ESD Protective Contactors for Optimal Test Performance

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Johnstech®

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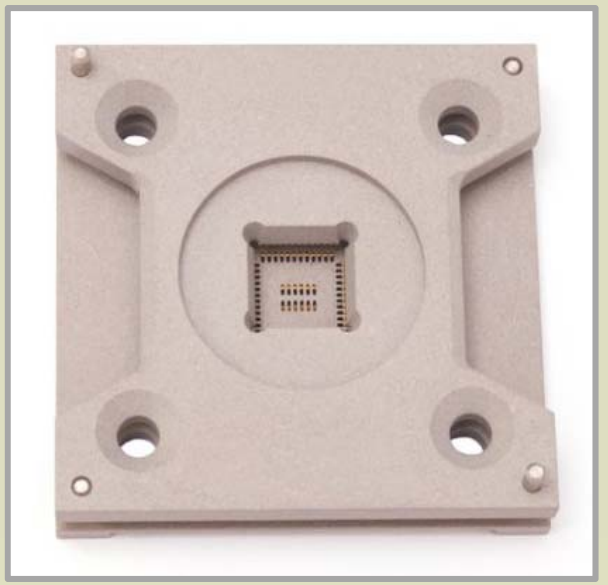
Introduction

- Management of electrostatic discharge (ESD) is a critical task in the semiconductor industry.
- Analog Devices requested Johnstech to qualify a new contactor material for ESD sensitive applications.
- This presentation describes the qualification of that material, ES-P.

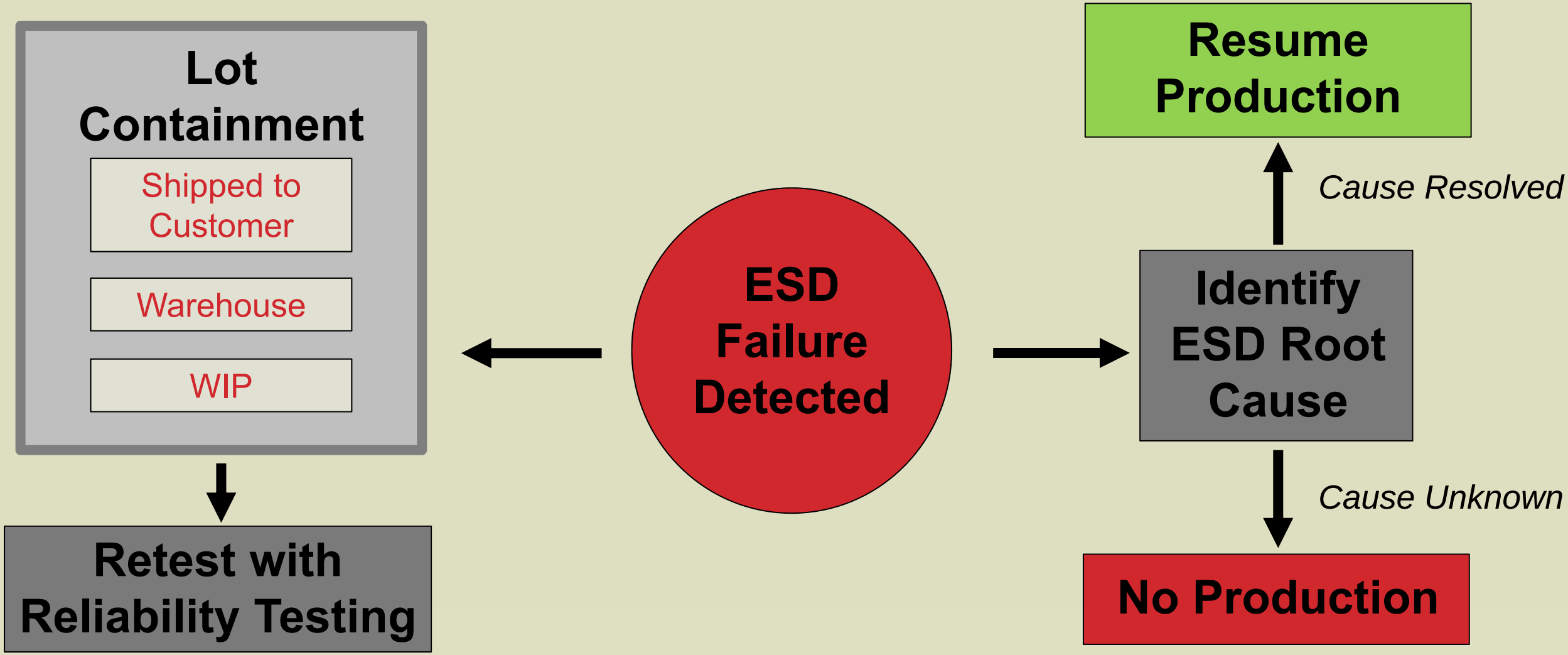
New Contactor Material



Background

- ESD is a “rapid, spontaneous transfer of electrostatic charge induced by a high electric field. Usually, the charge flows through a spark between two bodies at two different electrostatic potentials”. (ESD ADV1.0-2017)
- This rapid transfer of electricity can damage a semiconductor device depending upon its sensitivity.
- ESD events can lead to infant or latent failures and can have significant cost impact on semiconductor production.

ESD Failure Impact



ESD Failure Impact

- Determining ESD root cause is a resource heavy activity.
- Corrective actions requiring design or process changes would likely initiate a change notification process to customers.
- Prompt issue resolution is critical to avoid the following.
  - Machine operation time/costs
  - Customer shipment delays
  - Lost customer business risk

Background

- Device sensitivity to ESD can be evaluated with the Human Body Model, Machine Model, and Charged Device Model.
- For electrostatic discharge sensitive (ESDS) devices, it is important to avoid ESD events by implementing a control program to minimize risk.
- There are many industry best practices that are documented for ESD control.

Existing ESD Management Tools

- ESDS device identification informs processing and handling requirements.
- ESD Protected Areas (EPA)
  - Control temperature and humidity.
  - Use ionizers, floor mats, benches, curtains, etc.
  - Wear wrist straps, footwear, clothing, etc.
- Store parts in ESD protective packaging when outside the EPA.

Industry Trends

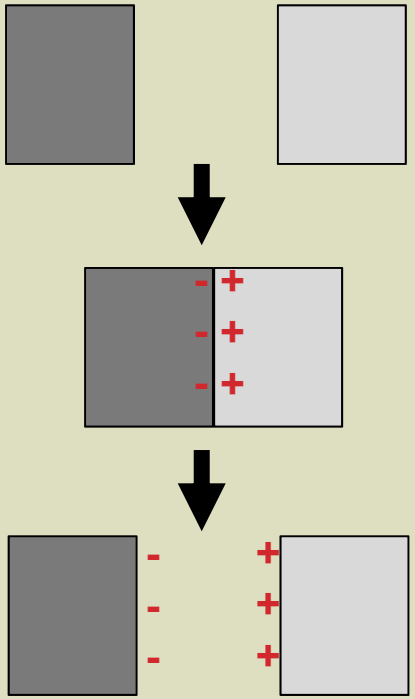
- As IC internal feature dimensions become smaller, they are more susceptible to ESD damage.
- ESD protective components can be omitted due to high performance pin requirements and size limitations.
- The ESD Association estimates the share of devices with a Human Body Model withstand voltage <500V will increase over the next 5 years.
- It is also expected that the trends will prioritize increased circuit performance over ESD protection.

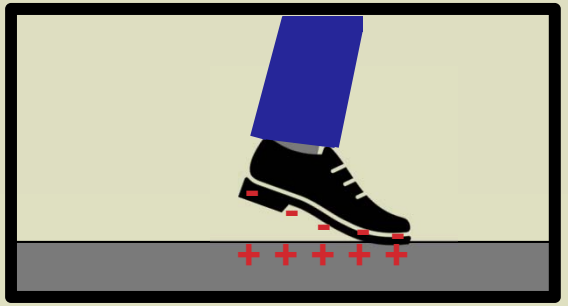
ESD Theory

- When two objects at different voltages come into proximity, charge can be rapidly transmitted between the two via electrical short or dielectric breakdown.
- The resistance of the discharging object impacts the amount of energy dissipated into the victim device.
- Conductors lead to rapid dissipation of charge due to their low resistivity.
- Therefore, it is important to ground conductors.

ESD Theory

- Charge can build up by tribo-charging, in which electrons are transferred from one body to another due to contact/separation.
- When insulators build up a charge it is stored and can discharge to another object at a lower potential.
- It is important to neutralize insulators when possible.

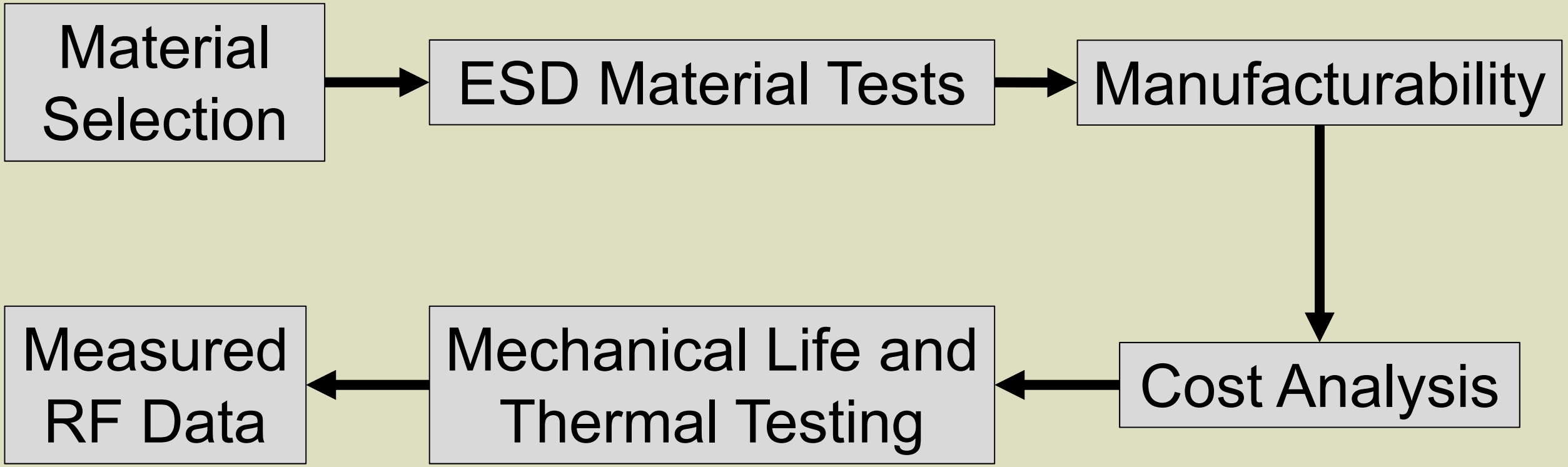




Product Requirements – New Contactor Material

- Analog had two requirements for the contactor material.
  - Surface resistivity must be >1.0E11Ω.
  - Electrostatic voltage below 100V before and after Tribo-Charging.
- Johnstech had standard contactor requirements.
  - Electrical performance requirements
  - Manufacturing requirements
  - Cost requirements
  - Mechanical/Thermal requirements
  - REACH/ROHS regulatory compliance

Johnstech Contactor Material Qualification Steps



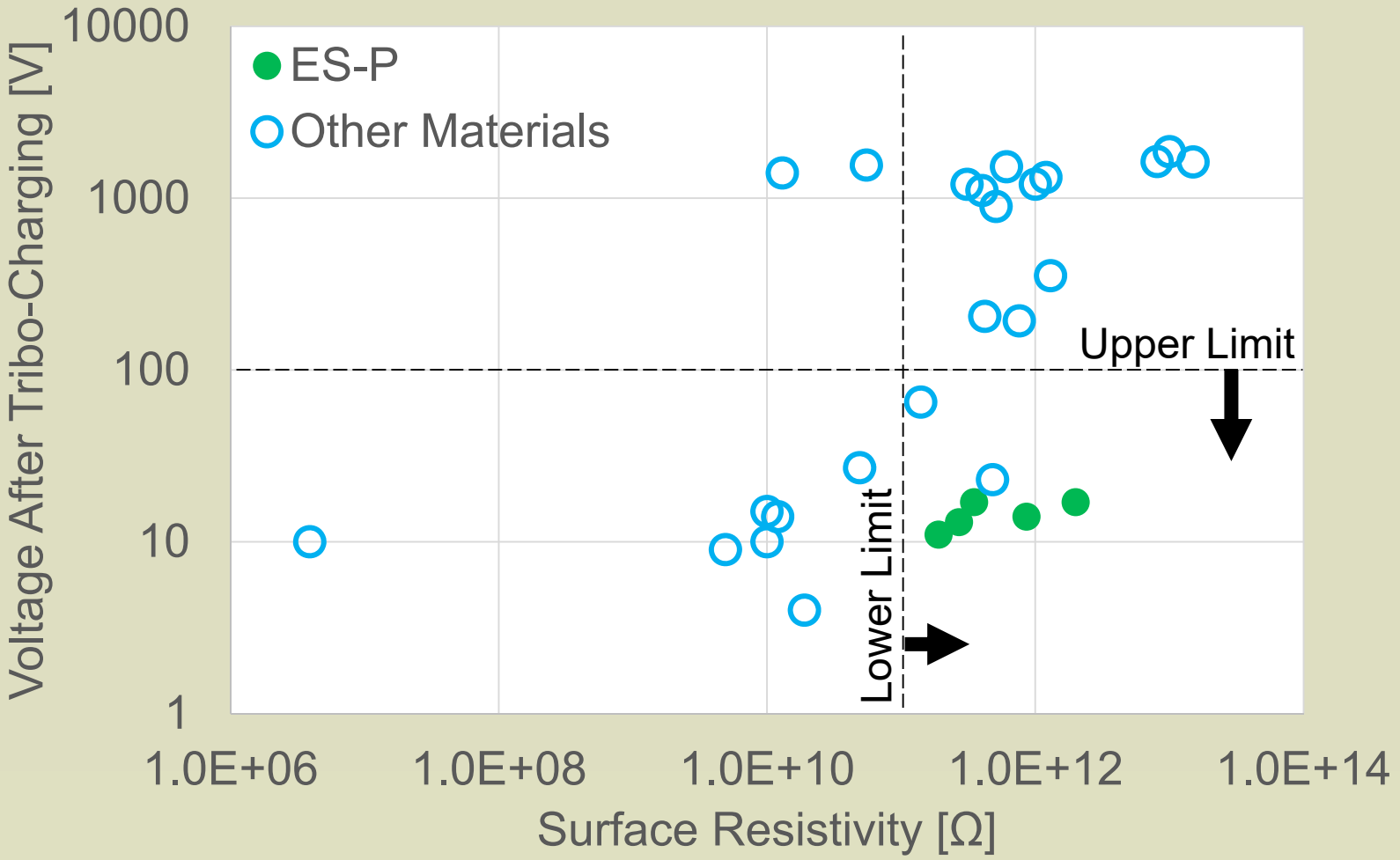
ESD Material Tests

- To evaluate material properties, Analog completed two tests to characterize material performance.
  - Surface resistivity measurement
  - Electrostatic voltage measurement before and after triboelectric charging
- Measurements were recorded with industry standard equipment.

ESD Material Tests

Materials were tested by Analog.

- Surface resistivity
- Electrostatic Voltage

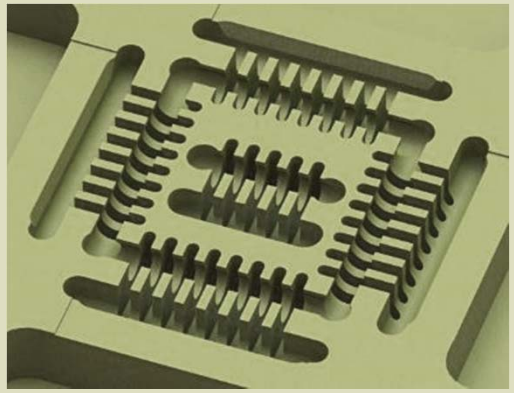


ESD Material Tests

- ES-P wasn't the only material to pass both of Analog's material tests.
- Multiple materials passed testing and were manufactured into Johnstech ROL series contactors.
- However, these alternatives ultimately failed downstream testing due to mechanical performance or processing challenges.

Manufacturing and Regulatory

- Contactor housings include many features at high aspect ratios with tight tolerances.
- ES-P required manufacturing engineering support for process optimization.
  - Machine prototype parts.
  - Define milling best practices.
  - Define deburring best practice.
- Record REACH/RoHS compliance.



REACH COMPLIANCE

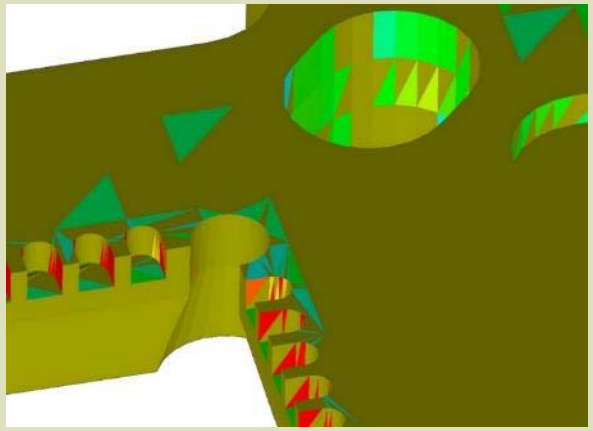
RoHS

Test Planning

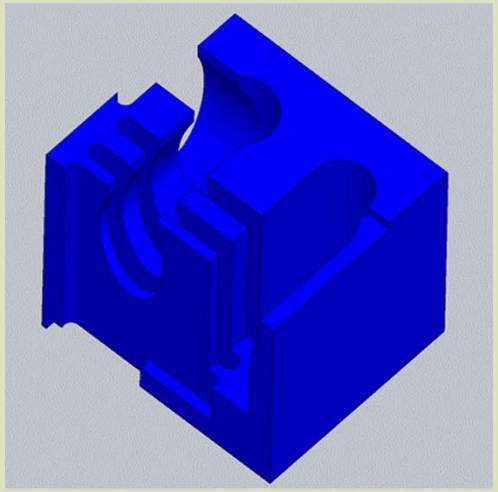
- A weighted risk analysis method was used to identify critical tests to ensure the new material met product requirements.
- For this material, tests were selected to evaluate product stiffness and wear resistance across wide temperature ranges.
- FEA simulation was also implemented to complement testing.

Mechanical Stress Simulation/Testing

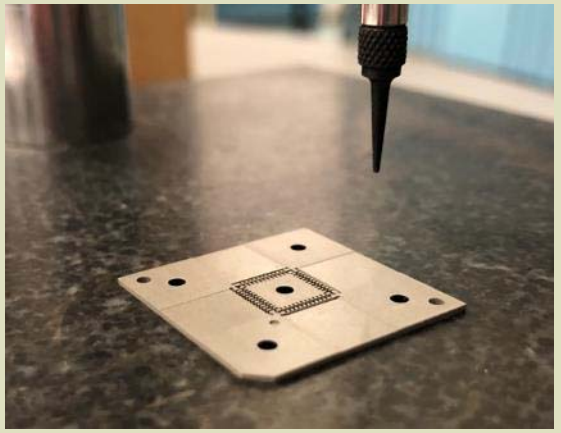
- Material strength requirements vary by application.
- About 40 different designs were evaluated with thickness analysis and high-risk features were simulated/tested.



Thickness Analysis



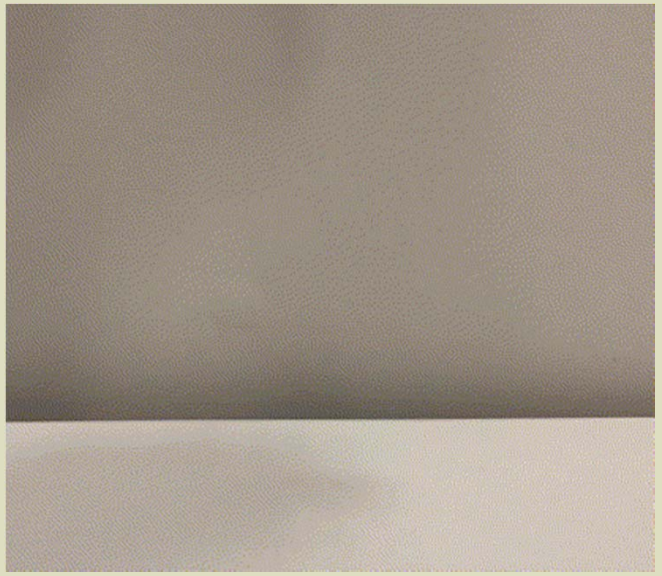
Simulation



Manufacture/Test

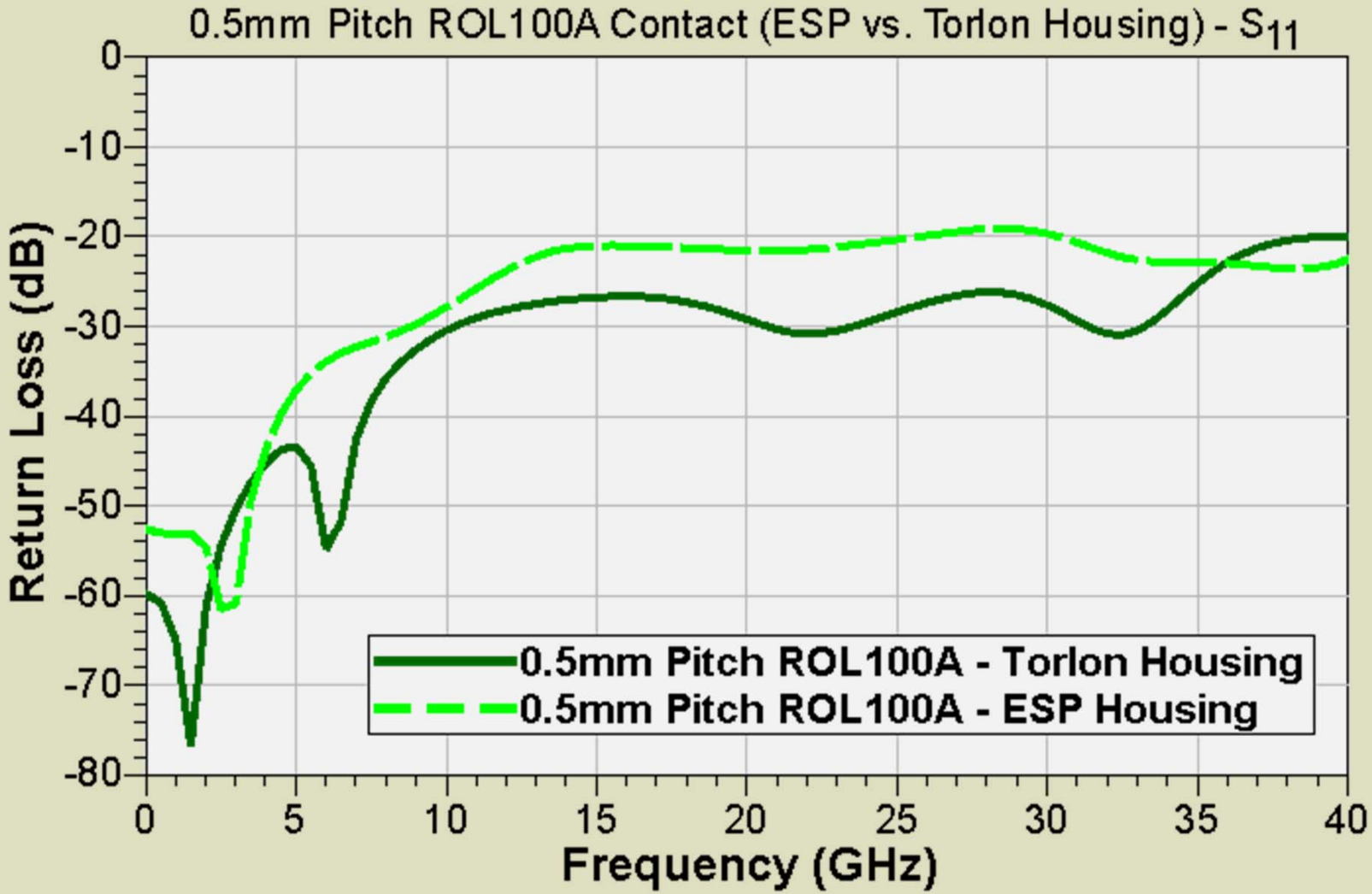
Mechanical Testing

- Mechanical performance was evaluated over tri-temperature.
  - Check housing life.
  - Check contact performance.
- Other standard product tests were also completed (e.g., bending, drop, and wear testing).
- ES-P passed all mechanical tests.

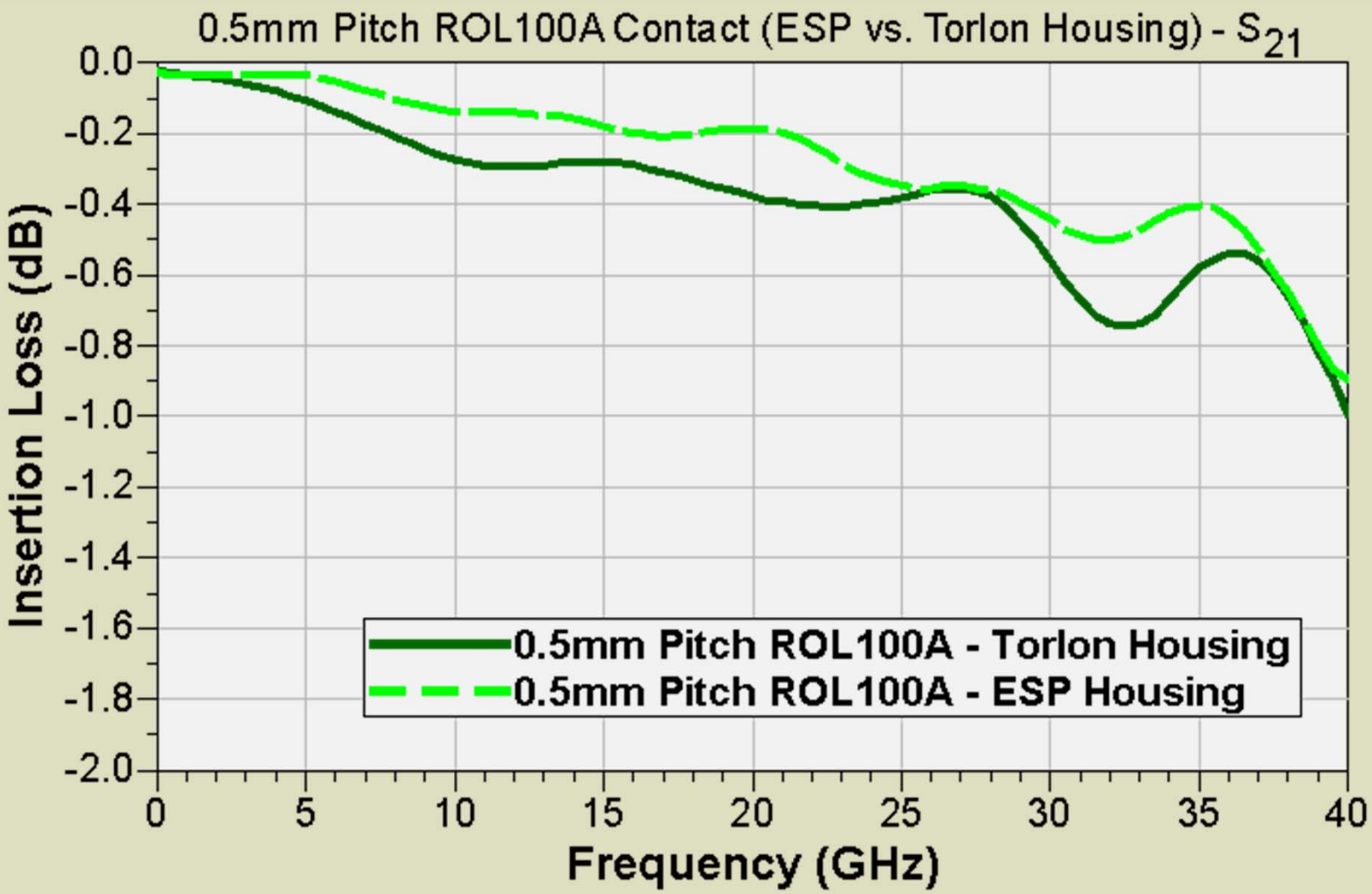


(Demonstration only)

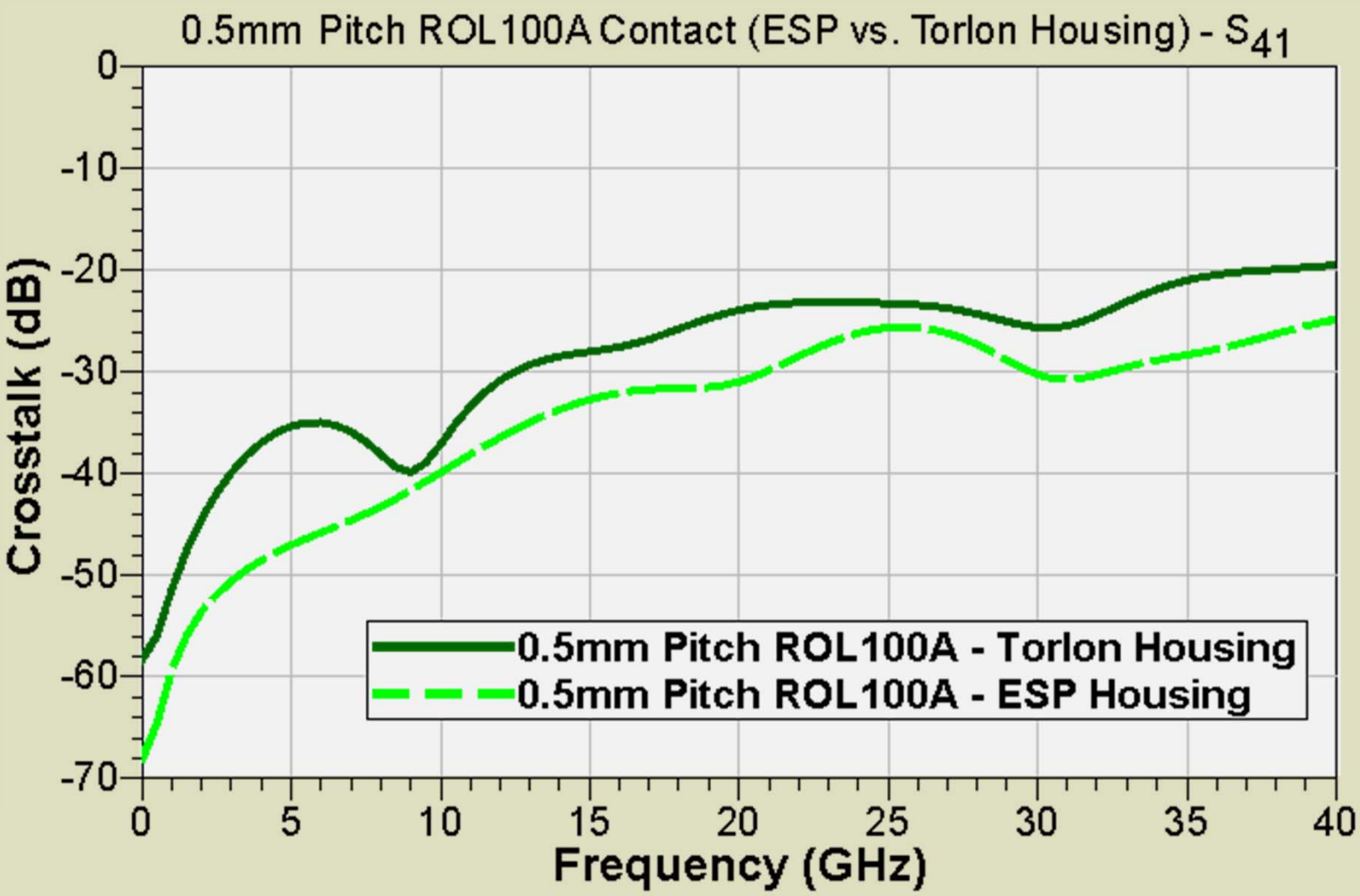
Return Loss – Measured Data



Insertion Loss – Measured Data



Crosstalk – Measured Data



ES-P Status at Analog

- ES-P has passed the following:
  - Analog's ESD test requirement.
  - Electrical correlation testing compared to standard Torlon housing material.
  - Visual mechanical qualification passed after running devices.
- High volume production fan-out expected after manufacturing validation acceptance.

ITEMS	READING	CRITERIA	RESULT
SURFACE RESISTIVITY MEASUREMENT	8.6E11 ohms	>1.0E11 ohms	PASSED
CONTACT VOLTAGE READING	WITHOUT TRIBOCHARGING: 8V	<100 V	PASSED
	WITH TRIBOCHARGING: 14V		

Conclusion

- ES-P satisfies the requirements of both Analog and Johnstech and is now ready for ESD sensitive applications.
- The mechanical and electrical test results support expanding ES-P to Johnstech product families beyond ROL100A and ROL200 in the future.

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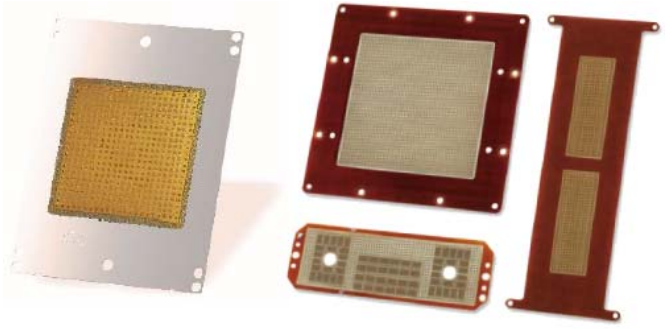
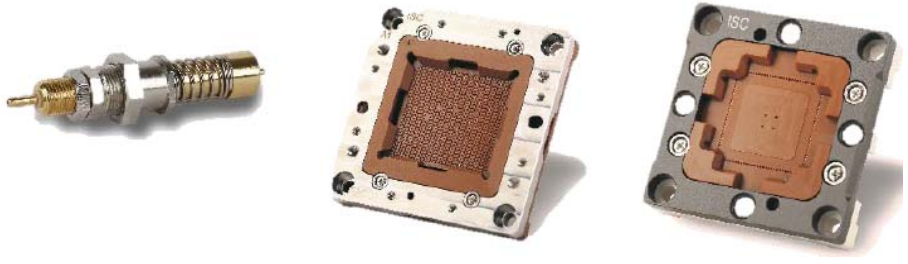


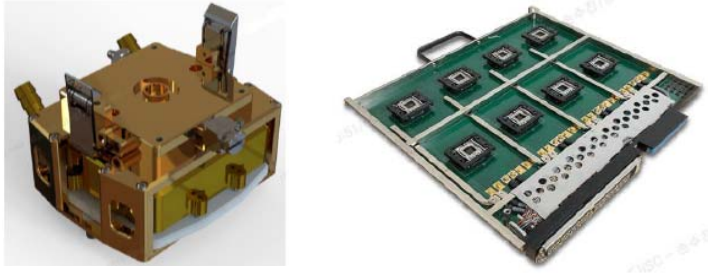
POGO SOCKET SOLUTIONS

- Excellent gap control & long lifespan
- High bandwidth & low contact resistance



THERMAL CONTROL UNIT

- Extreme active temperature control
- Safety auto shut-down temperature monitoring of the device & thermal control unit
- Full FEA analysis & Price competitiveness



BURN-IN SOLUTIONS

- Direct inserting on the board without soldering
- Higher performance BIB solution

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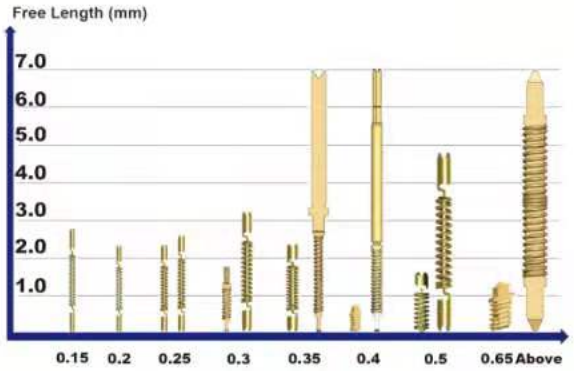
Spring probe by stamping



250 kinds of spring probe pin

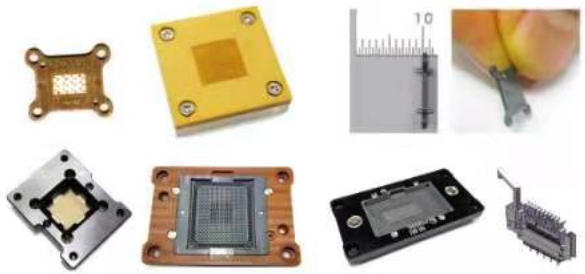
300 kinds of test socket (44,000 Pin count socket possible)

One piece spring probe

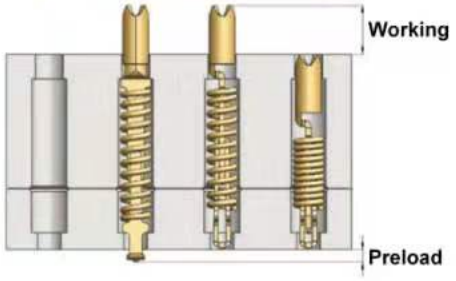
Three piece spring probe

High speed product → 0.63mm free length spring probe pin available

Finest Pitch → 0.15mm Pitch



Spring probe by stamping

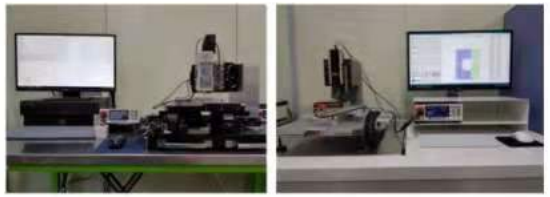


Patented

Pitch(mm)	Free Length(mm)	Current Carrying(Amps)
0.15/0.2/0.25	2.17~	0.5~
0.3	1.5~	1.5~
0.35	2.08~	1.8~
0.4	0.8~	2.5~
0.5	1.5~	3.0~
0.65	1.13~	9.0~
0.8	3.14~	3.0~

Automation

Pin assembly and Quality control



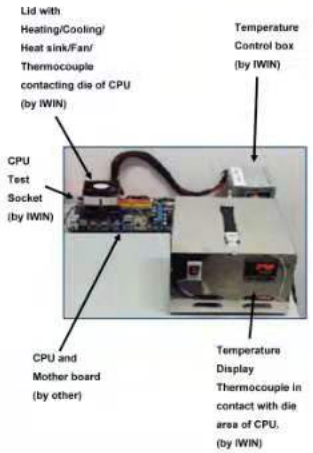
Top Figure: Socket CRES, Force, Stroke test

Bottom Figure: Data displayed

Top Figure: Socket CRES test

Bottom Figure: Data display 5,903 pins socket

Socket and Lid



Pin assembly

(Fully automated machines)

- Stamped piece parts attached to a reel fed into the assembly machine

- Assembled pins can be attached to a reel, or, supply in separate for socket assembly.

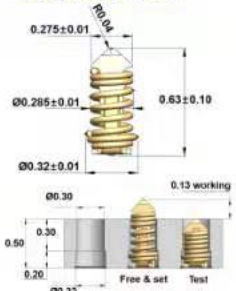
Spring probe pins for High speed

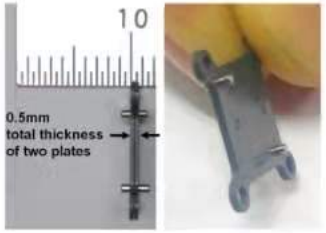
Extremely short spring probes by stamping

One piece spring probe

Three piece spring probe

Design approach





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