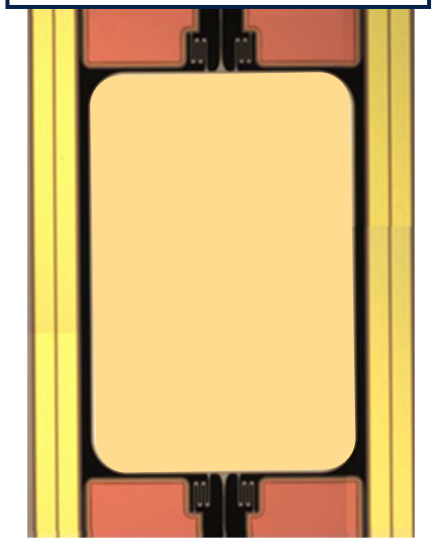
3D Mapping (ex. industrial LiDAR or 3D camera)
Automotive LiDAR and **A**dvanced **D**river **A**ssistance **S**ystems

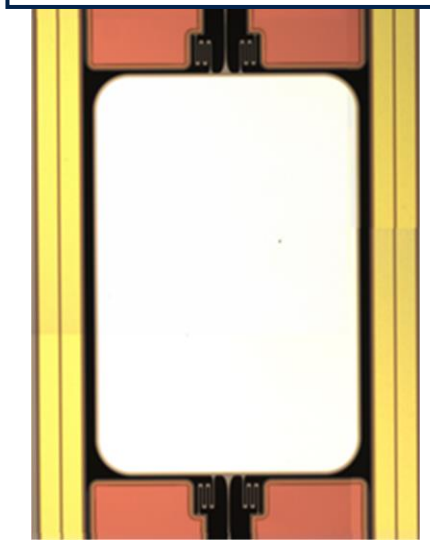


Optical Surface – Mirror Coating

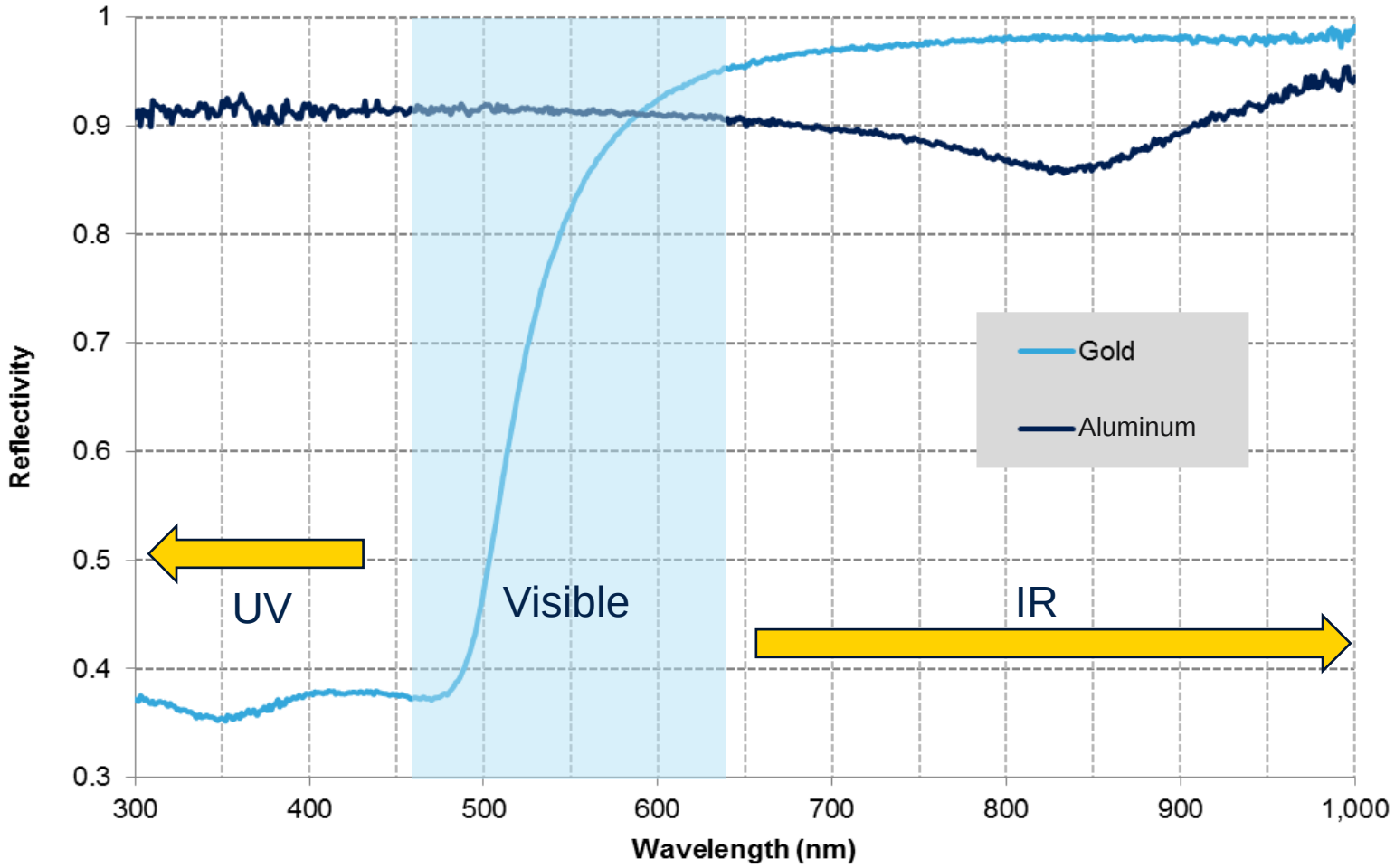
Gold coating → infrared projection

Aluminum coating → visible projection





Both coatings can be integrated on the same mechanical structures looking for the best performance in the target application.



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MEMS Micromirrors for XR

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XR: Augmented and Mixed Reality

Source: North

AR glasses:

Small

Lightweight

All day

Source: Microsoft

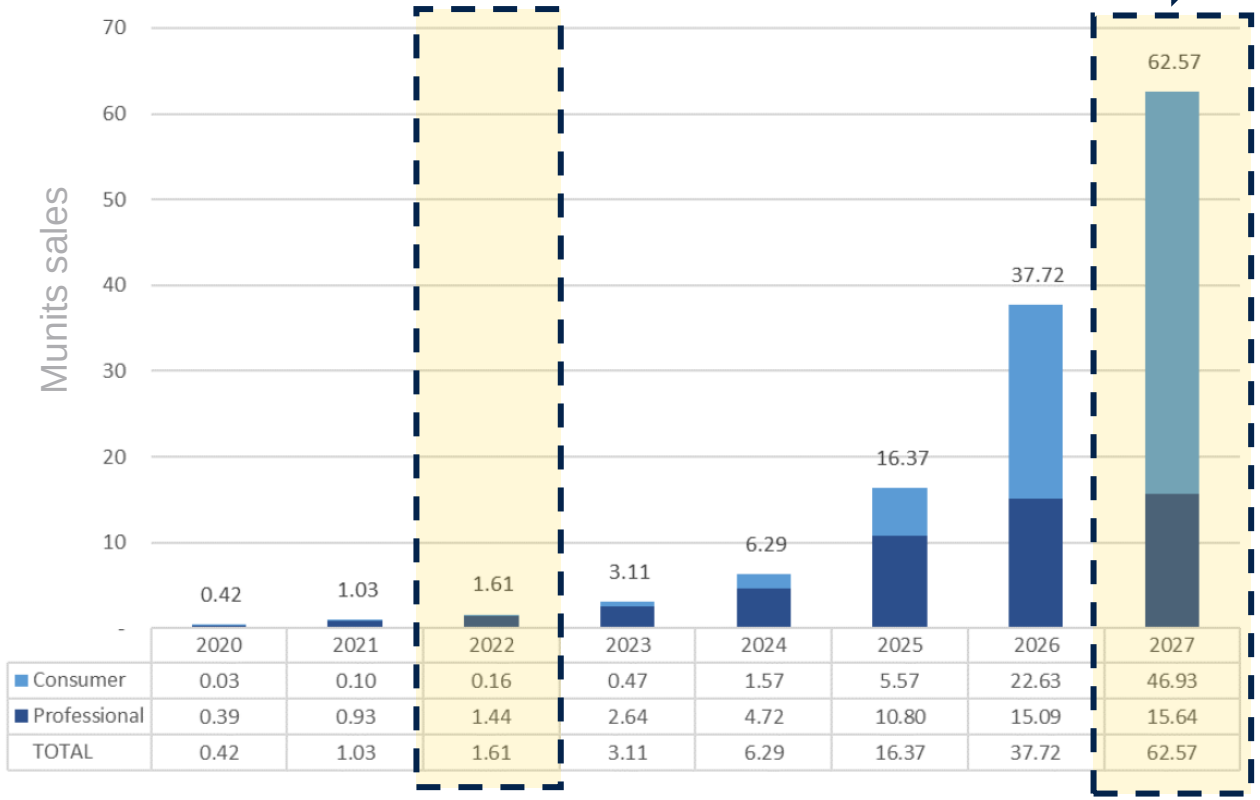
MR glasses:

High resolution

Immersive

Powerful

AR and MR headsets sales:
1Mu to 60Mu in 5 years



	2020	2021	2022	2023	2024	2025	2026	2027
Consumer	0.03	0.10	0.16	0.47	1.57	5.57	22.63	46.93
Professional	0.39	0.93	1.44	2.64	4.72	10.80	15.09	15.64
TOTAL	0.42	1.03	1.61	3.11	6.29	16.37	37.72	62.57

Source: Yolè Displays & optics for AR &VR 2022

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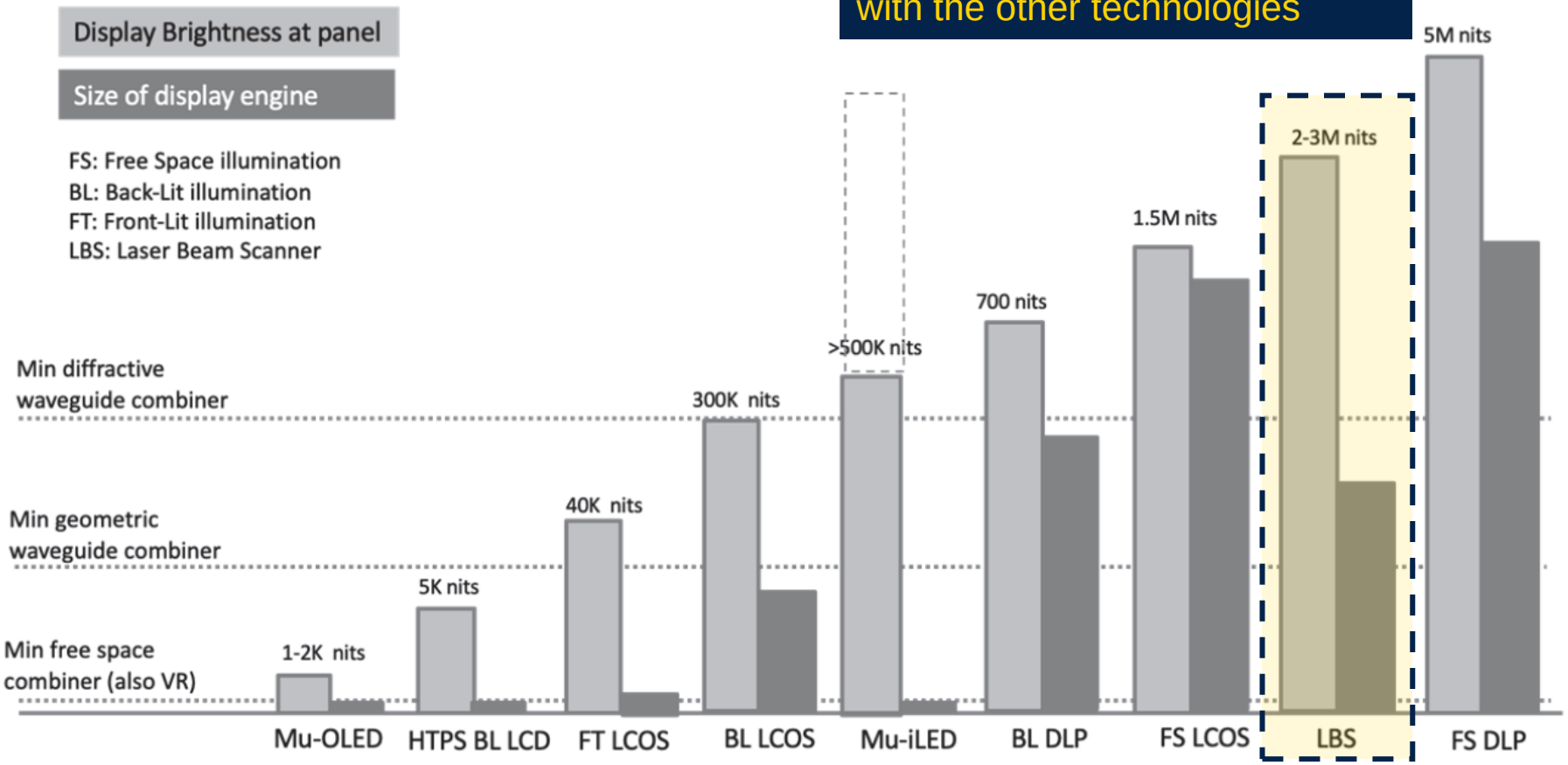
XR Glasses: Why Laser Beam Scanning?

LBS has the best brightness to volume ratio (nits/cc) compared with the other technologies

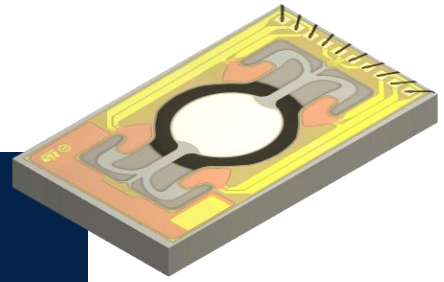
Enabling truly lightweight, all-day smart glasses



Source: Optical Architectures for Augmented-, Virtual-, and Mixed-Reality Headsets – B. Kress

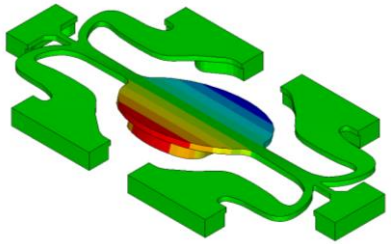
STAR1 MEMS Mirrors

MMR40100 - Castor



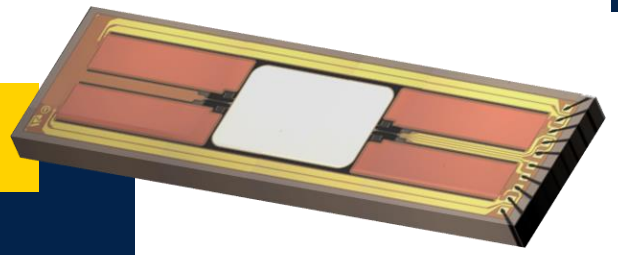
Eng. samples available now

- Resonant Mono-Axial
  - PεTRA™ TF PZT material
- Aluminum Coating
- PZR Position Sensing



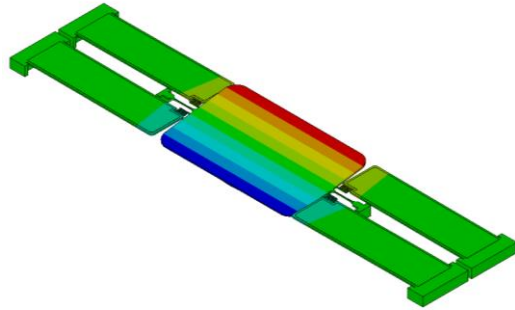
- 56˚ Optical Field-of-View
- 1.1mm Diameter Mirror
- 27.5 kHz Resonant Freq.
- ± 14˚ Mechanical Angle
- 4.0 x 2.4 mm^2 Die size

MML40100 - Pollux



Eng. samples available now

- Linear Mono-Axial
  - PεTRA™ TF PZT material
- Aluminum Coating
- PZR Position Sensing



- 32˚ Optical Field-of-View
- 2.45 x 1.44 mm^2 Mirror
- Up to 250 Hz Refresh Rate
- ± 8˚ Mechanical Angle
- 7.5 x 2.3 mm^2 Die size

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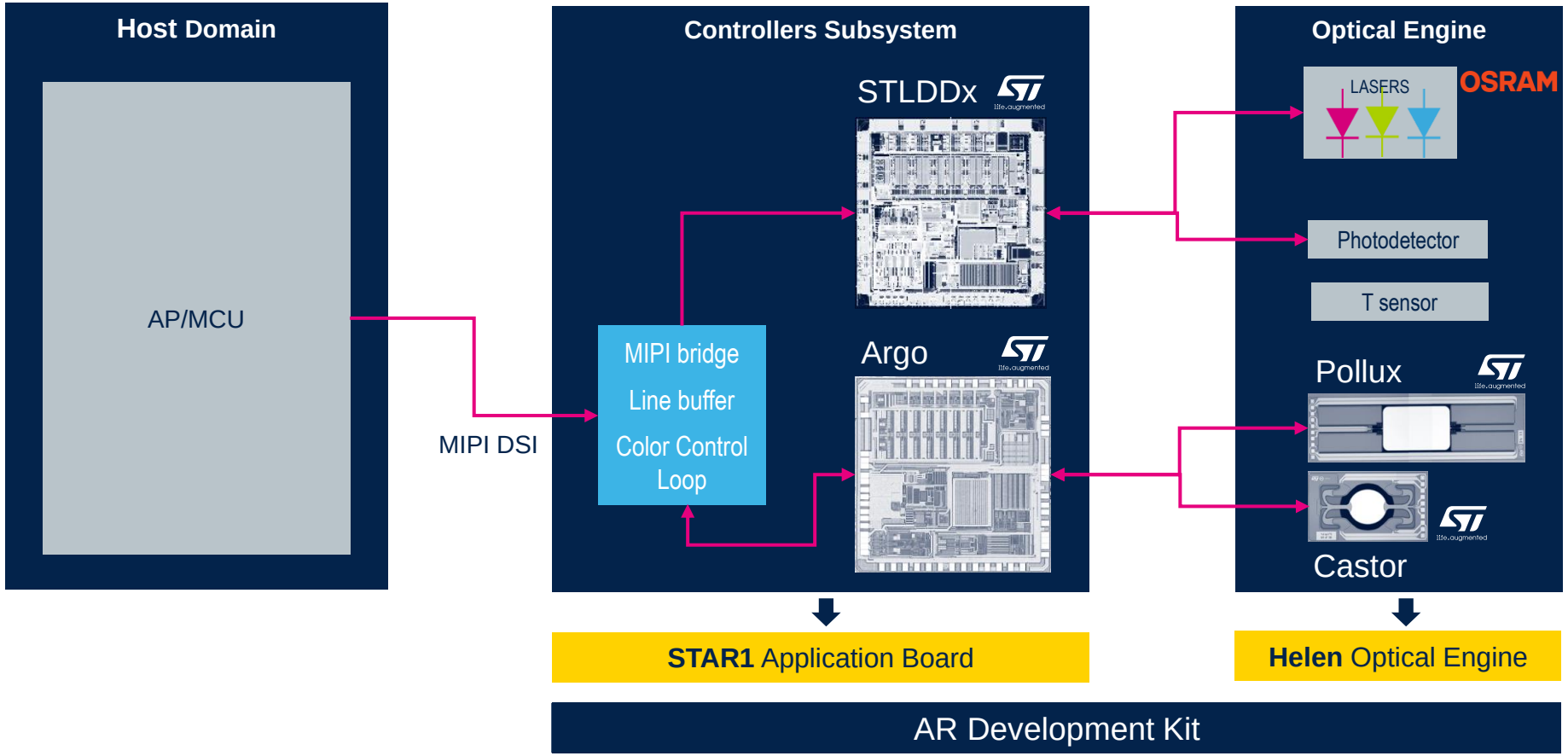
STAR1 Schematics

STAR1 development kit for XR applications

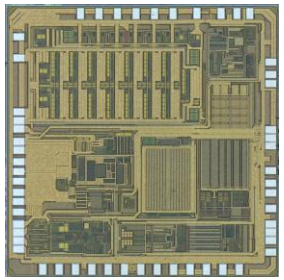
Based On ST Piezo Mirror Technology



STAR1 ASICS

MMD40100 - Argo

- Linear / Resonant Driver
- Configurable HW Control Loops:
  - Resonant Mirror
  - Linear Mirror
- Integrated Safety Mechanism
- Embedded Environmental Compensation

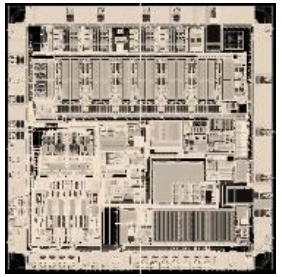


Eng. samples available now

- Low Power Consumption
- Energy Charge Recovery
- Compact Dimensions
  - BGA 5 x 5 x 1 mm^3 package

STLDDx

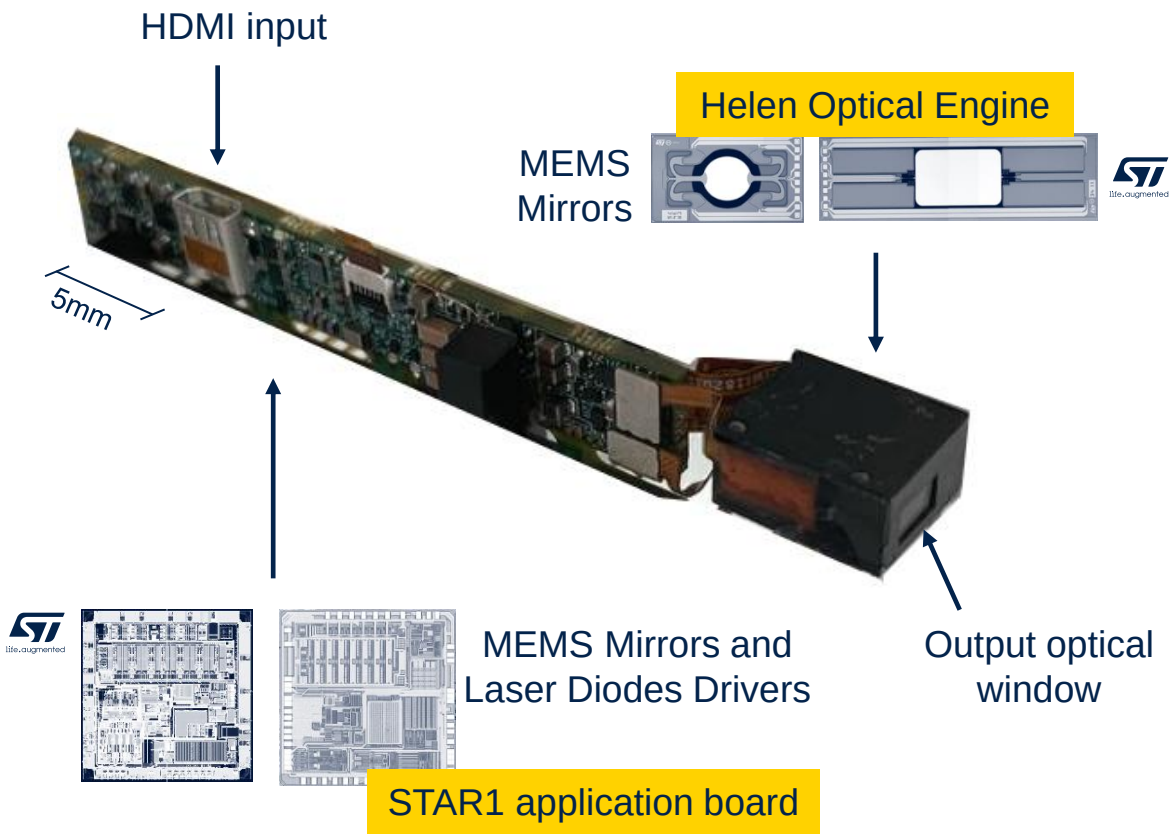
- Laser Diode Driver
- 2 Device Options:
  - Up To 4 Laser Diode Drive Channels
- Low-power Mode:
  - Automatically Triggered Based On Input Pixel Data



Eng. samples available now

- 500 ps Rise / Fall Time
- Up to 260MHz Pixel Rate
- Compact Dimensions
  - <20 mm^2 (WLCSP)

STAR1 Laser Beam Scanning



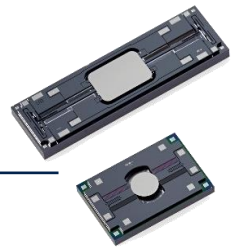
STAR1 Dev Kit– Main features:

- Complete projection system (HDMI input)
- Volume occupation: **<0.7cc** optical engine
- Optical FOV: up to **65deg**
- Output brightness: **1.5-10 lumens**
- Resolution: **720p**
- System power consumption: ~**350mW**

ST LBS Optical Engine: Roadmap

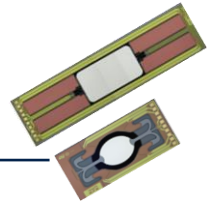
STAR0 → Electrostatic Mirrors

Optical Engine for STAR0	
Helen OE FoV (Diag)	56^0
Output Brightness	1.5 – 10 lm
Resolution	960 x 600p
Size	0.75 cc
MEMS Mirrors	**Electrostatic**



STAR1 → Piezoelectric Mirrors

Optical Engine for STAR1	
OE FoV (Diag)	65^0
Output Brightness	1.5 – 10 lm
Resolution	1280 x 720p
Size	< 0.7 cc
MEMS Mirrors	**Thin Film Piezo**



700mW power consumption → 350mW power consumption

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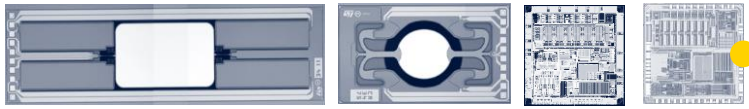
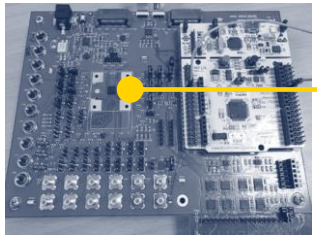
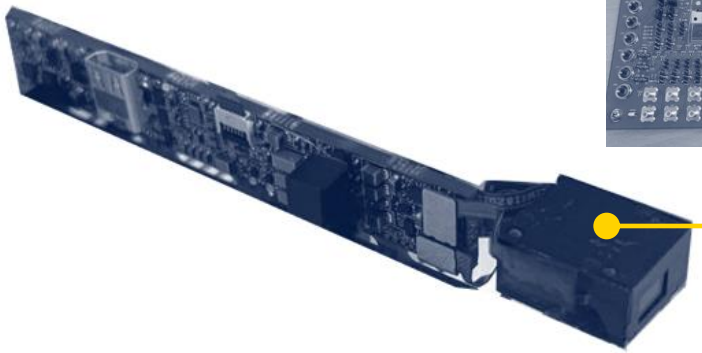
Laser Beam Scanning Solutions

for fast development of high-performance Augmented Reality applications







Components

Evaluation Boards

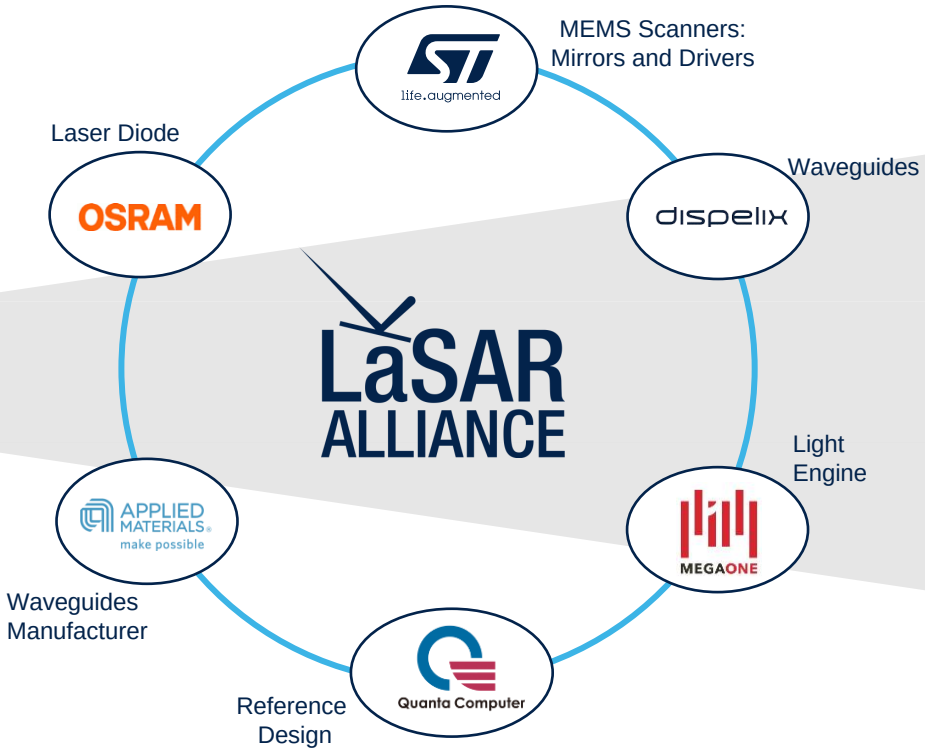
LBS Display Ref. Design
&
AR Development Kit

Full Reference Design
&
Manufacturing Partners

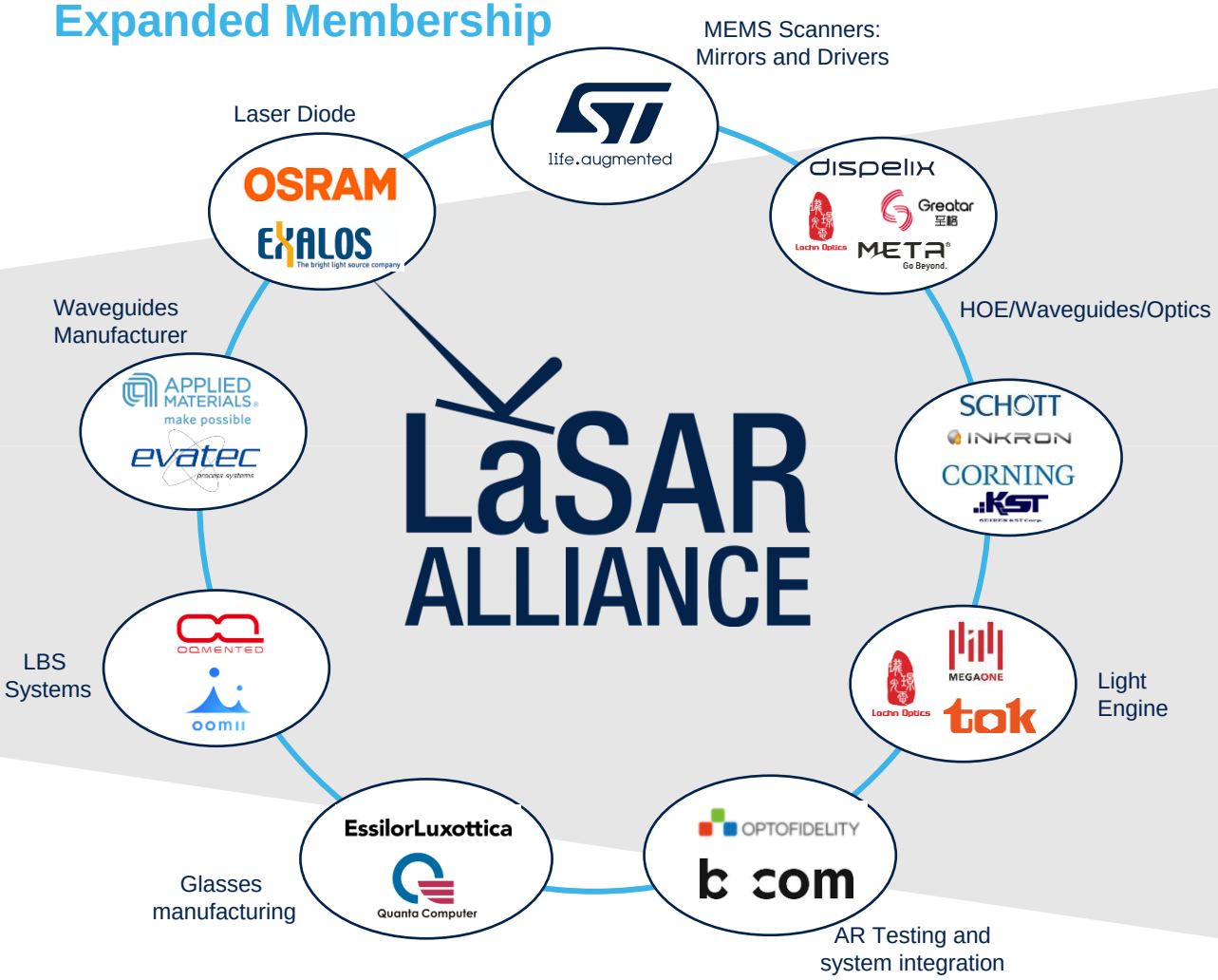
LaSAR
is an acronym for
Laser **S**canning
for **A**ugmented **R**eality

The LaSAR Alliance Ecosystem

Founding Members



Expanded Membership



Strategic partners for mass production

Other piezo actuators

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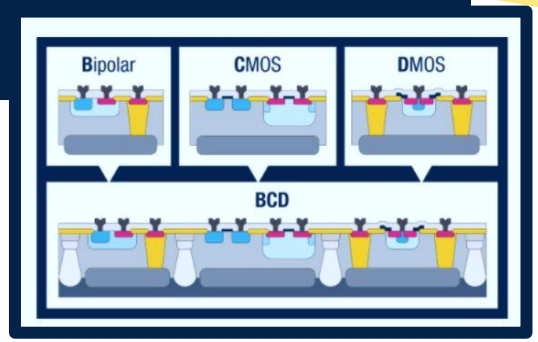
Micro-actuators: Technologies and Products

Different technologies for MEMS actuators

Thermal | **Electro-magnetic** | **Electrostatic** | **Piezo-Electric**

BCD



Design flexibility

- PMUT
- Speaker
- Valves
- Mirrors
- Printheads
- Autofocus
- Atomizer/ Vaporizer
- Custom Development

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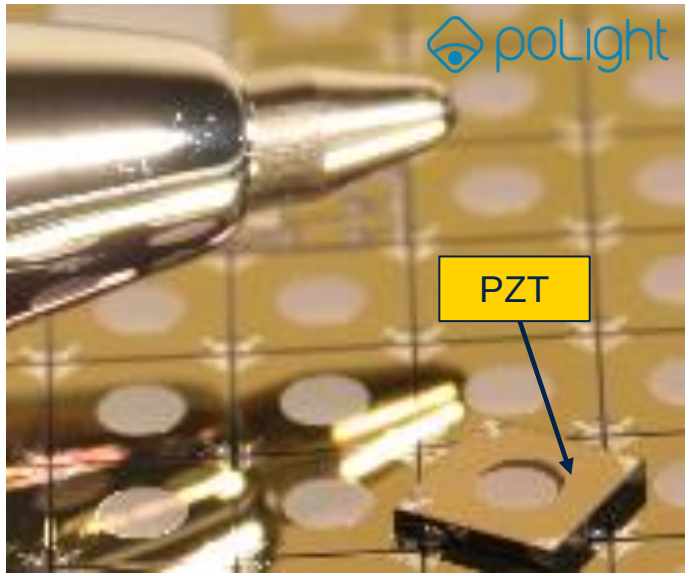
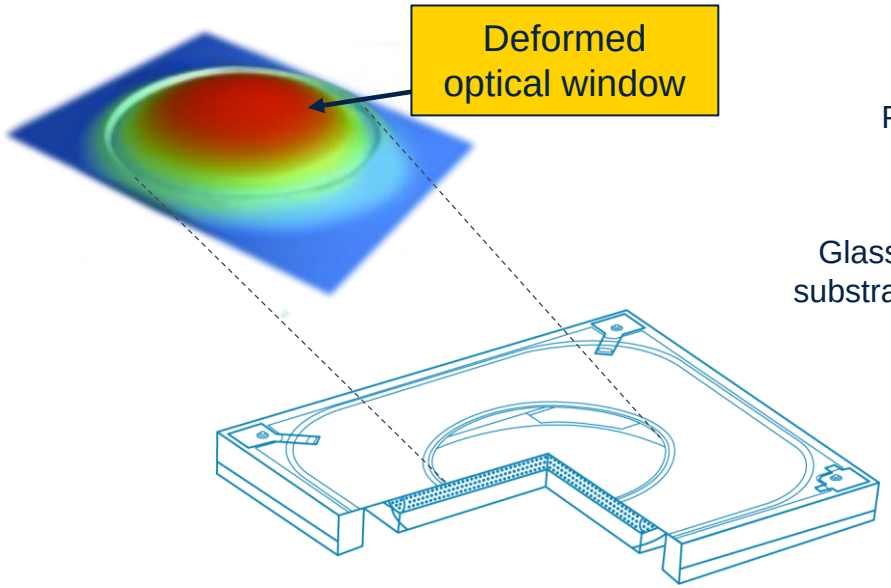
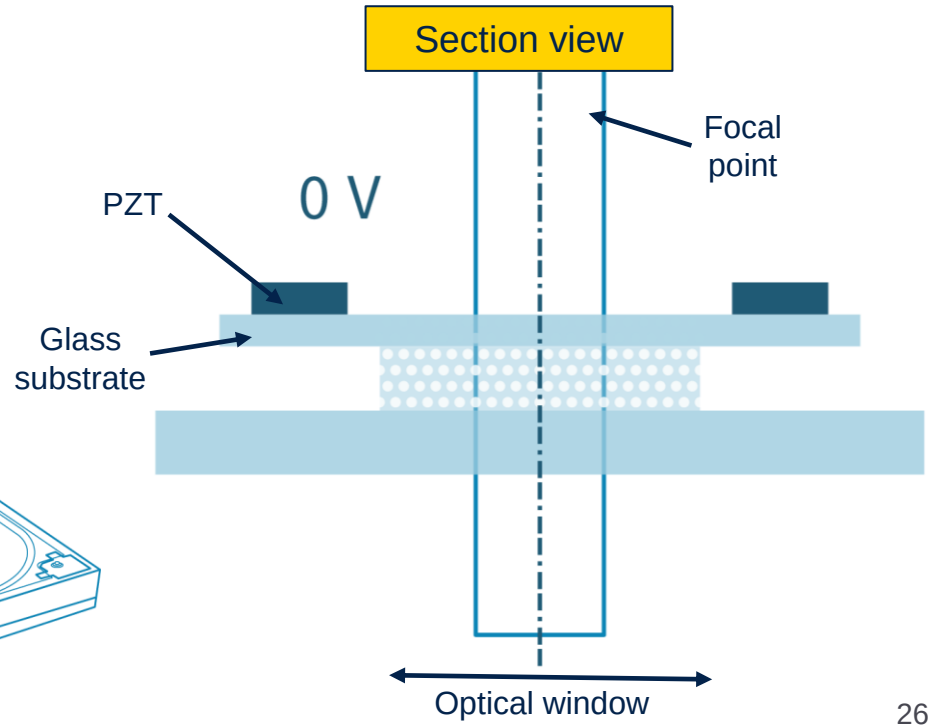
MEMS Autofocus Lens - PoLight

- **Working principle**:
  - PZT actuation used to deflect a glass substrate
  - Changing the driving voltage, the deformation changes and so the focal point of the lens
  - The MEMS has been developed in partnership with Polight



Source: Polight





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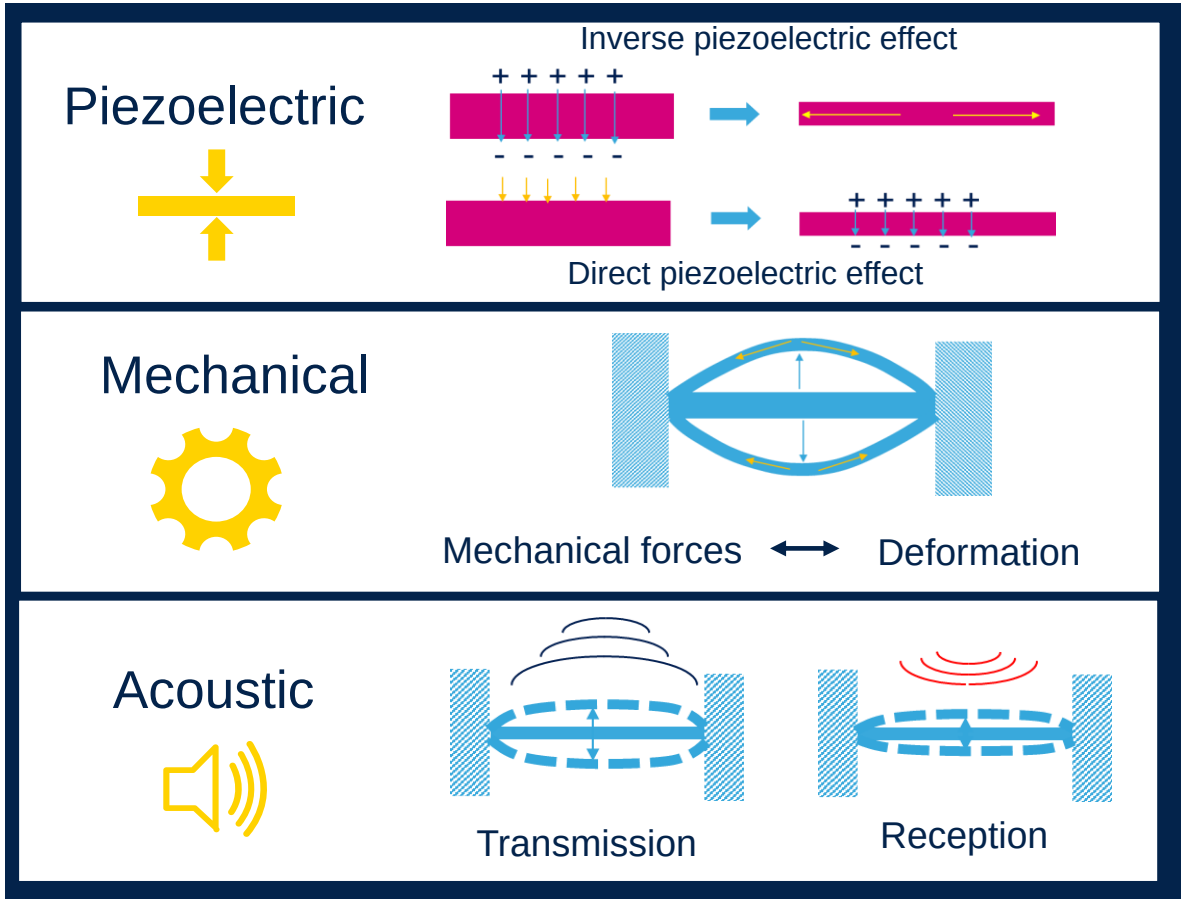
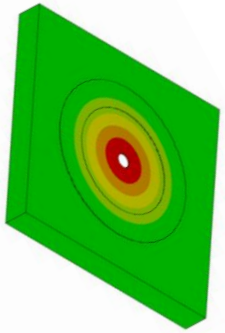
Ultrasounds - PMUT

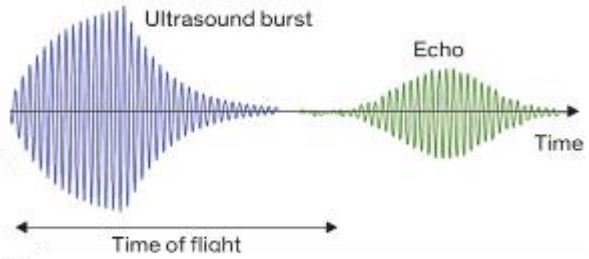
- **PMUT: Piezoelectric Micromachined Ultrasonic Transducer**
  - **Ultrasound wave used to scan the environment:** actuator and sensor embedded in the same device

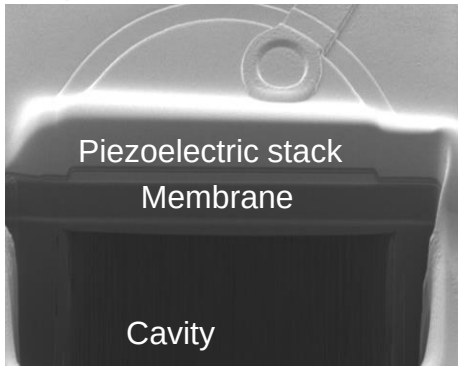


Three physical domains in one device, based on piezoelectric thin-film layer technology



PMUT





PMUT – Applications

Consumer

- Fingerprint Sensing
- Proximity Sensing
- User Interaction Gesture Rec.

Automotive

- Battery Monitoring
- User Interaction Gesture Rec.

Industrial

- Non-Destructive Testing
- Measurement & Automation

Medical

- Ultrasound Imaging
- Therapeutic Ultrasound
- Wearable Monitoring

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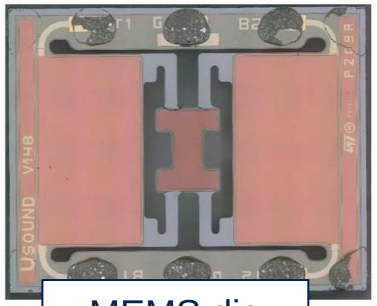
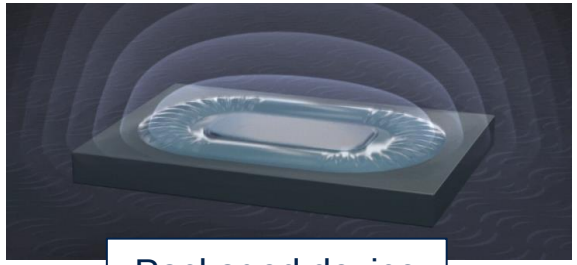
MEMS Speakers

- **Compared with other technologies, MEMS speakers offers:**
  - Lightweight, smaller size and power consumption
  - Simpler and repeatable manufacturing

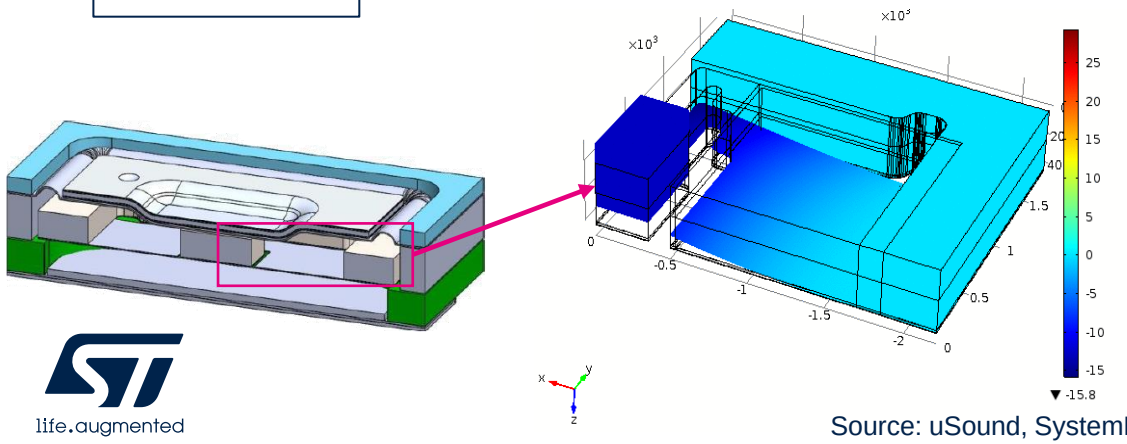
MEMS actuator + external membrane



MEMS die

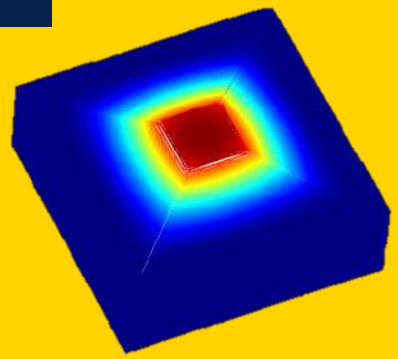


Packaged device



Source: uSound, SystemPlus

FULL SILICON



- Full silicon solution will further reduce the volume occupation and the complexity of the final device (no membrane needed)

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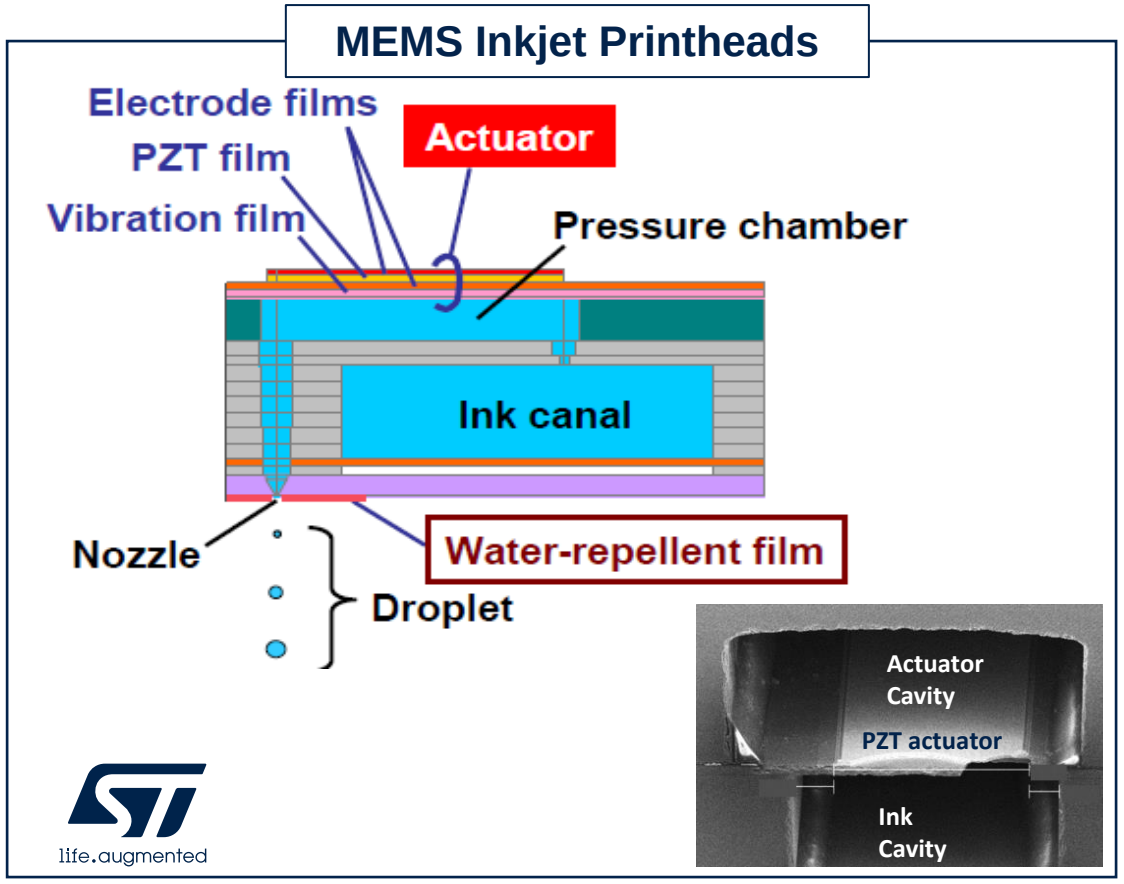
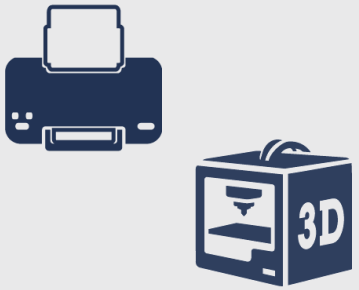
Microfluidics – Applications

- **Microfluidics actuators:**
  - Piezoelectric material used to shape the volume of a chamber and move fluids

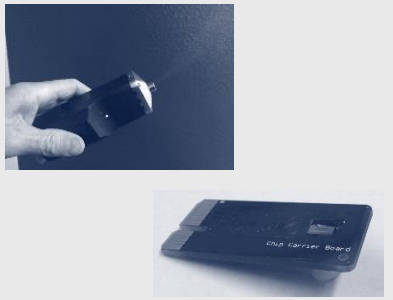


New applications

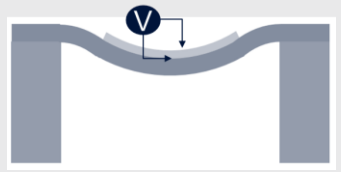


Smart Printing

MEMS pumps



Smart dosing

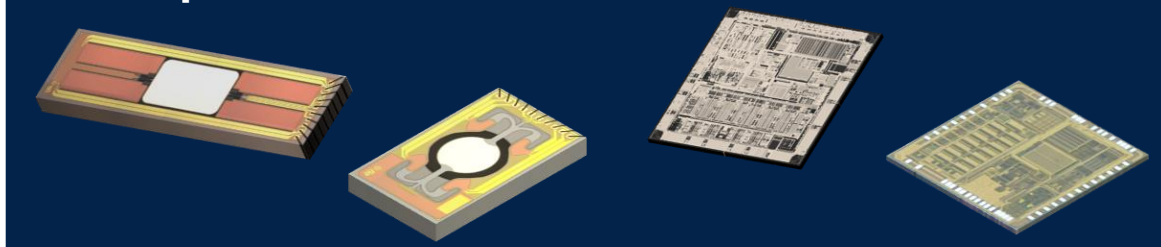


MEMS valves

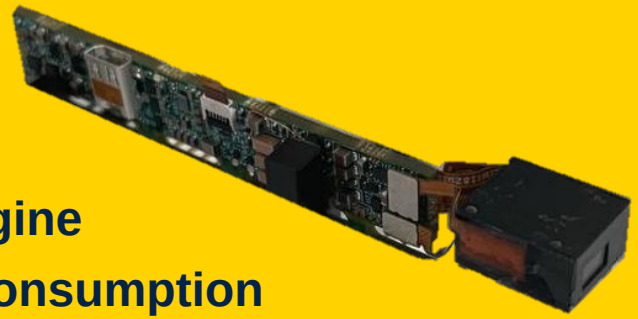
Takeaways

Takeaways

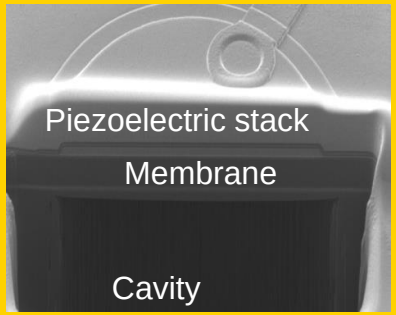
- ST MEMS mirrors and ASICs are key components to enable **all-day wearable AR glasses** thanks to **low power** and **small size**



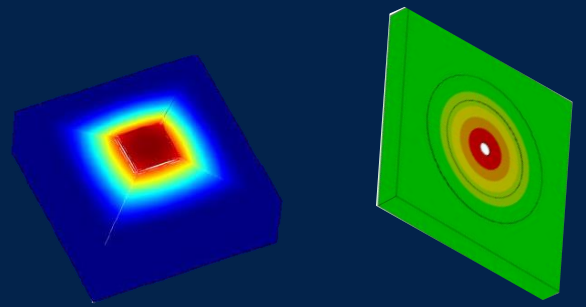
- STAR1 Dev Kit system capable of:
  - **65deg FOV**
  - **1.5-10 lumens**
  - **720p resolution**
  - **0.7cc optical engine**
  - **350mW power consumption**



- Improvements to the PεTRA piezoelectric technology platform will further improve MEMS performances:
  - **Higher force**
  - **Lower power**
  - **Smaller footprint**
  - **Higher resolution**



- **Flexible piezoelectric technology platform** suitable for different kinds of MEMS actuators



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Our technology starts with You

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