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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

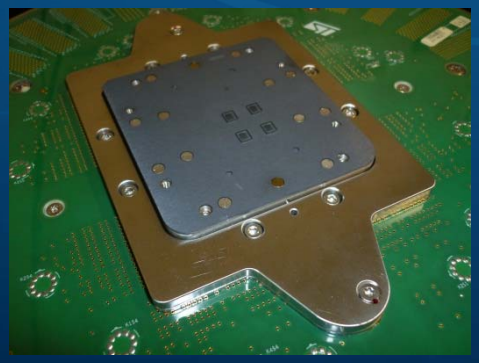
Objectives

- **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**

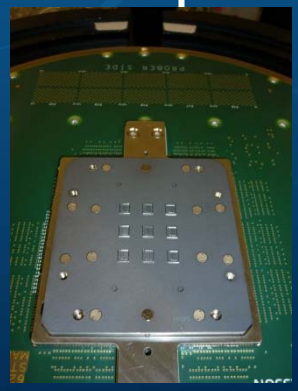
ST Qualification

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

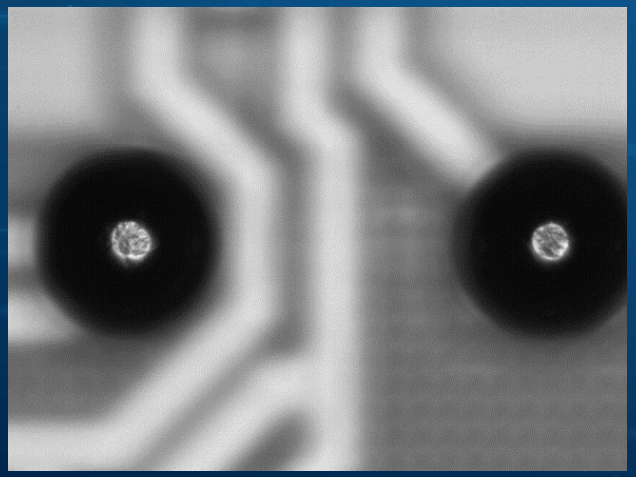


//9 version

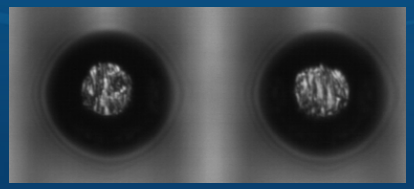
ST Qualification
Pitch compliance

- **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)

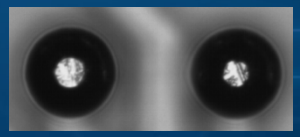


62 µm bump dia



Same Product

40 µm bump dia



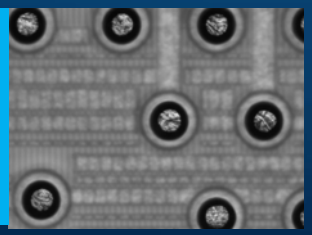
Scrub size = 23-20µm diameter

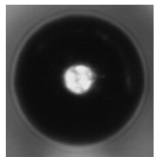
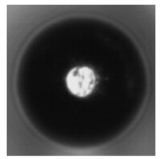
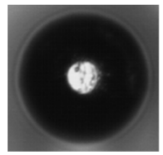
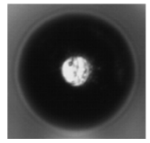
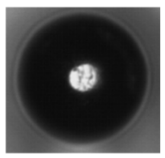
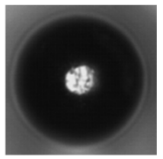
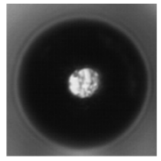
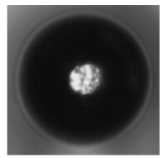
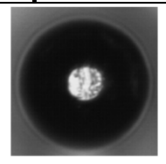
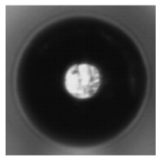
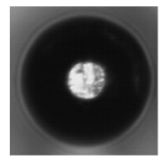
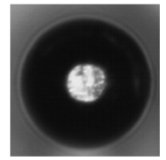
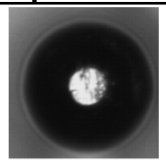
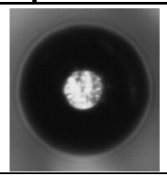
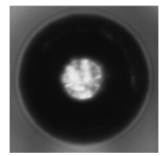
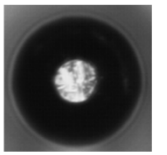
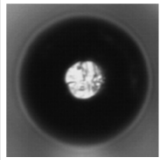
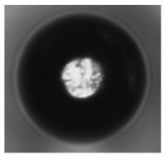
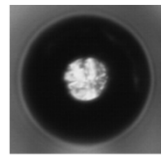
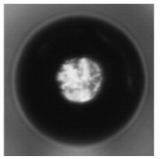
ST Qualification

Bump damage evaluation

- **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)

Vertical Probe Card
100µm OD
Scrub dia=23µm

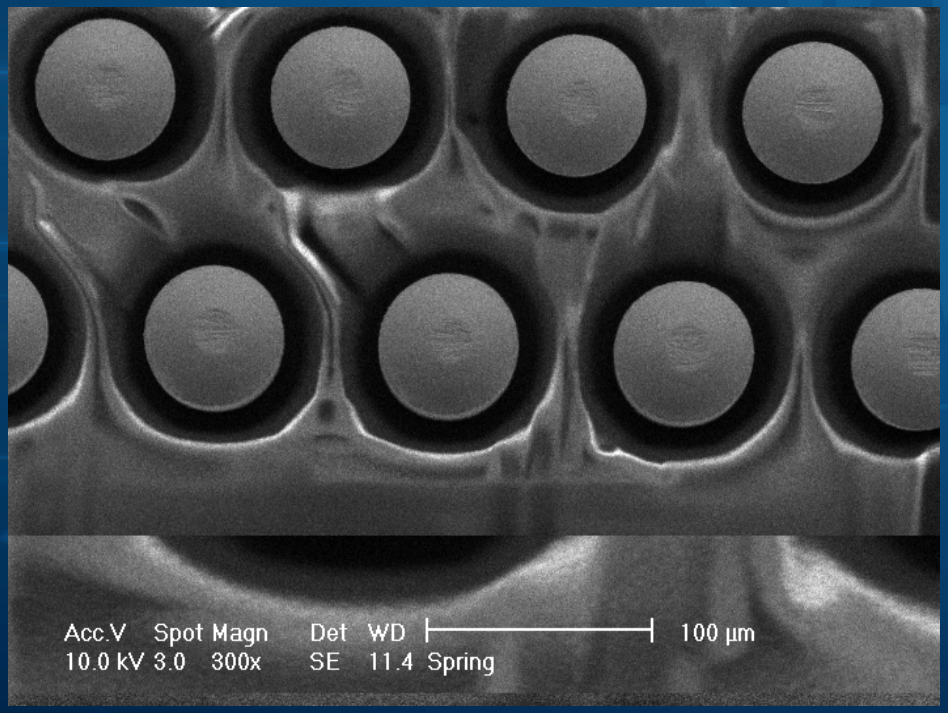


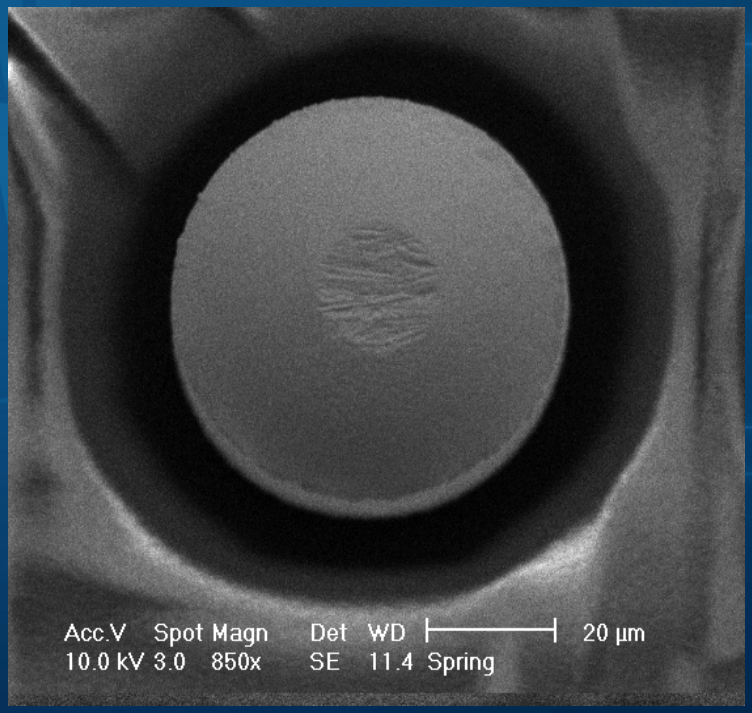
Overdrive (µm)	1 pass	2 passes	4 passes	6 passes
40				
Scrub diameter	15 µm	15µm	15µm	15µm
60				
Scrub diameter	14µm	14µm	14µm	16µm
80				
Scrub diameter	17µm	17µm	18µm	18µm
100				
Bump diameter	17µm	19µm	19µm	21µm
120				
Scrub diameter	18µm	18µm	18µm	20µm

ST Qualification

Bump damage evaluation

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

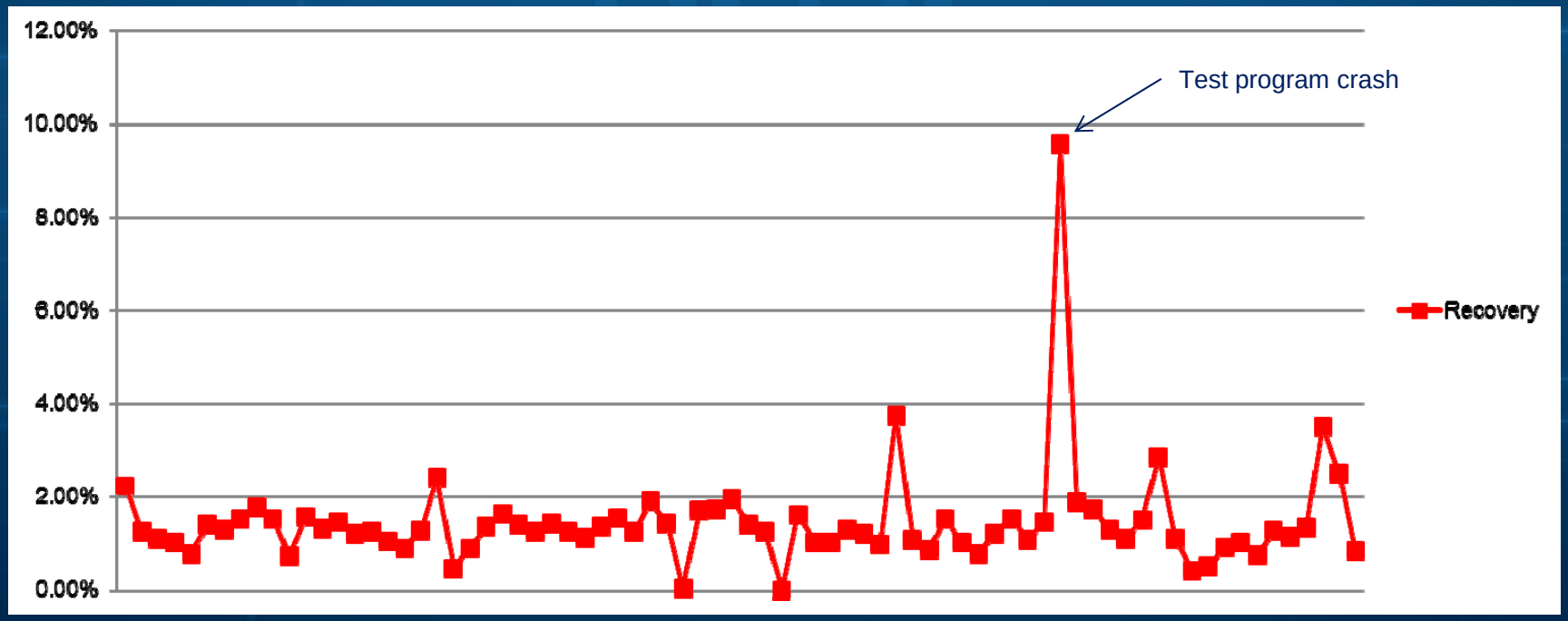




ST Qualification

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

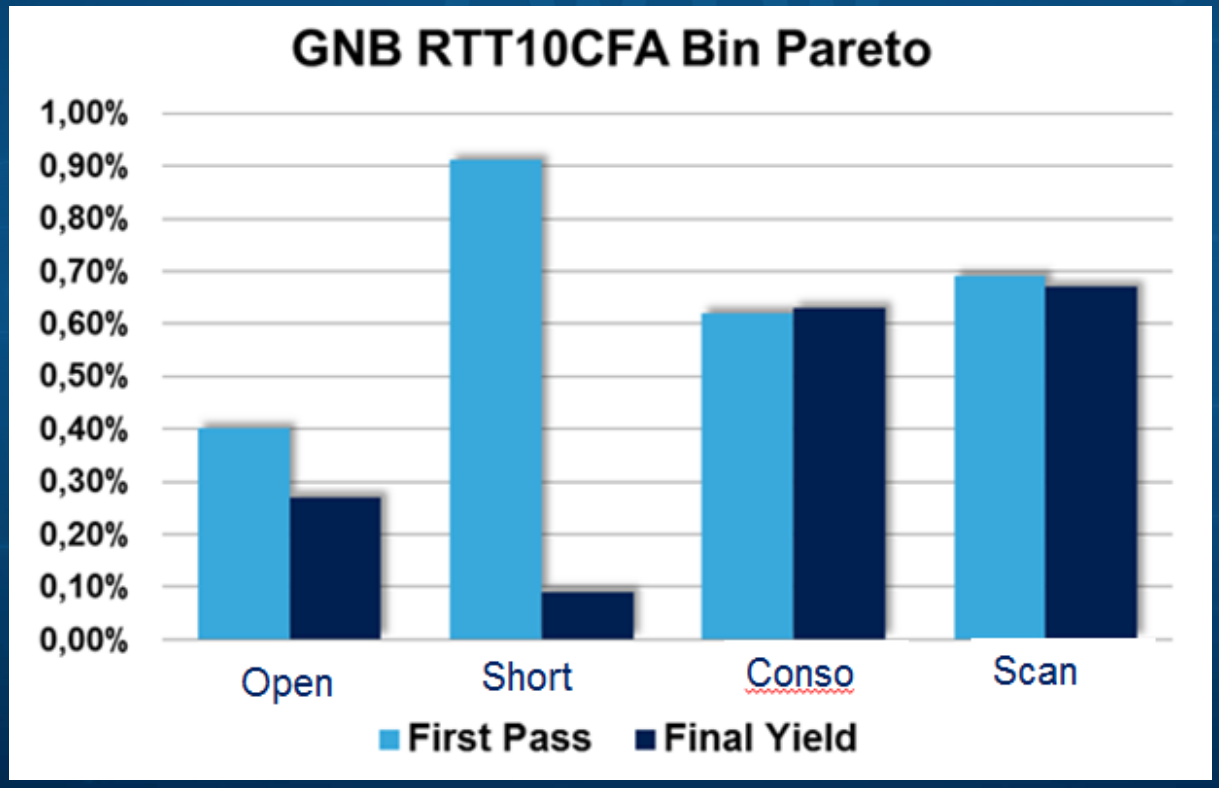


** Recovery is % of good dies gained after retest versus number of gross dies*

ST Qualification

Electrical performances – Eng phase

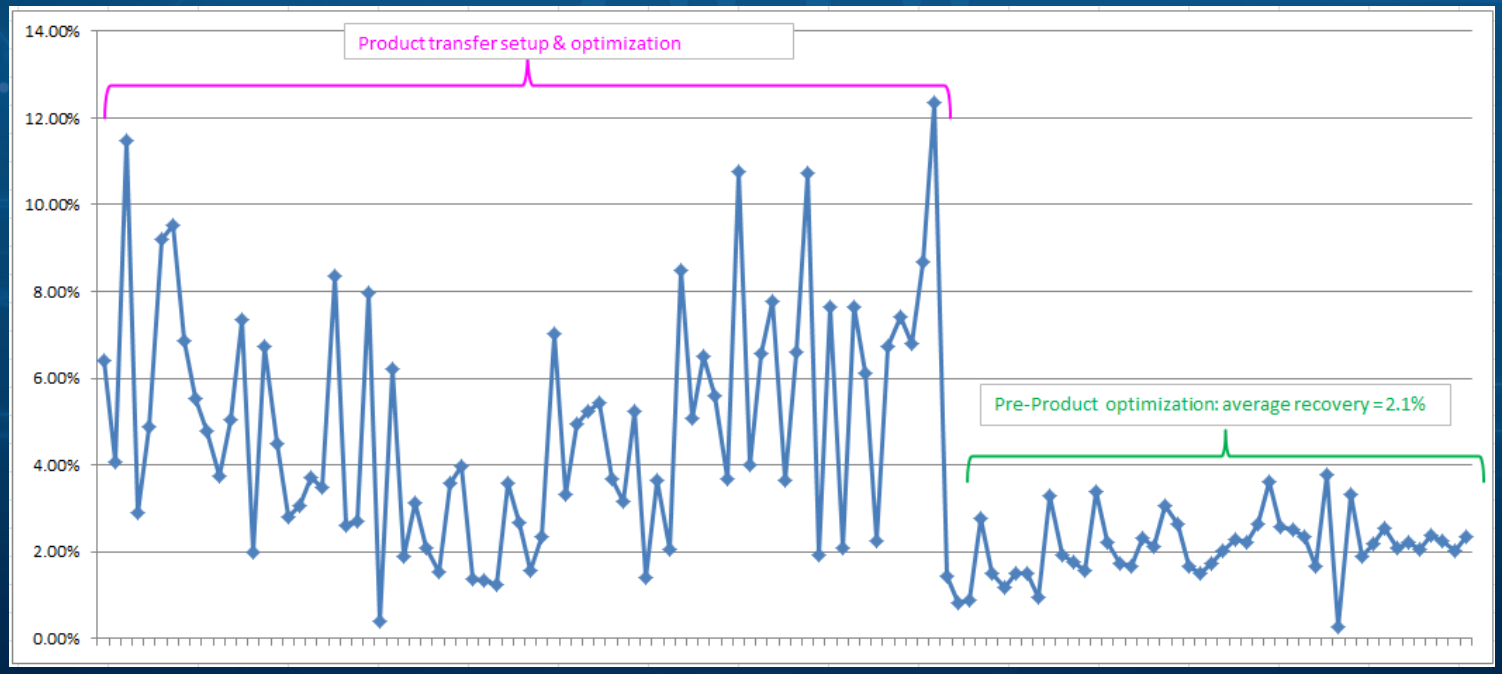
- **Contact bins Recovery Rate**
  - Contact bins recovery (vs nb of testable dies) = negligible (<0.5%)



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**

Description	ST Objectives	TPEG™ MEMS T3 Results
Bump Damage	< 25% bump area	<20% (6 passes at max OD)
Contact –related Recovery	< 1 %	<1 %
Offline Interventions	Max 1/week	0/week
Prober setup stability	No changes over PC lifespan	Stable
Needles lifespan	> 1 Million TD	Est: 3X actual non MEMS solution

TP's solution for Bumps Probing

Introduction

	2010 -2012	2013	2014	2014-2015+
Technology Request to TP	Probing on Eutectic bumps at pitch ≥ 130µm	Probing on Cu pillar bumps at 80µm pitch	Probing on Cu pillar bumps at 80µm pitch	Probing on µ-Cu pillar bumps (20µm diameter)
Key requirements	Reliability and lifetime	Reduced bump mark and path Resistance	Industrialization and further scalability	Proof of concept and roadmap readiness

Technoprobe developed new TPEG™ MEMS needle technology and process manufacturing

TPEG™ MEMS technology evolved and customized to scaling down requests

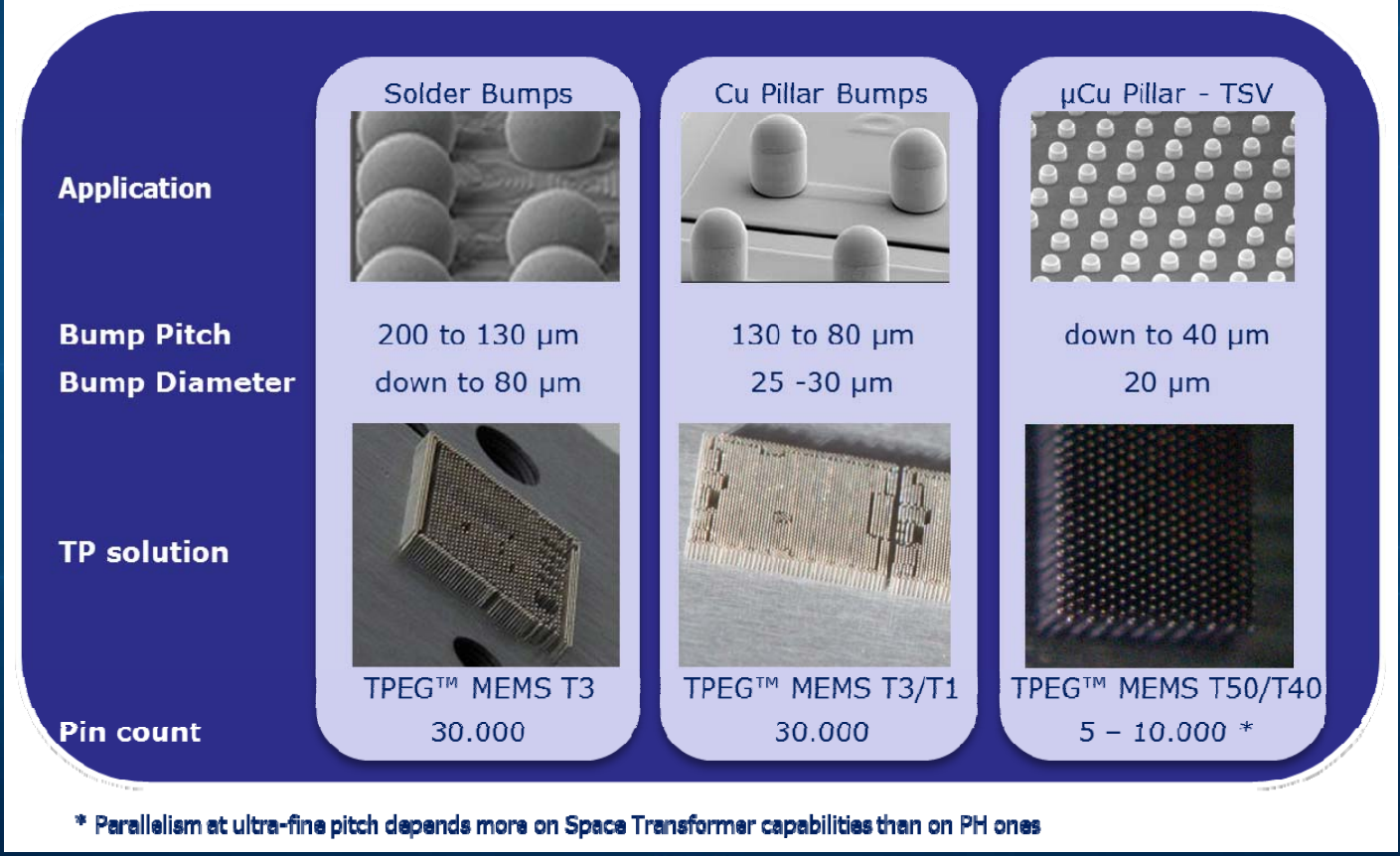
TPEG™ MEMS technology delivered in volume.

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

TP's solution for Bumps Probing

Probing solutions

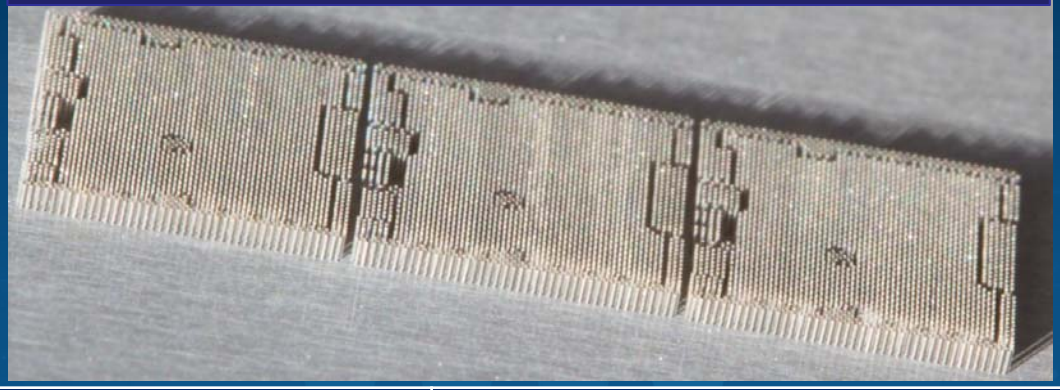
- **Different needle solutions have been developed and are now in mass production depending on pitch and bumps diameter**



Needles for Bumps/Cu pillar bumps

TPEG™ MEMS T3: the winning solution for Flip Chips

Probe Head with 6000+ needles, min pitch 130 µm



PARAMETER	TPEG™ MEMS T3
Needle diameter	2 mils equivalent
Max pin count	> 20.000 pins
X, Y alignment accuracy and Z planarity	X,Y: ± 10 µm; Z plan: Δ 20 µm
Min pitch and configuration	90 µm Full Array
Pin Current (CCC)	600 mA (1200 mA special alloy)
Force (at 3 mils OT)	4.5 g

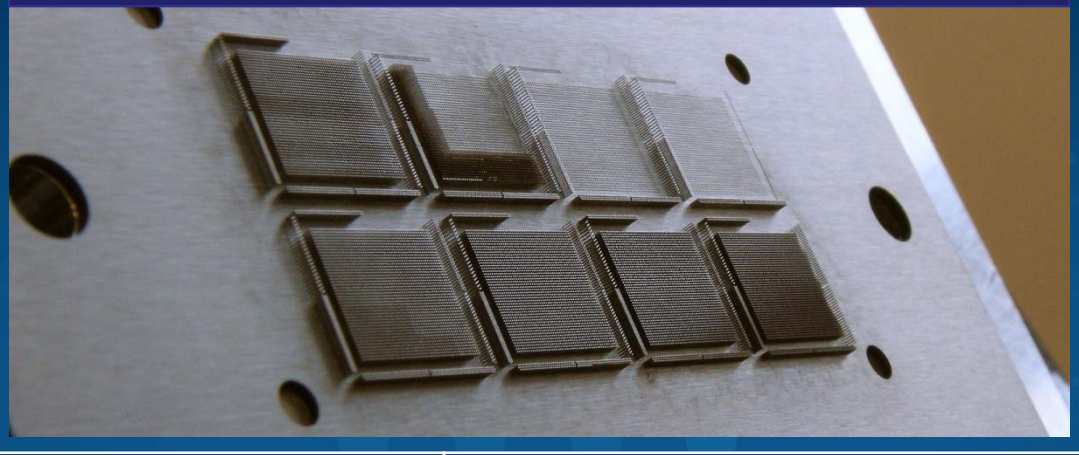
Technoprobe probing solution for µ-Cu pillar bumps

- **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

Probe Head with 25.000+ needles, min pitch 80 µm



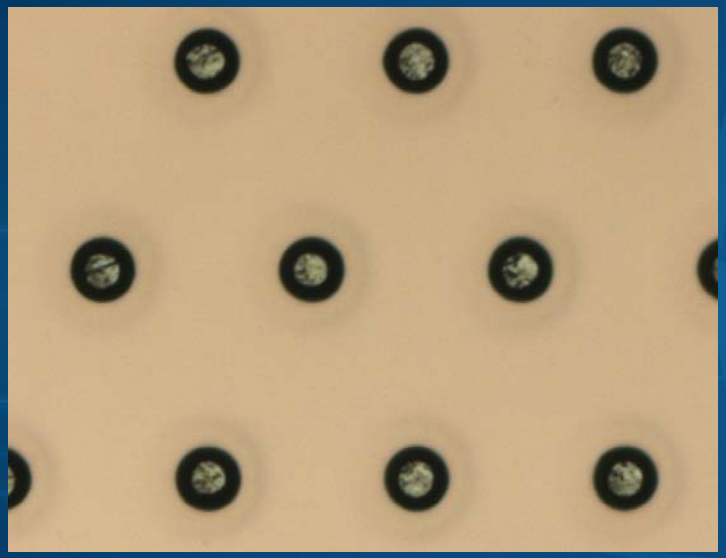
PARAMETER	TPEG™ MEMS T1 Flat
Needle body diameter	1,5 mils equivalent
Max pin count	> 20.000 pins
X, Y alignment accuracy	X,Y: ± 6 µm
Z planarity	Δ 20 µm
Pin Current (CCC)	800 mA (special alloy)
Force (at 3 mils OT)	2 g

TPEG™ MEMS T1 FLAT TECHNOLOGY

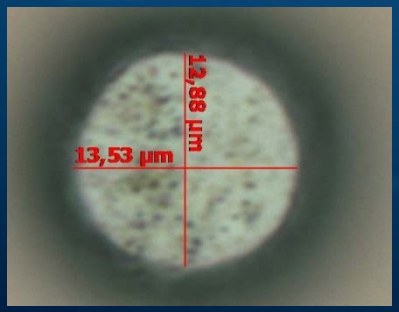
Characterization data – Probe Mark Analysis

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

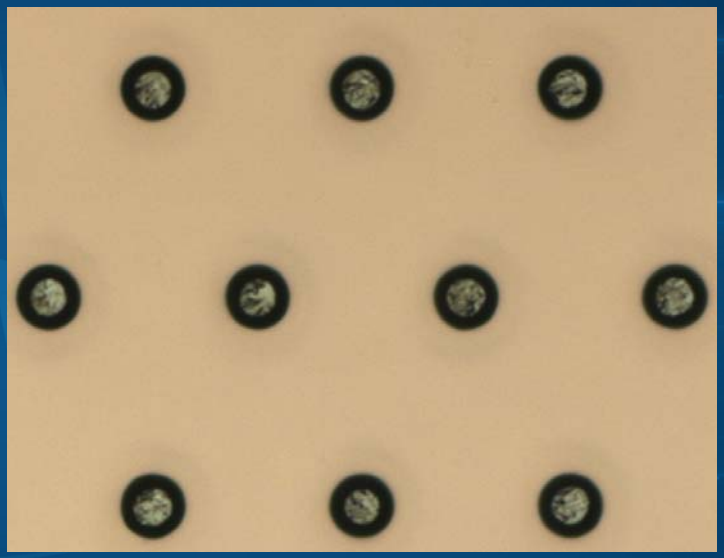
- **50 µm OT**



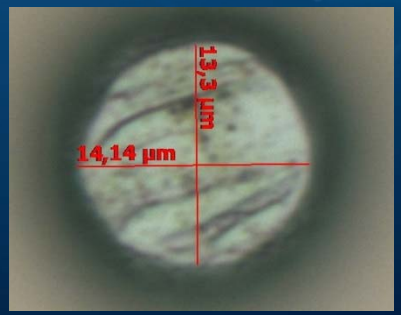
- **PM area ~ 28% of bump area**



- **75 µm OT**

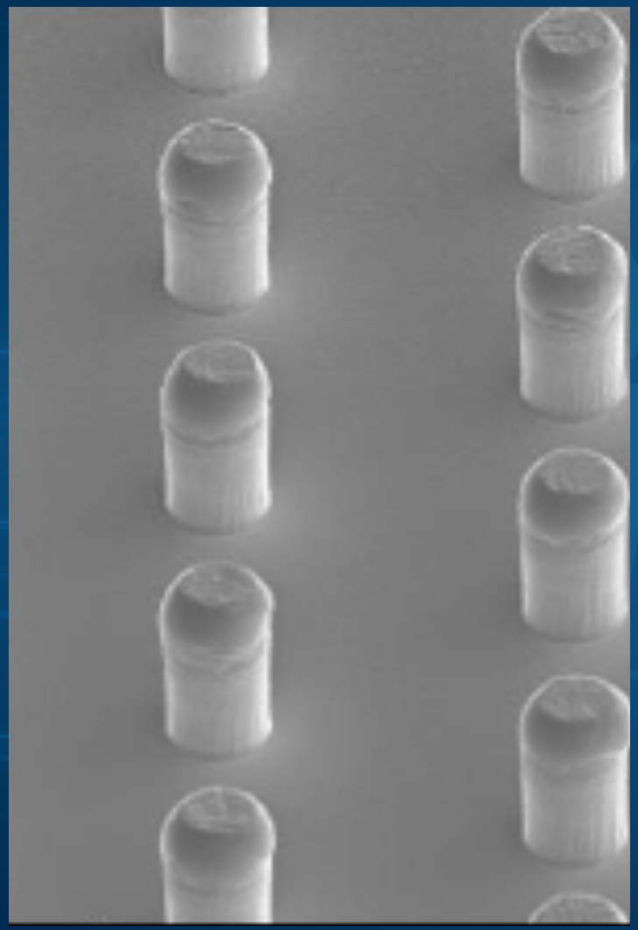


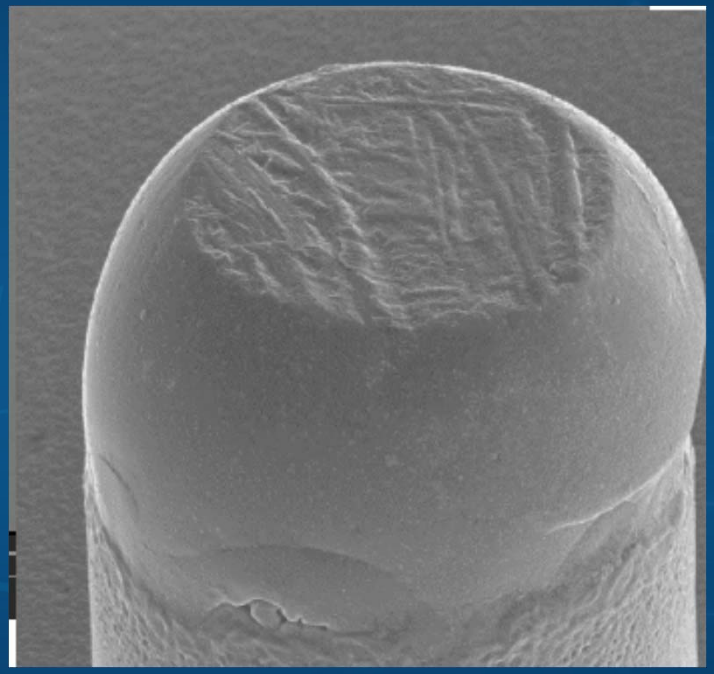
- **PM area ~ 30% of bump area**



TPEG™ MEMS T1 FLAT TECHNOLOGY

Customer Data – Probe Mark Analysis



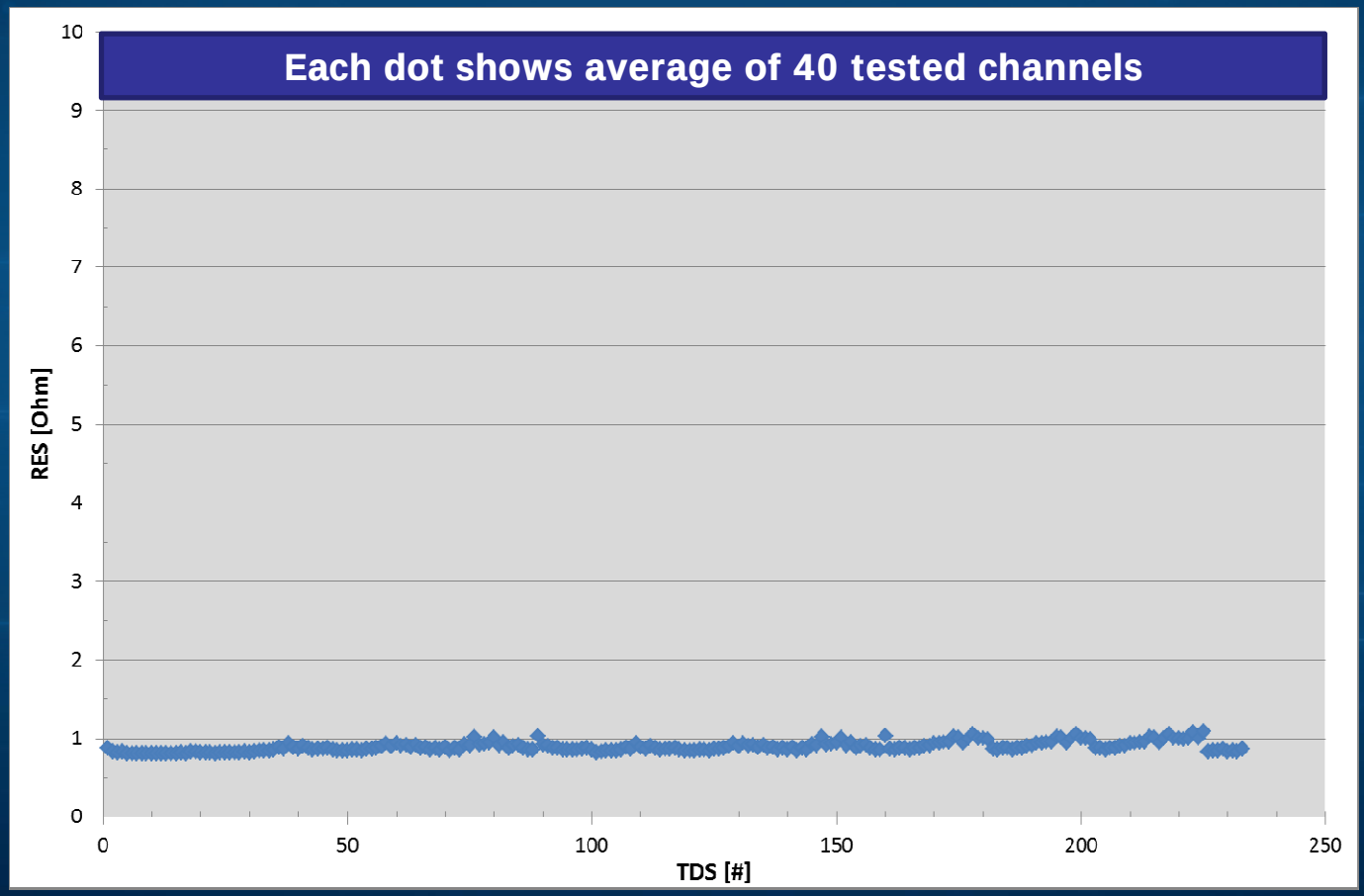


Probe Mark well within customer spec
(test done on 25 µm Cu-pillar diameter; pitch is 80 µm Full Array)

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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