The Role of Memory in Mobile Applications

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Hynix Semiconductor America
**Hynix Overview**

World’s leading semiconductor memory manufacturer

- Focus on DRAM and NAND Flash devices
- 2008 revenue: KRW 6.8tn (US $6.2B)
- Global presence with 3 manufacturing sites and 30 sales offices worldwide
- 20,500 employees worldwide as of May 2009

**Market Share (2008)**

- **#2 in DRAM**
  - Samsung: 30.2%
  - Hynix: 19.4%
  - Elpida: 15.3%
  - Micron: 11.3%

- **#3 in NAND Flash**
  - Samsung: 42.1%
  - Toshiba: 29.3%
  - Hynix: 12.3%
  - Micron: 8.4%

Source: iSuppli, Jun.’09, Revenue-based
Traditional Views on Memory

- Serves as Buffer/Storage in a system
- Industry (JEDEC) standard
- Multi-sourced
- Prices are never low enough
- Low tech compared to CPU/Logic
- User anathema for price premiums

No Respect !!!
What is Generally Overlooked

- Memory design and development is complex and time consuming
- Companies bet billions of dollars on new technologies, new products and new capacity
- High capacity memory can actually improve system performance and enable new applications
- Memory suppliers are consistently striving for very high quality and reliability
Memory – Matrix of Conflicting Variables

- Higher Cost
- Capacity
- Performance
- Low Power Consumption
- Reliability
- Die Shrink
- Time for development
- New Process
- New Design
- Low Vdd
- Larger Die
- Time for Development
- Fast Transistors
- Time for Redesign, Eng. Resources
- Time for Development, Resources
- Capex, Resources
- Enhanced Testing, B.I.
- Test/BI Equipment
- Test/BI Time
- Investments
- Fishbone Analysis

 Fishbone Analysis
Key Market Drivers
Target Applications

Mobile Handsets is the major driver of mobile memory technology
Growth Trends in Mobile Handsets

- NAND growing at CAGR of over 130%
- Mobile DRAM growing at CAGR of over 50%

Source: iSuppli 08-09
Mobile Handset Forecast

- Smartphone is the fastest growing category among Mobile Handsets

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>139</td>
<td>169</td>
<td>232</td>
<td>368</td>
<td>457</td>
</tr>
<tr>
<td>Mobile Handset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Unit: M pcs)

Source: Gartner 08-09
Mobile Memory Products
Mobile DRAM Trend

- Major density is **1Gb** which will grow to 50% market share by 2010
- DDR x32 rapidly replacing SDR x16

Source: Isuppli, Q1’08
## DRAM Power Supply Analysis

<table>
<thead>
<tr>
<th>Power Supply</th>
<th>Description</th>
<th>Low Power Design Strategy</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>Power Supply (1.8V for DDR2)</td>
<td>Lower VDD</td>
<td>Lower Power (possibly)</td>
</tr>
<tr>
<td>VSS</td>
<td>Ground</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>VDDQ</td>
<td>I/O Voltage equals VDD</td>
<td>Lower VDDQ</td>
<td>Lower Power</td>
</tr>
<tr>
<td>VSSQ</td>
<td>Ground</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>VCore</td>
<td>Regulated Power supply for Sense Amplifiers ~ VDD (internal)</td>
<td>Lower VCore with external supply</td>
<td>Lower Power, Ext. Pin</td>
</tr>
<tr>
<td>VPP</td>
<td>Word Line Power Supply (3x Multiple of VDD)</td>
<td>None</td>
<td>Lower VDD complicates charge pump design</td>
</tr>
</tbody>
</table>

Lowering VDD complicates charge pump design which is the source of VPP
LPDDR2 features significantly lower current values due to 1.2V core voltage compared to 1.8V on LPDDR.

Source: Hynix
Emergence of NAND Flash in Mobile

- **HDD Type**
  - I/F: SATA 3Gbps
  - Size: 1.8”, 2.5”
  - Density: 256GB in 2009

- **Module Type**
  - I/F: PATA, SATA
  - Size: Customized
  - Density: 64GB in 2009

- **Chip Type**
  - I/F: eMMC
  - Size: 14 x 18 x 1.3 mm, 169FBGA
  - Density: 32GB in 2009
Memory Density & Packaging
### Increasing Mobile Memory Densities

- Finer Processes enable higher density mobile memories
- Finer process technology lowers power

<table>
<thead>
<tr>
<th>Year</th>
<th>LPDDR/LPSDR</th>
<th>LPDDR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>128Mb, 512Mb, 1Gb</td>
<td>128Mb, 1Gb</td>
</tr>
<tr>
<td>2008</td>
<td>256Mb, 512Mb, 1Gb</td>
<td>256Mb, 1Gb</td>
</tr>
<tr>
<td>2009</td>
<td>512Mb, 1Gb, 2Gb</td>
<td>512Mb, 2Gb</td>
</tr>
<tr>
<td>2010</td>
<td>1Gb, 2Gb, 2Gb</td>
<td>2Gb, 512Mb</td>
</tr>
<tr>
<td>2011</td>
<td>1Gb, 2Gb, 2Gb</td>
<td>2Gb, 256Mb</td>
</tr>
<tr>
<td>2012</td>
<td>2Gb, 2Gb, 4Gb</td>
<td>2Gb, 4Gb</td>
</tr>
</tbody>
</table>

Source: Hynix
Mobile MCP Solutions

- NAND MCP will be the mainstream solution
- Hynix has developed a number of advanced MCPs for wide ranging applications

<table>
<thead>
<tr>
<th>Year</th>
<th>Tier</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>High Tier &amp; Smartphone</td>
<td>(One)NAND + MoDRAM</td>
</tr>
<tr>
<td>2009</td>
<td>Mid Tier</td>
<td>eMMC 4.2, NAND + MoDRAM</td>
</tr>
<tr>
<td>2010</td>
<td>Low Tier</td>
<td>NAND + MoDRAM, NOR + NAND + MoDRAM</td>
</tr>
<tr>
<td>2011</td>
<td></td>
<td>NAND + MoDRAM</td>
</tr>
</tbody>
</table>

- eMMC Combo
- eMMC 4.4
- Boot/ MLC & SLC Partition / DDR Mode / e-Security functions
- High Tier & Smartphone: NAND MCP will be the mainstream solution
- Hynix has developed a number of advanced MCPs for wide ranging applications
What is eMMC?

- One Package Solution: MMC (Multi Media Card) Controller + High Density MLC NAND
- Standard Product: Compatible with JEDEC JC64 physical spec / MMCA functional spec
  - Easy transition to NAND Technology changes ➔
  - Accelerates time to market
MCP/PoP Trends

Source: Hynix
Through Silicon Via (TSV)

<table>
<thead>
<tr>
<th>Via Forming</th>
<th>Via filling and etching (electroplating)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Via Dielectric isolation (CVD)</td>
<td>Wafer thinning</td>
</tr>
<tr>
<td>Via adhesion/seed layer forming (PVD)</td>
<td>Wafer Sawing &amp; Assembly</td>
</tr>
</tbody>
</table>

- TSV is an emerging wafer level packaging technology
- High density, thin packaging
- Mixed logic + Memory assembly

Source: Hynix
New Memory Architectures

Legacy Handset Architecture
- Lower bandwidth
- Memory separated between BP and AP
- Increases BOM cost

Serial Port Memory Technology
- Higher serial bandwidth
- Single memory solution
- Lowers BOM cost

Emerging Handset Architecture

Source: SPMT
Future Mobile Memory Technologies
Future Memory Technologies

- NV-RAM
- NOR Flash
- Mobile 1 Chip Solution
- New Code Storage Memory

- ZRAM
- Volatile
- Cap-Less Memory
- Embedded Memory

- PCRAM
- STT-RAM
- 2010
- 2011
- 2012
- 2014
- NV-RAM
- DRAM
- Embedded Memory
- 1 Chip Memory Solution
- New Storage Class Memory

Source: Hynix
Position of Future Memory

Storage Memory
- Non-Volatile
- Code & Data Memory

Buffer Memory
- Bit-Alterability
- Working Memory

Density
- NAND
- NOR MLC
- NOR SLC

Write Speed
- ReRAM • NV-RAM
- PCRAM • NV-RAM
- Z-RAM • Volatile
- STT-RAM • NV-RAM
- DRAM
- SRAM

Source: Hynix
Summary/Conclusions

- New feature sets offered by end use applications will demand higher density memory

- Highly integrated packaging required for small form factor applications (MCP, PoP, TSV)
  
  Smaller the area of memory subsystem, larger the battery

- Extending battery life key feature in future mobile platforms
  
  Demand for Low Power memory (DRAM and NAND)

- New memory architectures and interfaces required to improve system performance
  
  ONFI (One NAND Flash Interface)
  
  SPMT (Serial Port Memory Technology)
Thank You