Display Innovation

– Curved and Flexible –

Nov. 17, 2014

Chang Hoon Lee
Samsung Display
Contents

• Company Introduction

• LCD Innovation
  – Curved
  – Wide Color Gamut (WCG)

• AMOLED Innovation
  – Advanced Performance
  – Flexible
  – Transparent

• Strategy
Company Overview

Well balanced portfolio, technology leadership

Portfolio

Technology Leadership

Market Share 22%

※ Source: Display Search, 2013 Revenue Base
Display Centric World
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• Strategy
The Next Mainstream is Curved TV & WCG

- Wide Color Gamut

- Slim with Narrow Bezel
  - SNB 4.9mm

- LED TV
  - Set Depth 80 → 40mm

- FPD TV
  - CRT → LCD

- Convex TV
  - CRT

- FHD
  - 2X finer than HD

- UHD
  - 4X finer than FHD

- Curved TV

- WCG TV
Curved

Wide Color Gamut
Curved

New form factor, rapid growth

**CRT**
Big bang of visual information & entertainment

**Flat LCD**
Slim form factor

**Curved LCD**
Immersive experience

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**Samsung M/S in UHD TV**

<table>
<thead>
<tr>
<th>Year</th>
<th>Curved (%)</th>
<th>Source: NPD</th>
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<tbody>
<tr>
<td>'13.3Q</td>
<td>27.4</td>
<td></td>
</tr>
<tr>
<td>'13.4Q</td>
<td>47.0</td>
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<tr>
<td>'14.1Q</td>
<td>45.6</td>
<td></td>
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<tr>
<td>'14.2Q</td>
<td>56.7</td>
<td></td>
</tr>
<tr>
<td>'14.3Q</td>
<td>62.0</td>
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</tbody>
</table>

* Portion of curved

TV
(105”, 4200R, UHD)

Monitor
(27”, 2000R, FHD)
Benefits of Curved ①

Superb picture quality

Less Distortion

“Eyes are round, not flat"

Flat
Eyeball
Curved
Eyeball

Design of Parthenon

Flat design
Barrel distortion
Concave design
Distortion free

Low Reflectance

Reflectance

Curved 25%
Flat 44%

※ Source : SDC
Test Condition : Viewing Distance 2m, 55", f32m
Benefits of Curved ②

Wider field of view, immersive experience

**Immersive Experience**

- **Field of View**
  - $1^\circ \geq 20,000$ Rod Cells
  - Distribution of cells

- **Central Vision**
  - 20~30º

- **Peripheral Vision**
  - Rod Cells
  - (1,000x more motion sensitive than Cones)

**Better Contrast**

- **Radius of Curvature (R, mm)**
- **3000R 6000R Flat**

<table>
<thead>
<tr>
<th>R</th>
<th>6000R</th>
<th>4000R</th>
<th>3000R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree</td>
<td>66.3°</td>
<td>68.6°</td>
<td>69.8°</td>
</tr>
<tr>
<td>C/R Enhanced (against center)</td>
<td>52%</td>
<td>71%</td>
<td>82%</td>
</tr>
</tbody>
</table>

※ Source : SDC
Curved

Wide Color Gamut
Wide Color Gamut

You can see real color through Wide Color Gamut
Preparing various future technologies for Wide Color Gamut

Technology Development

- Color Filter: New material on the color filter
- External Sheet: New material and process on external sheet
- Backlight: New material and LED structure inside backlight
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AMOLED Innovation

“Display Performance”

AMOLED QHD Phone
Galaxy S5

AMOLED Bended Smartphone
Galaxy Edge

AMOLED Wearable
Galaxy Gear

AMOLED Bended Wearable
Gear Fit

AMOLED Tablet
Galaxy Tab 7.7

AMOLED Curved Phone
Galaxy Round

AMOLED Smart Phone
Galaxy S
Conventional Benefits … Color / Time / Contrast

Larger color gamut, fast time and virtually indefinite contrast

Superb Color

Fast Response Time

High Contrast

- Response time of AMOLED is faster than LCD

<table>
<thead>
<tr>
<th>AMOLED</th>
<th>LCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td></td>
</tr>
<tr>
<td>Black (nit)</td>
<td>0.00004</td>
</tr>
<tr>
<td>C/R @255Grey</td>
<td>8,000,000:1</td>
</tr>
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</table>

※ Source : UL / SDC
Pixel structure replicating human vision system

Eye Cells Distribution

AMOLED Pixel Distribution

[ SDC’s Proprietary Pixel Structure ]

“Pixel structure considering spatial frequency of each colors”
[ Using Smartphone in a Dark Area ]

Advanced Performance ... Super Dimming

Helping user to avoid light-strained eyes

Display Luminance (nit)

* Source: Monthly Display, Oct, 2009 (ESK/TMD)

Glare Area

Optimal Brightness Zone

2nit AMOLED

Dark Area

Bedroom 3~5lux

Indoor Brightness (lux)

“We recommended *dimming device at night as much as possible* in order to minimize melatonin suppression.”

*Source: Rensselaer Polytechnic Institute, 2012*
Advanced Performance • Color Weakness

Providing vision aid to color weakness

<table>
<thead>
<tr>
<th>Color Weakness</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>6% of men suffer from color weakness</td>
<td><strong>Cause</strong></td>
</tr>
<tr>
<td>Test Pattern</td>
<td>B</td>
</tr>
<tr>
<td>Color Weakness</td>
<td>437 nm</td>
</tr>
<tr>
<td></td>
<td>437 nm</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
<tr>
<td>6% of men suffer from color weakness</td>
<td><strong>Solution</strong></td>
</tr>
<tr>
<td></td>
<td>Brightness</td>
</tr>
</tbody>
</table>
Unbreakable Display (Hammer)

※ Source : SDC
YOUM (Flexible AMOLED by SDC) in the Market

Edge type flexible display debuted

- Gear Fit (March, 2014)
- Galaxy Round (Oct, 2013)
- Galaxy Gear S (Nov, 2014)
- Samsung Galaxy Note Edge

Released in October 2014
(5.6”, 2560x1440/2560x160)
Technology Challenges

A variety of challenges to make foldable display

4 Key Technologies

1. Flexible Window
2. Flexible Touch Sensor
3. Flexible Encapsulation
4. Flexible BP
Flexible Window

Glass / Plastic window → “New materials”

Surface Coating

Organic–inorganic hybrid materials

Structural Reinforcement

Organic Matrix

Inorganic Component

Hardness ↑ / Durability ↑

Multi layer structure

Hard

Soft

Hard
New electrode materials are required instead of Brittle ITO
Flexible Encapsulation

Thin Film Encapsulation (TFE) replaces glass for flexibility

Glass Encapsulation (Flat)

- Polarizer
- Encap(+Touch) Glass
- Substrate Glass

Thin Film Encapsulation (Flexible)

- Flexible Touch sensor
- Flexible Barrier Film

Organic / Inorganic TFE

- $O_2$, $H_2O$, $O_2$, $H_2O$, $O_2$

Need to reduce the No. of layers and thickness of organic layers
New material and process with flexibility and reliability are required.

**Flexible Backplane (BP)**

**Lower Stresses Panel**

Normal

*GI, ILD Island*/Neutral Plane

Stress : X 20

- GI : Gate Insulator
- ILD : Inter Layer Dielectric

**Organic TFT Materials**

- Source (Gold)
- Drain (Gold)
- Active (Organic)
- Gate Insulator (PVP)
- Gate (ITO)
- Substrate (Plastic)
Flexibility will overcome the design limitation of display
Advanced Performance
Flexible
Transparent
Another Innovation … Transparent

Transparent AMOLED will be more attractive to customers

- What you see
  “ON & THROUGH” the Display
- Actual Image + Information
  - Differentiated function + Design

New Market Creation

New Paradigm of Display

SDC’s Demo

30” Monitor
14” Notebook
Competitive Technology

Separating pixel hole to pass the external light

“SDC has a proprietary right for the core IPs to produce transparent AMOLED display.”

- Color Gamut: 100%
- Transmission: 30%

※ Color Gamut : 100%
Transmission : 30% ↑

※ Transparent AMOLED related issued Patents : 26 units
   (2014.11, US)
Expansion to New Application

Transparent Display will create new applications and life style

Building

Office

Others

School
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LCD Strategy

Deliver differenciation with overcoming technology limitation

**Curved / WCG**
- Curved: Curvature diversification
- WCG: Preparing technologies for wide color gamut

**UHD**
- UHD / Curved: Premium zone → Main stream
  - Resolution
  - Design
  - Premium
  - Main stream
  - FHD
  - Flat
  - Curved
AMOLED Strategy

H/E value up with Flexible, M/E penetration with Flat AMOLED

Smart Phone
Tablet
IT

New Market
Large Screen Portability + UX Differentiation

Foldable
Design / UX Differentiation

Bended

Flat
Unbreakable
AMOLED Strategy ... Cost Competitiveness
AMOLED Strategy … Customer Diversification

Sustain stable demand through diverse customer base

Product Line-up Expansion
- High-End → Mid/Low End
- Dedicated products

Marketing enhancement
- Reinforce marketing communication in strategic markets
- Enhance AMOLED value proposition
New Growth Engines for LCD and AMOLED

New market creation by new growth engines like curved, flexible

- **LCD**: Curved
- **AMOLED**: Flexible
“What is seen is all of our business area!”
Thank you