Optimizing Test Cell Performance

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Problem Statement

• How are we going to optimize Test Cell performance?
  – Investigate Prober performance
  – Investigate Probe Card performance
  – Investigate Probe Card Analyzer correlation to Test Cell
Design Of Experiment

- **Pass1**
  - Measure/Adjust probe card on PrecisionPoint® VX3
  - Probe wafers
  - Inspect probe marks with NSX® after probing
  - Measure Probing Process performance with WaferWoRx® on NSX
  - Compute VX3 correlation to scrub marks
Design Of Experiment

• Pass2
  – Adjust Probe Card on PrecisionWoRx® VX4 using “Predictive Scrub”
  – Probe wafers
  – Inspect probe marks with NSX after probing
  – Measure Probing Process performance improvements with WaferWoRx on NSX
Pass1: Measure/Adjust probe card on VX3

- VX3 data shows probe’s center of scrub is within spec and nominally centered on the pad
Pass1: Probe Wafers

- 200mm wafer
- 378 Touchdowns

- Cantilever probe card (4 X 1)
- 700+ probes
- Two tiers (different tip lengths)\(^1\)

Strom, “Multi-tier Probe Cards and Contact Resistance, SWTW 1998\(^1\)
Strom, A Study of Probing Process Analysis, SWTW 1999\(^1\)
### Pass1: PMI Results

#### Results Table

<table>
<thead>
<tr>
<th>Index</th>
<th>Die Column</th>
<th>Die Row</th>
<th>Die ID</th>
<th>Field ID</th>
<th>Scrub ID</th>
<th>Prober ID</th>
<th>DUT ID</th>
<th>Scrub X Size (µm)</th>
<th>Scrub Y Size (µm)</th>
<th>Scrub X Pos (µm)</th>
<th>Scrub Y Pos (µm)</th>
<th>Scrub Major Length (µm)</th>
<th>Scrub Minor Length (µm)</th>
<th>Scrub Angle (°)</th>
<th>Scrub Algn (°)</th>
<th>Edge Distance (µm)</th>
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- **Group By**:
  - **Non**
  - **Acc**
  - **Des**

- **Not Found**
  - **Min**: 6.853
  - **Max**: 6.853
  - **Average**: 6.853

**Pass1**:
- Need some raw PMI data here.
Pass1: Probing Process Analysis Overview

- PMI raw scrub mark data is input
- Prober, Probe to Pad Alignment (PTPA) and Probe Card performance is calculated
- Process performance is determined from combined Prober and Probe Card performance

Diagram:

- Raw Scrub Data
- Prober and PTPA Performance
- Probe Card Performance
- Probing Process Performance

Flow:
- Raw Scrub Data → Prober and PTPA Performance
- Prober and PTPA Performance → Probe Card Performance
- Probe Card Performance → Probing Process Performance
Pass1: Probing Process Performance Summary

- Process Length issues
  - Pad Size = 60 microns and the Process Length = 48 microns
  - Single Wafer CPK ~ 1.25

- Probe Card is the major error source

- Prober error contribution relatively small compared to Probe Card error
Pass1: Prober Performance Summary

- Overall prober error \( \approx 12 \) microns
- Probe to Pad Alignment larger than normal \((\sim 5 \text{ microns})\)
- Deflection/Translation under load relatively large for just 800 pins – may be problematic with higher load probe cards
- Small Orthogonality and Scaling errors in stage motion
Pass1: Probe Card Performance

- No XY scaling errors
- Good repeatability
- Scrub Length and Width typical for a cantilever probe card

- Probe Card Length Accuracy is the major error source (10 microns)
Pass1: Probe Card SuperPad View

- Probes are scrubbing short of pad center
- Different tiers have different offsets

Top row only

Bottom row only
Pass 1: Probe Card Vector View Of Alignment Errors

- Probes scrubbing short of the center of the pad
- Tiers have different errors / scrub characteristics

Vector pointing to the right = scrub center is to the right of pad center.
Pass1: Probe Card Scrub Length and Scrub Width

- Interleaved tiers have different scrub characteristics
  - Tier1: Shorter tip lengths = long and thin scrubs
  - Tier2: Longer tip lengths = short and wide scrubs
Pass1: Probe Card Performance Summary

• Pros
  • Probe positions show no XY scaling error
  • Probes positions (scrub marks) are repeatable

• Cons
  • Probes are scrubbing short of the pad center
  • Multiple tiers/tip lengths each have different scrub characteristics
    • Long Tip Length: Short wider scrub
    • Short Tip Length: Long thin scrub
      • Can not resolve by simply changing overtravel

• Probe card performance problems consume major part of pad
Probe Card Analyzer to Test Cell Correlation Analysis
Pass 1: Test Cell vs. VX3 Probe Card Correlation

- VX3 measures probe center of scrub ~ center of pad
- WaferWoRx shows probes scrubbing short of pad center

Vector pointing to the right = scrub center is to the right of pad center
Pass1: Test Cell vs. VX3 Probe Position – Absolute

Probe Relative analysis

PRVX3 vs. WWX - "Width" probe position

PRVX3 vs WWX - "Length" probe position
Review Cantilever Probe Scrub Properties on PCA Measurement Window vs. on Bond Pad

PCA Window – Low Friction
- Minimal probe tip deflection because friction is low
- Scrub length increases with tip length

Aluminum Bond Pad – High Friction
- Significant probe tip deflection because friction is high
- Longer tip lengths scrub shorter due to higher deflection
- Shorter tip lengths scrub longer due to lower deflection
Pass1: Test Cell to VX3 Correlation - Summary

- Good correlation in "Width" axis between VX3 and WaferWoRx data
  - VX3 is accurately representing the initial contact position of the probe

- Correlation issue in the "Length" axis
  - Losing ~ 10 microns of scrub position due to cantilever probe scrub characteristic differences on hard surface vs. aluminized pad
Process Improvement Opportunities

Prober Improvement
• Probe to Pad Alignment Improvements (Yaw and X Offset)
  • Process improvement available ~5 microns

Probe Card Improvement
• Use VX4 “Predictive Scrub” during card adjustment
  • Process improvement available ~10 microns
“Predictive Scrub”
1) PCA measurement

2) WaferWoRx Probe Card measurement from PMI data

3) Quantify differences between PCA and Test Cell

4) Measure Predictive Scrub with VX4
Pass 2: Measure Probe Card on VX4 Before and After Adjust

“Measured” Center of Scrub Positions

Before Adjust

“Predicted” Center of Scrub Positions

Before Adjust

“Predicted” Center of Scrub Positions

After Adjust

• VX4 Results BEFORE adjusting probe positions
  • Measured positions are well centered
  • Predicted positions have a donut hole of probes scrubbing short of center

• VX4 Results AFTER adjusting probe positions based on Predicted Positions
  • Predicted positions are now well centered
Pass 2: Measure Process Improvements

Pass 1 Results
Card Accuracy Error = 10 microns

Pass 2 Results
Card Accuracy Error = 4 microns
Pass 2: Probe Card Performance Details

Pass1 WaferWoRx Results

Pass2 WaferWoRx Results

- Probes scrubbing short of pad center for Pass1 data
- Probes are well centered for Pass2 data
  - Probe Card was adjusted using VX4 “Predictive Scrub”
Pass 2: VX4 “Predictive Scrub” Correlation to Test Cell

**PRVX3 vs WWX - "Length" probe position**

- **Pass 1 Correlation**

**VX4 “Predicted” vs WWX – Length” probe position**

- **Pass 2 Correlation**
Summary

• **We were able to improve Test Cell performance!**

• **CPK improvements**
  – Pass1 CPK = 1.25, Process Length = 48 microns
  – Pass2 CPK = 1.45, Process Length = 41.3 microns

• **Probe Card Performance improvements by adjusting probe positions based on VX4 “Predictive Scrub”**
  – Pass1 Length Accuracy Error = 10 microns
  – Pass2 Length Accuracy Error = 4 microns

• **Improved Probe Card Analyzer correlation to Test Cell using VX4 “Predictive Scrub”**

• **Identified Prober Stage and PTPA Errors with WaferWoRx on NSX Probing Process Analysis**
  – Additional performance improvement available to pursue
Acknowledgements

Freescale Semiconductor
John Vanderbilt, Greg Faulkner, Devin Sheridan

Rudolph Technologies
Darren James, Rod Doe, WooYoung Han

JEM
Patrick Mui

Other Contributors
Fred Megna, Kajiwara “Kaji” Kunitomo