Microdisplays: Development and Applications

James Anderson
Lead Scientist
Hana Microdisplay Technologies, Inc.
Outline

• Microdisplay Applications
  – Near to Eye
  – Projection

• Microdisplay Technologies
  – Emissive devices
  – Micro-Electro-Mechanical System (MEMS) devices
  – Liquid Crystal devices
Microdisplay Applications
Near to Eye

- Camcorder Viewfinder
- Digital Camera Viewfinder
- Video Phones
- Head Mounted Displays
Near to Eye
Near to Eye

Images from MicroOptical
Near to Eye

Image from Kopin
Primary Players in NTE

- Kopin
- Brillian (Formerly 3-5 Systems)
- DisplayTech
- MicroOptical
- eMagin (OLED)
- Olympus
Projection

- Conference Projector
  - Such as the one being used here
- Digital Cinema
- Rear Projection Television
Projection
CRT Rear Projection TVs

• Advantage
  – Good picture for least money

• Disadvantages
  – Big and Heavy
  – High Definition is difficult
  – Already pushing technology, can’t be pushed much further

• Today’s 90% market share is expected to fall to <15% by 2007.
Microdisplay
Rear Projection TVs

• Advantage
  – Excellent picture quality
  – High resolution
  – Light
  – Small form factor
  – Lots of room for future improvement

• Disadvantages
  – Expensive
  – Availability
Primary Players in Microdisplay RPTV

• Commercially Available Now
  – Philips (LCoS)
  – Hitachi (LCoS, HTPS)
  – Sony (LCoS, HTPS)
  – Samsung (DLP)
  – RCA (DLP)
  – Gateway (DLP)
  – Optiva (DLP)

• Future
  – Intel (LCoS)
  – Every TV Manufacturer
Microdisplay RPTV

Philips 55” CINEOS LCoS TV
Microdisplay RPTV

Philips 55” CINEOS LCoS TV
Microdisplay RPTV

Gateway™ 56” DLP™ Rear Projection TV

Gateway 56” DLP TV
Microdisplay RPTV

RCA / Thomson 61” DLP TV
Microdisplay RPTV

RCA / Thomson 70” DLP TV
Mitsubishi WL-82913 LCoS TV specs

- 82-inch diagonal
- 29 3/8 inches deep
- Resolution: 1920 x 1080
- 16:9 Aspect Ratio
- 500 lbs
- 1000:1 dark room, 250:1 bright ambient
- $16,500
Sony Grand WEGA HTPS TV specs

• 70-inch diagonal
• 25 1/2 inches deep
• Resolution: 1386 x 788
• 16:9 Aspect Ratio
• 222 lbs (100kg)
• $5,500
Philips 55PL9773 LCoS TV specs

• 55-inch diagonal
• 17.4 inches deep
• Resolution: 1280 x 720
• 16:9 Aspect Ratio
• 84 lbs
• 450 nits
• >400:1
• $3,500 - $4,500
RCA Scenium DLP TV specs

- 50-inch diagonal (also a 60-inch model)
- 15.5-inches deep
- Resolution: 1280 x 720
- 16:9 Aspect Ratio
- 90 lbs
- $3,000
Gateway 56-inch DLP TV specs

- 56-inch diagonal
- 19 inches deep
- Resolution: 1280 x 720
- 16:9 Aspect Ratio
- 130 lbs
- 400 nits
- 1000:1
- $3,500
• Announced at CES in January that they are working on LCoS
• “High definition, large screen TVs, with clearer pictures than current systems for less than $2,000”
• Expect to ship LCoS displays by 2\textsuperscript{nd} half of 2004.
• OEMS:
  – InFocus, TCL, Skyworth, Primax PDC . . .
RCA / Thomson

- Ultra-thin DLP based HDTV
- Demo shown at CES in January
- Cabinets less than 7 inches deep
- Light weight so they can be easily mounted on a wall
- 50-inch and 61-inch models available in 2004
- 70-inch widescreen available in early 2005
Microdisplay Technologies
Organic Light Emitting Diode

- Silicon IC Substrate
- Organic Layers
- Anode
- Transparent Cathode
OLED

Images from eMagin
OLED

• Advantages
  – Emissive
  – Sensitivity to vibration
  – Low power

• Disadvantages
  – Lifetime
  – Cost
  – High volume manufacturability is unproven
Micro-Electro-Mechanical Systems (MEMS)

- Based on Micromachined devices
- Tilting mirrors (Texas Instruments’ Digital Light Processing, DLP)
- Selective Diffraction (Silicon Light Machines)
MEMS

Texas Instruments’ DLP
MEMS

Link to TI movie
MEMS

1 Chip DLP™ Projection

- DLP Board
- Processor
- Memory
- Projection Lens
- DMD
- Shaping Lens
- Optics
- Color Filter
- Condensing Lens
- Light Source
- Screen
3 Chip DLP™ Projection

Optics

Light Source

Color Filtering Prism

DMDs
MEMS

Structure

6 Ribbons = 1 Pixel

Magnified

3 ribbons move by signal

Principle of GLV Display

Light Source

Lens

Scanning Mirror

Screen

Grating Light Valve

Full-HD (1920x1080 pixels)
60Hz Progressive Scanning
MEMS

• Advantages
  – Single chip design
  – Brightness (no polarizing optics)
  – High contrast
  – Thin
  – Light
  – Small form factor
MEMS

• Disadvantages
  – Slight “shimmer” artifact noticeable
  – Expensive to produce
  – Color depth lacking in some versions
  – Only one major supplier (TI)
Liquid Crystal Devices

- Transmissive
  - High Temperature Poly-Silicon (HTPS)

- Reflective
  - Liquid Crystal on Silicon (LCoS)
1.2“HDTV, 1.3”XGA, 0.9”XGA, 0.7”XGA

Ultrahigh resolution small LCD panel

Audio/Visual Projector

Rear Projection TV
HTPS

Image from Seiko-Epson
HTPS

Image from Seiko-Epson
HTPS

Image from Seiko-Epson
HTPS

• Advantages
  – Thin
  – Light
  – Small Form Factor
  – Good value vs Plasma or Direct View LCD
HTPS

- Disadvantages
  - Pixelization from TFTs, signal line line and scan line
  - Must use microlens array to increase effective aperture ratio
  - Low Contrast
  - Must use 3 panel design
    - Panel alignment
    - More complex engine
    - More displays = More expensive
LCoS

Image from JVC
LCoS

Image from Philips
LCoS

Image from MicroDisplay Corporation
LCoS

Image from Brillian Corporation
Image from Intel Corporation
LCoS

Image from Philips
Image from KinOptics
LCoS

• Advantages
  – High resolution
  – Excellent fill factor
  – High Speed (enabling 1 panel designs)
  – Potentially low cost (based on standard CMOS)

• Disadvantages
  – Manufacturability is unproven
    • TVs now on market, this will be proven/disproven soon
Microdisplay Light Engines
Emissive

Optics

Emissive Microdisplay
3-Panel Projection Engine
Hana Microdisplay

Pure Contract Manufacturing Service Provider for Microdisplays
- Experience manufacturing most microdisplay technologies
  - LCoS, HTPS, MEMS
  - Interested in getting into OLED microdisplays also

Focused on microdisplay manufacturing and technology solutions
- Formed in August of 1999 in Ohio
- Missing link between fab-less product design companies and systems integrators
- Experienced and Knowledgeable Microdisplay Manufacturing Team
- Automated processing of 6-inch and 8-inch wafers

Located in Twinsburg, Ohio, USA
- 20 miles from the Liquid Crystal Institute at Kent State University
- 24,000 square foot facility
- Technical Staff of 40 people

End Markets for our Customers
- Personal Viewers / Head sets
- Large Screen Monitors
- Digital Television
- Multimedia Projectors
- Fiber-optic switches and routers
Microdisplay Future

- Enable new technologies
  - Head Mounted Displays
  - Projection of Computer Images
- Create higher quality monitors and TVs
  - Higher resolution
  - Brighter
  - Lighter
  - Thinner
Microdisplay Future

- CRT monitors and TVs have limited lifetime
- Direct View LCD and Plasma will take most of market for screen sizes <40 inches
- Microdisplay-based projection will rule:
  - Large screen TV (40-inch - 50-inch +)
  - Conference projection
  - Near to Eye displays