SEMICON Taiwan: DRAM/NAND Industry Outlook

Structural Improvement is already Fact, now Focus on Cycle
Unprecedented DRAM Upcycle

- DRAM stocks outperformed S&P index over past year, Inotera made the biggest gains
- Samsung, Hynix, and Micron, share prices are at highest point since 2006
- Memory industry revenue grows to US$75bn in 2014, an all time high
Part 1: Structural Improvements Recap
Structural Improvement #1: DRAM Oligopoly

- Following 2012 consolidation, sovereign-backed DRAM companies exited commodity DRAM business.
- Evidence of oligopoly:
  - **Bargaining power**: DRAM vendors were able to maintain DRAM price in 2Q14 when Hynix’s China fab recovered.
  - **Partnership**: contract price negotiation turned to quarterly basis in 3Q14.

**DRAM industry consolidation**

**DRAM contract price, since 2013**

Source: DRAMeXchange, Morgan Stanley Research
Structural Improvement #1: DRAM Oligopoly

- Hard-disk industry is the best analogy to the DRAM oligopoly
- It remains to be seen whether DRAM makers will cut production while their margins are still positive

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**Hard-Disk industry consolidation**

**DRAM industry consolidation**

Source: Company Data, Morgan Stanley Research
Structural Improvement #2: Mobile DRAM Growth

Average DRAM Content per Unit (MB)

- Avg. PC content
- Avg. Smartphone/Tablet content

Global End Demand Shipment (in million units)

- Global Desktop and Notebook Shipment
- Global Smartphone and Tablet Shipment

Source: Morgan Stanley Research, E= Morgan Stanley Research estimates
**Structural Improvement #2: Mobile DRAM Growth**

We expect HD720 and Full HD displays to become mainstream.

### 1GB DRAM will be the minimal requirement for most brand smartphones

<table>
<thead>
<tr>
<th>Brand</th>
<th>model name</th>
<th>Resolution</th>
<th>DRAM content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nokia</td>
<td>Lumia 625</td>
<td>WVGA (480 x 800)</td>
<td>512MB</td>
</tr>
<tr>
<td>Samsung</td>
<td>Galaxy Core Advance</td>
<td>WVGA (480 x 800)</td>
<td>1GB</td>
</tr>
<tr>
<td>HTC</td>
<td>Desire 610</td>
<td>qHD (540x960)</td>
<td>1GB</td>
</tr>
<tr>
<td>LG</td>
<td>Volt</td>
<td>qHD (540x960)</td>
<td>1GB</td>
</tr>
<tr>
<td>SONY</td>
<td>Xperia M2</td>
<td>qHD (540x960)</td>
<td>1GB</td>
</tr>
<tr>
<td>XiaoMi</td>
<td>Hongmi</td>
<td>HD (720x1280)</td>
<td>1GB</td>
</tr>
<tr>
<td>GPLUS</td>
<td>E3 mini</td>
<td>qHD (540x960)</td>
<td>1GB</td>
</tr>
<tr>
<td>BBK</td>
<td>VOVO V1</td>
<td>HD (720x1280)</td>
<td>1GB</td>
</tr>
<tr>
<td>InFocus</td>
<td>M210</td>
<td>HD (720x1280)</td>
<td>1GB</td>
</tr>
<tr>
<td>Samsung</td>
<td>Galaxy S5 mini</td>
<td>HD (720x1280)</td>
<td>1.5GB</td>
</tr>
<tr>
<td>Asus</td>
<td>Padfone 2 A68</td>
<td>HD (720x1280)</td>
<td>2GB</td>
</tr>
</tbody>
</table>

**5.0” and above models (Average DRAM content: 2GB)**

<table>
<thead>
<tr>
<th>Brand</th>
<th>model name</th>
<th>Resolution</th>
<th>DRAM content</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTC</td>
<td>Desire 816</td>
<td>HD (720x1280)</td>
<td>1.5GB</td>
</tr>
<tr>
<td>Samsung</td>
<td>Galaxy Mega 6.3 i9200</td>
<td>HD (720x1280)</td>
<td>1.5GB</td>
</tr>
<tr>
<td>BlackBerry</td>
<td>Z3</td>
<td>qHD (540x960)</td>
<td>1.5GB</td>
</tr>
<tr>
<td>Samsung</td>
<td>Galaxy S5</td>
<td>Full HD (1080x1920)</td>
<td>2GB</td>
</tr>
<tr>
<td>XiaoMi</td>
<td>Mi3</td>
<td>Full HD (1080x1920)</td>
<td>2GB</td>
</tr>
<tr>
<td>LG</td>
<td>G Pro 2</td>
<td>Full HD (1080x1920)</td>
<td>3GB</td>
</tr>
<tr>
<td>Sony</td>
<td>Xperia Z2</td>
<td>Full HD (1080x1920)</td>
<td>3GB</td>
</tr>
<tr>
<td>BBK</td>
<td>VIVO Xplay 3S</td>
<td>WQHD (1440x2560)</td>
<td>3GB</td>
</tr>
<tr>
<td>XiaoMi</td>
<td>Mi4</td>
<td>Full HD (1080x1920)</td>
<td>3GB</td>
</tr>
</tbody>
</table>

Source: Company Data, Display Search, Morgan Stanley Research (E) estimates
Structural Improvement #2: Mobile DRAM Growth

### High-resolution (WQHD) displays and 4K2K video recording both require 3GB DRAM

<table>
<thead>
<tr>
<th>Vendor</th>
<th>LG</th>
<th>SONY</th>
<th>BBK</th>
<th>Samsung</th>
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</thead>
<tbody>
<tr>
<td>G Pro 2</td>
<td>G Pro 2</td>
<td>G Pro 2</td>
<td>G Pro 2</td>
<td>G Pro 2</td>
</tr>
<tr>
<td>Resolution</td>
<td>Full HD</td>
<td>Full HD</td>
<td>WQHD</td>
<td>Full HD</td>
</tr>
<tr>
<td></td>
<td>1080x1920</td>
<td>1080x1920</td>
<td>1440x2560</td>
<td>1080x1920</td>
</tr>
<tr>
<td>Video</td>
<td>4K2K shooting</td>
<td>4K2K shooting</td>
<td>4K2K shooting</td>
<td>4K2K shooting</td>
</tr>
<tr>
<td>Memory</td>
<td>3GB</td>
<td>3GB</td>
<td>3GB</td>
<td>2GB</td>
</tr>
</tbody>
</table>

Xiaomi Mi 4 using 3GB DRAM could start the spec competition

Source: Company Data, Morgan Stanley Research
Part 2: Our View on the DRAM Cycle
Our Key Thesis: High DRAM Margin Will Attract More Investment

**DRAM Industry Operating Margin Trend**

- Samsung
- SK Hynix
- Micron
- DRAM Industry OPM

**NAND Flash Industry Operating Margin Trend**

- Samsung
- Toshiba+SanDisk
- SK Hynix
- Micron
- NAND Flash Industry OPM

**DRAM and NAND Flash Industry Operating Margin Trend**

- DRAM Industry OPM
- NAND Flash Industry OPM

Source: Company Data, Thomson Reuters, Morgan Stanley Research, Morgan Stanley Research estimates
Cyclical Factor #1: Supply Dynamics – Overall Capex Seems to be Rational

- Memory capex has been flat in 2014
- KLA and ASML memory orders back to normal in 1H14

Source: Company Data, DRAMeXchange, Morgan Stanley Research
Cyclical Factor #1: Supply Dynamics – More Investment in DRAM

- The portion of DRAM equipment orders are increasing at LAM and TEL
- Samsung revised up its bit shipment forecasts for 2014
- Samsung will add DRAM capacity at Line 17 instead of NAND
- Micron will spend 50% of its F2015 capex on DRAM

Source: Company Data, Morgan Stanley Research
Cyclical Factor #1: Supply Dynamics – Other Factors to Watch For

- Hynix Fire effect should not be recurrent
- Technology migration continues
- We should care about clean room space

### Technology migration

<table>
<thead>
<tr>
<th>Process Ratio (%)</th>
<th>1Q10</th>
<th>1Q11</th>
<th>1Q12</th>
<th>1Q13</th>
<th>1Q14e</th>
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<tbody>
<tr>
<td>0.12/0.11um</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90nm</td>
<td></td>
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<td>80nm</td>
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<td>7Xnm</td>
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<td>6Xnm</td>
<td></td>
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<td>5Xnm</td>
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<td>4Xnm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3Xnm</td>
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<tr>
<td>2Xnm</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

### Clean room space

<table>
<thead>
<tr>
<th>Company</th>
<th>Clean room announced to be used</th>
<th>Spare clean room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micron</td>
<td>40kwpm Inotera Meiya fab</td>
<td>75kwpm Rexchip R2 fab</td>
</tr>
<tr>
<td>Samsung</td>
<td>30-40kwpm Line 17</td>
<td>60-70kwpm Line 17</td>
</tr>
<tr>
<td>SK Hynix</td>
<td></td>
<td>120kwpm M14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>70kwpm</strong></td>
<td><strong>250kwpm</strong></td>
</tr>
</tbody>
</table>

Source: Company Data, DRAMeXchange, Morgan Stanley Research
Cyclical Factor #2: Demand Dynamics – End Market Shipment Growth

- **China smartphone**: Sell-in data (MIIT) has been weak due to operator subsidy cuts
- **PC**: Replacement cycle was the key upside in 2014, but may not be sustainable in 2015
- **Server**: Muted growth in 2014 given virtualization trend

**China smartphone growth slowing down in 2014**

**PC shipment growth**

Source: Bureau of Economic Analysis, IDC, MIIT, Morgan Stanley Research
### Cyclical Factor #2: Demand Dynamics – Apple Products DRAM Spec

#### Apple Mobile Device Spec Comparison

<table>
<thead>
<tr>
<th></th>
<th>Apple iPad mini 2</th>
<th>iPad Air</th>
<th>iPhone 5S</th>
<th>iPhone 6 (expected)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAND Flash</td>
<td>16/32/64GB</td>
<td>16/32/64/128GB</td>
<td>16/32/64GB</td>
<td>16/32/64GB or up to 128GB?</td>
</tr>
<tr>
<td>DRAM</td>
<td>1GB RAM DDR3</td>
<td>1GB RAM DDR3</td>
<td>1GB RAM DDR3</td>
<td>1 or 2GB?</td>
</tr>
<tr>
<td><strong>Display</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td>7.9&quot;</td>
<td>9.7&quot;</td>
<td>4.0&quot;</td>
<td>4.7&quot; and 5.5&quot;</td>
</tr>
<tr>
<td>Resolution</td>
<td>1024x768 (163ppi)</td>
<td>2048x1536 (264ppi)</td>
<td>1136x640 (326ppi)</td>
<td>1280x720 for 4.7&quot;</td>
</tr>
</tbody>
</table>

#### iPhone Resolution and Memory Content Comparison

<table>
<thead>
<tr>
<th>Model</th>
<th>Resolution</th>
<th>Screen size</th>
<th>DRAM content</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone 3G</td>
<td>480 x 320 (165 ppi)</td>
<td>3.5&quot;</td>
<td>128MB</td>
</tr>
<tr>
<td>iPhone 3GS</td>
<td>480 x 320 (165 ppi)</td>
<td>3.5&quot;</td>
<td>256MB</td>
</tr>
<tr>
<td>iPhone 4</td>
<td>960 x 640 (326 ppi)</td>
<td>3.5&quot;</td>
<td>512MB</td>
</tr>
<tr>
<td>iPhone 4S</td>
<td>960 x 640 (326 ppi)</td>
<td>3.5&quot;</td>
<td>512MB</td>
</tr>
<tr>
<td>iPhone 5</td>
<td>1136 x 640 (326 ppi)</td>
<td>4.0&quot;</td>
<td>1GB</td>
</tr>
<tr>
<td>iPhone 5S</td>
<td>1136 x 640 (326 ppi)</td>
<td>4.0&quot;</td>
<td>1GB</td>
</tr>
</tbody>
</table>

Source: Company Data, DRAMeXchange, Morgan Stanley Research, E= Morgan Stanley Research estimates
We Expect an Oversupply at DRAM in 2Q15

DRAM Sufficiency Forecast

NAND Flash Sufficiency Forecast

DRAM Contract Price Forecast

NAND Flash Contract Price Forecast

Source: Company Data, DRAMeXchange, Morgan Stanley Research, E= Morgan Stanley Research estimates
Part 3: Opportunities for Taiwan Memory Supply Chain
Opportunities and Challenges for Taiwan DRAM Industry

- **Wafer foundry:** Inotera has proven to be very profitable; Powerchip to revamp?
- **IDM players:** Benefit from 4K2K TV and Smart STB demand
- **Backend:** More competition from ASE and in-house
- **NAND module and controller IC vendors:** SSD business is area to grow

![Taiwan DRAM Industry Business Model](source: Morgan Stanley Research)
Inotera posts highest gross margin in memory industry

**80% of capacity to be 20nm by 2015**

Source: Company Data, Morgan Stanley Research, E= Morgan Stanley Research estimates
### IDM: Winbond Benefits from Increasing Specialty DRAM Demand

**Higher DRAM contents in 4K2K TV and Smart STB**

High-end TVs are now equipped with 1.5GB to 2 GB DRAM for high resolution and operating system.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model code</th>
<th>Application Processor</th>
<th>Specialty DRAM</th>
<th>OS</th>
<th>Storage</th>
<th>Screen Size (inch)</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lenovo</td>
<td>Terminator S9</td>
<td>NVIDIA Tegra K1 5327 Dualcore 1.2GHz</td>
<td>1.5GB</td>
<td>Android 4.2</td>
<td>4GB Flash</td>
<td>50&quot;</td>
<td>3840 x 2160</td>
</tr>
<tr>
<td>LeTV</td>
<td>x50 Air</td>
<td>Mstar 6A918 Quadcore 1.7GHz</td>
<td>2GB DDR3</td>
<td>Android 4.1</td>
<td>16GB Flash</td>
<td>50&quot;</td>
<td>3840 x 2160</td>
</tr>
<tr>
<td>Xiaomi</td>
<td>2013 version MiTV</td>
<td>QCOM Snapdragon 600 8064M Quadcore 1.7GHz</td>
<td>2GB DDR3</td>
<td>Android 4.1</td>
<td>8GB Flash</td>
<td>47&quot;, 48&quot;</td>
<td>1920 x 1080</td>
</tr>
<tr>
<td>Xiaomi</td>
<td>2014 version MiTV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55&quot;</td>
<td>3840 x 2160</td>
</tr>
</tbody>
</table>

Source: Company Data, Morgan Stanley Research, E= Morgan Stanley Research estimates
Memory Backend: More Demand, but Competition Intensifying

Mobile DRAM consumers more wire-bonder

ASE, Amkor, ChipMOs are turning aggressive in Memory Backend

<table>
<thead>
<tr>
<th>Company</th>
<th>Product Line</th>
<th>Backend Vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micron/Elpida</td>
<td>DRAM</td>
<td>Packaging: Powertech, Walton, Akida, ChipMOS, ASE; Testing: In-house, Powertech, Walton</td>
</tr>
<tr>
<td>Toshiba</td>
<td>NAND Flash</td>
<td>ChipMOS, UTAC, Powertech, Amkor</td>
</tr>
</tbody>
</table>

DDR4 requires more testing time

Source: Company Data, Morgan Stanley Research, E= Morgan Stanley Research estimates
NAND Module/Controller: SSD is the next Growth Driver for Phison

SSD is the fast growing market

More challenges in to SSD controller design

Enterprise Market TAM

Source: Micron, Morgan Stanley Research,
Conclusion

- DRAM industry remains cyclical given the competition and long lead-time of supply
- Upside to DRAM equipment orders given the attractive margin
- DRAM contract price may decline in 1Q15 to anticipate an oversupply in 2Q15
- Taiwan memory supply chain is repositioning to add more value
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<table>
<thead>
<tr>
<th>Stock Rating Category</th>
<th>Coverage Universe Count</th>
<th>% of Total</th>
<th>Investment Banking Clients (IBC) Count</th>
<th>% of Total IBC</th>
<th>% of Rating Category</th>
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<tbody>
<tr>
<td>Overweight/Buy</td>
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<td>35%</td>
<td>343</td>
<td>40%</td>
<td>32%</td>
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<tr>
<td>Equal-weight/Hold</td>
<td>1357</td>
<td>44%</td>
<td>411</td>
<td>48%</td>
<td>30%</td>
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<tr>
<td>Not-Rated/Hold</td>
<td>113</td>
<td>4%</td>
<td>22</td>
<td>3%</td>
<td>19%</td>
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<tr>
<td>Underweight/Sell</td>
<td>558</td>
<td>18%</td>
<td>88</td>
<td>10%</td>
<td>16%</td>
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<tr>
<td>Total</td>
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</table>

Data include common stock and ADRs currently assigned ratings. Investment Banking Clients are companies from whom Morgan Stanley received investment banking compensation in the last 12 months.

Analyst Stock Ratings
Overweight (O). The stock’s total return is expected to exceed the average total return of the analyst’s industry (or industry team’s) coverage universe, on a risk-adjusted basis, over the next 12-18 months.
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