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Probing of bump wafers : TPEG™ MEMS T3 versus Cobra-like probe technology

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Outline

- Background
- Need of a breakthrough in needle technology: TPEG™ MEMS T3
- Performance comparison between TPEG™ MEMS T3 needles and Cobra-like needles on a high volume flip-chip product
- A quantification of the benefits delivered through the new solution
- Conclusions

Background

- Production worthiness of Probe Cards dedicated to test high volume flip-chip applications on bump wafers is impacted when using standard Cobra-like technology
- Low yield at first pass and high retest rate experienced
- Test cells uptime reduced by frequent off-line interventions
- As a result, the equipment efficiency and production output are affected, with an increase of the Overall Cost of Test

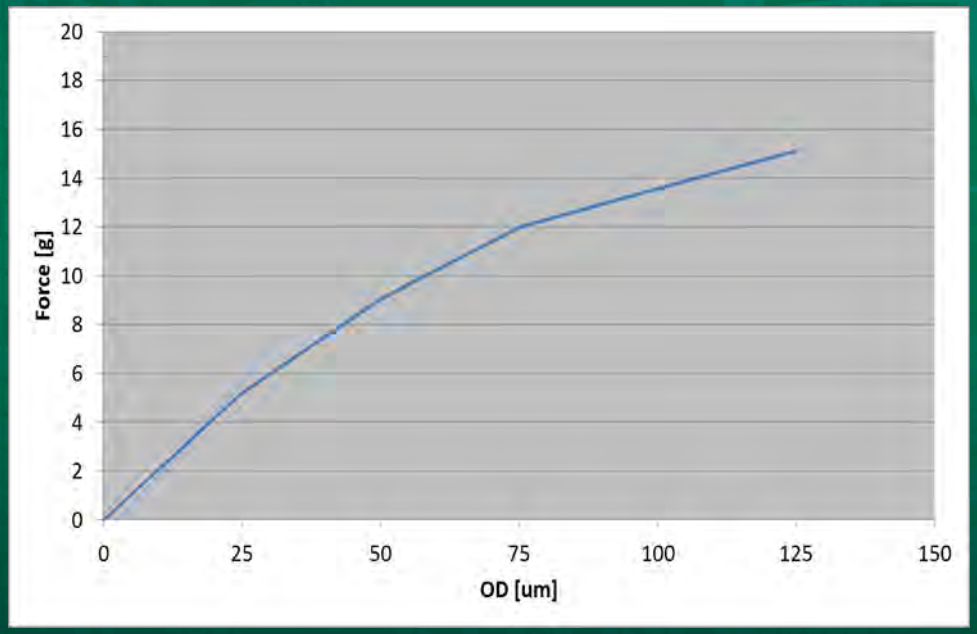
- A new technology capable of superseding Cobra-like one and its inherent limitations and of ensuring scalability to next generation requirements was introduced by Technoprobe and qualified/adopted by ST

Cobra-like needle technology: limited production worthiness (1)

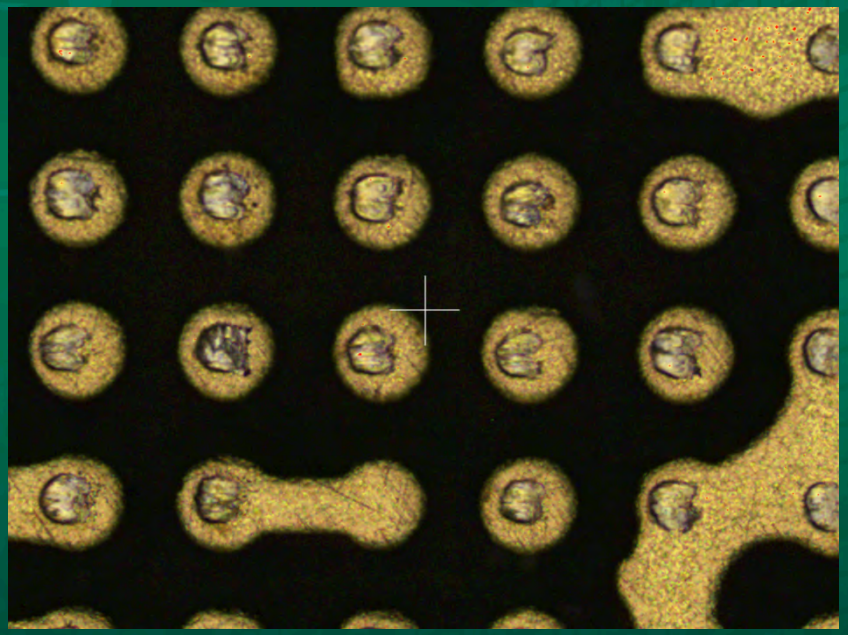
- **ST's experience accumulated during the last years of probing on high volume flip-chip products with Cobra-like needle technology demonstrates a not sustainable overall cost of test**
- **This is mainly due to the inherent Cobra-like features, such as:**
  - High needle force
  - Force increasing with testing overdrive
  - Limited lifespan
  - Floating
- **As a consequence, the massive usage of Cobra-like probe cards in production impacted seriously the test cell uptime and wafer yield**
  - A solid solution was not found, despite several containment actions put in place, like optimization of Online cleaning parameters and frequent Offline interventions

Cobra-like needle technology limited production worthiness (2)

Force – OD plot



IP pads after 100K TDs

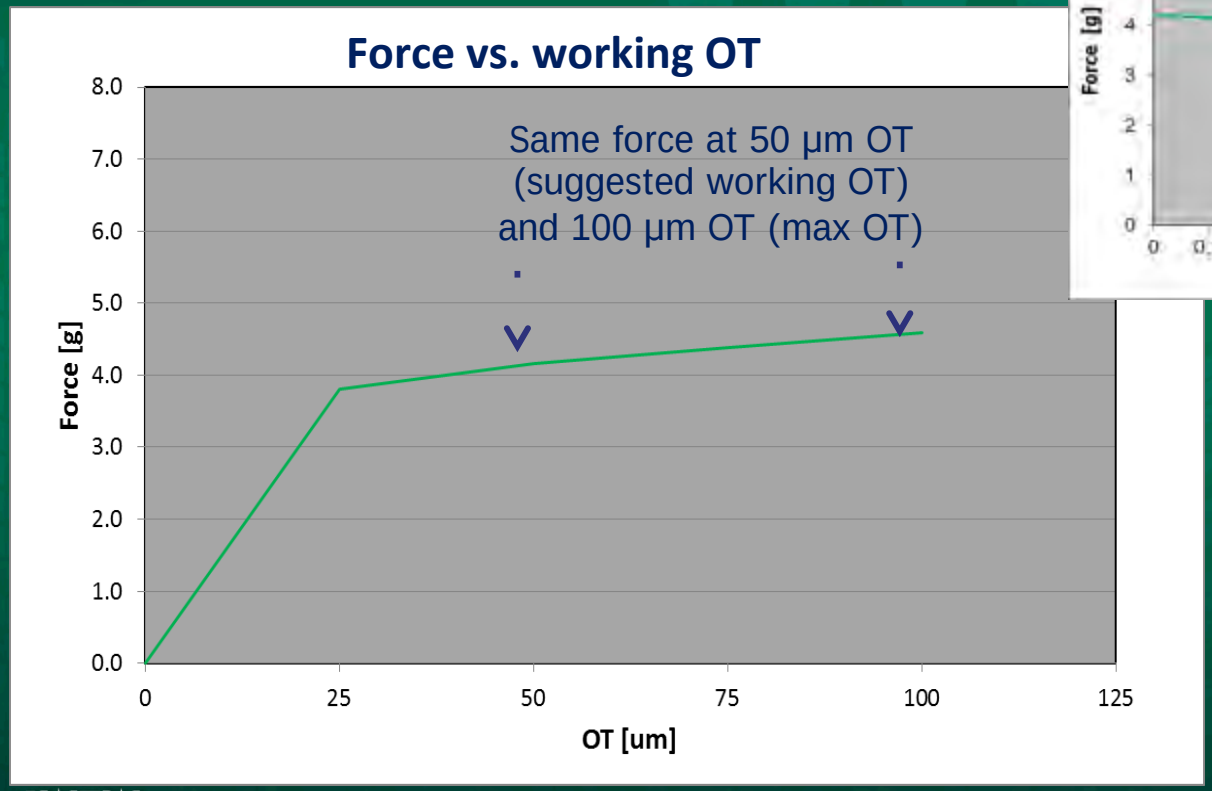


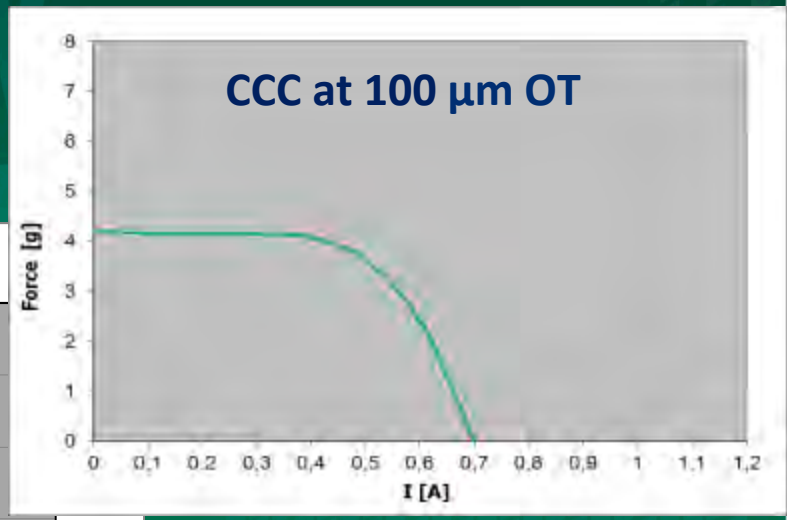
What drove Technoprobe to the new needle technology

- **We needed to provide ST with a needle technology capable of:**
  - Reduction of open and contact related functional failures to improve test cell uptime and wafer yield :
    - Reduction of Tester Stop Alarms
    - Reduction of Offline retest
    - Less or no Offline cleaning needed
    - Stable probing setup
  - Increase of Probe Head needles lifespan
  - Minimum damage of the Interposer pads to increase the overall probe card lifespan and to ensure performance stability over time
- **The issue/opportunity paradigm gave us the boost to conceive a technological breakthrough, not only capable of solving the issues faced but also to guarantee scalability to the next generation requirements: TPEG™ MEMS T3**

Technoprobe TPEG™ MEMS T3

Force and CCC characteristics





Force = 4.5 g +/- 20%

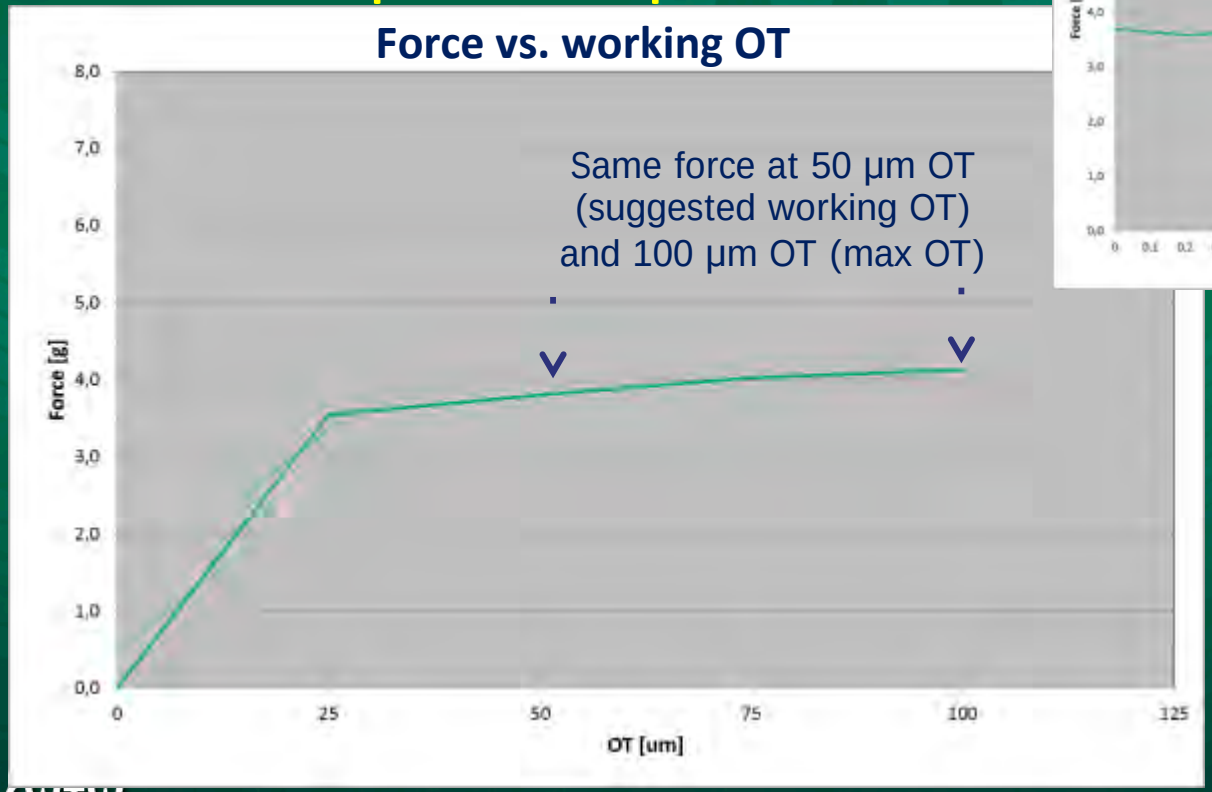
CCC = 600 mA

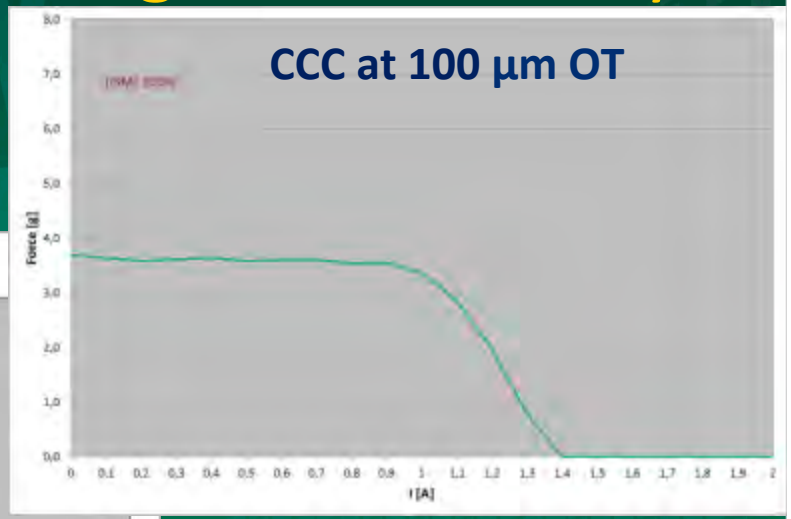
Technoprobe TPEG™ MEMS T3

Force and CCC characteristics – high current alloy

Suited for applications with a requirement

of max current per needle up to 1200 mA





Force = 4.0 g +/- 20%

CCC = 1200 mA

Proving and Comparing the performances…

- **The promise to overcome all the issues faced was then only on paper**
- **ST needed to touch with their hands the value added of TPEG™ MEMS T3 technology w.r.t. Cobra-like one**
- **A complete qualification of the technology and a thorough performance comparison was therefore decided**
  - A top runner flip-chip product was selected by ST
  - New technology's mechanical and electrical qualification was performed on a pilot line in Europe
  - A benchmark between TPEG™ MEMS T3 needles and Cobra-like needles was performed in a high volume manufacturing environment, gathering production data on a 3 quarters base

Specifications comparison

- **TPEG™ MEMS T3 is representing a breakthrough in terms of minimum pitch and reduced force**

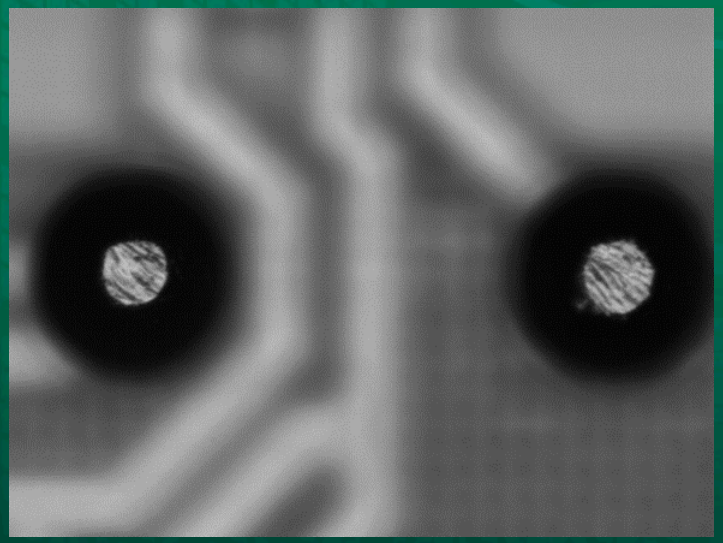
PARAMETER	Cobra-like	TPEG™ MEMS T3
Needle diameter	3.5 mils (89 µm)	2.0 mils equivalent
Max pin count	Limited by prober chuck rigidity	> 20.000 pins
Min pitch full array	150 µm	80 µm
X, Y alignment accuracy	± 25 µm	± 10 µm
Z planarity	Δ 40 µm	Δ 20 µm
Z floating	100+ µm	~ 0 µm
Force (at 3 mils OD)	13 – 15 g	4.5 g

Probe marks

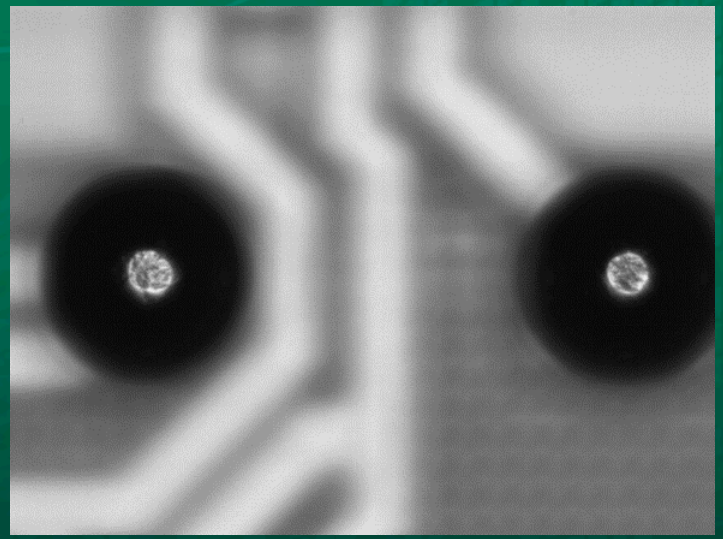
Probe marks on bumps

- **55% reduction of probe mark area**

Cobra-like
1TD @ 75 µm OT



TPEG™ MEMS T3
1TD @ 75 µm OT

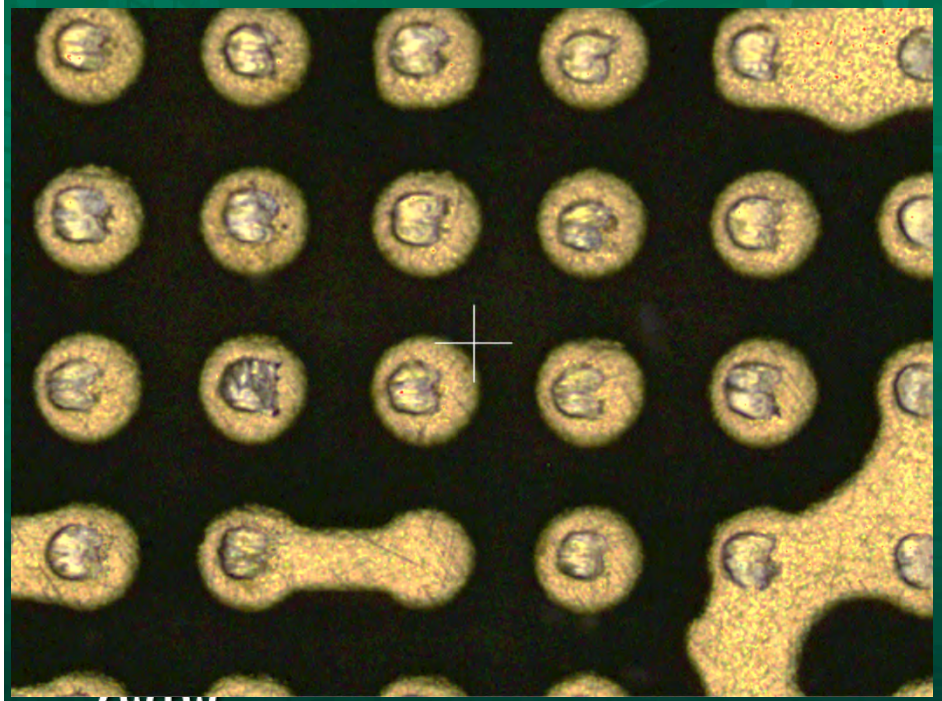


Probe marks

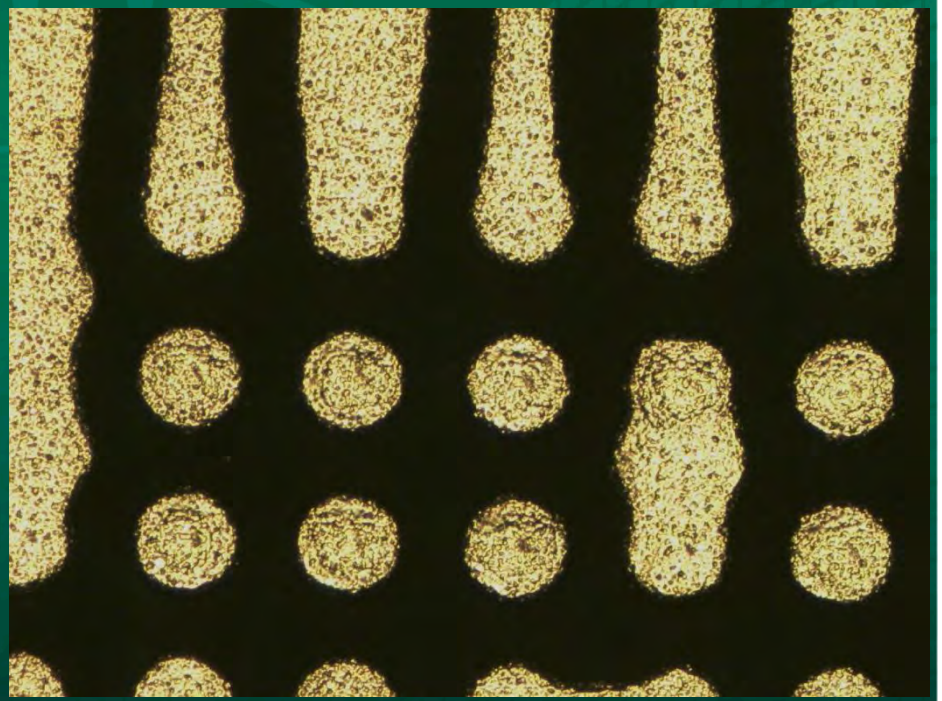
Probe marks on interposer pads

- **Quite invisible probe marks on hard-gold interposer pads even after 1.0 MTDs**

Cobra-like after 0.1 MTDs

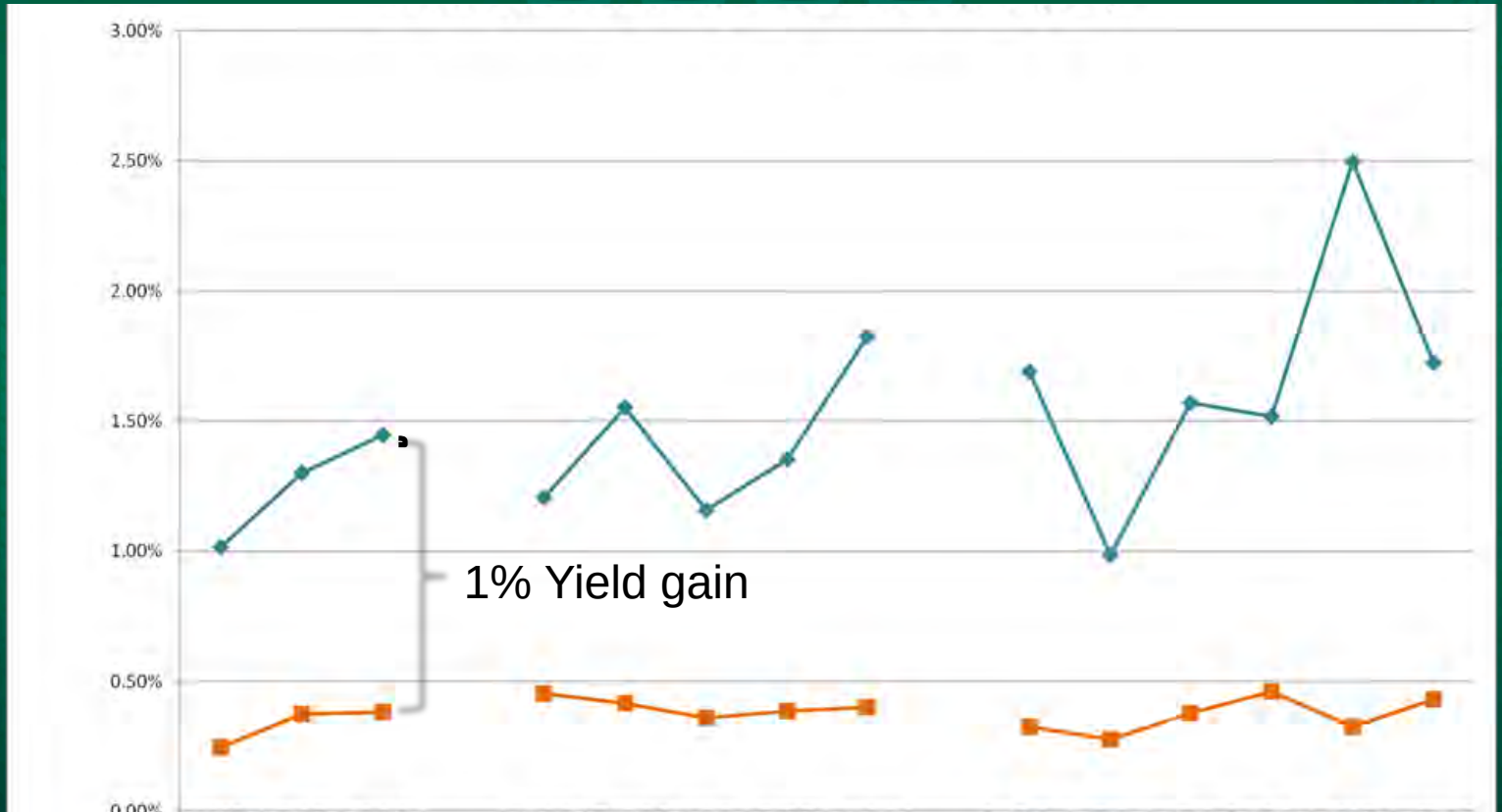


TPEG™ MEMS T3 after 1.0 MTDs



Contact-related Failures

- **About 1% Yield Gain improvement from contact-related failures with TPEG™ MEMS T3 needle over Cobra-like needles**



	Q3'12	Q4'12	Q1'13		Nov'12	Dec'12	Jan'13	Feb'13	Mar'13		8'13	9'13	10'13	11'13	12'13	13'13
Cobra-like	1.02%	1.30%	1.45%		1.21%	1.55%	1.16%	1.35%	1.83%		1.69%	0.98%	1.57%	1.52%	2.50%	1.72%
T3MEMS	0.25%	0.37%	0.38%		0.45%	0.42%	0.36%	0.38%	0.40%		0.33%	0.28%	0.38%	0.46%	0.33%	0.43%

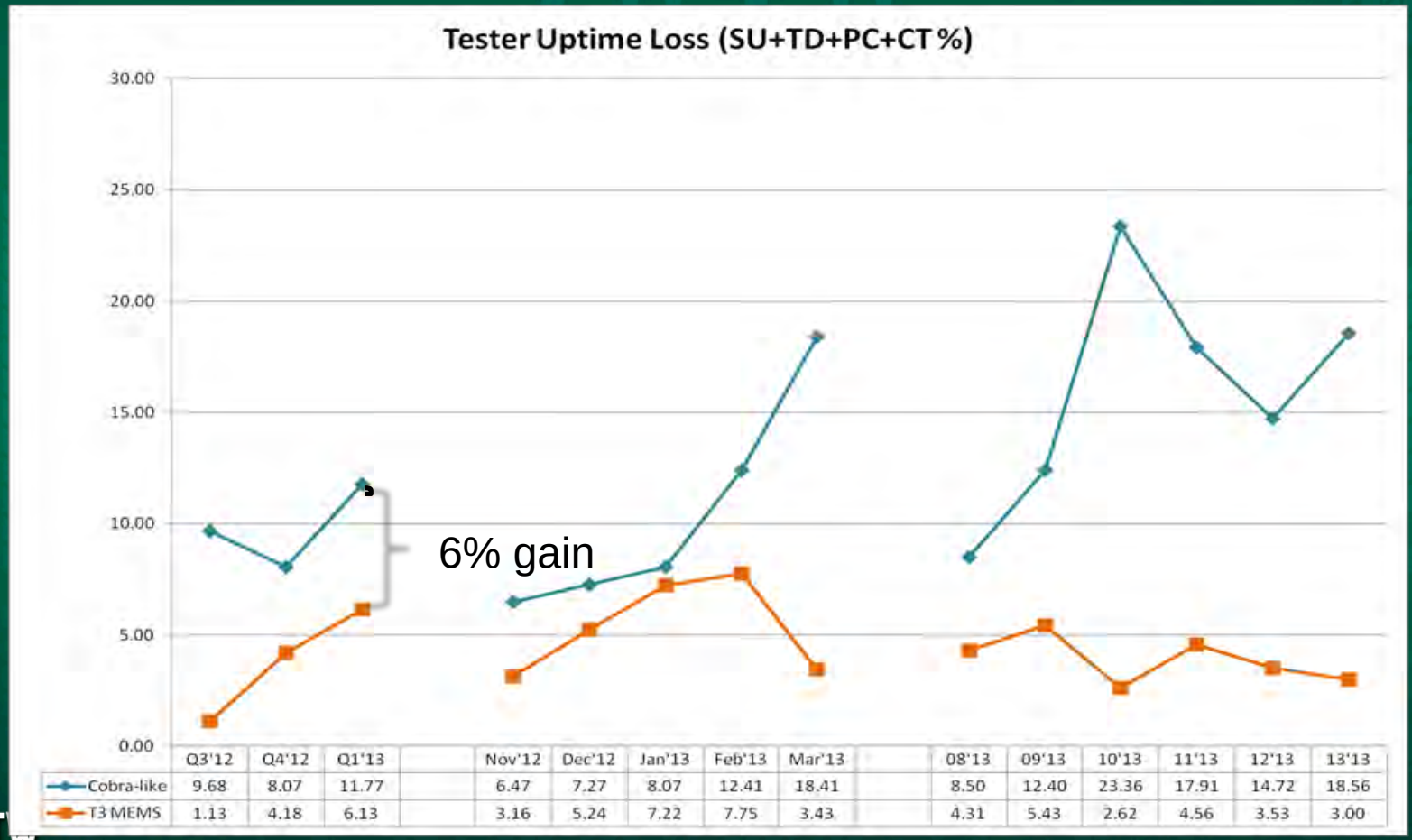
Offline retest %

- **TPEG™ MEMS T3 offline Retest at 1% versus Cobra-like needles at about 15%.**

	Q3'12	Q4'12	Q1'13		Nov'12	Dec'12	Jan'13	Feb'13	Mar'13		8'13	9'13	10'13	11'13	12'13	13'13
Cobra-like	8.23%	15.16%	15.85%		14.50%	21.48%	20.01%	9.97%	21.01%		11.96%	6.66%	26.97%	24.80%	12.59%	22.67%
T3MEMS	6.37%	1.06%	0.97%		0.66%	0.93%	0.93%	1.73%	0.69%		3.23%	0.00%	0.44%	1.02%	0.62%	0.65%

Tester uptime loss

- **TPEG™ MEMS T3 average tester uptime sees a 6% increase**



	Q3'12	Q4'12	Q1'13		Nov'12	Dec'12	Jan'13	Feb'13	Mar'13		08'13	09'13	10'13	11'13	12'13	13'13
Cobra-like	9.68	8.07	11.77		6.47	7.27	8.07	12.41	18.41		8.50	12.40	23.36	17.91	14.72	18.56
T3 MEMS	1.13	4.18	6.13		3.16	5.24	7.22	7.75	3.43		4.31	5.43	2.62	4.56	3.53	3.00

Performance comparison summary

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

Description	ST Objectives	Cobra-like	TPEG™ MEMS T3
Tester uptime	> 85 %	83 %	89 %
Offline Retest	< 3 %	15 %	1 %
Offline Interventions	Max 1/week	7/week	0/week
Prober setup stability	No changes over PC lifespan	Unstable	Stable
Contact-Related Failures	< 0.5 %	1.27 %	0.38 %
Needles lifespan	> 1 Million TD	1 Million TD	2 Million TD
Damage to Interposer Pads	Minimum	Pads are damaged	No damage observed
Interposer lifespan	>1.5 Million TD	1 Million TD	Est. > 4 Million TD

Field-proven benefits

- **The promise at the end was fulfilled and a lot of benefits were brought to ST along the course of this experience**

Adoption of TPEG™ MEMS T3 Probe Cards in production allows to gain **8.1% additional revenues per year**

- 7.2 % additional revenues from the Tester Uptime improved by 6%
- 0.9 % additional revenues from electrical wafer yield gain

Adoption of TPEG™ MEMS T3 Probe Cards in production allows to save **60% in probe cards repairing costs**

- Needle lifespan 2 times higher than Cobra-like
- Interposer lifespan 4 times higher than with Cobra-like case

Summary and Conclusions

- **Severe limitations on equipment efficiency and throughput were experienced by ST when using Cobra-like Probe Cards to probe on flip-chip bumps wafers**
- **Technoprobe introduced a new needle technology to overcome all those limitations (TPEG™ MEMS T3)**
- **The new Probe Cards proved to be a production worthy solution and to deliver a value added if compared to previous needle technology**
  - Target parameters set fully met
  - Production output, uptime, performance stability and lifespan expectations exceeded
  - Additional revenues generated
- **Probe Cards' CoO and the overall Cost of Testing dramatically reduced paving the way for advanced testing of flip-chip application on bump and Cu-pillar bump wafers**

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Thank you!

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