Addressing 80 µm pitch Cu Pillar Bump Wafer probing:
Technoprobe TPEG™ MEMS solution

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Overview

• Background

• ST Qualification of TPEG™ MEMS T3 probing technology on Cu pillar bumps products
  – Objectives
  – Test vehicles description
  – Results

• Technoprobe overview TPEG™ solutions for Cu pillar bumps
  – Down to 80 µm pitch (full array) and 25 µm Cu pillar bump diameter

• Conclusions
Background

- TPEG™ MEMS T3 Probe Cards delivered in volume to ST proved to be a production worthy solution on solder bump products, as presented last year at SWTW 2013.

- Since then, a qualification process has been jointly completed on advanced Cu pillar bump products also.
  - In the first part of this paper ST will describe the outcome of those qualification activities and will show the outstanding results obtained in terms of electrical yield, bump damage and overall CoO reduction.
  - In the second part Technoprobe will offer an overview of the scalability of this needle technology to address the need of probing down to 80 µm pitch (full array) and down to 25 µm Cu pillar bump diameter.
ST Qualification

Objectives

• Improve performance versus actual vertical probe card solution: PC lifetime & Bump damage on small bumps
• Pitch compliance
• Low Bump damage
• Confirm electrical performances obtained on solder bumps
• Confirm lifetime & reliability (off line servicing) obtained on solder bumps
• Scalability advantage of technology versus standard vertical
ST Qualification
Test vehicles

• **Short description**
  – TPEG™ MEMS T3 //4 (MLO interconnection)
  – Wireless application
  – 2500 pins (//4 configuration)
  – Minimum pitch 108µm
  – Cu pillar Bumps (different bump sizes possible)

• **Photos**

//4 version

//9 version
ST Qualification
Pitch compliance

• Homogenous scrub through different bump sizes
  – A very good stability in term of forces showed by an homogenous scrub size through different bump sizes (photos= 6passes@100µm OD)

80 µm bump dia
(solder bump)

62 µm bump dia

40 µm bump dia

Scrub size = 23-20µm diameter

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Very low bump damage even with up to 6 passes at max OD:

- <17% of bump area at max OD =100µm (bump size = 40µm diameter)
ST Qualification
Bump damage evaluation

- SEM inspection:
  - PMs are well centered
  - Cu pillar bumps are not damaged
ST Qualification

Electrical performances – Eng phase

• Overall Recovery Rate
  – Average=1.54% (= all bins process, contacts...)
  – Below graph is showing data from 3 different PCs, recorded from Jan to end of March 2014

* Recovery is % of good dies gained after retest versus number of gross dies
ST Qualification
Electrical performances – Eng phase

- **Contact bins Recovery Rate**
  - Contact bins recovery (vs nb of testable dies) = negligible (<0.5%)
ST Qualification

Electrical performances – Prod phase

- Product has been transferred to ST Singapore mass production site
  - Below graph is showing data from 2 different PCs, recorded during the 1st two weeks of production transfer
ST Qualification
PC Reliability evaluation

- **No maintenance/ offline servicing was needed so far**
  - Several and different PCs used for Engineering & Production phase without any offline servicing
  - Tip wear negligible under 60ktds

- **Lifetime estimated x3 versus previous vertical solution**
- **Robustness of technology confirmed on fine pitch**
  - No bent, no burnt probes
ST Qualification
Summary

- **TPEG™ MEMS T3 needles** met and exceeded the objectives set by ST

<table>
<thead>
<tr>
<th>Description</th>
<th>ST Objectives</th>
<th>TPEG™ MEMS T3 Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bump Damage</td>
<td>&lt; 25% bump area</td>
<td>&lt;20% (6 passes at max OD)</td>
</tr>
<tr>
<td>Contact –related Recovery</td>
<td>&lt; 1 %</td>
<td>&lt;1 %</td>
</tr>
<tr>
<td>Offline Interventions</td>
<td>Max 1/week</td>
<td>0/week</td>
</tr>
<tr>
<td>Prober setup stability</td>
<td>No changes over PC lifespan</td>
<td>Stable</td>
</tr>
<tr>
<td>Needles lifespan</td>
<td>&gt; 1 Million TD</td>
<td>Est: 3X actual non MEMS solution</td>
</tr>
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</table>
TP’s solution for Bumps Probing

Introduction

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Probing on Eutectic bumps at pitch ≥ 130µm</td>
<td>Probing on Cu pillar bumps at 80µm pitch</td>
<td>Probing on Cu pillar bumps at 80µm pitch</td>
<td>Probing on µ-Cu pillar bumps (20µm diameter)</td>
</tr>
<tr>
<td>Reliability and lifetime</td>
<td>Reduced bump mark and path Resistance</td>
<td>Industrialization and further scalability</td>
<td>Proof of concept and roadmap readiness</td>
</tr>
</tbody>
</table>

Technoprobe developed new TPEG™ MEMS needle technology and process manufacturing

TPEG™ MEMS technology evolved and customized to scaling down requests

TPEG™ MEMS technology delivered in volume.

TPEG™ MEMS technology at 40 µm pitch to ensure further scalability

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TP’s solution for Bumps Probing

Probing solutions

- Different needle solutions have been developed and are now in mass production depending on pitch and bumps diameter

<table>
<thead>
<tr>
<th>Application</th>
<th>Bump Pitch</th>
<th>Bump Diameter</th>
<th>TP solution</th>
<th>Pin count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solder Bumps</td>
<td>200 to 130 μm</td>
<td>down to 80 μm</td>
<td>TPEG\textsuperscript{1st} MEMS T3</td>
<td>30,000</td>
</tr>
<tr>
<td>Cu Pillar Bumps</td>
<td>130 to 80 μm</td>
<td>25 -30 μm</td>
<td>TPEG\textsuperscript{1st} MEMS T3/T1</td>
<td>30,000</td>
</tr>
<tr>
<td>μCu Pillar - TSV</td>
<td>down to 40 μm</td>
<td>20 μm</td>
<td>TPEG\textsuperscript{1st} MEMS T50/T40</td>
<td>5 – 10,000 *</td>
</tr>
</tbody>
</table>

* Parallelism at ultra-fine pitch depends more on Space Transformer capabilities than on PH ones

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Needles for Bumps/ Cu pillar bumps

TPEG™ MEMS T3: the winning solution for Flip Chips

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TPEG™ MEMS T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle diameter</td>
<td>2 mils equivalent</td>
</tr>
<tr>
<td>Max pin count</td>
<td>&gt; 20,000 pins</td>
</tr>
<tr>
<td>X, Y alignment accuracy and Z planarity</td>
<td>X,Y: ± 10 µm; Z plan: Δ 20 µm</td>
</tr>
<tr>
<td>Min pitch and configuration</td>
<td>90 µm Full Array</td>
</tr>
<tr>
<td>Pin Current (CCC)</td>
<td>600 mA (1200 mA special alloy)</td>
</tr>
<tr>
<td>Force (at 3 mils OT)</td>
<td>4.5 g</td>
</tr>
</tbody>
</table>
Technoprobe probing solution for µ-Cu pillar bumps

• Since Q2 2013, Technoprobe has been engaging with major customers on a few projects dedicated to evaluate the best solution for probing on µ-Cu pillar bumps with
  – 80 µm pitch
  – 25/30 µm bump diameter

• We learned that key factors to succeed for probing on such applications are:
  – Reduced and controlled bump damage
  – Stable electrical contact

• The advantage of customization of TP’s manufacturing process allowed to implement flat tips on TPEG™ MEMS T1 HC needles (normally dedicated to probing on pads) and hence to provide a solid solution for next generation microprocessors probing
# Needles for μ-Cu pillar bumps

**TPEG™ MEMS T1 flat**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>TPEG™ MEMS T1 Flat</th>
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<tbody>
<tr>
<td>Needle body diameter</td>
<td>1,5 mils equivalent</td>
</tr>
<tr>
<td>Max pin count</td>
<td>&gt; 20,000 pins</td>
</tr>
<tr>
<td>X, Y alignment accuracy</td>
<td>X,Y: ± 6 µm</td>
</tr>
<tr>
<td>Z planarity</td>
<td>Δ 20 µm</td>
</tr>
<tr>
<td>Pin Current (CCC)</td>
<td>800 mA (special alloy)</td>
</tr>
<tr>
<td>Force (at 3 mils OT)</td>
<td>2 g</td>
</tr>
</tbody>
</table>

Probe Head with 25,000+ needles, min pitch 80 µm
TPEG™ MEMS T1 FLAT TECHNOLOGY
Characterization data – Probe Mark Analysis

Test Done on 25 µm Cu-pillar diameter (pitch is 80 µm Full Array)

- 50 µm OT
- PM area ~ 28% of bump area

- 75 µm OT
- PM area ~ 30% of bump area

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TPEG™ MEMS T1 FLAT TECHNOLOGY
Customer Data – Probe Mark Analysis

Probe Mark well within customer spec
(test done on 25 µm Cu-pillar diameter; pitch is 80 µm Full Array)
TPEG™ MEMS T1 HC FLAT
C-RES on 80 µm pitch/ 25 µm dia µ-Cu pillar bumps

- C_RES measurements @ 40 µm OT from last touch, no online cleaning
Summary and conclusions

• Technoprobe introduced in 2012 TPEG™ MEMS T3 new needle technology to overcome all limitations of previous technologies when probing over Solder bumps
  – Probe Cards proved to be a production worthy solution and to deliver a value added if compared to previous needle technology as showed last year

• Same results has been obtained on Cu pillar bumps that are even more demanding in terms of min pitch and bump damage

• An overview of customization and scalability of TP’s manufacturing process to provide a solid solution for next generation microprocessors probing has been also presented
Thank you!

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<thead>
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