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

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Computing Platform Evolution

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

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

  ![Focals by 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
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
Thin Film PZT technology for MEMS Mirrors

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

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)

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

Reduced Power Consumption thanks to capacitive load drive and energy recovery driver from ST
Pεtra™: ST PZT Technology platform

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

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
LBS Performances: Resolution and FoV

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

- 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

<table>
<thead>
<tr>
<th>Display Resolution</th>
<th>Mirror type</th>
<th>Resonant Freq (Khz)</th>
<th>Diagonal FOV (deg)</th>
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<tr>
<td>720p (0.9Mpixel)</td>
<td>RES</td>
<td>26</td>
<td>80</td>
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<tr>
<td></td>
<td>LIN</td>
<td></td>
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</tr>
<tr>
<td>1080p (2Mpixel)</td>
<td>RES</td>
<td>36</td>
<td>70</td>
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<tr>
<td></td>
<td>LIN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1440p (3.7Mpixel)</td>
<td>RES</td>
<td>48</td>
<td>60</td>
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<td></td>
<td>LIN</td>
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</table>
LBS Resolution and FoV vs Power Consumption

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

Power Consumption = \( \sim CV^2 f \)

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: \( CV^2 f \rightarrow \frac{1}{6} CV^2 f \)

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
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