Cost-Effective Fully Tested Die with High-Frequency and High-Throughput Wafer-Test Solution

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Nobuhiro Kawamata FormFactor Inc., Asia
Southwest Test Workshop Workshop 2004
Presentation Outline

• Mobile RAM introduction
• Mobile RAM wafer-level-final-sort tests objectives and goals
• High performance probing technology solution
• New probing technology internal qualification
• Customer qualification
• Follow on work
• Summary and conclusion
Elpida DRAM Plant

300mm Fabrication in Japan
# Mobile RAM Introduction

**Lowest IDD6, Low Voltage (1.8V), and JEDEC Mobile Functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>SDRAM</th>
<th>Low Power SDRAM</th>
<th>Mobile RAM</th>
<th>ex) 128Mb Density</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Regular SDRAM based</strong></td>
<td></td>
<td><strong>Deep Power Down</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Low Power</strong></td>
<td></td>
<td><strong>PASR</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Low Power</strong></td>
<td></td>
<td><strong>TCSR</strong></td>
<td></td>
</tr>
<tr>
<td>Self Refresh Current</td>
<td>3.3V Standard</td>
<td>Read / Write</td>
<td>1.8V Low Power</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Read / Write</td>
<td>Synchronous</td>
<td>Read / Write</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Synchronous</td>
<td>Synchronous</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2.0mA</td>
<td>0.6mA</td>
<td>0.25mA</td>
<td></td>
</tr>
</tbody>
</table>

*Low Power Mode*

PASR: Partial Array Self Refresh
TCSR: Temperature Compensated Self Refresh

Additional Mobile Functions

- Control min memory size
- For refresh
- Control Self Refresh by Temperature
- I/O Driver Control

For refresh (ex) 128Mb Density

- 2.0mA
- 0.6mA
- 0.25mA
Required Density in Cellular Phone

Application memory is higher than Baseband memory.

(Source: Elpida)
Due to advanced application, required bandwidth is rapidly growing.
Japanese 3G Market Penetration Plan and SIP demand projection

Year 2003

Year 2004

(MCP Demand Increase due to Space limitation)

(file Size Increasing)

(HTML Mail Receiving)

(SIP is really launching)

(Source: Elpida)

Japanese 3G Users

Japanese 3G with SIP

(Orange)

(Green)

400
300
200
100
0
April
May
June
July
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

(Source: Elpida)
Mobile Memory TAM Trend

Memory TAM for Mobile Phone

Mobile SDRAM TAM
Advanced Mobile RAM KGD Flow

- Conventional Wafer Sale Flow

  ![Flowchart](chart.png)

- Elpida Mobile RAM Wafer Sale Flow (Under Evaluation)

  ![Flowchart](chart.png)

  - Wafer Level BI Test
  - High Speed and High Throughput Wafer Level Final Tests
  - High, Ambient, Cold Test Temperature Tests
Wafer-Level Final-Sort-at-Probe Objectives

• On-spec Mobile RAM testing
  – Low-voltage
  – High-frequency
  – Wide temperature

• Low TCOO

High Performance Probing Solution

High performance probing solution enables “Value-Added Mobile RAM Wafer-Sale Business”
High Performance Probing Solution

**FFI S200™ probing technology**

**TRE™ probing technology**

**HFTAP™ probing technology**

128 Multi DUT testing, 66MHz  
500MHz, High signal integrity

200MHz High signal integrity 128 Multi DUT
FFI Internal Qualification

Signal Integrity: Cross-talk simulation*

*180° out-of-phase cross-talk effects super-imposed
FFI Internal Qualification
Signal Integrity: cross-talk simulation

\[
NEXT (dB) = 20 \log_{10} \left( \frac{V1}{V2} \right) \quad V1: \text{Measured Power in volts}
\]
\[
-20dB = 20 \log_{10} \left( \frac{0.1}{1} \right) \therefore 10\% \quad , \quad -30dB = 20 \log_{10} \left( \frac{0.032}{1} \right) \therefore 3.2\%
\]
FFI Internal Qualification
Signal Integrity: Tr/Tf Measurement

<table>
<thead>
<tr>
<th>FFI TRE Probing Technology</th>
<th>S200 Probing Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>t m3-m4 = 0.45ns</td>
<td>t m1-m2 = 0.35ns</td>
</tr>
</tbody>
</table>
# S200 Internal Qualification Results

<table>
<thead>
<tr>
<th>Attenuation</th>
<th>S200 Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1 dB Bandwidth</td>
<td>225MHz</td>
</tr>
<tr>
<td>-3 dB Bandwidth</td>
<td>850MHz</td>
</tr>
<tr>
<td>Rise/Fall Time</td>
<td></td>
</tr>
<tr>
<td>20%-80% Tr/Tfl</td>
<td>350 pS</td>
</tr>
<tr>
<td>Skew</td>
<td>+/- 70 pS</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
<tr>
<td>Operation Range</td>
<td>-40 to 125°C</td>
</tr>
<tr>
<td>Parallelism</td>
<td></td>
</tr>
<tr>
<td>Driver Sharing Level</td>
<td>x2</td>
</tr>
<tr>
<td>// per Station</td>
<td>128///</td>
</tr>
</tbody>
</table>
Wafer-Level Final-Sort Test
Customer Qualification

- 143MHz tester + 100MHz Mobile RAM
  - Output pin waveform
  - DQ signal skew
  - Input and output voltage margins
  - Vcc margin
  - Timing margin
  - Wafer-to-wafer high-speed binning correlation
Customer qualification: DUT to DUT Skew

![Graph showing DUT to DUT Signal Skew](image)

- **FFI TRE Probing Technology**
- **S200 Probing Technology**

**Frequency**

- **S200**
- **TRE**

**DUT to DUT Signal Skew [ps]**

- 0
- 25
- 50
- 75
- 100
- 125
- 150
- 175
- 200
- 225

**2004年6月29日**

Southwest Test Workshop 2004

Elpida / FFI
Customer qualification: VIH/VIL Margin Shmoo

S200 Probing Technology

FFI TRE Probing Technology

S200 Probing Technology
Customer qualification: tHOLD-Control / tHOLD-Address Margin Shmoo

- S200 Probing Technology
- FFI TRE Probing Technology
Customer Qualification: DQ SMHOO Plot

S200 Probing Technology: 0.6ns

TRE Probing Technology: 1.6ns
### Summary and Conclusion

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-frequency testing</td>
<td>100MHz beta evaluation</td>
</tr>
<tr>
<td>Low TCOO</td>
<td>128 parallel per station</td>
</tr>
<tr>
<td></td>
<td>1.5x throughput compared with non-TRE probing</td>
</tr>
<tr>
<td></td>
<td>1.1x throughput compared with low-frequency testing</td>
</tr>
<tr>
<td>Wide temperature</td>
<td>Low-to-high temperature testing throughout the test process</td>
</tr>
<tr>
<td>On-spec testing</td>
<td>To be applied to 133MHz Mobile RAM at device speed testing</td>
</tr>
</tbody>
</table>
Follow-on Work

• Elpida Memory Inc.
  – 100MHz Mobile RAM production using S200
  – Evaluation of 133MHz Mobile RAM at-device-speed testing with S200

• FormFactor, Inc.
  – Customer qualification for 133MHz and beyond
  – Beta site evaluation of multi-bit FLASH memory 100MHz and beyond
Project Members

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