Augmented Reality Symposium
STMicroelectronics – Laser Beam Scanners for AR/MR Near-Eye-Displays

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Computing Platform Evolution

Laptop

Smartphone

AR/MR

- AR/MR: the next generation computing and communication platform
  - KEY CHALLENGES:
    - Display Performances
    - Low Latency Processing: IMU and Display synchronization (SLAM)
    - Power Consumption / Weight

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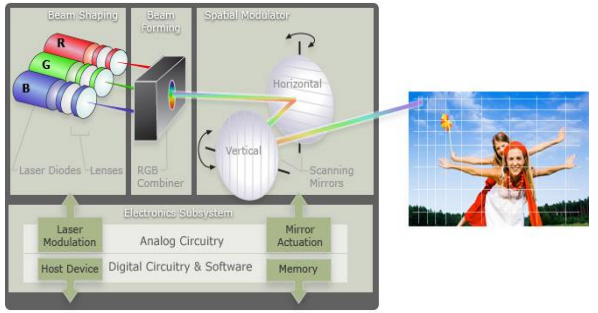
Laser Beam Scanning for AR Display

- How: Creating an image by scanning color lasers thru MEMS Mirrors and modulating the lasers per pixel. Why:
  - Always in focus
  - No Blur → Low Persistency
    - 10nsec persistency per laser pixel vs milli seconds of microdisplays
  - Viewer Comfort → Low Latency
    - One pixel displayed at the time. Pixel rendered just before being displayed
    - Entire Frame to be rendered before being displayed with LCoS
  - High brightness for wearable / displays:
    - LBS Illumination more efficient than LCoS
    - Laser operates only when pixel is “on”
    - AR content is sparse (<10%)
  - Scalable FoV with Thin Film PZT actuated MEMS Mirrors
    - 40deg → 70deg → 100deg diagonal
  - Size



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Laser Beam Scanning For AR Glasses

- Focals™ by North: the first all-day wearable fashion smart glasses based on LBS displays

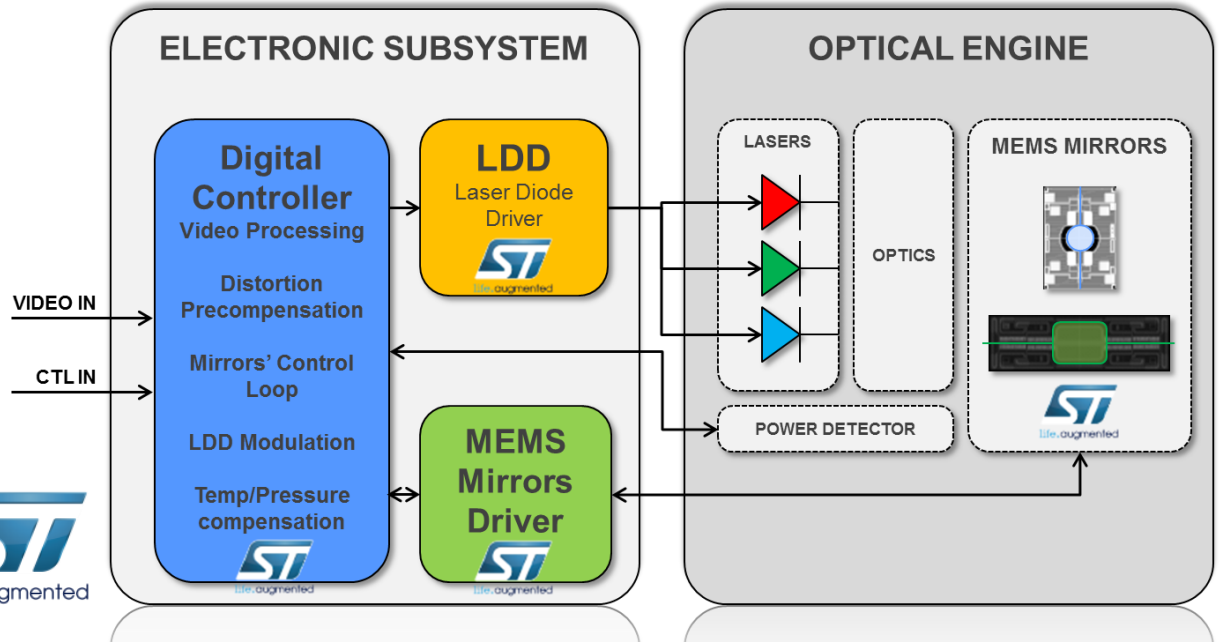
NORTH

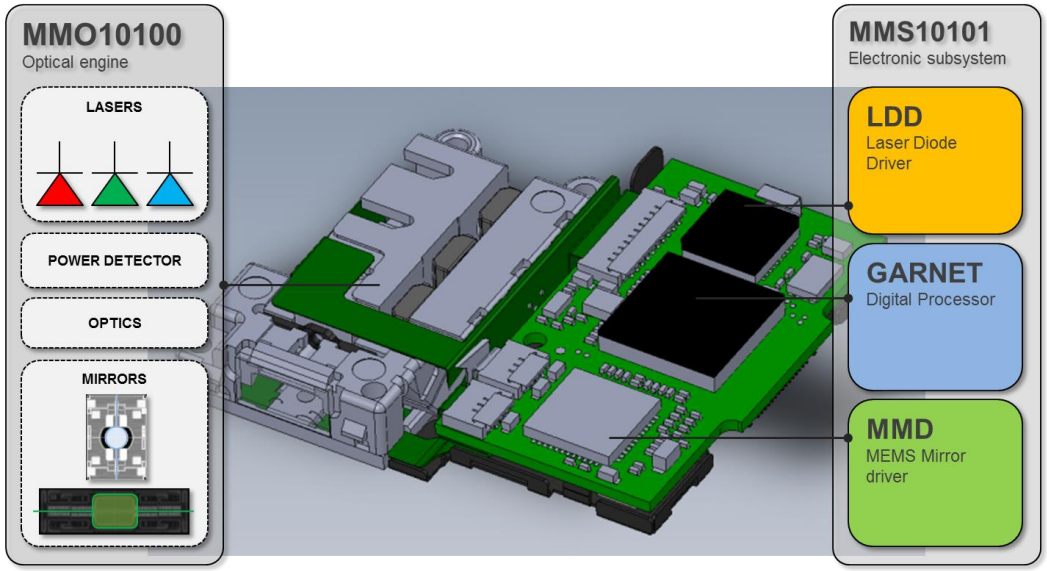
https://www.youtube.com/watch?v=eqFqtAJMtYE

- Microsoft announced Hololens-2 at MWC: LBS based HMD
  - Press reported Improving FoV, Resolution (2KK) and Brightness vs existing solutions based on LCoS

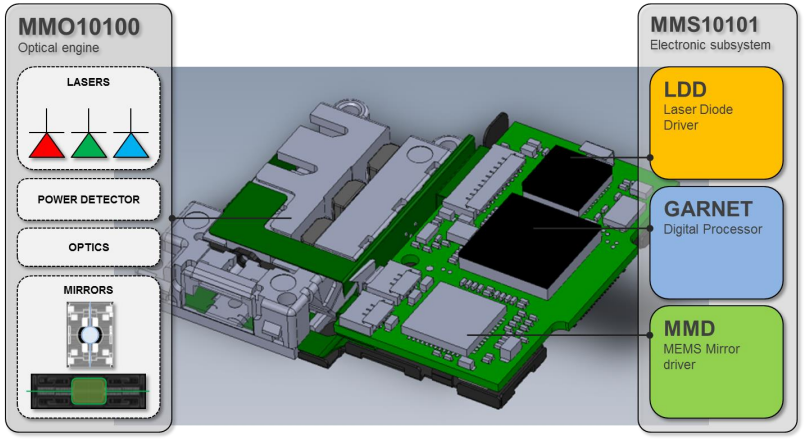
ST Laser Beam Scanning Display

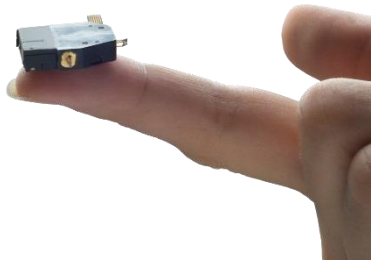
- ST One Stop Shop for LBS Solutions:
  - MEMS Mirrors embedding position sensing, MEMS drivers and Laser Diode Drivers
  - Control Loop and Video Processing HW and SW
  - Building the Ecosystem for LBS based AR Glasses:
    - Strategic Partnership with Laser Diodes Makers
    - Cooperation with different Optical Combiners manufacturers
    - AR/MR AP providers for system integration



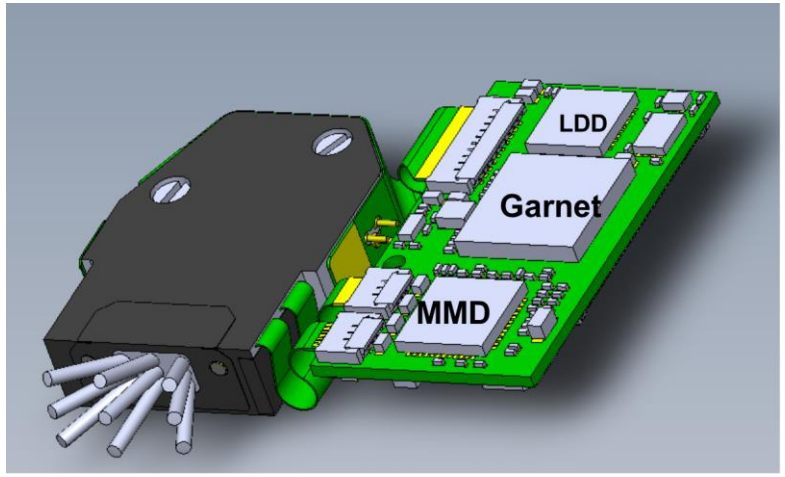


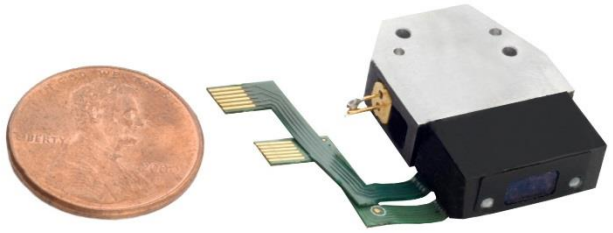
ST LBS Display: Today Size

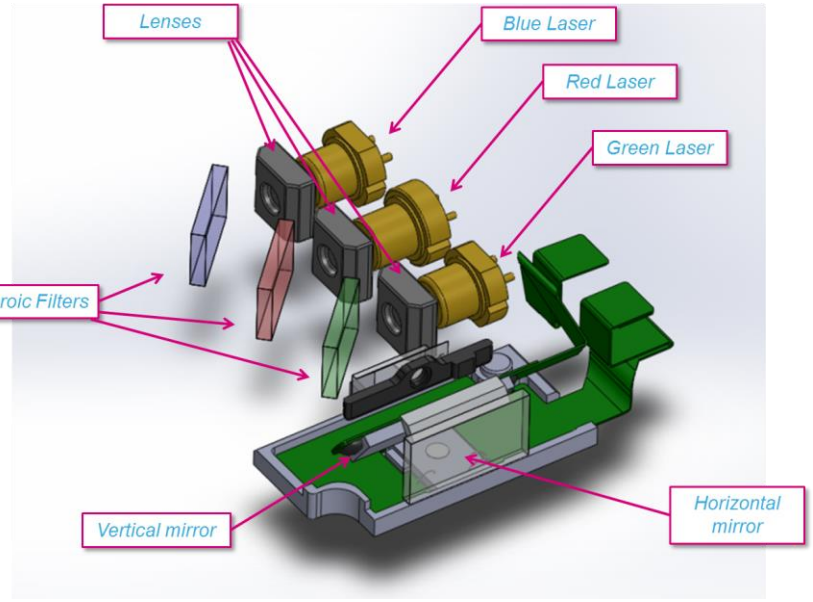




Actual Size: 1.7 cc







30% size and weight vs LCoS based Display
Further size reduction can be achieved relatively easily

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ST MEMS Mirrors

> 10M MEMS Mirrors shipped addressing different applications

Augmented Reality

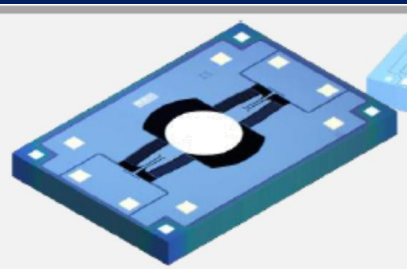
- Visible Projection
- Small volume occupation
- Low Power Consumption

Projection

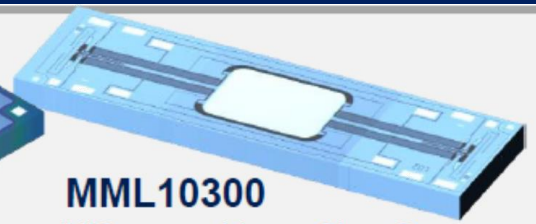
- Visible Projection
- High Brightness
- High Resolution

Gesture & Face Recognition

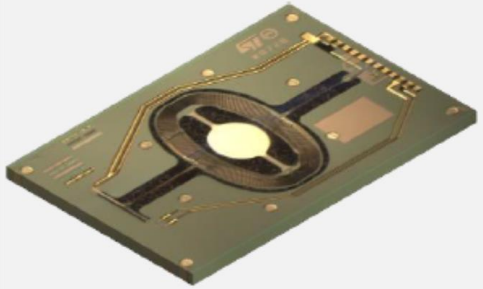
- Infrared Projection
- Small volume occupation
- Large Scan Angle



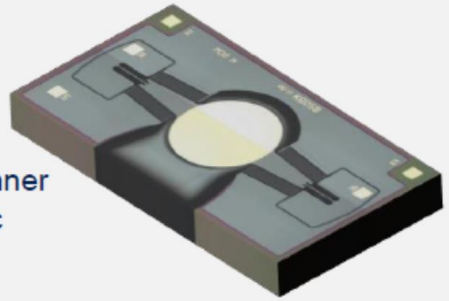
MML10300
VIS range, Linear Slow Scanner
Monoaxial, 60Hz, Electrostatic



MMR10300
VIS range, Resonant Fast Scanner
Monoaxial, 21kHz, Electrostatic



MMM10100
VIS range, Raster Scanner
Biaxial, 27kHz x 60Hz,
Electromagnetic



MMR10700
IR range, Resonant Fast Scanner
Monoaxial, 5kHz, Electrostatic

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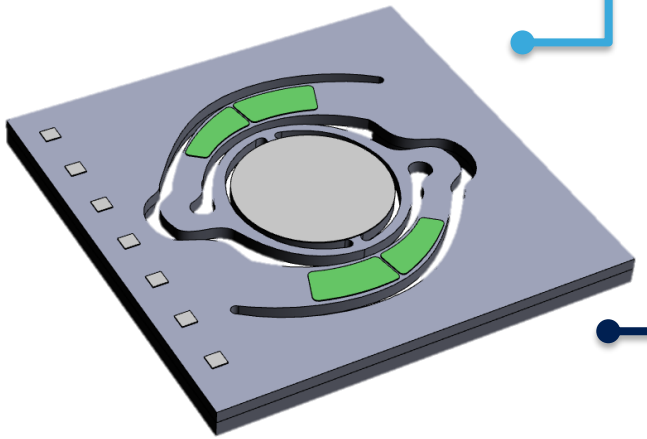
Thin Film PZT technology for MEMS Mirrors

Enabling performance required for **high resolution** display solutions (1080p → 1440p)

Expanding FoV: to enable AR/MR display requirements (50deg → 80deg)



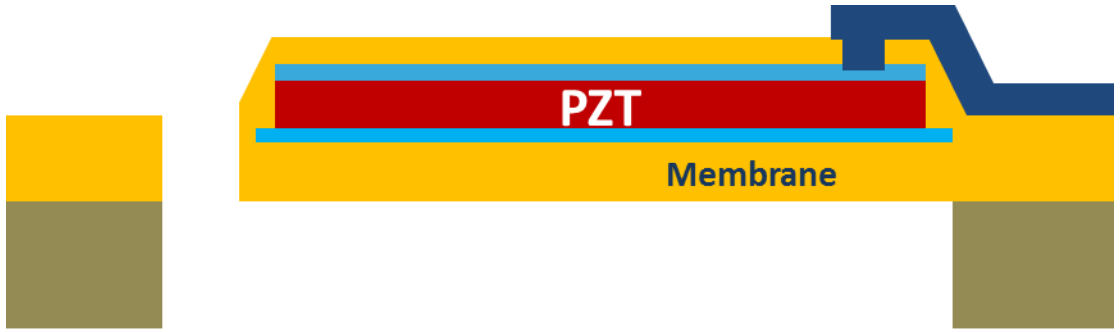
Smaller Real Estate than other actuation technologies:

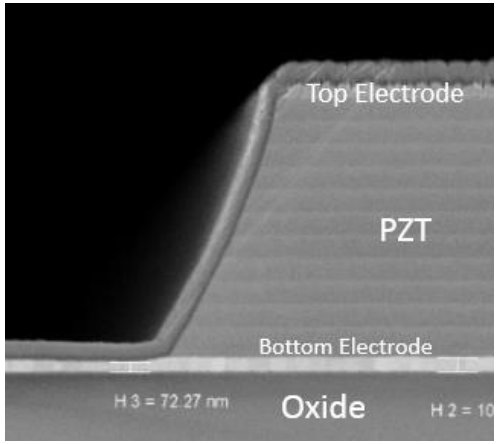
- Smaller die size than Electrostatic actuation thanks to higher force coming from PZT
- No additional volume occupation from external components (NO MAGNETS / NO BULK PIEZO)

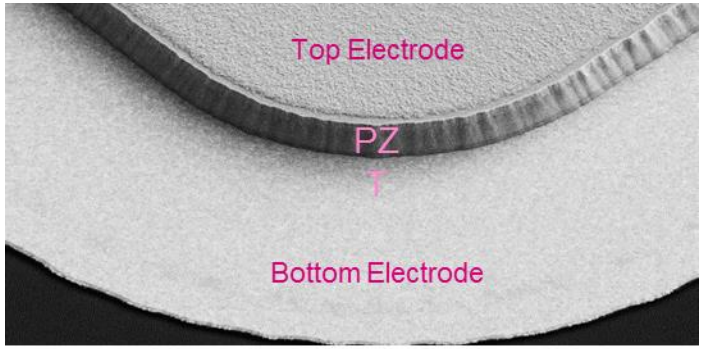
Reduced Power Consumption thanks to capacitive load drive and energy recovery driver from ST

PεtraTM: ST PZT Technology platform

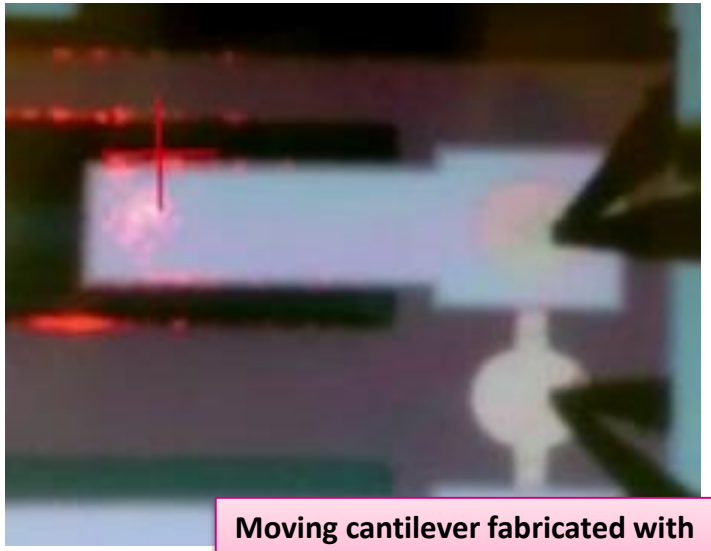
Fully Qualified and Mass Production "Thin Film PZT" process module integrated in the ST MEMS Line







PZT and the metallic electrodes patterned by dry-etch



Moving cantilever fabricated with ST Agrate PZT technology (20V triangular driving Voltage)

1. Deposit/pattern **low stress membrane**
2. Deposit/pattern **PZT & Electrodes**
3. Deposit **moisture barrier/passivation**
4. Vias / Metal / **Bonding pads**
5. *Optional: **etch hole** or **pattern cantilever***
6. Silicon etch / **Release Membrane**

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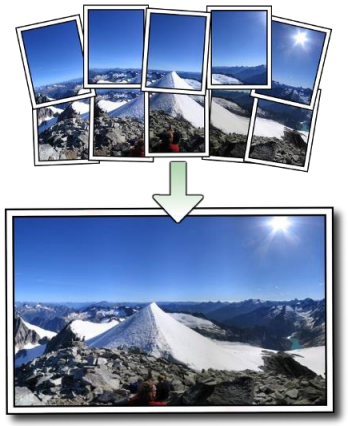
LBS Performances: Resolution and FoV

- High Resolution LBS - Mirror requirements:
  - Mirror Size
  - Resonant Frequency
  - Die Size and Power consumption

Display Resolution	Mirror type	Resonant Freq (Khz)	Diagonal FOV (deg)
720p (0.9Mpixel)	RES	26	80
	LIN		
1080p (2Mpixel)	RES	36	70
	LIN		
1440p (3.7Mpixel)	RES	48	60
	LIN		

- Other System Improvements Options:
  - Multi Laser Stripe (RR, GG, BB)
    - Cutting by N the resonance frequency of the MEMS Mirrors
      → Improving FoV and MEMS consumption
  - Multi-image stiction with same mirror
    - Increasing FoV
    - Achieving 1440p resolution with 720p mirrors requirements



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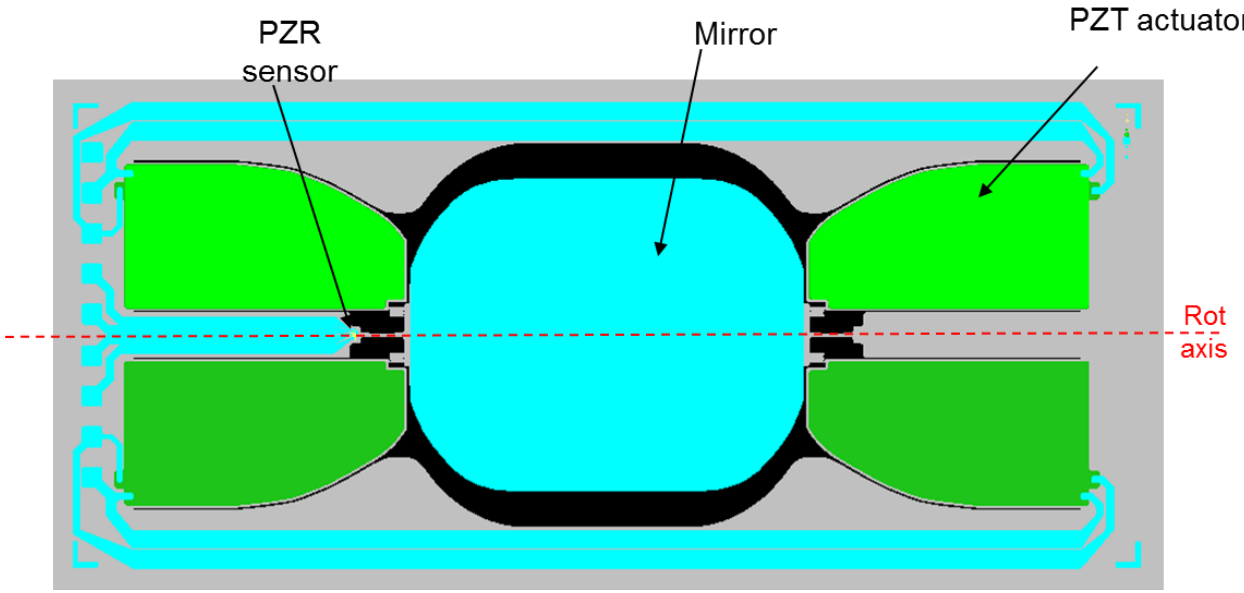
LBS Resolution and FoV vs Power Consumption



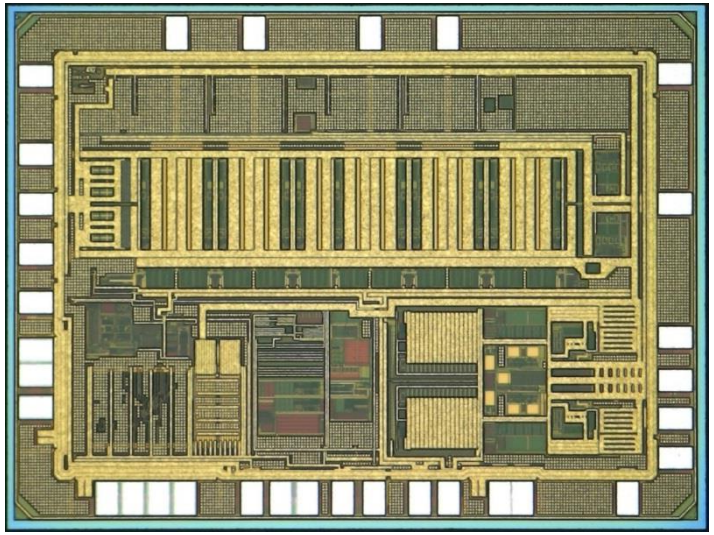
Higher Resolution / Higher FoV = Bigger TF PZT Actuators Higher Voltage OR Improved PZT displacement force

Power Consumption = ~ CV^2f

C = PZT Actuators Capacitor; V = Driving Voltage; f = frequency

MEMS Mirror Driver: Energy Recovery

- ST patented adiabatic design on ST BCD technology
  - 4 tank capacitors to store charge
  - Driving Voltage up to 40V
  - Up to 60KHz Resonance Frequency
- 6 times saving Power Consumption on Resonant Mirror



Power Consumption : $CV^2f \rightarrow \frac{1}{6}CV^2f$

Allowing Resolution and FoV scalability at acceptable consumption level

Laser Diode Driver

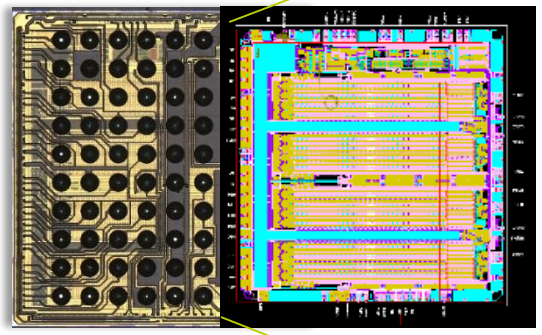
- Laser Diode Driver is the current limitation for > 720p resolution LBS display
- ST developed a custom LDD to enable 1080p resolution

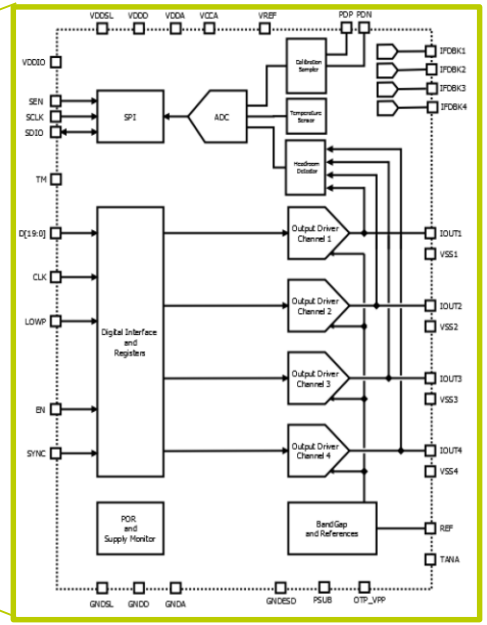
ST – Laser Driver

Hi-Resolution, Hi-Speed 4-channel laser driver:

- 4 channel driver (R-G-B-IR or CCCC) for high resolution AR/VR projection
- 500ps rise/fall time
- <4% overshoot
- 300MHz pixel clock
- 1.8-3.3V Supply
- Ultra-low power operations
- CSP package – 4.3 x 4.4 mm

ES Available





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Conclusion

- LBS Technology already in the market today:
  - To enable fashion all-day-wearable AR glasses
  - To improve performances of existing MR glasses

- Technology development and Industry Investments still required to boost AR market: Optics, Lasers Diodes, Electronics

- ST Committed to this market by:
  - Continuous Front End Silicon Process Investment:
  - Building an ecosystem with key technology players (Optics, Laser Diodes, Application Processors)
  - Building key Components (i.e. LDD) and System Know How

Thank You

AR/MR glasses: Display Requirements

Low Weight and Comfortable viewing experience

- Field of View: today limited < 50°. Target: 80°
- Short Persistency and Latency
- Brightness: Outdoor application / Transparent Lenses
- Resolution: 720p → 1080p → 1440p
- Power Consumption: Impacting weight and size
- Size and Weight: All day wearable (<80gr)

To make AR the next Big Thing

Display Performances: Brightness

- LBS Illumination is more efficient than LCoS
- Laser only operates when pixel is “on”
- AR content is sparse (<10% full white)

Amount of Light on Retina:

3000 nits equals 6 femto Watts on 20/20 vision spot

Full FoV at 8K resolution few tens of micro Watts of lights