Laser Beam Scanning (LBS): The Ideal Solution for AR Wearable Applications

Bharath Rajagopalan, Ph.D.
Director, Strategic Marketing
STMicroelectronics
Definitions

**Virtual Reality** – Occluded view and a fully immersive experience

**Augmented Reality** – Simple digital content is overlaid onto physical world

**Mixed Reality** – Physical and Virtual worlds are fully merged with visually accurate depth, perspective, texture, shade etc.
The Main Challenge

➢ To achieve the desired form factor key determinants, to first order, are:
  ❖ Near-to-eye compact display technology
  ❖ Highly efficient combiner optics technology
➢ Start with simple and broadly useful applications ➔ smart glasses
➢ Then, add additional functionality as technology & solutions mature


Key requirements for AR wearable devices

Goal: Head-up, Hands-free, All-day-wearable AR glasses which means glasses must be usable, comfortable with the requisite performance

- Indoor and outdoor use
- Form factor
- Low Power (system)
- Light weight
- Low latency (motion to photon)
- Range of FoV
- Range of resolution
- Eyebox size

- Peak brightness $> 1000 \text{ cd/m}^2$ (transparent lenses)
- Fashionable eyeglasses
  - < 1W
  - < 70g
  - < 4ms
- $30^\circ – 40^\circ$ (AR) to $> 80^\circ$ (MR/XR)
- 720P (AR) to $> 1400P$ (MR/XR)
- $> 10\text{mm} \times 10\text{mm}$
Laser Beam Scanning (LBS) – The Ideal Solution

- Ultra small microdisplay
- Compact illumination source
- High brightness (light engine)
- Low Power (system)
- Thin, lightweight lenses

MEMS Micromirror with LBS
Advanced laser diode packaging
>10^6 cd/m^2 (nits)
< 1W
DOE or HOE Waveguides

Operating Principle of LBS

MEMS Die

MEMS Mirror
Beam Collimation Lens
Blue LD
Green LD
Red LD
Beam Combining Lenses

Electronics Module

OSRAM

1.2mm
7.0mm
4.6mm

11 mm
6 mm
10 mm

7.0mm
13.0mm

LBS Reference Design Architecture

- **MEMS Mirrors**
- **Mirrors Drivers**
  - Electrostatic, Magnetic, Piezo drivers
  - High efficiency / Energy recovery drivers
- **Laser Diodes Drivers**
  - <500ps rise/fall time for crisp pixels
  - Ultra low power – Optimized for AR
  - 3 / 4 channels (RGB / + IR)
- **Control Loops and Video**
  - HW / SW Mirror control loop
  - Laser control loop
  - Calibration
  - Video processing
- **Relay Optics**
  - ST patented design to maximize performances with waveguides
Anatomy of the ST LBS Optical Module

https://www.spie.org/PWO/conferencedetails/moems-miniaturized-systems?SSO=1#session-1

Session 6: Novel Optical Components II

Compact and innovative laser beam steering optical engine for smart glasses applications
Paper 11697-24
Author(s): Dadi Sharon, Eitan Roth, Alex DemBITS, Shlomo Erlich, STMicroelectronics Ltd. (Israel)
Putting it All Together – A Proof-of-Concept

<table>
<thead>
<tr>
<th>Demo Specification</th>
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<tbody>
<tr>
<td>FOV (diagonal)*</td>
<td>30°</td>
<td>24°(H)x18°(V)</td>
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<tr>
<td>Brightness</td>
<td>1300</td>
<td>cd/m²</td>
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<td>Image Aspect Ratio</td>
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<td>Eyebox</td>
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<td>Eye Relief</td>
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<td>Fresh Rate</td>
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<tr>
<td>Full System Weight</td>
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* Note: The FoV of the MEMS Mirror scanner is 56° diagonal
Images as Seen Through the Glasses
Trade-offs (system consideration)

- Design of AR wearables must be holistic in nature
- Optimize for the application
  - Simple text, symbology and graphical overlay
    - FoV ~ 30°-40°, >10mm eyebox, >1000 nits, <70g, monocular, eyeglass style
  - Fully immersive experience with holographic rendering
    - FoV >80°, >10mm eyebox, >500 nits, >1440P, <200g, binocular, HMD style
- LBS addresses a number of constraints and challenges

Example only
It Takes a Village: LaSAR Alliance Ecosystem

More Partners to be Announced & Open to More Members
Join the Alliance!
Thank you

Contact info: bharath.rajagopalan@st.com
A wide range of mirror technologies in mass production

ST is the leader in LBS solutions with more than 12 million mirrors shipped to date

**ELECTROSTATIC**
- Staggered comb fingers
- In-plane comb fingers
- High aspect ratio DRIE silicon etch for comb drive actuators (silicon thickness $\geq 40\,\mu m$), allowing both quasi-static and resonant operation
- Use of wafer-to-wafer bonding techniques to realize 3D integrated structures

**ELECTROMAGNETIC**
- Thick metal layers integrated with silicon mechanical structure
- Thick metal cross section for coil
- Thick metal ECD growth ($\geq 20\,\mu m$) to allow low resistance coil actuator
- Integrated piezoresistive position sensors
- Thin (160 $\mu m$) finished holed wafers in production

**PIEZO ELECTRIC**
- Thin Film PZT Mirror
- Thin Film PZT ($\leq 2\,\mu m$), in Mass Production
- Integrated piezoresistive position sensor
- Use of wafer-to-wafer bonding for 3D integrated structures
High Efficiency TF PZT Drivers

MAIA
Bellatrix
ASIC PCB

Now

ARGO

Soon

\[ P = CV^2 f \rightarrow \frac{1}{10} CV^2 f \]

- Smaller footprint
- Less external components
- Fully Integrated Raster Scan (HW ctrl loop)