



Spring Probe WLCSP Probe Head CCC – ISMI Characterization Is Not Enough

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Abstract:

A recognized standard for evaluating the CCC (current carrying capacity) of an interconnect used at wafer probe has been the ISMI Probe Council Current Carrying Capability Measurement Guideline, published by International SEMATECH Manufacturing Initiative in 2009. The ISMI test is a relatively simple way to observe the interconnect force degradation as a function of current applied. The guideline evaluates at what point the contact sees a 20% force reduction. This 20% force reduction, means that the contact has been permanently deformed, and this is therefore a truly destructive test.

The ISMI guideline has been used to measure the CCC of spring probes for several years, and it does provide a value that can be used to compare one technology to another. The resulting value, however, does not describe the CCC for the actual test application. It will be shown that in controlled laboratory experiments, probes run at or near the ISMI CCC values in simulated test environments prematurely fail by taking a permanent set. Data from several configurations and probe types will be shown that behave in this manner.

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Cohu

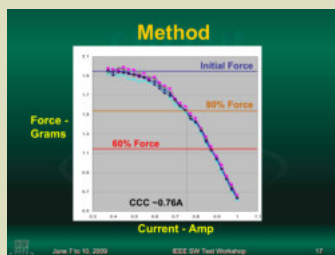


Presentation Agenda

- ISMI CCC Test Overview
- BiTS/SWTW Background Data
- ISMI Data of a 200 μm Pitch Spring Probe
- ISMI Result Put To The Test – High Current Cycling
- Determination of the ISMI de-rating value
- Validation of the proposal based on a different spring probe



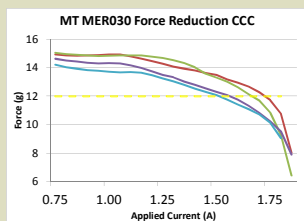
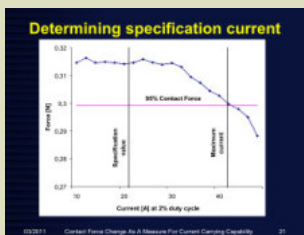
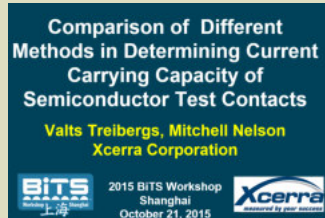
ISMI* Test Overview



- From the MFGM042M project and presented at SWTW 2009 for wafer probe current carrying capacity (CCC)
- Failure defined as 20% force reduction
- DC current applied at nominal overdrive, then force is measured at room temp. after prescribed cool-down period
- Test is stopped when probe force reduction reaches 40%
- 30 probes are tested – selected randomly
- Is it useful for socket contacts – one piece or assembled probes?

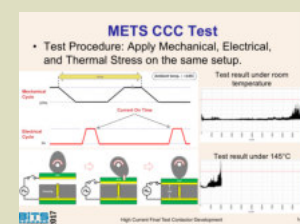
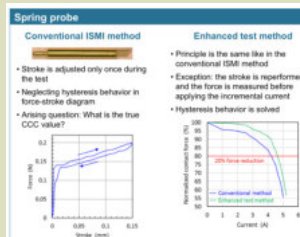
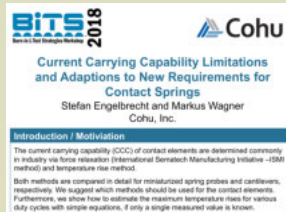
*International SEMATECH (Semiconductor Manufacturing Technology) Manufacturing Initiative

Additional Presentations of Note



- 2011 – Marcus Frey from Multitest – showed correlation for T-rise in large cantilever springs with force reduction
- 2015 – Valts Treibergs – Xcerra. ISMI tests on spring probes can be done, however the reported force reduction values and CCC results are highly variable

Additional Presentations of Note



- 2018 – Englebrecht – Cohu. Modified ISMI – stroke is reperformed and force measured before applying current – eliminating hysteresis
- 2017/20188 – Shwe, Ata (TI) and Sato (Yokowo). During ISMI test – also monitor Cres. Introduction to METS test at elevated temperature



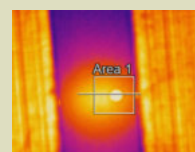
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ISMI CCC Test – Good Enough? No

- For spring probe CCC testing, the consensus is that a simple ISMI force reduction test is not good enough
- Other CCC measurement methods (IR camera and thermocouple) can be used but are difficult at fine WLCSP pitches
- The task is to find the proper derating value or find a better method!



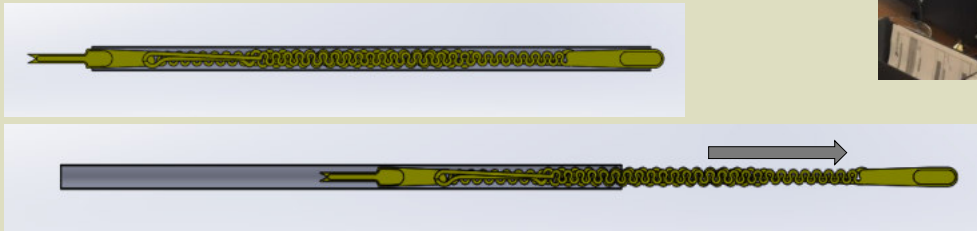
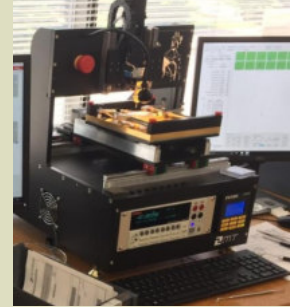
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Let's Start With ISMI

- 200 μm probe was chosen as a test vehicle – NEX020 based on a MEMS spring.
 - This pin was chosen because of extensive recent development work and it has a spring element that is easily removed from its barrel
- Fully automated FReD tester to run ISMI on 35 individual pins



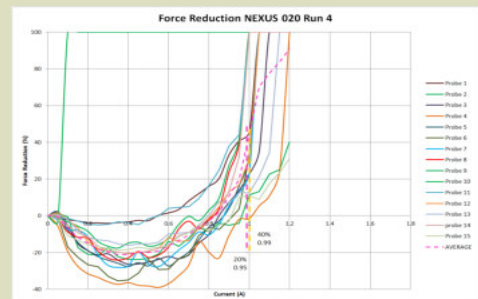
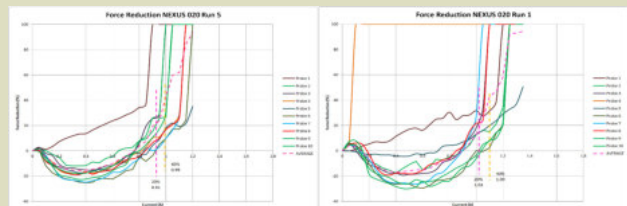
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Baseline ISMI CCC Results

- Based on 35 probes tested, 20% force reduction occurs at 960mA DC on average



Run	Probe Type	Fixture Type	Qty Probes	No. "Early" Failures	CCC 20% Force Reduction	CCC 40% Force Reduction
Nex 250	new	new	10	0	1.21	1.39
1	new	new	10	1	1.03	1.09
4	new	old	15	1	0.95	0.99
5	new	new	10	0	0.91	0.99
All 200 Runs			Count	200 Average	0.96	1.02
			35	200 Stdev	0.06	0.06



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Step 2 – High Power Electrical Cycling

- FReD tester was set up to cycle probes under the following test conditions:
 - 2 second dwell time (power on) per cycle
 - Record probe force and resistance to 10K cycles
 - Cycle test individual probes under various current loads: none, 400 mA, 600 mA, 860 mA, 1000 mA – approx. 100 hours continuous testing
 - Repeat 0, 725 mA, 1000 mA

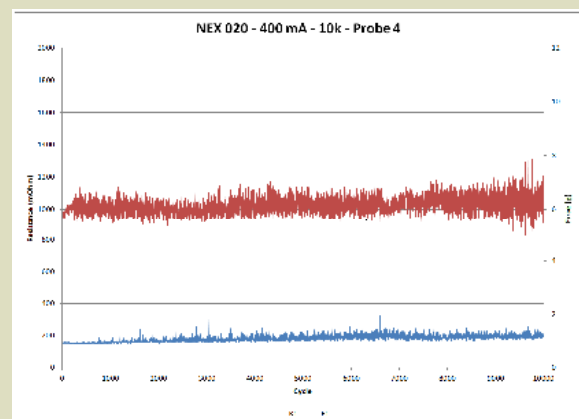
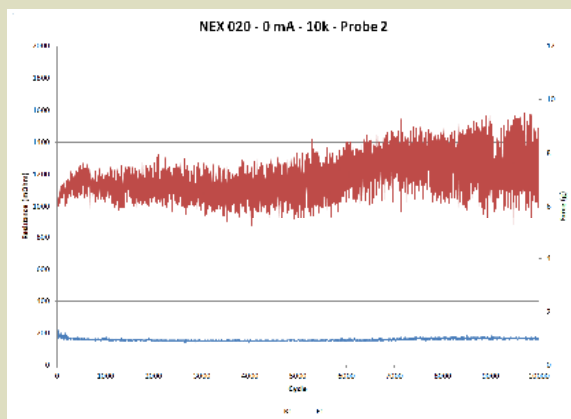


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High Power Electrical Cycling

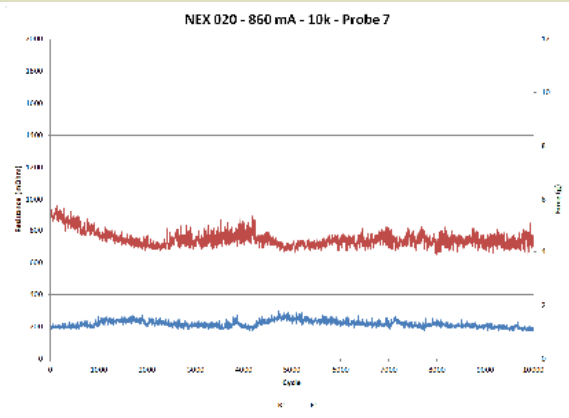
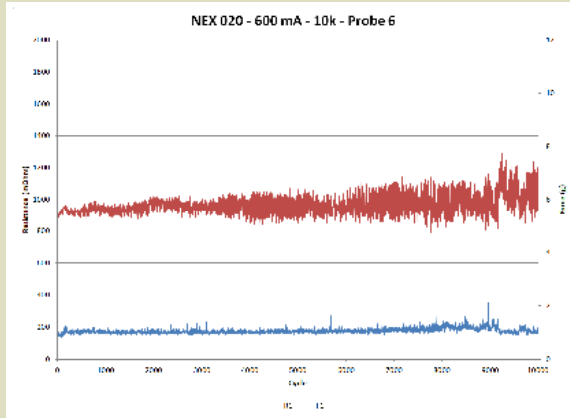


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High Power Electrical Cycling

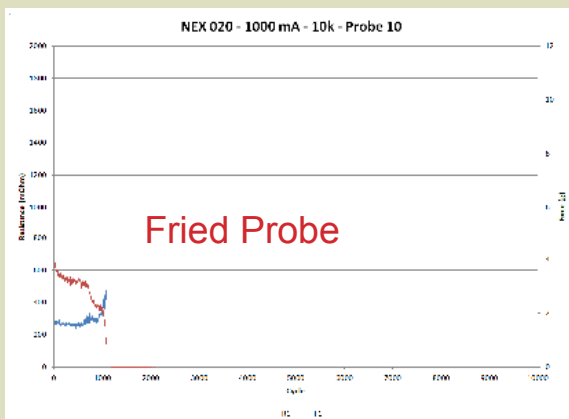
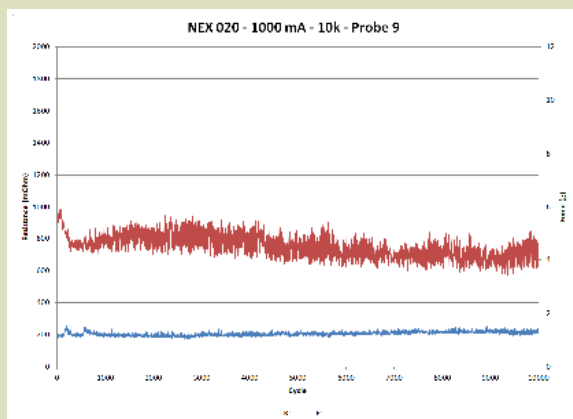


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High Power Electrical Cycling



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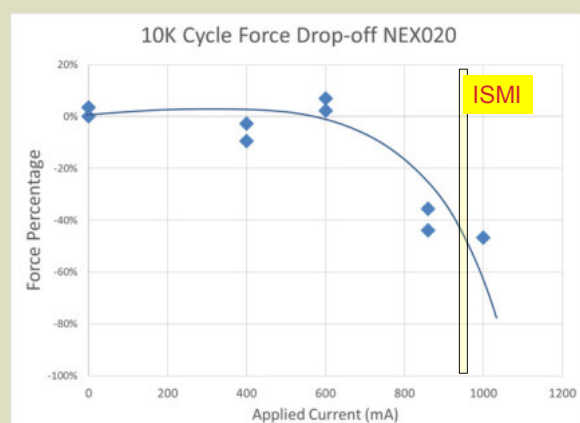
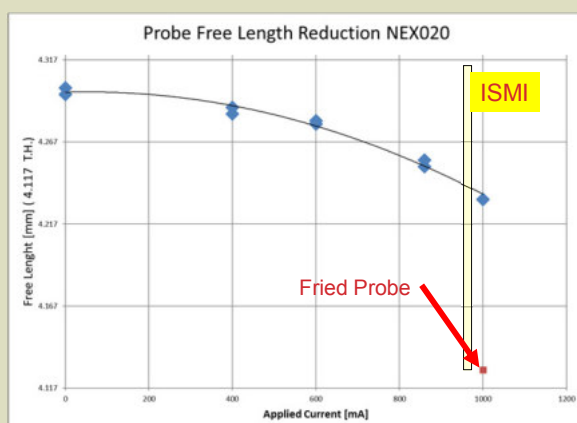


Results Summary

Probe	Current (mA)	F.L. (mm)	Final Force		Force Difference (final-start)
			Avg F (g)	F Std (g)	Percentage
1	10	4.300	7.747	0.701	0%
2	10	4.296	7.532	1.001	4%
3	400	4.284	7.478	0.737	-3%
4	400	4.288	6.230	0.490	-10%
5	600	4.278	7.059	0.947	7%
6	600	4.280	6.440	0.514	2%
7	860	4.252	4.535	0.187	-36%
8	860	4.256	4.155	0.167	-44%
9	1000	4.232	4.044	0.294	-47%
10	1000	4.128	0.027	0.001	-117%

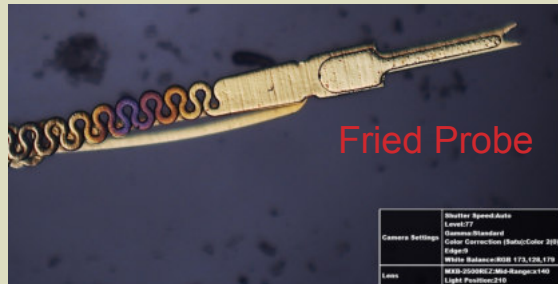
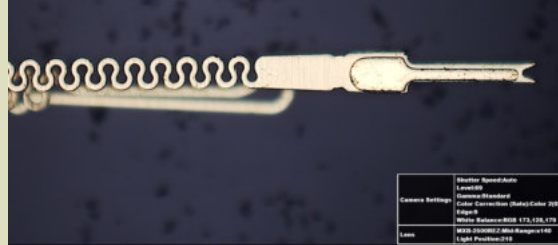
- ISMI predicted 20% force reduction did not correlate to probe CCC during cycling
- Rapid drop-off after 700 mA

Results Summary



Probe Visual Inspection After Cycling

- Probe spring elements removed from barrels
- Most probes showed no physical marks
- Only one fried probe showed internal spring discoloration



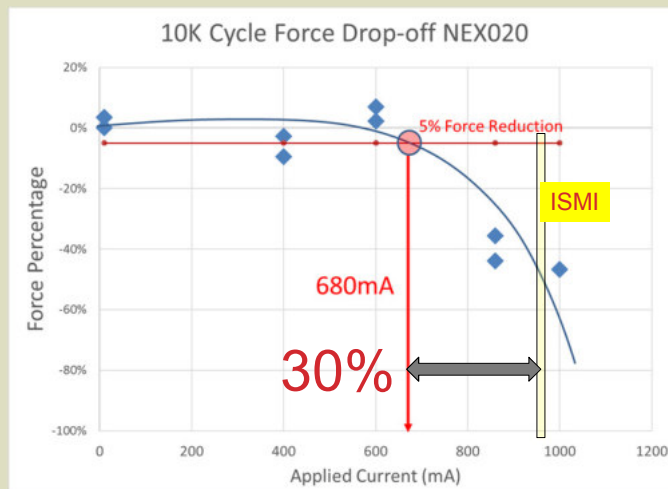
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Bounding the Limits

- $\pm 5\%$ force reduction
 - 680mA limit
 - ISMI: 960mA
- 29.2 % reduction
- Therefore propose ISMI derating percentage at 30%



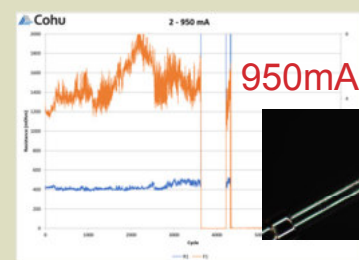
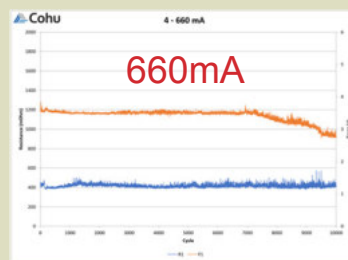
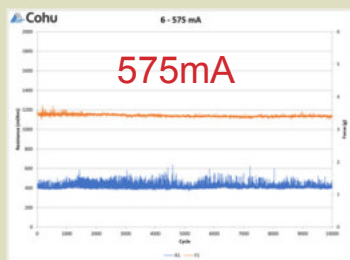
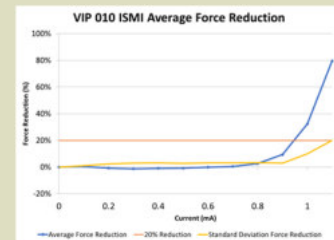
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Validation on Other Spring Pins

- The 30% derating was then applied to another spring pin: cViper 010
- ISMI 20% force reduction @ 950 mA
- 30% derating = 660 mA



Wrap-Up

- It has clearly been shown that a straight ISMI CCC value based on 20% force reduction is not adequate for CCC specification for spring probes
- If a 30% derated current value from tested ISMI is specified, then the results are more believable
 - More validation required to refine this value for all probe types and technologies
- ISMI will then still remain a useful test to compare technologies side-by-side in the lab and on paper only

Wrap-Up

- Advance qualification testing, such as the METS Test as used and proposed by TI appears to be the best tool to predict the lifetime of spring pin contact interfaces
- Further industry cooperation and standardization on this method is warranted, although every interface has unique requirements, thus needs to be applied properly