TWENTY-SEVENTH ANNUAL

TestConX™

Archive

DoubleTree by Hilton
Mesa, Arizona
March 1-4, 2026

cRes Test Cell: Reliable Contacting for SACQ Across Temperature Extremes

Jason Mroczkowski - Cohu
Chris Argento - Cohu

TestConX™

Mesa, Arizona ● March 1–4, 2026

Cohu®

Agenda

- SACQ Background & Motivation
- cRes Test Cell
- SACQ Test Results
- Findings (Time, Temperature, Current, cRes)
- Conclusion
- Next Steps

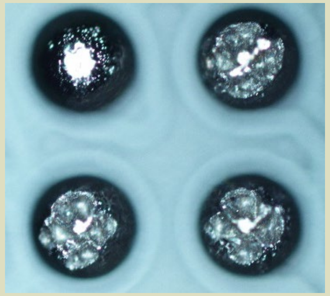
Background: SACQ

- Sn3.5Ag
  - 96.5% Tin (Sn), 3.5% Silver (Ag)
- SAC305:
  - 96.5% Tin (Sn), 3% Silver (Ag), 0.5% Copper (Cu) Lowest silver = lowest cost
- SACQ:
  - 92.45% Tin (Sn), 4% Silver (Ag),0.5% Copper (Cu), 3% Bismuth (Bi), and 0.05% Nickel (Ni).
- SACQ Advantages:
  - Improved drop shock resistance
  - Improved thermal fatigue performance
  - Excellent Solder joint reliability, resistance to oxidation

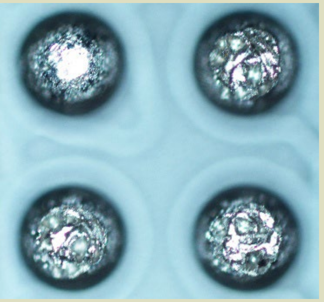
High-current semiconductor devices
Automotive and power electronics
Infrastructure and networking ASICs

- SACQ Disadvantages
  - Lower melting temperature
  - Exhibits a hard surface at cold temperatures and a soft, adhesive surface at elevated temperatures
- SACQ impact on test
  - New challenges for stable electrical contact during high-volume production testing

Sn3.5Ag



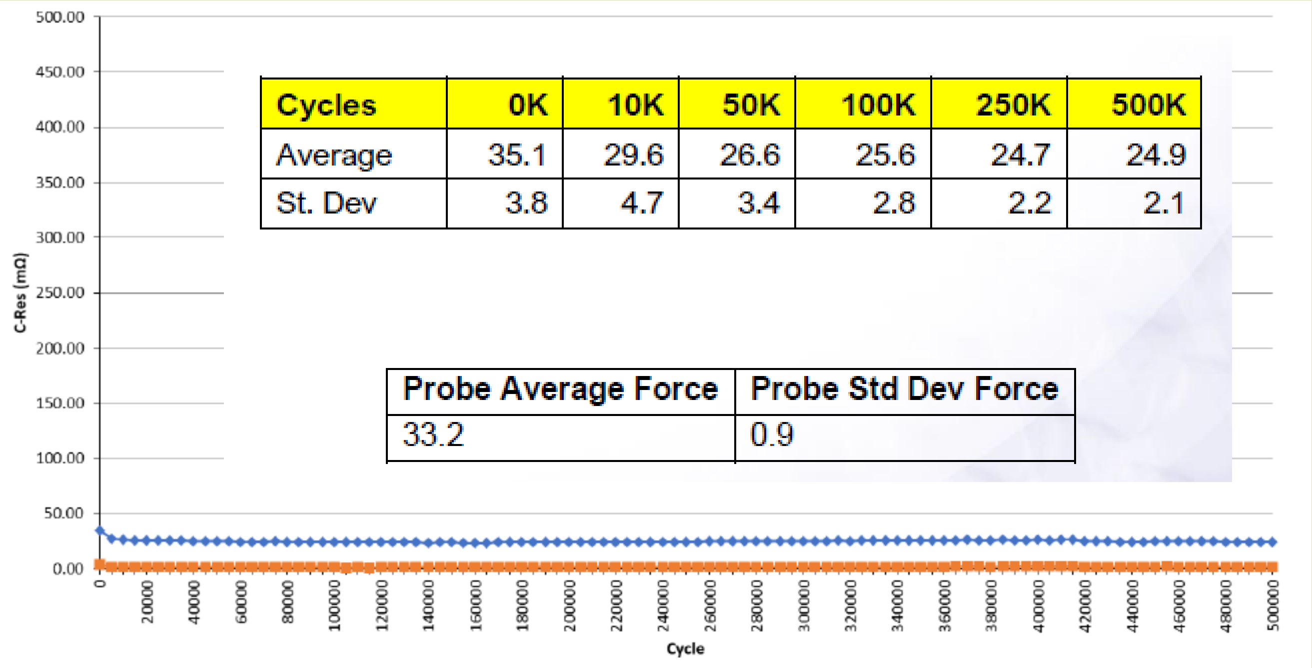
SACQ



Background: Probe Life Cycle Report

- What it is:
  - Gold on Gold Interface
  - Confirms integrity of internal probe components/design
  - Comparison to other probes under same conditions

- What it is not:
  - Direct correlation to the production environment
  - Probe tip to device solderball interface performance estimate



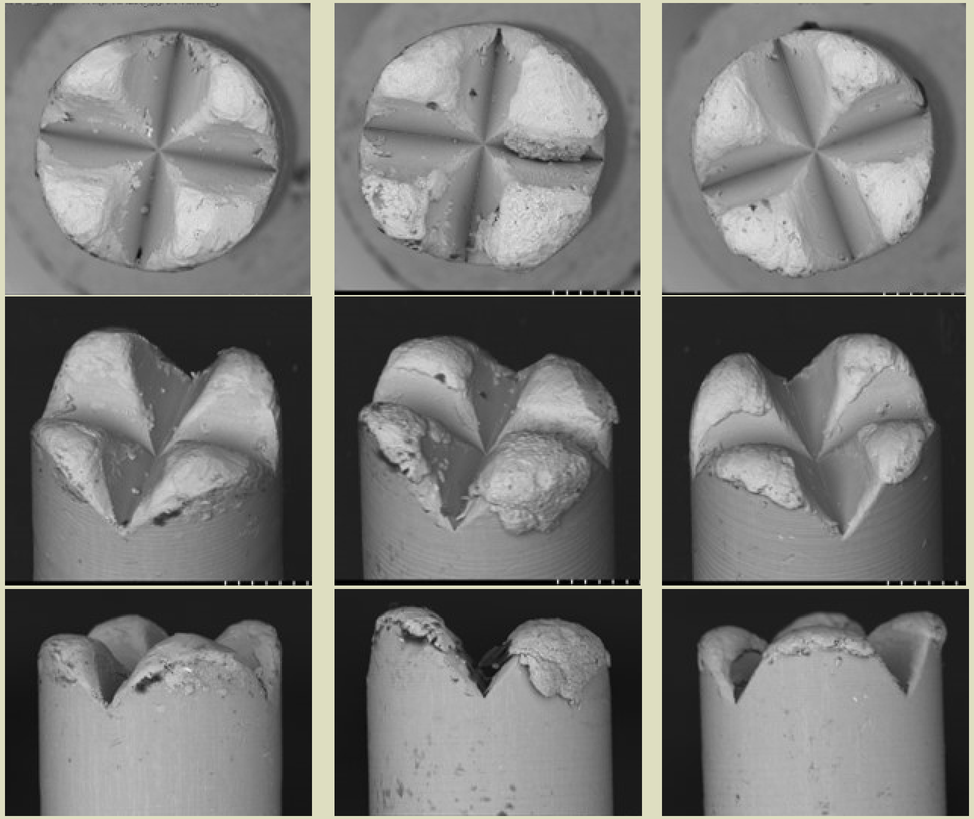
Cycles	0K	10K	50K	100K	250K	500K
Average	35.1	29.6	26.6	25.6	24.7	24.9
St. Dev	3.8	4.7	3.4	2.8	2.2	2.1

Probe Average Force	Probe Std Dev Force
33.2	0.9

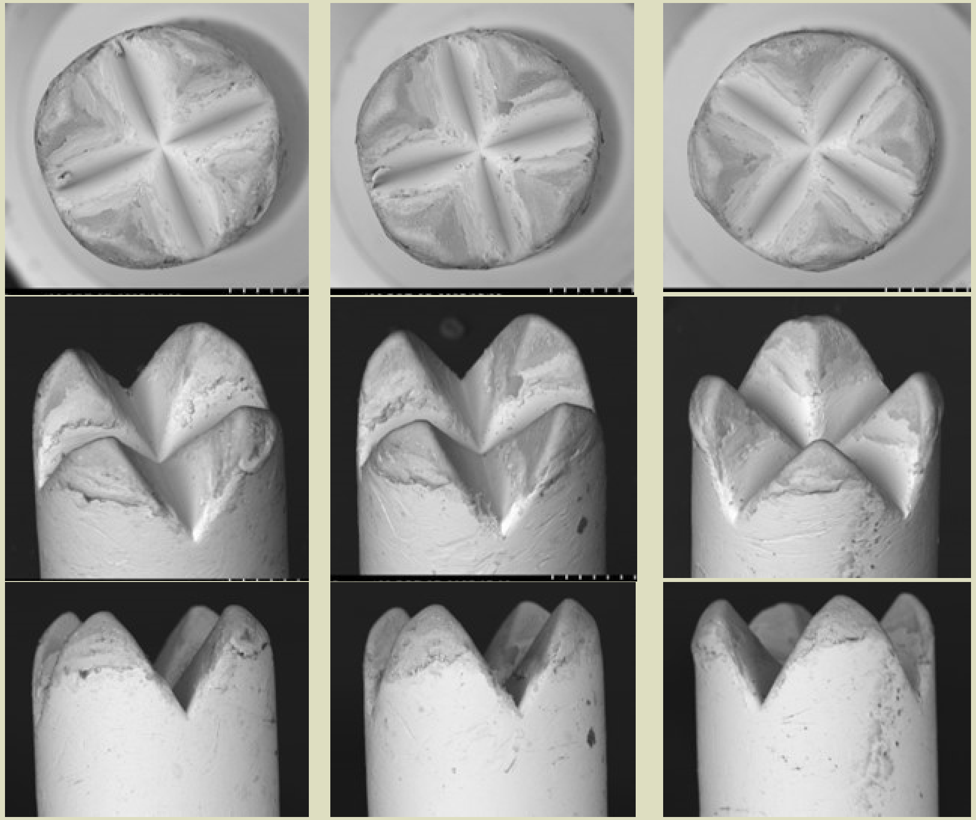
Motivation: Sn3.5Ag 15k cycles

- Homogeneous vs plated probe after 15k cycles on Sn3.5Ag solder balls in production test
- Slightly more solder transfer and wear than the plated tip.

Homogeneous

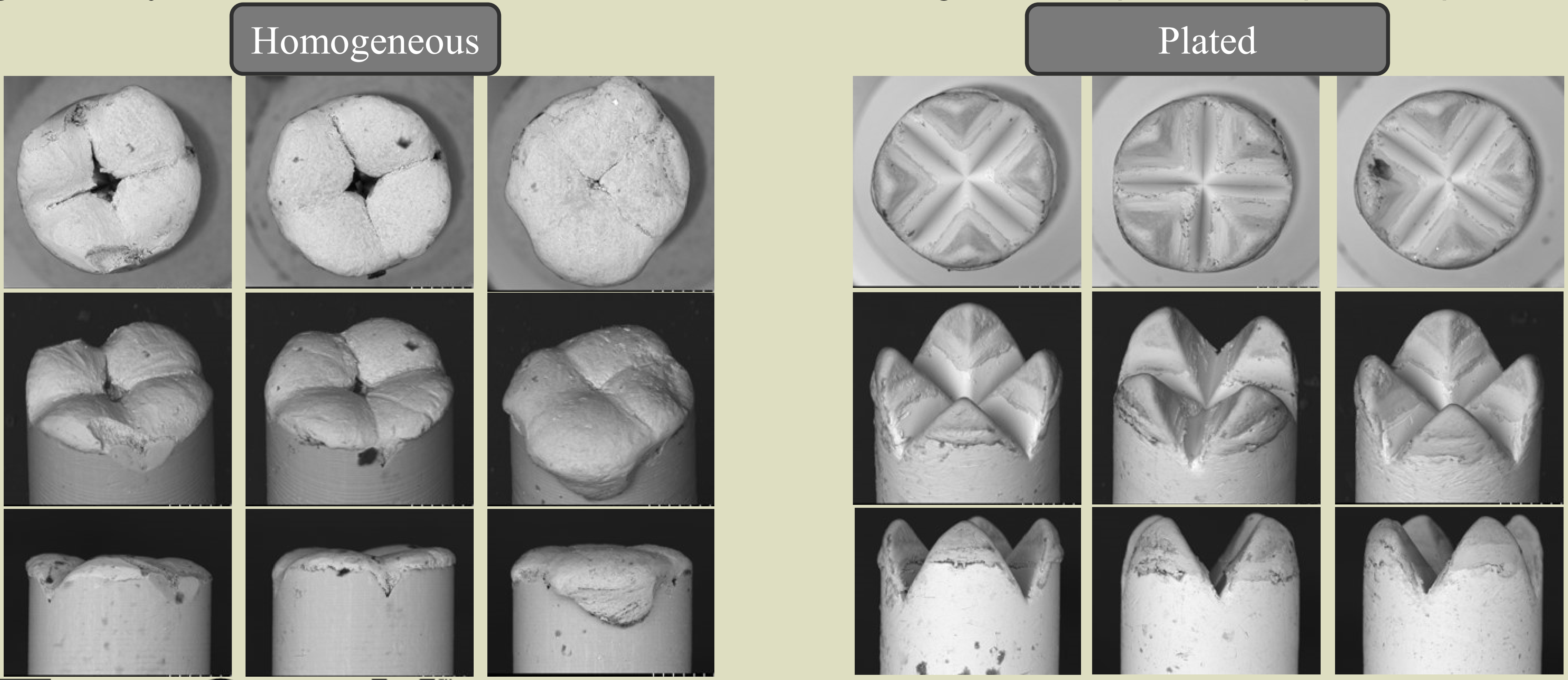


Plated



Motivation: SACQ 15k cycles

- Homogeneous vs plated probe tip after 15k cycles on SACQ solder balls in production test
- The Homogeneous tip was significantly more worn than plated.
- Significantly more solder transfer and wear on the homogeneous tip than the plated tip



Motivation: cRes 15k cycles

- Customer SACQ Findings:
  - Despite tip wear and contamination, Homogeneous tip shows lower and more consistent cRes through 15k cycles
  - Significant cRes instability @7k-12k of plated tip on Sn3.5Ag significantly worse than SACQ
- Conditions:
  - 150C, 25C, -40C mixed testing
  - Testing combined SACQ and Sn3.5Ag Devices
    - Possible impact from cross contamination of probes/devices
- Conclusion:
  - Wear and contamination results counterintuitive to cRes results
  - Inconclusive results
  - Need more controlled experiment on SACQ

Introduction

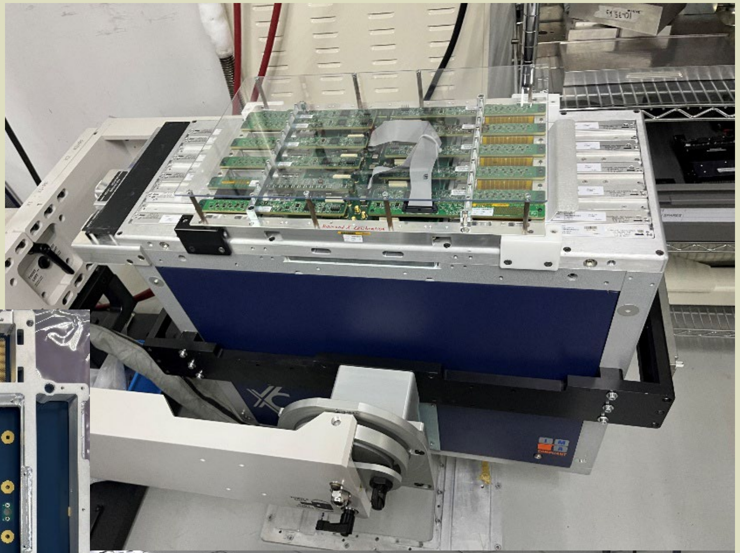
- Hypothesis: SACQ at high temperature causes increased cRes due to increase solder buildup, at low temperature SACQ causes increased cRes due to poor contact

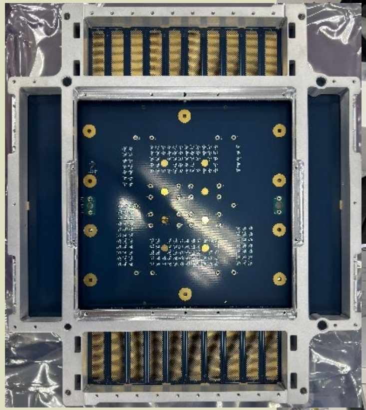
- Phase 1:
  - Develop a universal cRes Test Cell enabling reliable, repeatable contact resistance measurements across tri-temp on customer devices in a production environment.
- Phase 2:
  - Test probe variations on SACQ with customer supplied devices
  - Characterize probes with varying temperatures, test times, and currents
- Phase 3:
  - Improve probe performance and lifetime when testing against SACQ

Phase 1: cRes Test Cell Architecture

- Universal Socket Tester for full socket cRes and probe life testing
  - Diamondx™ tester + MATRiX™ handler
  - Tri-temp (−50°C to 150°C)
  - Kelvin measurement
  - PMVI Test Instrument
- Modular design:
  - Standardized contactor footprint/Change kit
  - Motherboard/daughtercard compatible
  - Conversion to other tester configurations

Diamond$_x$



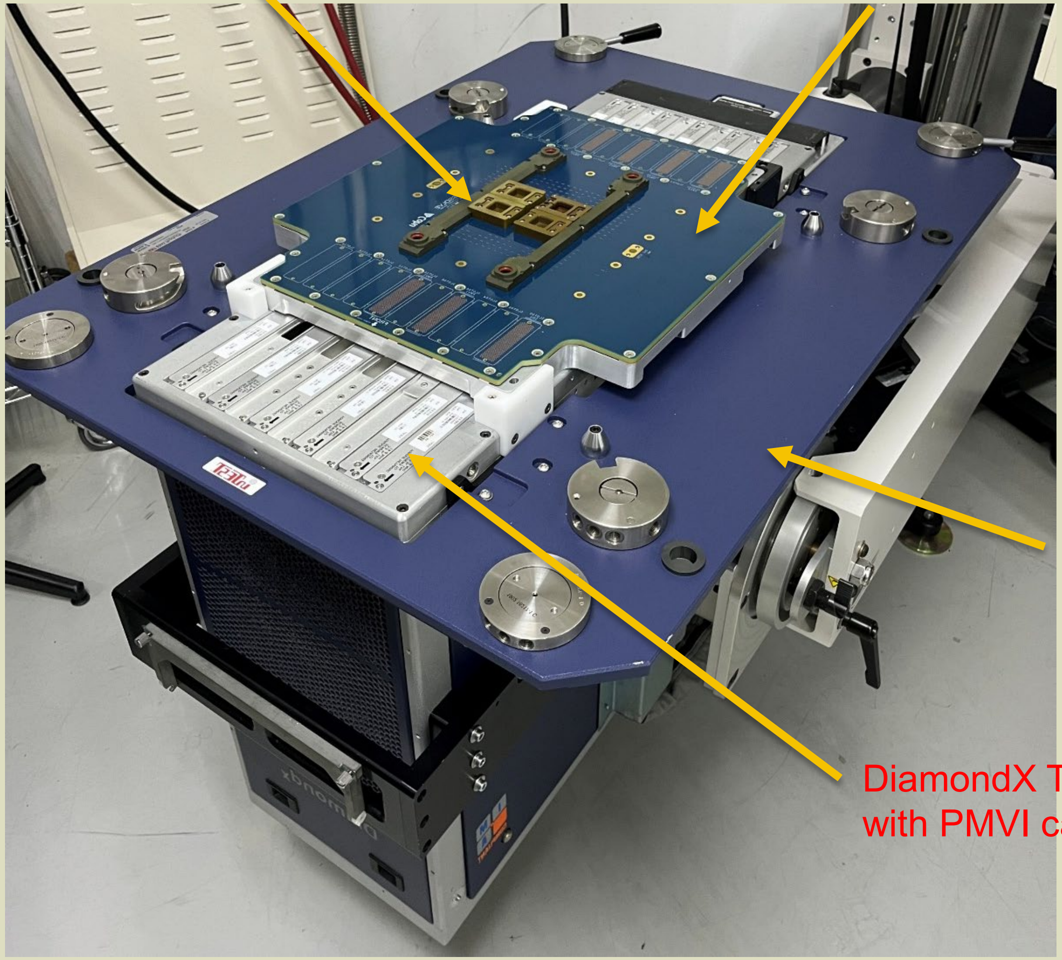


MATRiX™

Tester, Docking, and Kit

Delta Contactors

Oversize Loadboard

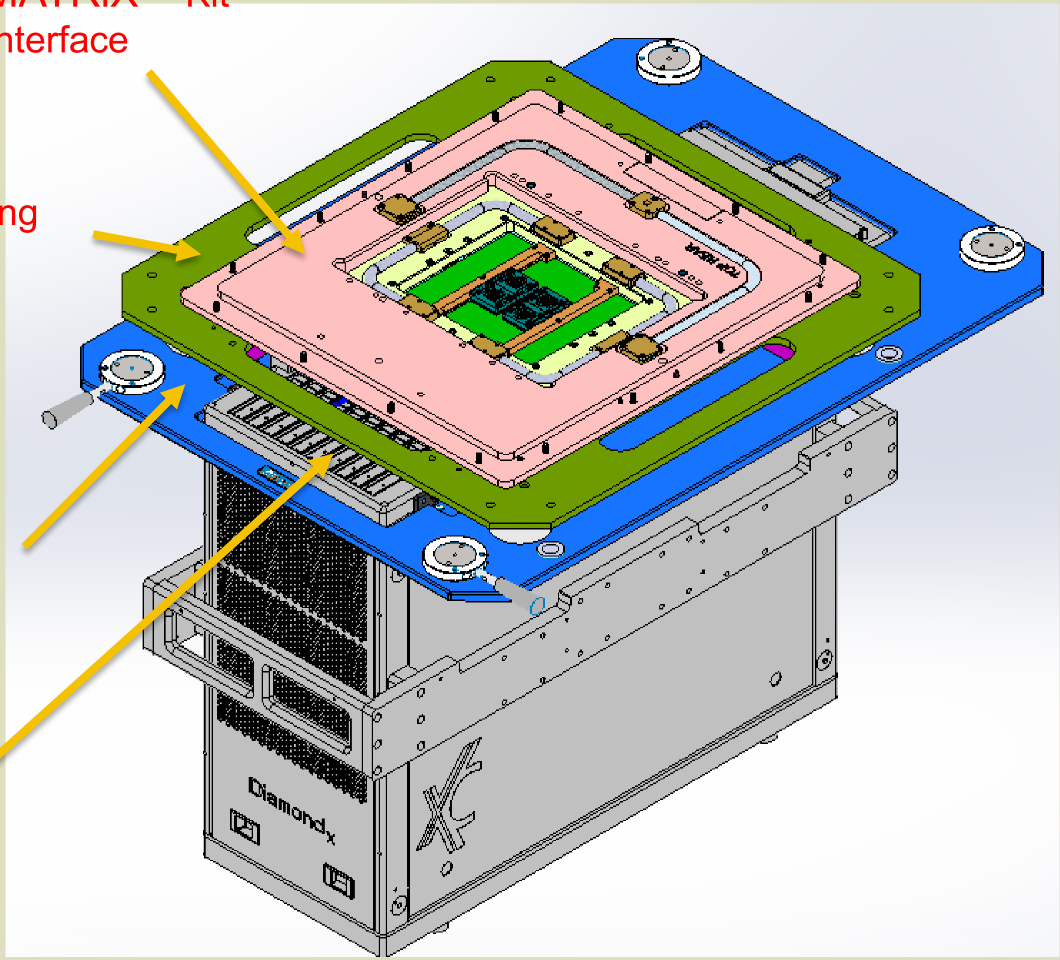


MATRiX™ Kit Interface

Tester Docking Plate

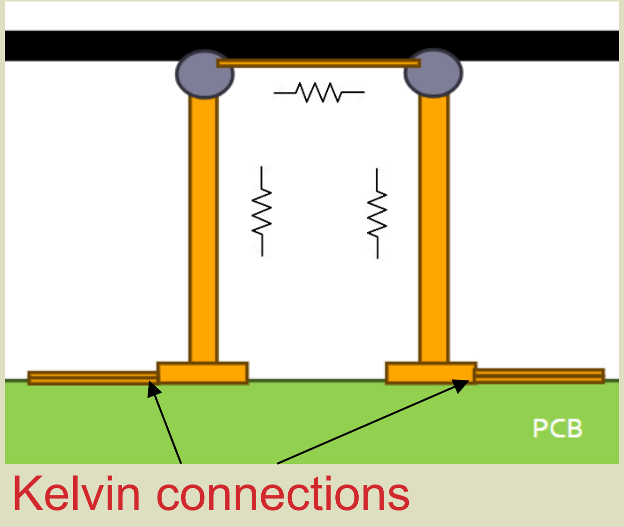
MATRiX™ Handler Docking Plate

DiamondX Test Head with PMVI cards



cRes Test Instrument: PMVI

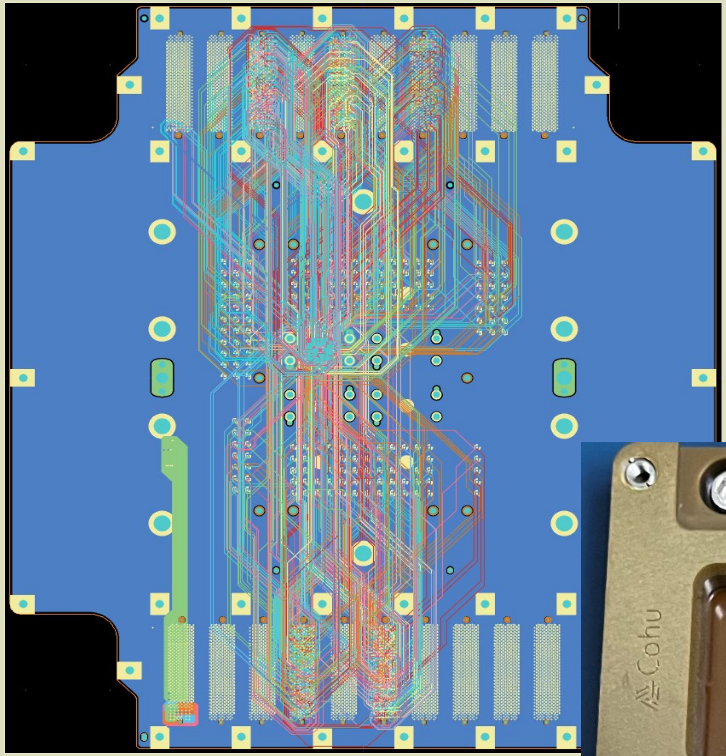
- High Density Power supply
- Mobility, ASSP, Logic, Power Management
- 2.5V up to 1A (can be ganged)
- 72 Kelvin channels
  - 1 Voltage Meter per 8 channels (9)
  - 1 Current load per 4 channels (18)
- 120W max load
- Kelvin to PCB, measurement includes 2 probes and package

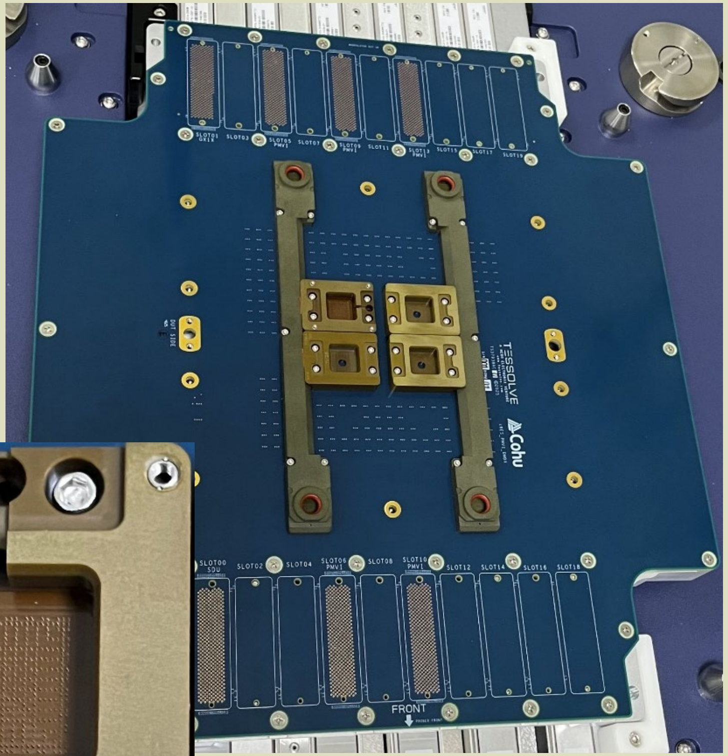


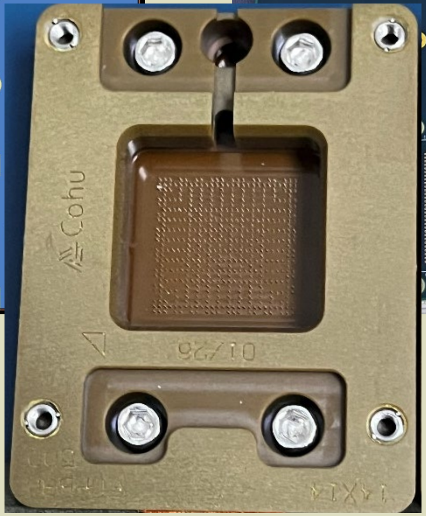
Instrument	Force Current (A)	Force I Accuracy	Meas V	Measure V Accuracy	Max Error (Ohms)*	Channels / Instrument
GX1	0.05	0.001	0.005	0.0025	3.33	192
HDVI	0.20	0.002	0.020	0.0018	0.79	72
PMVI	0.20	0.004	0.020	0.0001	0.03	72

Loadboard and Contactor Information

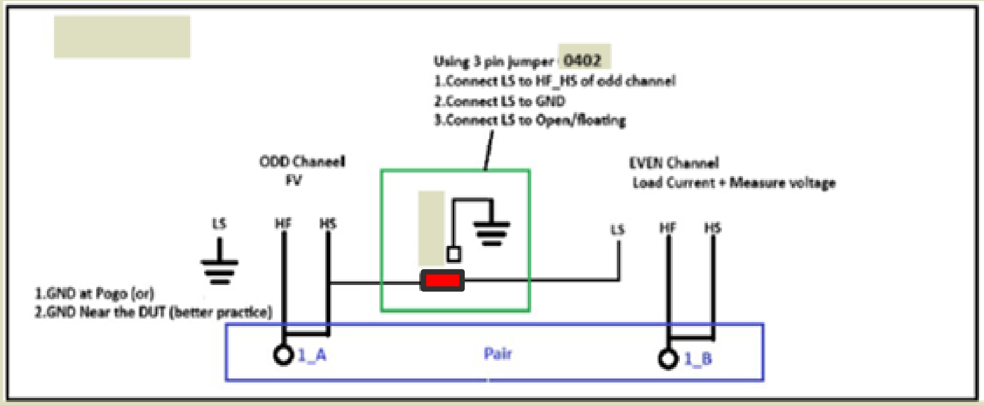
- Quad site loadboard and kit
  - Wide formfactor PCB
  - 36 layers
  - 1 Active contactor
  - 3x Dummy contactors
  - Kelvin connections routed to contact pads
  - 1 A/channel rating
- Hydra Contactor
  - 3.22mm test height
  - 500 probes
  - Thermocouple
- PMVI connections
  - 360 channels total
- Manifold connections

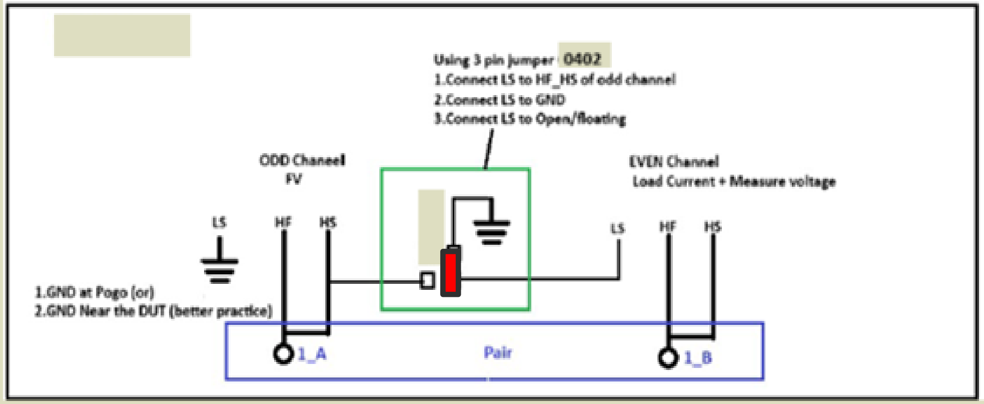






Loadboard Design



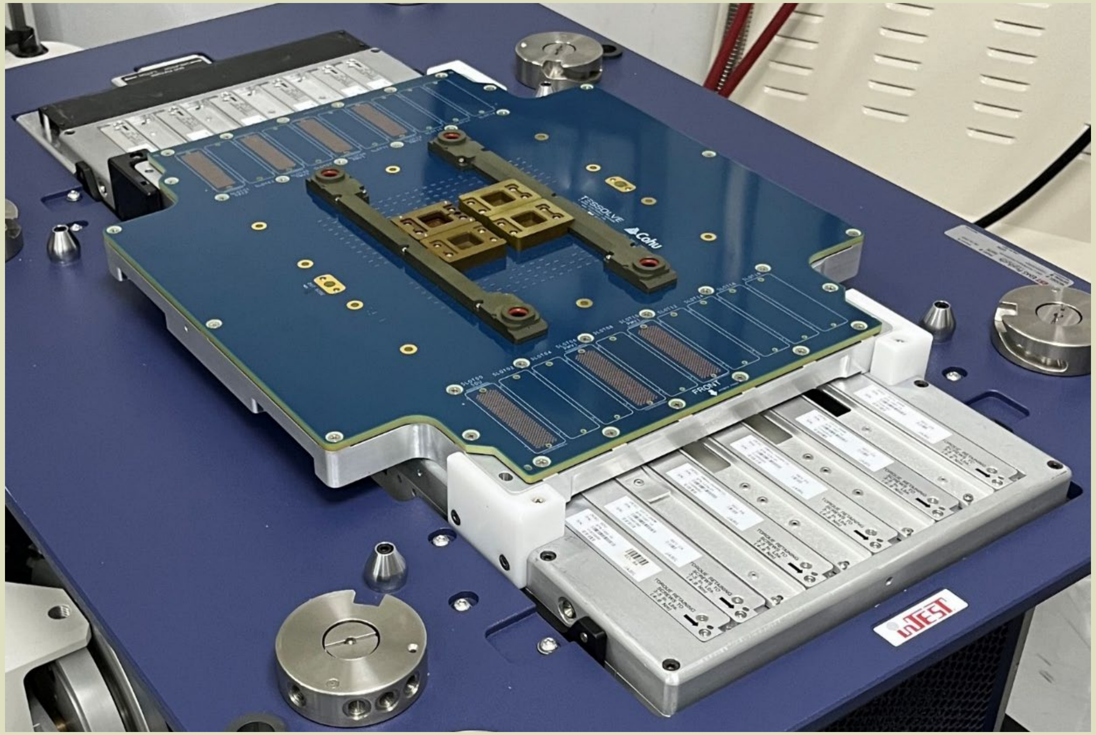


- LS to HS
  - 125mV max voltage
  - Unable to achieve 1A (current load shutdown)
  - Max achievable current <200mA
- LS to GND
  - Able to increase voltage above 125mV
  - At 2.5V able to achieve 1A
    - 2.5W x 36CH = 90W

Tester Configuration

- Test Head
  - Single IMA 20 slots
  - Converted from GX1X
  - 5 PMVI Currently loaded

- GX1x high channel count, low accuracy
- PMVI low channel count, high accuracy
- Limit installation to match application



Future Configuration (1368 channels)

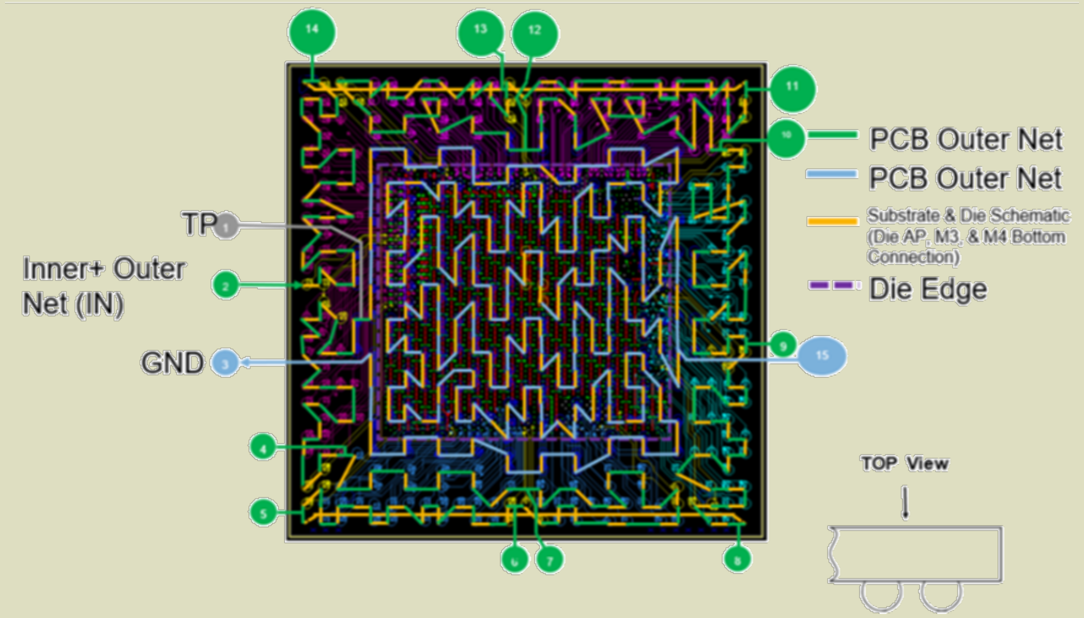
Current Configuration (360 channels)

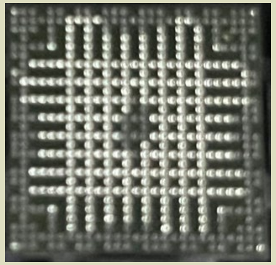
Previous Configuration (2112 channels)

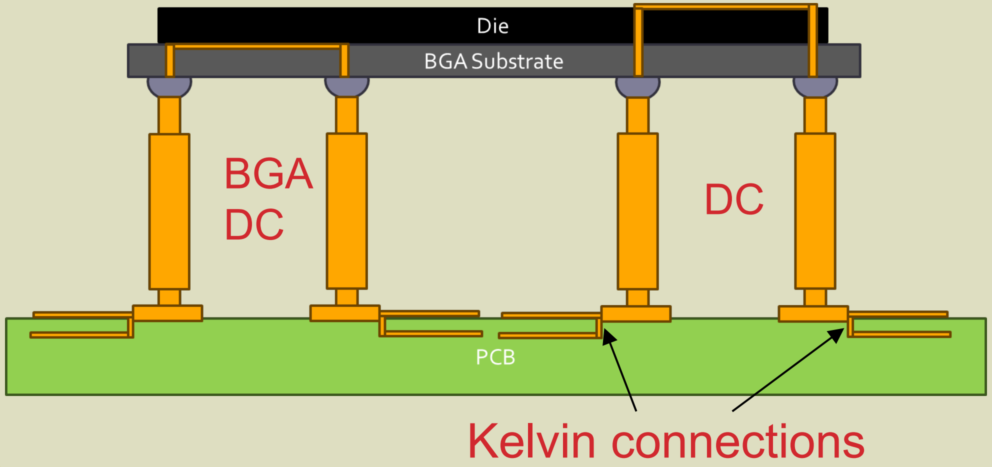
SDU	SDU	SDU	0	1	GX1x-256M	GX1x-256M	PMVIx
PMVIx		GX1x-256M	2	3	blank		PMVIx
PMVIx		blank	4	5	GX1x-256M	PMVIx	PMVIx
PMVIx	PMVIx	GX1x-256M	6	7	blank		PMVIx
PMVIx		blank	8	9	GX1x-256M	PMVIx	PMVIx
PMVIx	PMVIx	GX1x-256M	10	11	blank		PMVIx
PMVIx		blank	12	13	GX1x-256M	PMVIx	PMVIx
PMVIx		GX1x-256M	14	15	blank		PMVIx
PMVIx		blank	16	17	GX1x-256M		PMVIx
PMVIx		GX1x-256M	18	19	GX1x-256M		PMVIx

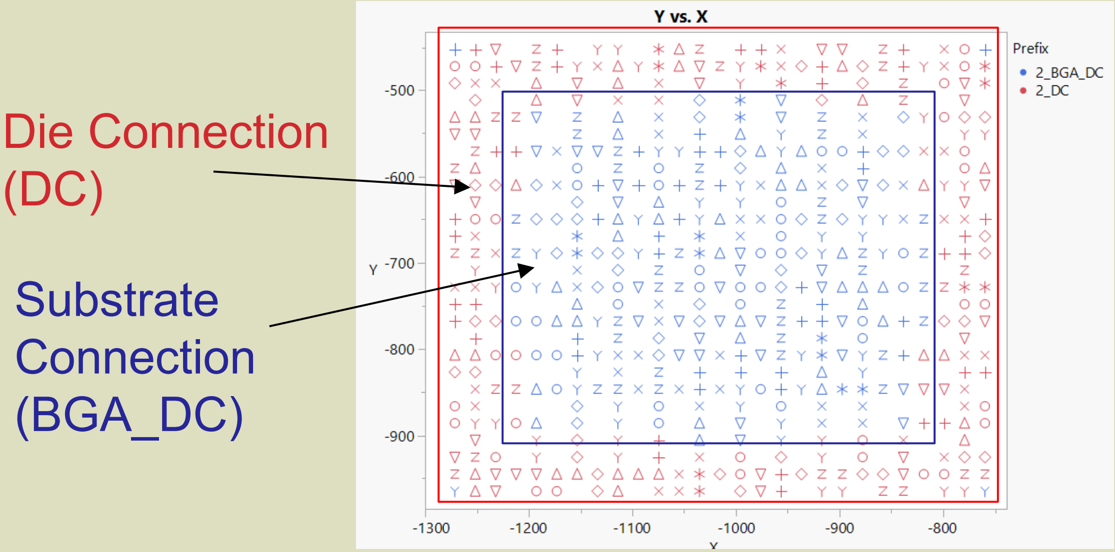
Device

- 27mm x 27mm 0.5mm pitch 500 pin BGA package with Die Test Vehicle
- Daisy-chain routing through die and substrate









Contactor and Probes

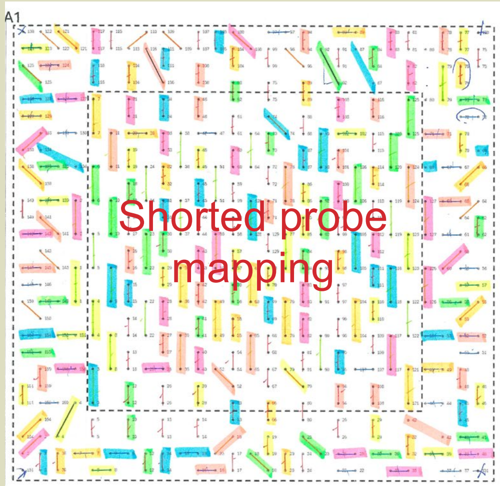
- Customer standard contactor and kit
  - Nest alignment and hardstop
  - Integrated Airflow channels
  - Vespel Housing
  - Hydra Probes
    - Pitch
      - 0.5mm
      - 0.3mm
    - Contact Tip Material
      - PD Alloy
      - 2-2H
      - Pico

HYD050 HYD030

Plating / Material Options

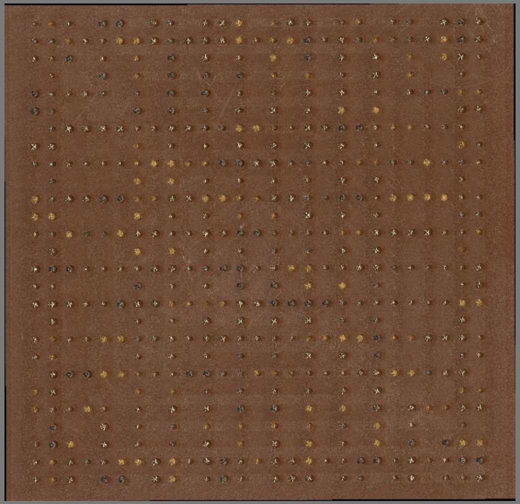
Plating / Material Hardness (HV)	Gold Pads	Matte Tin	NiPd	SACQ
Hard Au (150 HV)	+			
Pd Alloy (450 HV)		+		
2-2H (670 HV)		++	+	+
NO1 (1000 HV)		+	++	
PICO (750 HV)		++	+	+

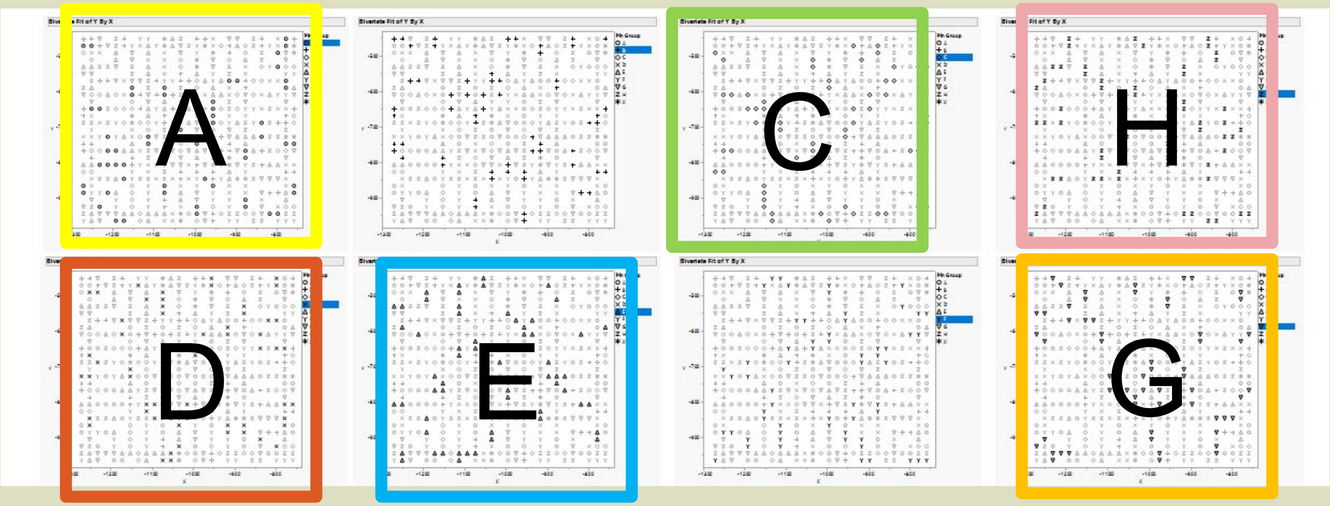
Contactor and Probes Setup



- 500 probes in contactor, 360 active probes, 180 pin pairs, 60 pin pairs per probe type
- Distributed Probe Variants across device to minimize localized anomalies from impacting data
- Substate and Die connections for all variants

Group	HYD	Force @ test	Material	Plating
A				
C				
D				
E				
G				
H				





Test Plan

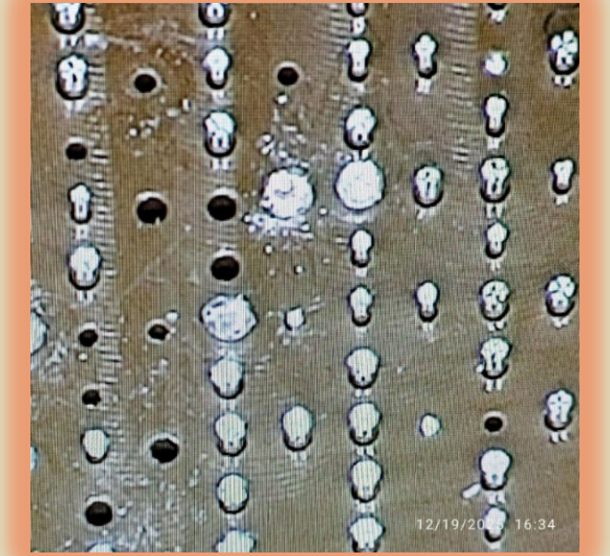
- Pre & Post Golden Unit Runs
  - 40 Units run 2x each
  - Room (25C) and/or Cold (-45C)
- Stress Runs
  - Time (3.6 → 36,000 s)
    - 150C, 266 devices, 10000 insertions
  - Temperature (25 → 150°C)
    - 60sec, 90 devices, 30k insertions
  - Current (10 mA → 1 A)
    - 36sec, 340 devices, 5000 insertions

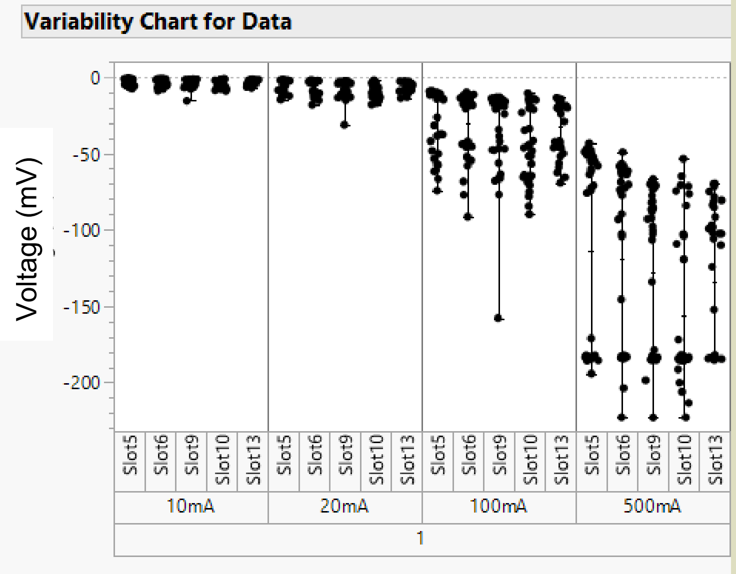
			Test Parameters		
Current (A)	Temperature (Deg C)	Test Time (sec)	# of Cycles	Set Up Time (sec)	Tester Time / Sets (sec)
0	150	36000	1	3600	36000
		3600	10	3600	36000
		360	100	3600	36000
		36	1000	3600	36000
		3.6	10000	3600	36000

Study	Test	#	Samples	Runs	Current	Temp	Time	Cycles	Test Time (sec)	Test Time (hrs)	Test Time (days)
Current Effect	Golden Unit Set B, Run 1 Pre	16	40	2	0	25	1	80	80	0.0	0.0
Current Effect	Test Run 6	17	100	50	0.01	150	60	5000	1200000	333.3	13.9
Current Effect	Golden Unit Set B, Run 1 Post	18	---	2	0	25	1	80	80	0.0	0.0
Current Effect	Golden Unit Set B, Run 2 Pre	19	---	2	0	25	1	80	80	0.0	0.0
Current Effect	Test Run 7	20	100	50	0.1	150	60	5000	1200000	333.3	13.9
Current Effect	Golden Unit Set B, Run 2 Post	21	---	2	0	25	1	80	80	0.0	0.0
Current Effect	Golden Unit Set B, Run 3 Pre	22	---	2	0	25	1	80	80	0.0	0.0
Current Effect	Test Run 8	23	100	50	1	150	60	5000	1200000	333.3	13.9
Current Effect	Golden Unit Set B, Run 3 Post	24	---	2	0	25	1	80	80	0.0	0.0
Totals			607	323					3600480.0	1000.1	41.7

Results: Initial High Current

- Cannot force more than 500mA at 2.5V?
- Increase voltage to get to 1A
- Opens
- Check contactor condition
- Melted solder balls stuck to probes!
- Die connections cannot support 1A current

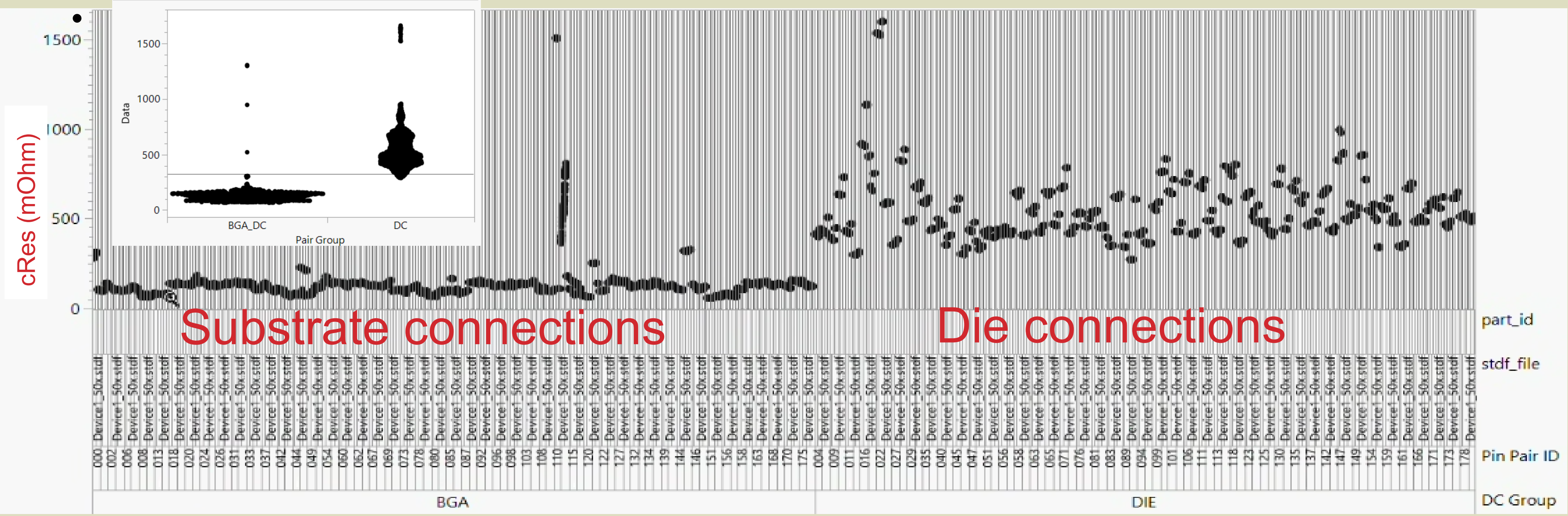




Pin	10mA	20mA	100m/	200m/	300m/	400m/	500m/	600m/	700m/	800m/	900m/	1A	
DUT_A1_BGA_DC_1_B_Slot6_VI_66	-10.022	-19.922	-99.7308	-199.952	-299.525	-399.647	-499.725	-599.774	-699.856	-799.969	-900.094	-1000.24	1000
DUT_A2_BGA_DC_19_B_Slot6_VI_50	-10.1376	-20.0345	-99.8261	-200.089	-299.172	-399.296	-499.425	-599.526	-699.669	-799.817	-899.859	-1000.02	1000
DUT_A3_BGA_DC_46_B_Slot6_VI_42	-10.1113	-19.9525	-99.6539	-200.098	-299.08	-399.23	-499.399	-599.514	-699.698	-799.917	-900.079	-1000.35	1000
DUT_A4_BGA_DC_79_B_Slot6_VI_58	-10.0423	-19.9744	-99.7833	-199.959	-299.234	-399.354	-499.42	-599.612	-699.705	-799.861	-900.063	-1000.21	1000
DUT_A5_DC_123_B_Slot6_VI_18	-9.94385	-19.9273	-99.8515	-199.868	-299.211	-399.33	-417.272	-414.897	-413.608	-410.499	-446.853	-483.702	400
DUT_A6_DC_19_B_Slot6_VI_2	-10.1264	-19.9449	-99.6266	-200.107	-299.188	-399.338	-432.004	-429.872	-428.554	-426.517	-448.326	-498.897	400
DUT_A7_DC_46_B_Slot5_VI_50	-9.93636	-19.8803	-99.717	-199.853	-299.702	-341.76	-339.883	-336.987	-347.044	-396.622	-385.973	-382.127	300
DUT_A8_DC_79_B_Slot6_VI_26	-10.0524	-19.9606	-99.7886	-200.009	-299.268	-399.38	-422.277	-420.103	-419.474	-415.914	-449.44	-476.126	400

Results: Initial cRes

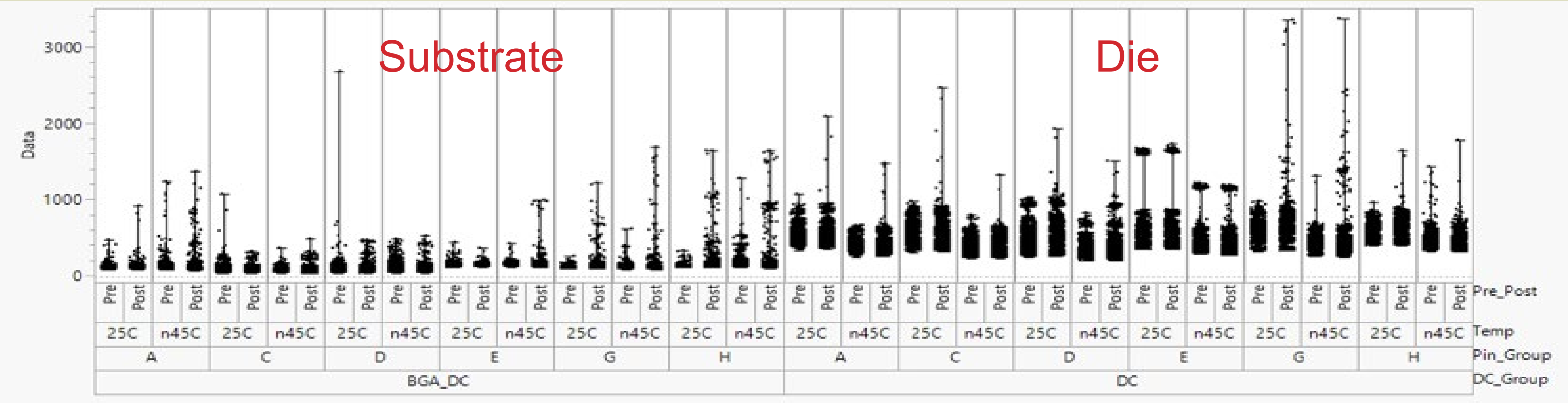
- 3.6sec test, 50 loops 1 device, 10mA
- Same probe throughout socket
- Substrate shows lower cRes and standard deviation than Die path



Focus on substrate data to compare probe performance

Results: Golden Unit Test

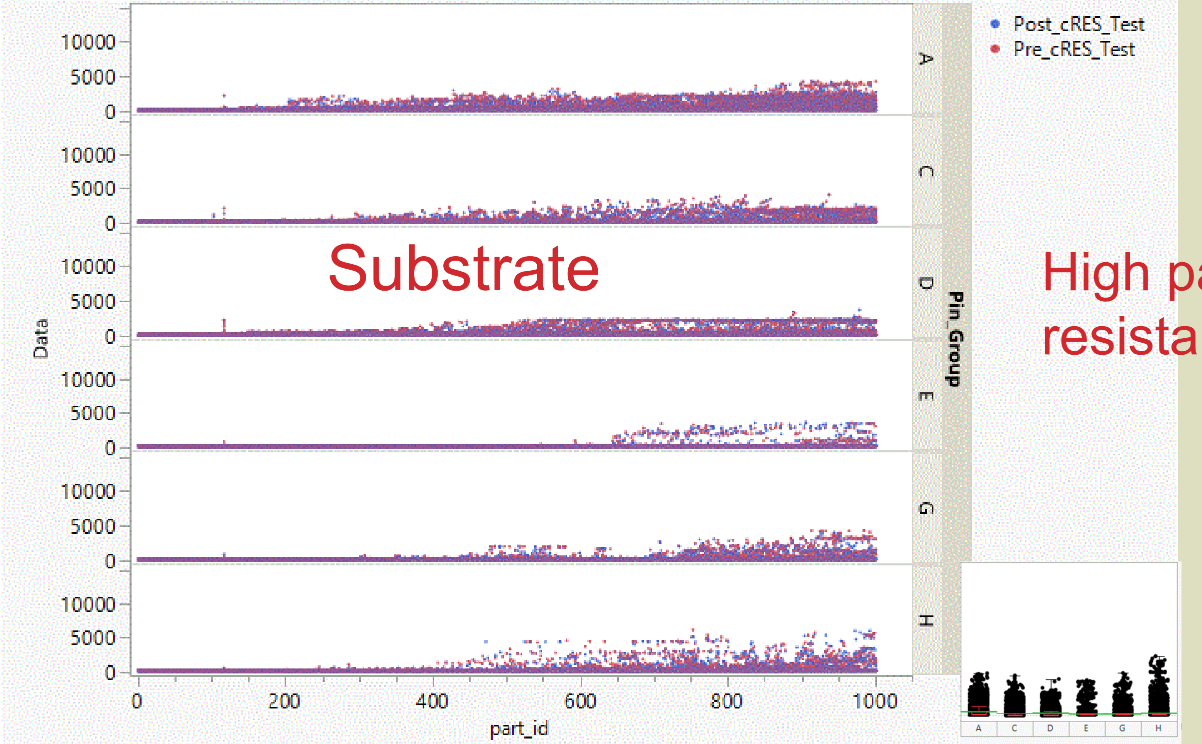
- Test:
  - 25C, -45C
  - Same probes throughout socket
  - 2 devices 40 insertions each
  - Pre stress and post stress data
- Substrate connections
  - Post and -45C data is slightly worse
  - E has lowest cRes and standard deviation
- Die connections
  - -45C show lower cRes than 25C
  - 25C shows significantly higher standard deviation
  - H exhibits the lowest variation
  - G exhibits the highest variation



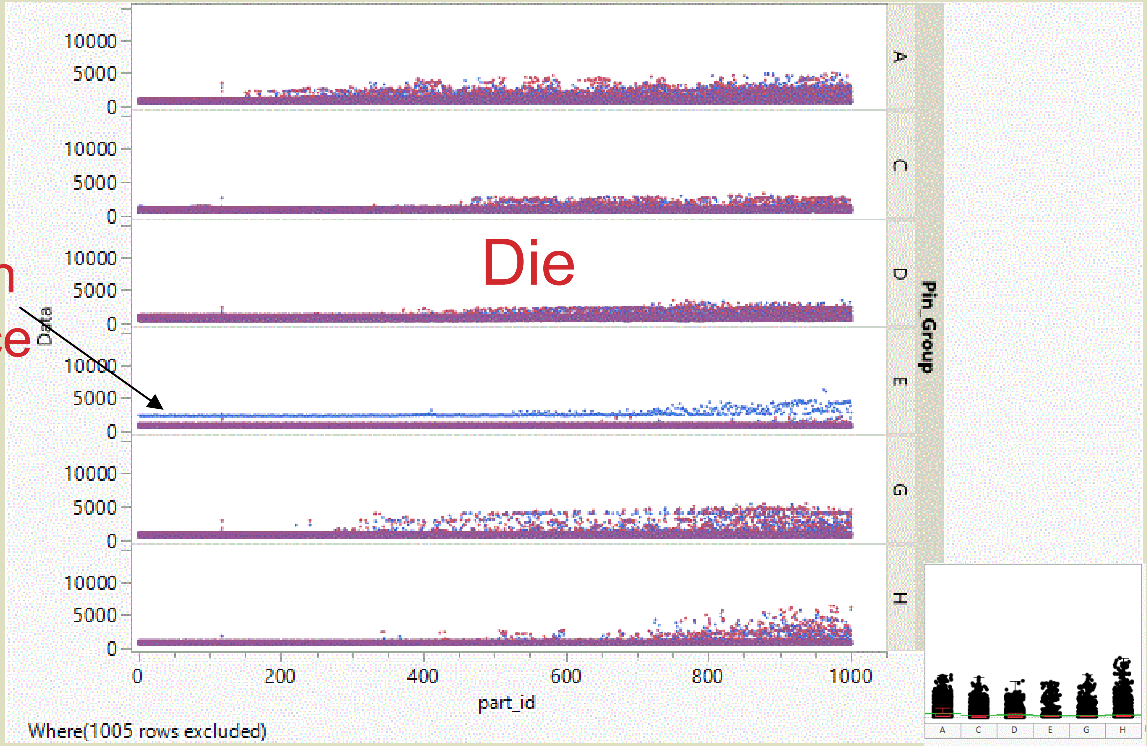
Results: Time effect 1k Test

- Test:
  - 1k insertions @ 36sec
  - 150degC (to match production temp)
- Substrate Results:
  - E is best performance, A worst

- Die connections:
  - E is best performance
  - 1 probe has high path resistance (blue)

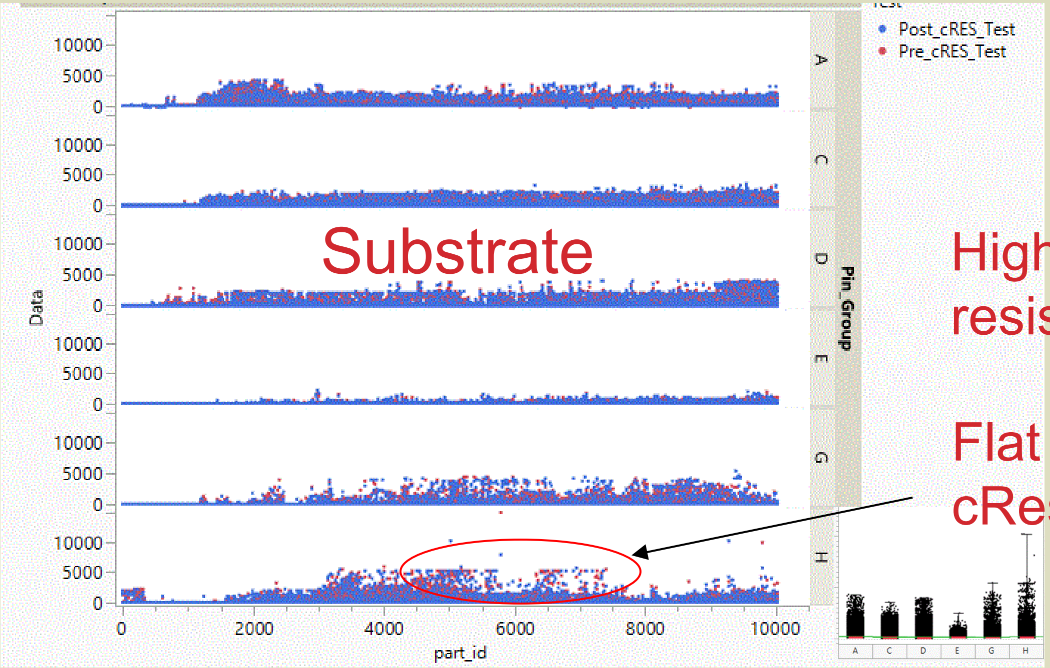


High path resistance



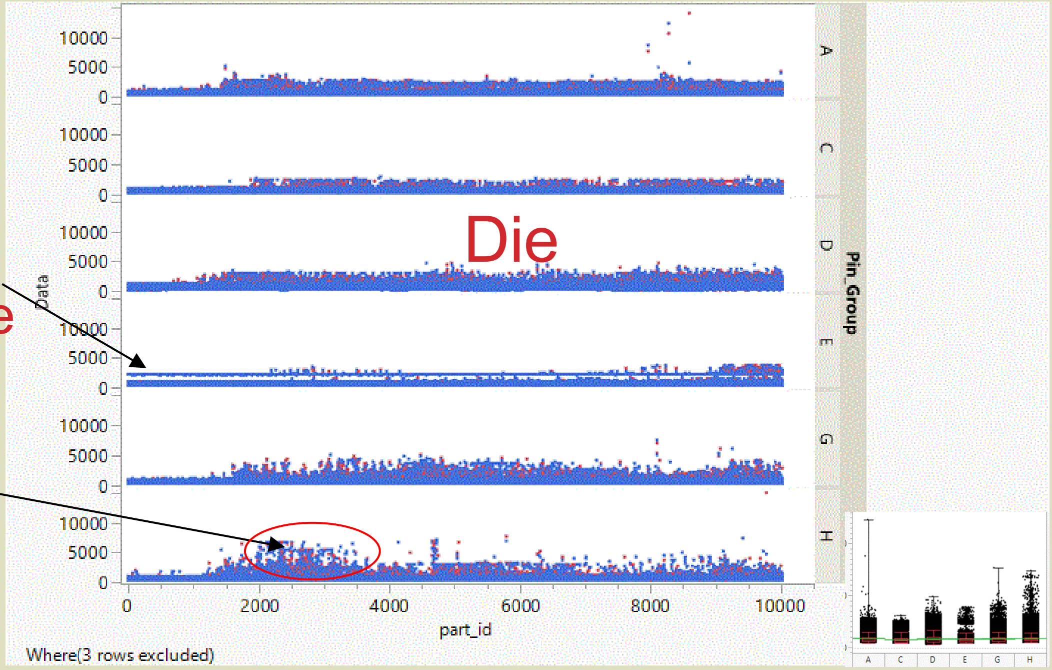
Results: Time effect 10k Test

- Test:
  - 10k insertions @ 3.6sec
  - 150degC (to match production temp)
- Substrate Results:
  - E is best performance, A worst
- Die connections:
  - E is best performance
  - 1 probe has high path resistance (blue)



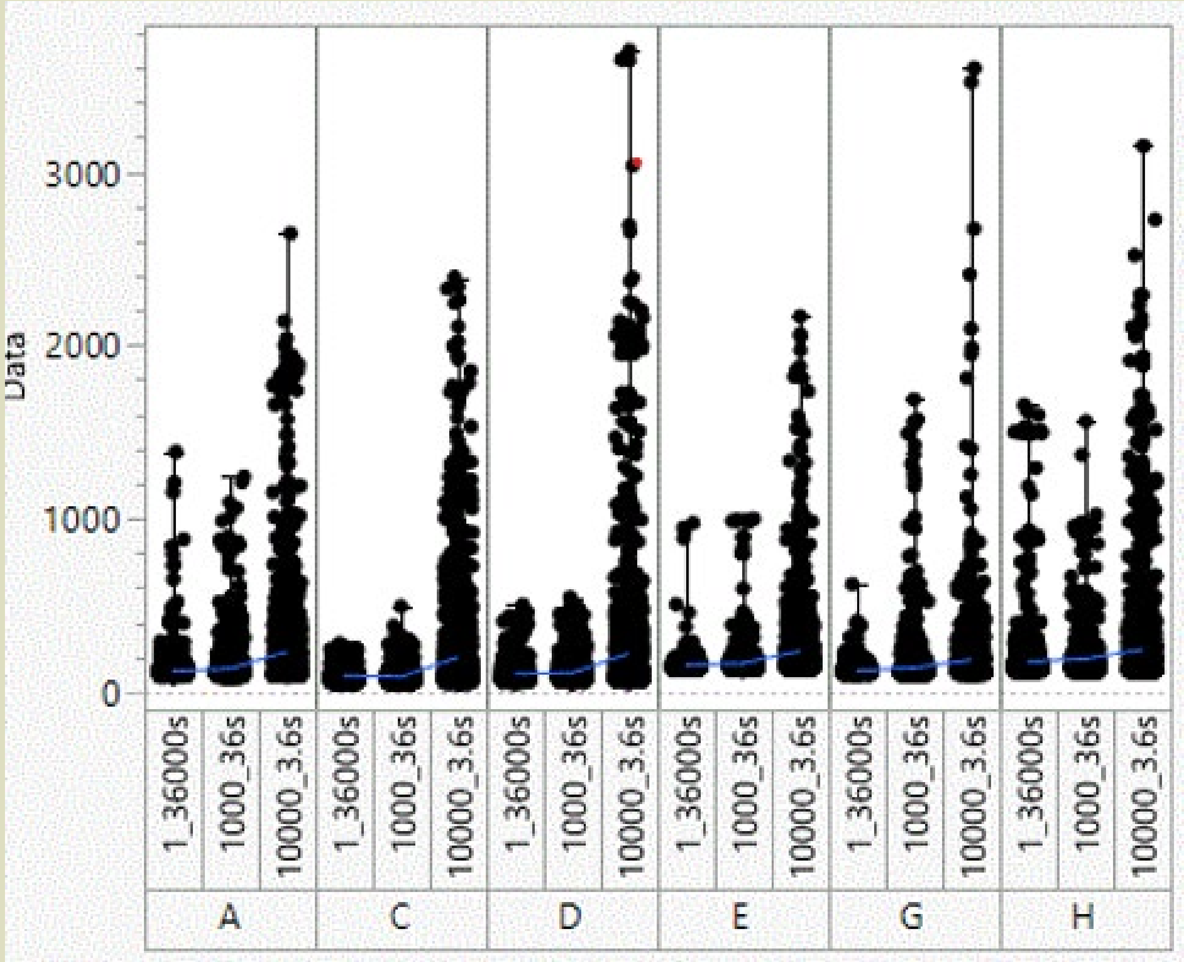
High path resistance

Flat line cRes?



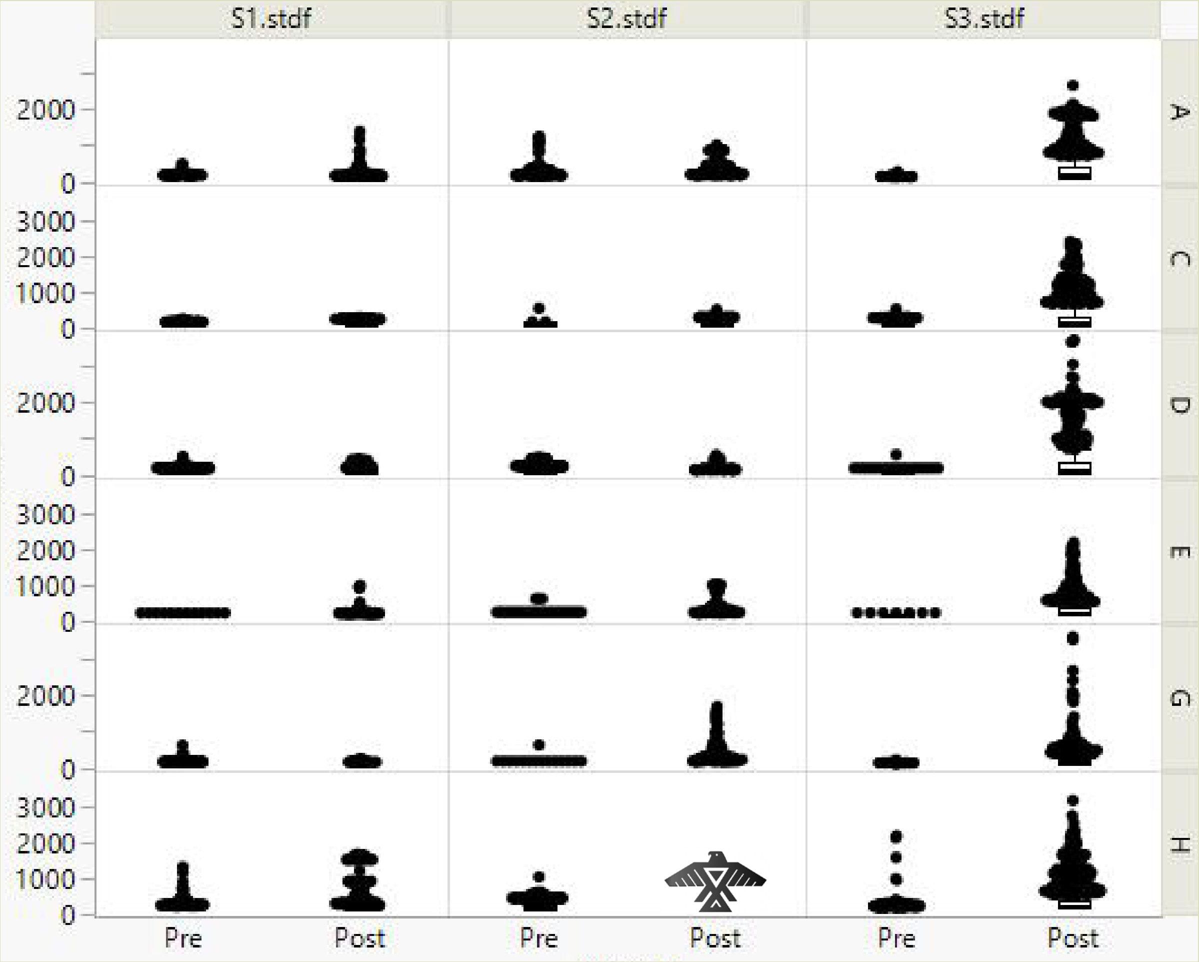
Results: Time Effect Summary

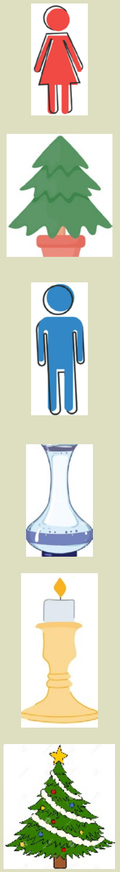
- 1 insertion and 1k insertions results similar
- 10k results show increase in cRes and standard deviation
- E remains lower average and standard deviation
- Insertions not test time has bigger impact on Cres results



Results: 1, 1k, 10k cycle Summary

- Tests:
  - S1: 1 cycle
  - S2: 1k cycles
  - S3: 10k cycles
- Results
  - Hieroglyphs?
  - Inkblot test?
  - Association?



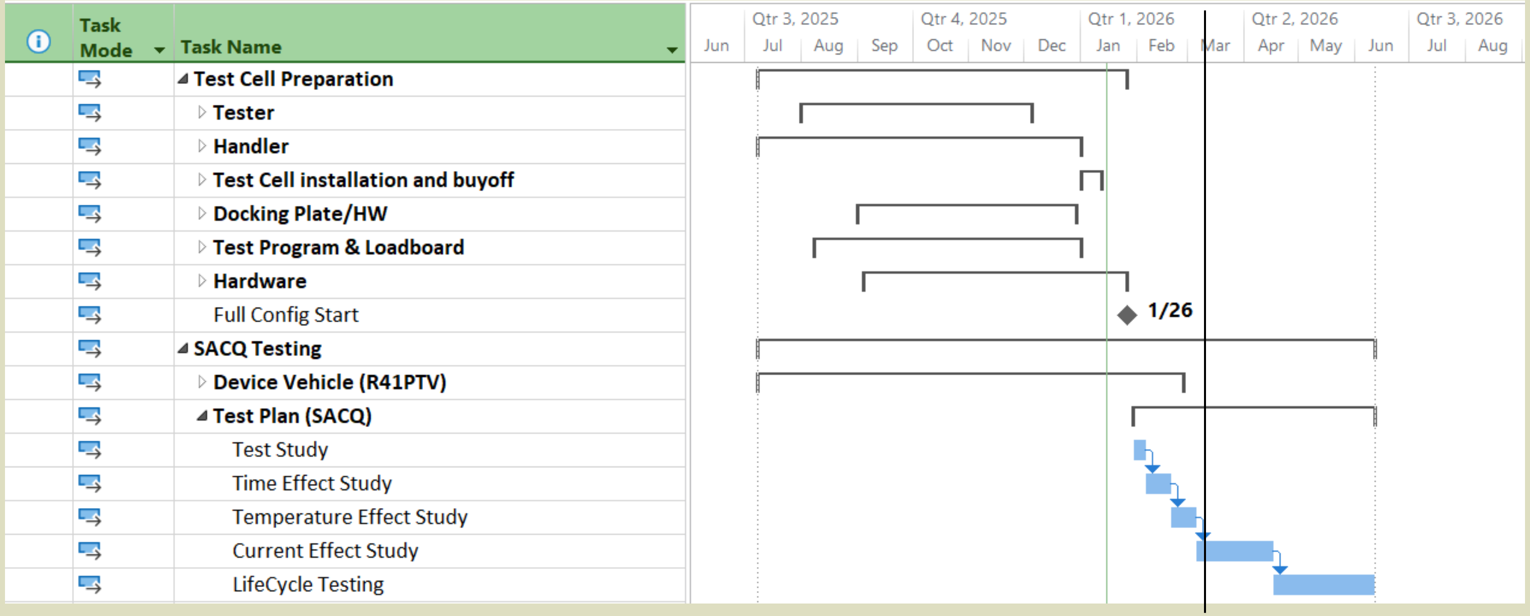


Key Findings and Conclusion

- Observations on cRes Test Cell to date (more to come)
  - Some device die connections cannot handle >500mA and can damage socket
  - Long test times (36k sec) results in stuck devices
  - Insertion count impacts cRes more than time in contact with device
  - Insertions not test time has bigger impact on Cres results
  - E probe performance shows best results up to 10000 cycles
  - Expensive and time consuming to setup a test cell!
  - Extremely valuable information can be gathered from it!
- The cRes Test Cell offers:
  - Offline experimentation and development of contactors
  - Insight to production contactor performance at temp with applied current on customer packages
  - First time right verified deliveries

Next Steps

- Complete SACQ Time, Temp, Current, Lifetime study on customer cevices
- Conclude on probe type best suited for SACQ
- Compare performance to SAC305 or Sn3.5Ag
- Define optimized cleaning recipe based on contamination rate
- Expand test matrix to additional packages and higher pin counts
- Expand Test Cell to accept turnkey loadboards



Contributions

- Cohu Handler Team (Melaka)
- Cohu Contactor and Kit Applications Team (Singapore)
- Cohu Tester Applications Team (US and Melaka)
- Tessolve Loadboard and Test Program Design Team (US and India)
- InTest Team
- Customer