Understanding the Probe Damage Risk thru Determination of Minimum Bond Pad Opening Capability of Different Prober and Needle Type Set-up

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Introduction
Introduction

Ring Carrier

Probecard

Needle

Dice

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Introduction

What happen when Probe Needle is off-center?

This will result to off-center probe-marks leading to Probe Damage.

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What is Probe Damage?

- Is a phenomena when a part of a die specifically at the Pad Area such as Seal Ring or other metallization has been damaged by the Probe Needle during Testing.
- Probe damage is the number one visual defect contributor at wafer sort process having a direct impact on yield and cycle time.
At 1000 ppm, Probe Damage related to Probe Needle is on top of Pareto in terms of wafer scrappage reason.
Introduction

100% of those 1000 ppm have been contributed by the Prober E which uses a Blade Type Needle for Probing.
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Further data stratification shown Top Devices with high Probe Damage Occurrence
Devices with high PND occurrence have an average bond pad size less than 4 x 4 mils compared with devices with no PND occurrence. Initial assumption on high PND occurrence is due to Prober X when using blade type needle is not capable of probing devices with a minimum bond pad.
What are the causes Probe Damage?

- Probe Capability limitation in terms of minimum bond pad opening has been identified as one of the many causes of Probe Damage on wafers.
- Smaller pad is high risk to Probe Damage.
Objective/Goals

- To determine the different minimum bond pad opening capability at Probe using different Prober and Needle Type.
- To assess the Probe Damage risk and come up with a solution to reduce the risk.
Methodology

- Identify all possible Prober and Needle Type Combination.
  - Block all the other factors that will serve as noises. This is to eliminate the un-necessary variation that will affect the overall accuracy of the study.

- Create a Data Collection Plan
- Perform Data Analysis
- Perform Capability Study
- Risk Assessment
Methodology

I. Old Prober Tandem with Blade Type Needle
II. Old Prober Tandem with Epoxy Type Needle
III. New Prober Tandem with Blade Type Needle
IV. New Prober Tandem with Epoxy Type Needle
V. New Prober Tandem with Vertical Type Needle
Methodology

Data Collection Plan:

1. Measure the Length X & Y value as shown in Figure 1. Perform measurements on dice illustrated in Figure 2.

2. Repeat #1 until 30 data sets is achieved.
Computation of Minimum Bond Pad Capability using “Components of Variation”:

**Capability** = \( \bar{x} + 3 \sigma_{\text{Scrub Mark}} \); 

\[ \sigma_{\text{Scrub Mark}} = \sqrt{\sigma^2_{\text{Scrub Mark Length}} + \sigma^2_{\text{Scrub Mark Placement}}} \]
Capability Assessment Result

I. Old Prober Tandem with Blade Type Needle

\[ \bar{x} = 2.79 \text{ mils} \]

\[ \text{Scrub Mark Length} = 0.43 \text{ mils} \]

\[ \text{Scrub Mark Placement} = 0.30 \text{ mils} \]
I. Old Prober Tandem with Blade Type Needle

**Capability** = \( \bar{X} + 3 \sigma_{\text{Scrub Mark}} \)

\( \sigma_{\text{Scrub Mark}} = \sqrt{\sigma_{\text{Scrub Mark Length}}^2 + \sigma_{\text{Scrub Mark Placement}}^2} \)

\[ \sigma_{\text{Scrub Mark}} = \sqrt{(0.43)^2 + (0.30)^2} \]

\[ \sigma_{\text{Scrub Mark}} = 0.5264 \]

\[ \text{Capability} = 2.79 + 3 \sigma_{\text{Scrub Mark}} \]

\[ \sigma_{\text{Scrub Mark}} = 0.5264 \]

\[ \text{Capability} = 2.79 + 3(0.5264) \]

\[ \text{Capacity} = 4.37\text{mils} \approx 4.5\text{mils} \]
Capability Assessment Result

II. Old Prober Tandem with Epoxy Type Needle

\[ \bar{X} = 1.74 \text{ mils} \]

\[ \text{Scrub Mark Length} = 0.21 \text{ mils} \]

\[ \text{Scrub Mark Placement} = 0.30 \text{ mils} \]
Capability Assessment Result

II. Old Prober Tandem with Epoxy Type Needle

\[
\text{Capability} = \bar{X} + 3 \sigma_{\text{Scrub Mark}}
\]

\[
\sigma_{\text{Scrub Mark}} = \sqrt{\left(\frac{\sigma_{\text{Scrub Mark Length}}}{\text{Length}}\right)^2 + \left(\frac{\sigma_{\text{Scrub Mark Placement}}}{\text{Placement}}\right)^2}
\]

\[
\text{Capability} = 1.74 + 3 \sigma_{\text{Scrub Mark}}
\]

\[
\sigma_{\text{Scrub Mark}} = \sqrt{(0.21)^2 + (0.30)^2}
\]

\[
\text{Capability} = 1.74 + 3 \times 0.3665
\]

\[
\text{Capability} = 2.84 \text{ mils} \approx 3 \text{ mils}
\]
Capability Assessment Result

III. New Prober Tandem with Blade Type Needle

Formula for Capability:

\[ Cp = \mu + 3\delta \text{ ; where } \delta = \sqrt{\delta_1^2 + \delta_2^2} \]

Given Values:

\[ \mu = 2.51 \text{ mils} \]
\[ \delta_1 = 0.21 \text{ mils} \]
\[ \delta_2 = 0.14 \text{ mils} \]

Computation for \( \delta \):

\[ \delta = \sqrt{\delta_1^2 + \delta_2^2} \]
\[ \delta = \sqrt{0.21^2 + 0.14^2} \]
\[ \delta = 0.25 \text{ mils} \]

Computation for \( Cp \):

\[ Cp = \mu + 3\delta \]
\[ Cp = 2.51 \text{ mils} + 3 \times (0.25 \text{ mils}) \]
\[ Cp = 3.26 \text{ mils} \approx 3.5 \text{ mils} \]
Capability Assessment Result

IV. New Prober Tandem with Epoxy Type Needle

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Formula for Capability:
\[ Cp = \mu + 3\delta \text{ where } \delta = \sqrt{\delta^2 + \delta^2} \]

Given Values:
- \( \mu = 1.63 \text{ mils} \)
- \( \delta_1 = 0.13 \text{ mils} \)
- \( \delta_2 = 0.16 \text{ mils} \)

Computation for \( \delta \):
- \( \delta = \sqrt{(\delta_1^2 + \delta_2^2)} \)
- \( \delta = \sqrt{0.13^2 + 0.16^2} \approx 0.21 \text{ mils} \)

Computation for \( Cp \):
- \( Cp = \mu + 3\delta \)
- \( Cp = 1.63 \text{ mils} + 3(0.21 \text{ mils}) \approx 2.25 \text{ mils} \)
Capability Assessment Result

V. New Prober Tandem with Vertical Type Needle

Formula for Capability:

\[ Cp = \mu + 3\delta ; \text{ where } \delta = \sqrt{(\delta_1^2 + \delta_2^2)} \]

Given Values:

\[ \mu = 0.76 \text{ mils} \]
\[ \delta_1 = 0.06 \text{ mils} \]
\[ \delta_2 = 0.11 \text{ mils} \]

Computation for \( \delta \):

\[ \delta = \sqrt{(0.06^2 + 0.11^2)} = 0.13 \text{ mils} \]

Computation for \( Cp \):

\[ Cp = \mu + 3\delta = 0.76 \text{ mils} + 3(0.13 \text{ mils}) = 1.16 \text{ mils} \approx 1.5 \text{ mils} \]
Sigma Assessment

I. Old Prober Tandem with Blade Type Needle

Definition of a Defect

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Spec Limit (LSL)</td>
<td></td>
</tr>
<tr>
<td>Upper Spec Limit (USL)</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Known Sample Statistics

<table>
<thead>
<tr>
<th>Question</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is Mean of Distribution?</td>
<td>2.79</td>
</tr>
<tr>
<td>What is Standard Deviation of Distribution?</td>
<td>0.5264</td>
</tr>
</tbody>
</table>

Note: Before entering data, go to tools menu, select options, select calculations, and check Manual button. Enter data into appropriate sections of calculator, and push F9 button to perform.

- **DPMO**: 88,703
- **Sigma (ZST)**: 2.85

Draw Conclusions

- Below Industry Average

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Sigma Assessment

II. Old Prober Tandem with Epoxy Type Needle

<table>
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<tbody>
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<tr>
<td>Upper Specification Limit (USL)</td>
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Note: Before entering data, go to Tools Menu, select options, select calculations, and check manual button. Enter data into appropriate sections of the calculator, and push F9 button to perform.

<table>
<thead>
<tr>
<th>Draw Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPMO 1</td>
</tr>
<tr>
<td>Sigma (ZST) 6.30</td>
</tr>
</tbody>
</table>

World Class
Sigma Assessment

III. New Prober Tandem with Blade Type Needle

**Definition of a Defect**

<table>
<thead>
<tr>
<th>Lower Specification Limit (LSL)</th>
<th>Upper Specification Limit (USL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Known Sample Statistics**

- **What Is Mean of Distribution?** 2.52
- **What Is Standard Deviation of Distribution?** 0.25

**Note:** Before entering data, go to Tools menu, select options, select calculations, and check Manual button. Enter data into appropriate sections of calculator, and push F9 button to perform.

**Draw Conclusions**

- DPMO: 44
- Sigma (ZST): 5.42

*Significantly Above Average*
Sigma Assessment

IV. New Prober Tandem with Epoxy Type Needle

**Definition of a Defect**

<table>
<thead>
<tr>
<th>Lower Specification Limit (LSL)</th>
<th>Upper Specification Limit (USL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td></td>
</tr>
</tbody>
</table>

**Known Sample Statistics**

- What Is *Mean* of Distribution? 1.63
- What Is *Standard Deviation* of Distribution? 0.21

**Note:** Before entering data, go to Tools Menu, select options, select calculations, and check Manual button. Enter data into appropriate sections of calculator, and push F9 button to perform.

**Draw Conclusions**

- DPMO 0
- Sigma (ZST) 7.50
- World Class
Sigma Assessment

V. New Prober Tandem with Vertical Type Needle

Definition of a Defect

- Lower Specification Limit (LSL)
- Upper Specification Limit (USL) 3.5

Known Sample Statistics

- What Is Mean of Distribution? 0.76
- What Is Standard Deviation of Distribution? 0.13

Note: Before Entering Data, Go To Tools Menu, Select Options, Select Calculations, and Check Manual Button. Enter Data into Appropriate Sections of Calculator, and Push F9 Button To Perform.

- DPMO 0
- Sigma (ZST) 7.50
- World Class

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## Summary

### Minimum Bond Pad Size Opening Capability

<table>
<thead>
<tr>
<th>Prober</th>
<th>Needle Type</th>
<th>Probe marks Size (x)</th>
<th>3 Sigma (Placement and Length)</th>
<th>A</th>
<th>B</th>
<th>Σ - Level</th>
<th>DPMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old</td>
<td>Blade Type (1.5 mils)</td>
<td>2.79 mils</td>
<td>1.6 mils</td>
<td>4.39 mils</td>
<td>4.39 mils</td>
<td>2.85</td>
<td>88703.00</td>
</tr>
<tr>
<td></td>
<td>Epoxy Type (1 mil)</td>
<td>1.74 mils</td>
<td>1.1 mils</td>
<td>2.84 mils</td>
<td>2.84 mils</td>
<td>6.30</td>
<td>1.00</td>
</tr>
<tr>
<td>New</td>
<td>Blade Type (1.5 mils)</td>
<td>2.51 mils</td>
<td>0.74 mils</td>
<td>3.25 mils</td>
<td>3.25 mils</td>
<td>5.42</td>
<td>44.00</td>
</tr>
<tr>
<td></td>
<td>Epoxy Type (1 mil)</td>
<td>1.63 mils</td>
<td>0.63 mils</td>
<td>2.25 mils</td>
<td>2.25 mils</td>
<td>7.50</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Vertical Probe (2.5 mils)</td>
<td>0.9 mils</td>
<td>0.36 mils</td>
<td>1.27 mils</td>
<td>1.27 mils</td>
<td>7.50</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Summary

Capability Study:

✓ Old Prober tandem with Blade Type needle minimum bpo = 4.39 mils.
✓ Old Prober tandem with Epoxy Type = 2.84 mils.
✓ New Prober tandem with Blade Type = 3.25 mils.
✓ New Prober tandem with Epoxy Type = 2.25 mils and for New Prober tandem with Vertical Probe = 1.27 mils.

Sigma Assessment:

✓ Old Prober tandem with Blade Type needle sigma = 2.85 which has an expected defect per million opportunity = 88703.
✓ Old Prober tandem with Epoxy Type needle sigma = 6.30 which has an expected dpmo = 1.
✓ New Prober tandem with Blade Type needle sigma = 5.46 which has an expected dpmo = 37.
✓ New Prober tandem with Epoxy Type or Vertical Probe sigma level = 7.5 which has an expected = 0.
Follow-On Work

- For new product development, Wafer Probe Equipment capability in terms of placement and stepping accuracy should be considered primarily. Current trend of technology causes the Die Size shrunk. BPO becomes smaller and smaller.

- Probe Technology should also be considered. A wide spread variety of Probe Technology such as Cantilever, Buckling Type, Cobra and Pogo can be chosen depending on the current process requirement and what the customer needs.

- MPCPS should be done on every New Product/Process. This is an anticipation of risk that prevents the issue during the Production Run that cost a lot. Solving the problem at the source is much cheaper.