High-Frequency Test at Probe (HFTAP)

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Southwest Test Workshop Workshop 2005
Presentation Outline

• Introduction
• DDR2 DRAM wafer-level-final-sort tests objectives and goals
• High performance probing technology solution
• New probing technology internal qualification
• Customer evaluation
• Summary and conclusion
• Follow on work
Wafer-Level Final-Sort Challenge

Elpida: 333MHz DDR2 DRAM
FFI: K3 [x30DUT]
533MHz tester
Presented at SWTW2005

Elpida: 100MHz Mobile RAM
FFI: (S200, shared driver 200MHz)
143MHz tester
Presented at SWTW2004
High Performance K3 Probing Solution

HFTAP™ probing technology

FFI K3 probing technology

K3 performance enables
DDR2 testing @ 333MHz / 667Mbs
FFI Attenuation & Cross-talk Simulation

Attenuation

Cross-talk

m1
freq=142.0MHz
\(dB(S(4,1))=-1.004\)
m2
freq=877.0MHz
\(dB(S(4,1))=-3.004\)
m3
freq=277.0MHz
\(dB(S(2,1))=-23.964\)
m4
freq=277.0MHz
\(dB(S(3,1))=-31.299\)
FFI Internal qualification
Tpd Distribution by TDR Measurement

Distributions

<table>
<thead>
<tr>
<th>Quantiles</th>
<th>Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0% maximum</td>
<td>Mean</td>
</tr>
<tr>
<td>99.5%</td>
<td>Std Dev</td>
</tr>
<tr>
<td>97.5%</td>
<td>Std Err Mean</td>
</tr>
<tr>
<td>90.0%</td>
<td>upper 95% Mean</td>
</tr>
<tr>
<td>75.0% quartile</td>
<td>lower 95% Mean</td>
</tr>
<tr>
<td>50.0% median</td>
<td>N</td>
</tr>
<tr>
<td>25.0% quartile</td>
<td>1.451825</td>
</tr>
<tr>
<td>10.0%</td>
<td>0.0094868</td>
</tr>
<tr>
<td>2.5%</td>
<td>0.0003536</td>
</tr>
<tr>
<td>0.5%</td>
<td>1.4525191</td>
</tr>
<tr>
<td>0.0% minimum</td>
<td>1.4511309</td>
</tr>
<tr>
<td>1.4810</td>
<td>1.4515</td>
</tr>
<tr>
<td>1.4772</td>
<td>1.4640</td>
</tr>
<tr>
<td>1.4720</td>
<td>1.4575</td>
</tr>
<tr>
<td>1.4640</td>
<td>1.4515</td>
</tr>
<tr>
<td>1.4575</td>
<td>1.4465</td>
</tr>
<tr>
<td>1.4465</td>
<td>1.4396</td>
</tr>
<tr>
<td>1.4396</td>
<td>1.4325</td>
</tr>
<tr>
<td>1.4325</td>
<td>1.4270</td>
</tr>
<tr>
<td>1.4270</td>
<td>1.4220</td>
</tr>
</tbody>
</table>

Channel to channel skew was +/- 30ps
Elpida Evaluation Items

• Basic characteristic
  – Skew
  – Waveform
  – Tr/Tf
  – Jitter

• Device evaluation
  – At-speed test
  – Correlation between wafer and package
    ▪ TCK-VDD Shmoo
    ▪ AC parameters
    ▪ Idd current
Elpida evaluation:
Channel to Channel Skew

(TDR Measurement)

Tpd spec (±75ps) is satisfied.

σ: Standard Deviation

n=576

<table>
<thead>
<tr>
<th>σ [ps]</th>
<th>3σ [ps]</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7</td>
<td>23.2</td>
</tr>
</tbody>
</table>
Elpida evaluation: Input Waveform (Amplitude 0.5V Vt:0.9V )

① 0ps 937.5ps

② 0ps 1875ps

③ 0ps 1875ps 937.5ps
Elpida evaluation: Tr/Tf (Amplitude 0.5V 20-80%, Vt:0.9V)
Elpida evaluation: Jitter

- Evaluated at 533MHz

The source of jitter is caused by attenuation, cross talk, and tester timing control.

Jitter of K3 is similar of existing final tester
Elpida evaluation: At-Speed Test (1)

High-speed WT → Assembly → Package Test

Packaging separately divided by the result of High-speed WT

PC533
PC667
Elpida evaluation: At-Speed Test (2)

- Correlation Result

<table>
<thead>
<tr>
<th>Result of Wafer Test</th>
<th>Correlation of at-speed test between wafer and package</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC667</td>
<td></td>
</tr>
<tr>
<td>PC533</td>
<td></td>
</tr>
</tbody>
</table>

Correlation test result was similar to final test.

<table>
<thead>
<tr>
<th>Result of Package Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
</tr>
</tbody>
</table>

- PC533:
  - Upgrade: 10%
  - Same grade: 70%
  - Downgrade: 20%

- PC667:
  - Upgrade: 5%
  - Same grade: 60%
  - Downgrade: 35%
Elpida evaluation: Correlation (core test)

Test Item: TCK-VDD Shmoo for some pattern

These are evaluated at high temperature with Vdd set in 3 points.

White line means “Be equal” for wafer test and package test. If plot is near this white line, correlation is OK.

Correlated well
Elpida evaluation: Correlation (AC parameters) 1

Test Item: AC Parameters (setup, hold, TCK etc.)

AC Parameter Correlation of K3

※Sub line is indicated the range of Timing accuracy (±100ps)

These are evaluated at high temperature with Vdd set in 3 points.

Compared by package test result
• Different 100ps～150ps for some test item

Available for testing with adjustment

6/6/2005
Southwest Test Workshop 2005
Elpida evaluation: Correlation (AC parameters) 2

Test Item: AC Parameters (VIH/VIL)

These are evaluated at high temperature with Vdd set in 3 points.

- 40mV higher VIH for specific pins

Available for testing with adjustment
Elpida evaluation: Correlation (Idd)

Test Item: Idd Current

These are evaluated at high temperature with Vdd set in 3 points.

Correlated well
Summary and Conclusion

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic characteristics (Waveform, Tr/Tf, Jitter)</td>
<td>PC667 (333MHz) evaluation passed all criteria.</td>
</tr>
<tr>
<td>Correlation between wafer and package test</td>
<td>Correlation test result was similar to final test.</td>
</tr>
<tr>
<td>High-frequency wafer testing</td>
<td>Available to device measurement for 333MHz DDR2 DRAM at device speed testing</td>
</tr>
</tbody>
</table>
Follow-on Work

- **Elpida Memory, Inc.**
  - Further evaluation for volume production

- **FormFactor, Inc.**
  - Higher parallelism K3 [x64 DUT & x 128 DUT]
  - Production qualification at > 300 MHz.
  - Customer evaluation for 500MHz and beyond with K5