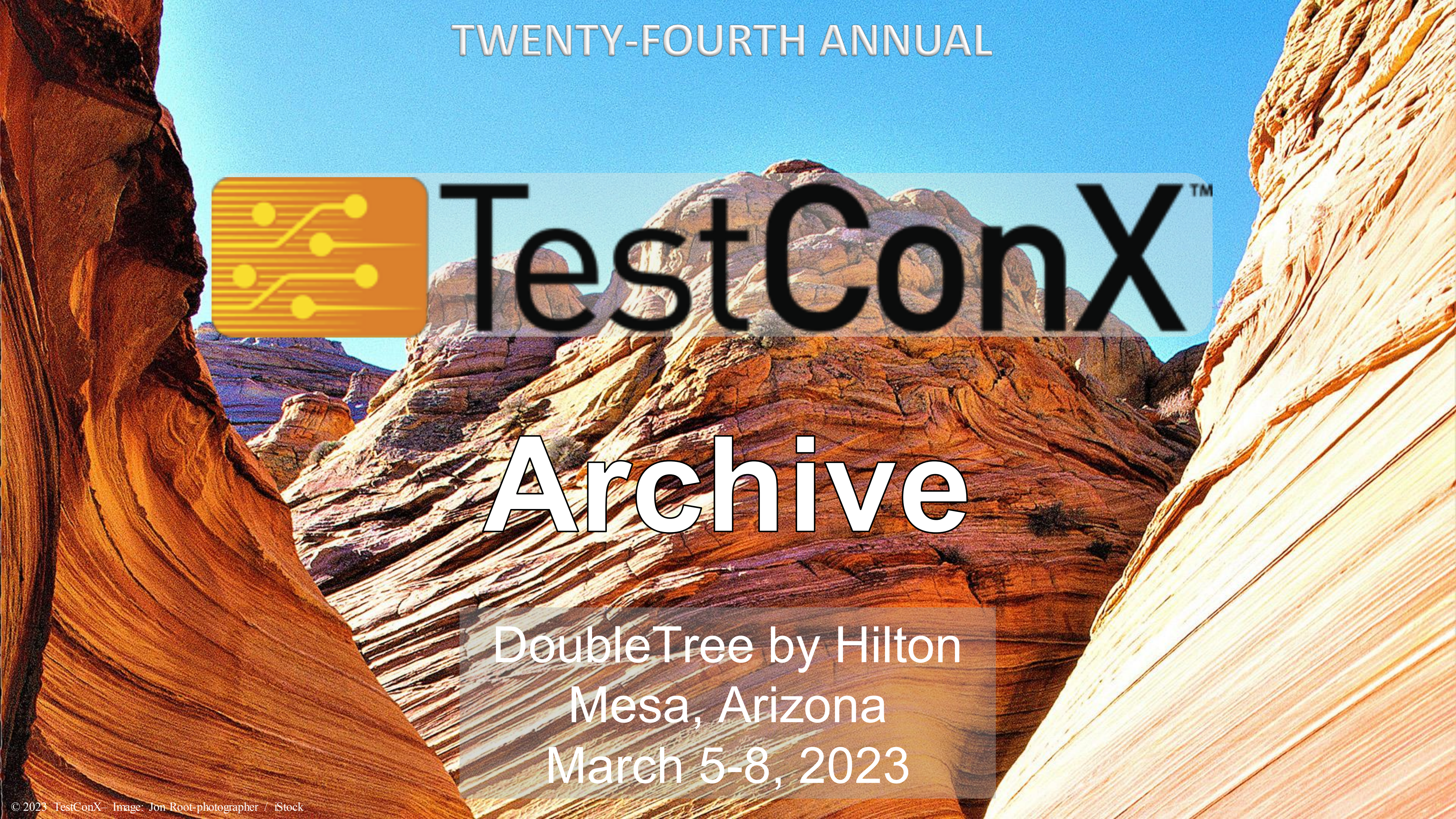

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IC Chip Testing in Liquid-in-Socket

Jiachun Zhou (Frank), Annie Mu, Cleveland Chen, & Jeff McCallion
Smiths Interconnect

Tom Gong
Nvidia

TestConX™

Mesa, Arizona ● March 5-8, 2023

smiths interconnect

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- Socket Performance
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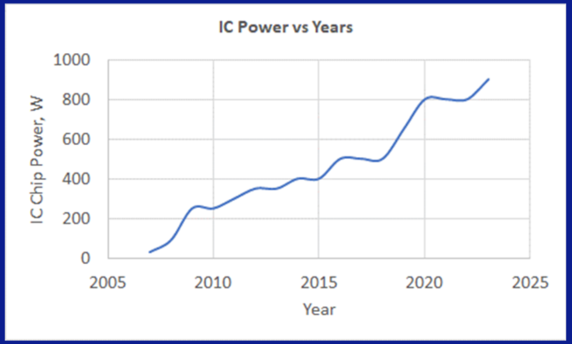
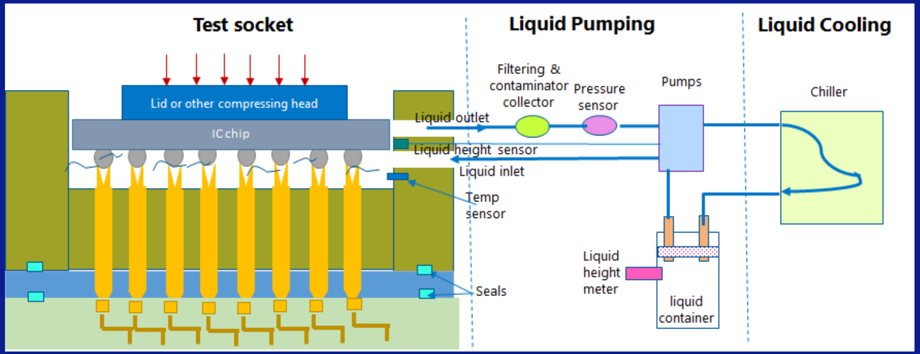
Background

- Higher power & heat dissipation requirements.
- High current going through test socket.
- Cooling technologies evolution, heat dissipation mainly through lid, from IC top side.
- Prompting a need for developing a new cooling technology for IC testing.



Design 1 & Fundamental

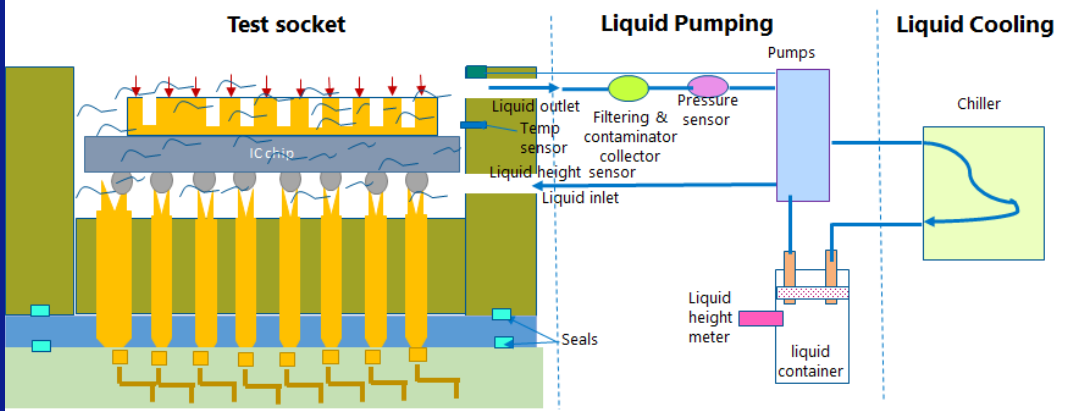
- A special electronic cooling liquid is pumped through pocket of socket and contact interfaces the bottom side of the IC package (including solder balls or pads), spring probe or other contacts, deemed as the Liquid-in-Socket.
- Liquid absorbs and releases heat generated from spring probe or any other contact array.
- Heat transfer through conduction and convection of liquid.
- Liquid stream is cooled by flowing through a chiller.



Patent pending

Design 2 & Fundamental

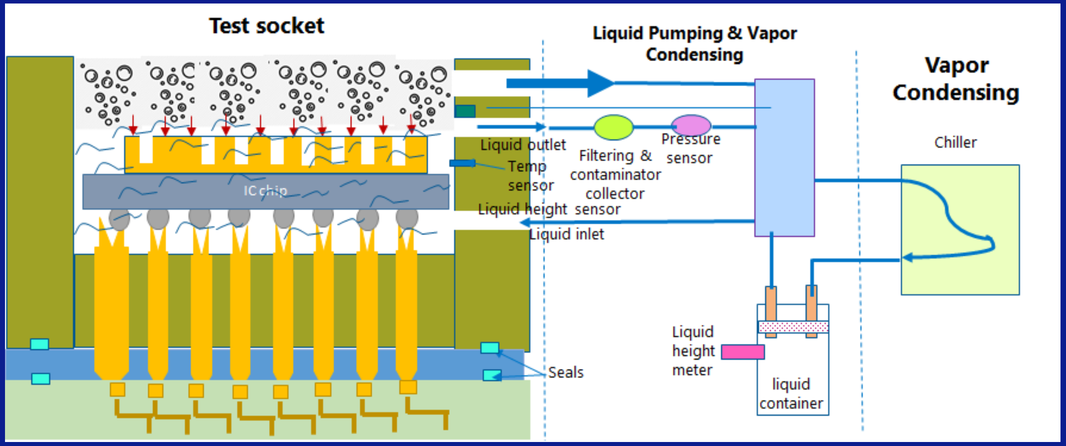
- The special liquid goes through pocket of socket and across the entire IC package (fully submerged).
- Liquid absorbs and releases heat generated from spring probe or any other contact array, including from the IC package.
- Heat transfer mainly by conduction and convection of liquid.
- Liquid stream is cooled by flowing through a chiller



Patent pending

Design 3 & Fundamental

- The special liquid goes through pocket of socket and across the entire IC package (fully submerged).
- Liquid absorbs and releases heat generated from spring probe or any other contact array, including from the IC package.
- Heat transfer through conduction, convection, vaporization of the liquid.
- Liquid & vapor steam are condensed and cooled by flowing through a chiller.

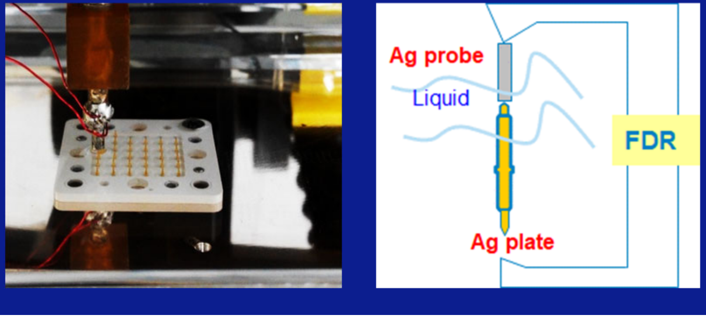


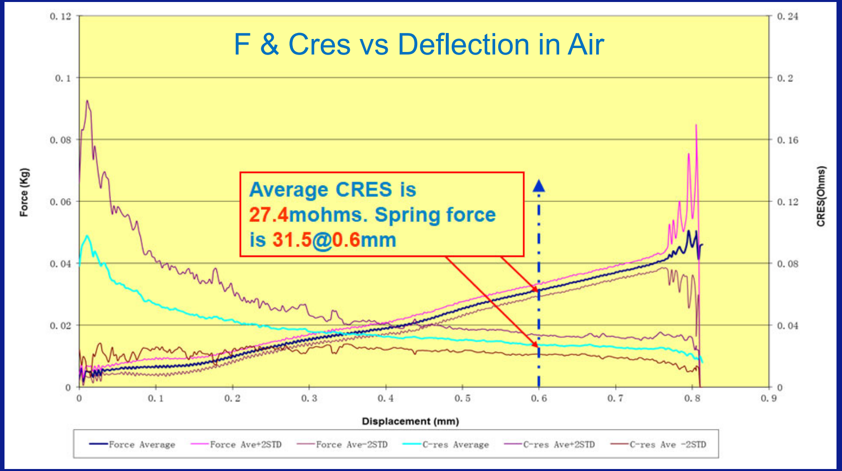
Patent pending

Performance – Force/Cres vs Deflection

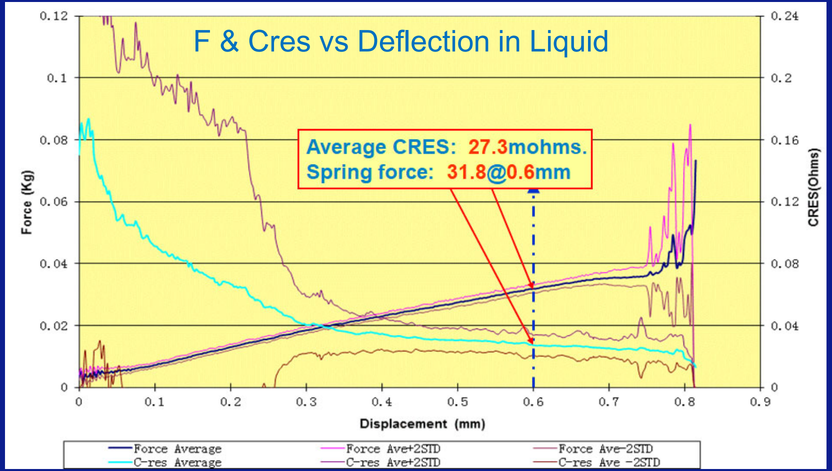
- Common Force-Deflection-Resistance tester used in measurement of force & Cres.
- Dry – normal air environment.
- Liquid – test block with spring probes soaked in liquid.
- Force & Cres in working range of spring probes are same in air vs in liquid.

FDR set up





Average CRES is 27.4mohms. Spring force is 31.5@0.6mm

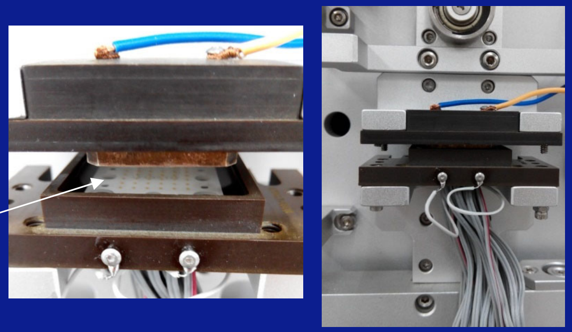


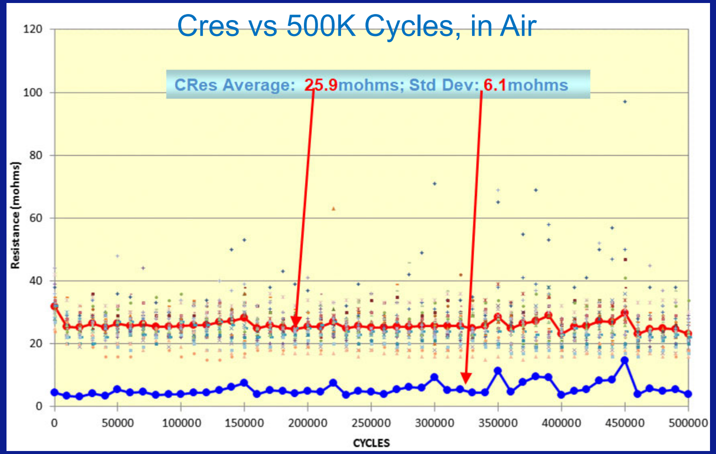
Average CRES: 27.3mohms.
Spring force: 31.8@0.6mm

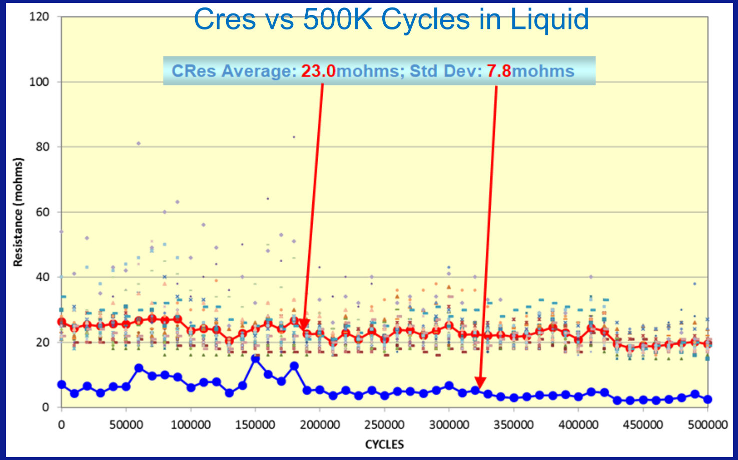
Performance – Cres vs Compress Cycling

- Common spring probe cycle tester, Cres vs 500K cycles.
- Dry – normal air environment.
- Liquid – test block with spring probes soaked in liquid.
- Over 500K cycles, Cres of spring probes in air and in. liquid is in same range. Liquid test results are slightly better.

Spring Probe Life Test set up



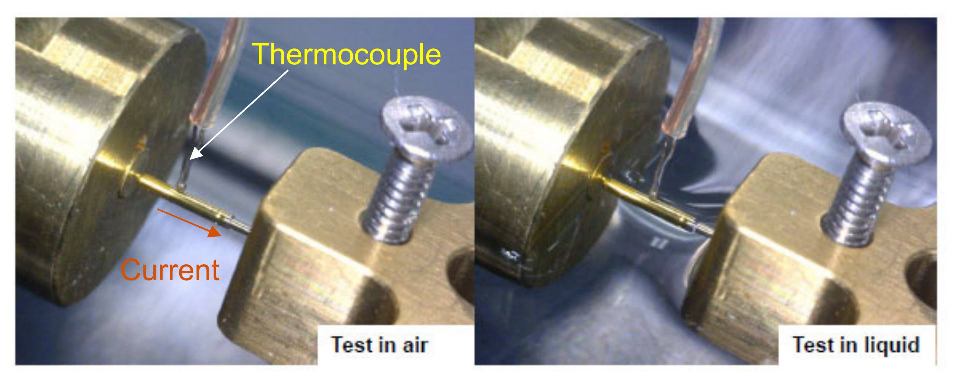




Performance – CCC

- Current Carrying Capacity was tested by thermocouple method.
- Current going through spring probe in air or in liquid.
- Temperature increases as more current going through. This T-Rise is significantly less in liquid vs in air.
- As shown in the table, CCC of spring probe is about ~3A. While in liquid, CCC is 3 times more than in air.

Spring Probe CCC Test Set up

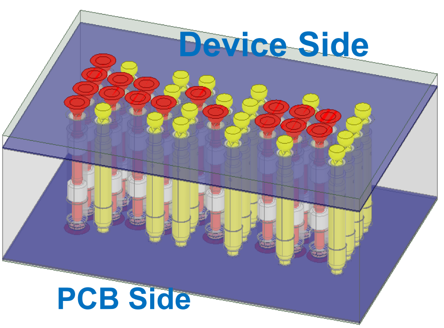


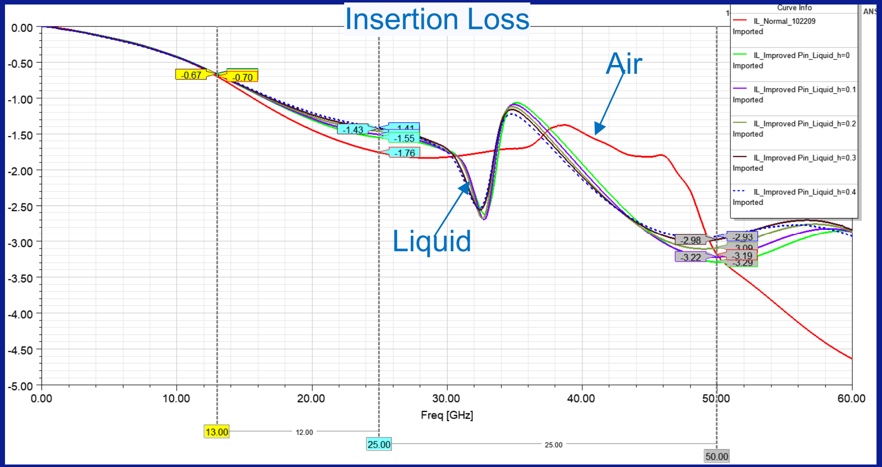
CCC Measurement Results

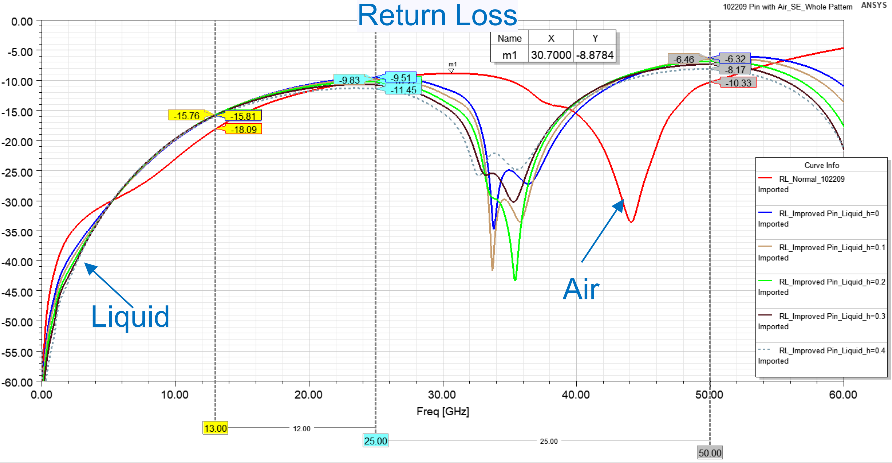
	W0UlvhC #6D	W0UlvhC #9D	W0UlvhC #<D
Whvw#lq#dlu	:;19	5481;	
Whvw#lq#dtxlg	4613	7418	961:

Performance – Signal Integrity

- Signal integrity simulation (single ended) is performed per one specific pattern.
- Insertion Loss (IL): ~15GHz @ -1dB, in air or in liquid
- Return Loss (RL): ~ 25GHz @ -10dB, in air or in liquid
- The simulation results look similar in performance. Due to difference of dielectric constant of liquid vs air, socket structure is adjusted slightly.

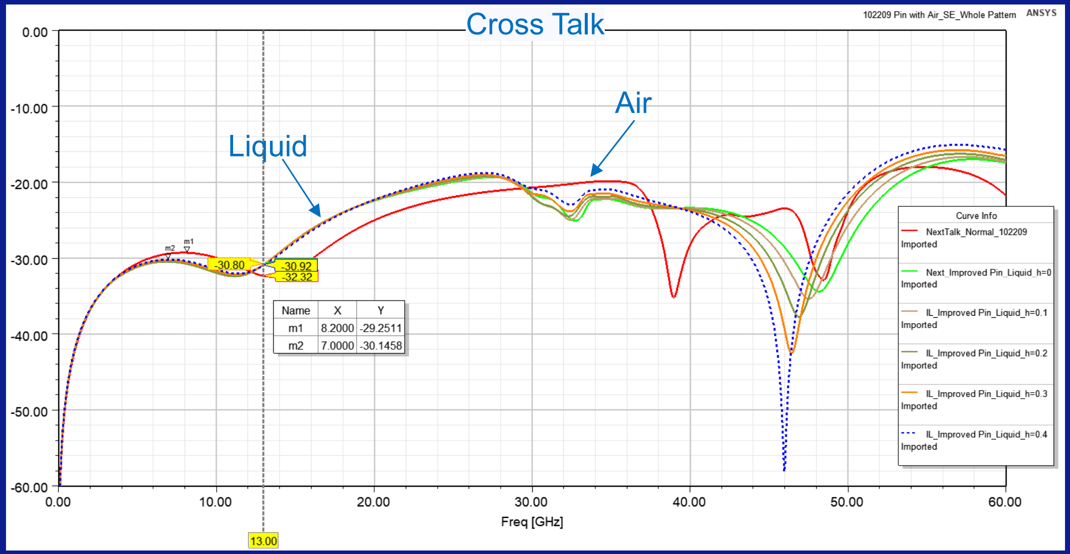






Performance – Signal Integrity

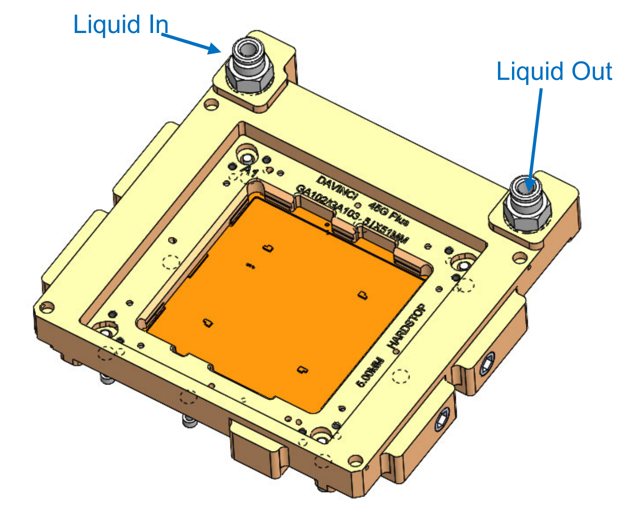
- Simulation on crosstalk is on same pattern with results below.
- The results below exhibit almost identical crosstalk, in air and in liquid.
- Metal body socket with coaxial structure (DaVinci Socket at Smiths Interconnect) is used for the signal integrity simulation.

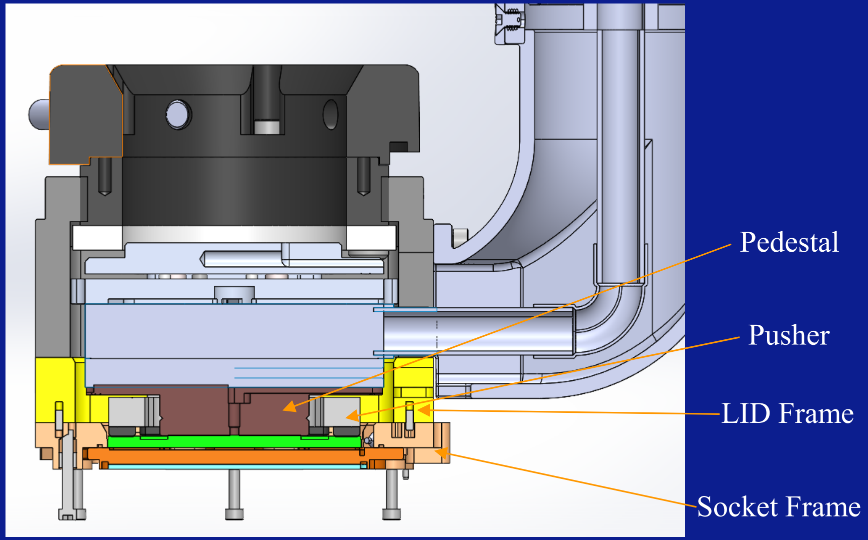


Name	X	Y
m1	8.2000	-29.2511
m2	7.0000	-30.1458

Application Example

- Socket with liquid cooling feature has been developed on the base fundamentals of the DaVinci Socket (metal based on IM material with coaxial structure).
- The electronic cooling liquid is used in this application. This liquid has low dielectric constant and a high electric volume resistivity.

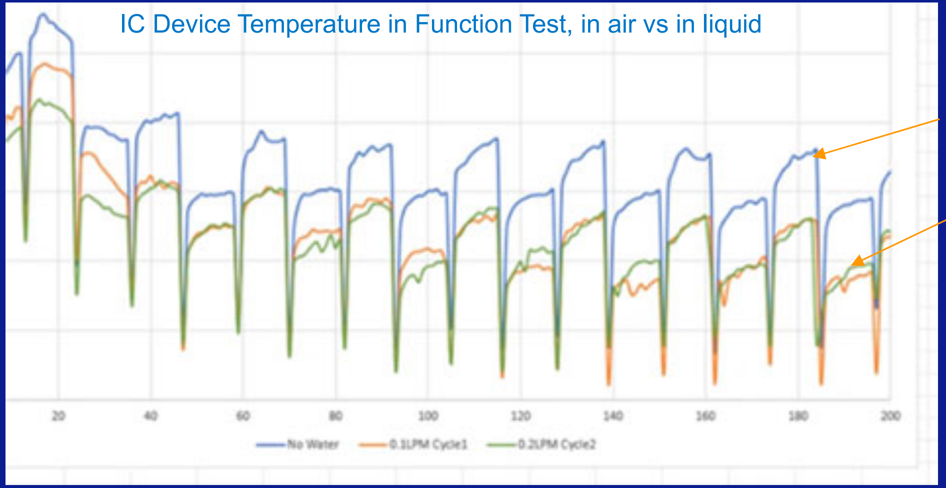




Patent pending

Application Example

- A volume of IC packages have been tested in this liquid-in-socket with reliable liquid supply system without leakage or other issues.
- Device 1st pass yield is equal and higher than tested in air.
- Measured IC device temperature data during functional test in liquid are lower than in air, average 5~7°C.



Device temperature, in air

Device temperature, in liquid

Summary

- A Liquid-in-Socket has been developed by Smiths Interconnect as a new cooling method for all types of IC wafer and packaged chip testing (BGA, LGA, QFN, etc.), based on the increasing growth of IC chip power requirements (*Patent Pending*)
- This technology has shown various advantages in IC chip testing
  - More reliable contact at interface of IC package and spring probes or other contact.
  - Very stable Cres
  - Equal or greater signal integrity performance
  - More effectively cooling on spring probe and contact, significantly increase their Current Carrying Capacity.
  - Potential function of avoiding electric spark due to extra high pulse current during IC chip testing
  - Device 1st pass yield is equal and higher than tested in air.
  - Enhancement in cooling capacity, with same cooling system in lid, IC device temperature during functional test can be reduced 5~7°C, about 10% cooling power.
- With this technology, more developments are on going for more applications in IC testing industry.