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Evolution of High-Performance Spring Probes

Bert Brost
Technoprobe

Virtual Event • May 3 - 7, 2021

Contents

Challenges/Opportunities

- Typical Technical Requirements (Challenges)
  - DC Electrical: Contact resistance, leakage, signal path resistance, probe current capacity, etc.
  - AC Electrical: Bandwidth, capacitance, crosstalk, rise times, etc.
  - Mechanical: Alignment, planarity, contact force, pad, bump, or ball size, pitch, layout, etc.
  - Other: Environment (temperature), pad damage, lifetime (number of touchdowns), cost, etc.

- Path forward
  - Higher power
  - Increasing I/O density
    - Pitch shrink
    - Number of I/Os
  - Higher system integration
  - Smaller devices
  - Thermal performance
  - Automated and manual test
  - Cost reduction

Measures

Mechanical

- Repeatable contact force
- Short probe length for electrical parameters
- Large over travel (plunge) compliance for reliable contact
- Long lifetime
- Effective cleaning method
- Easy to maintain

Electrical

- High bandwidth for functional tests and AC tests.
- Low noise on signal, power, and ground.
- Low resistance for DC measurements.
- High current capacity for power delivery and DC parametric tests.
- Kelvin probes for analog and mixed signal.

Micro-Composite MEMS

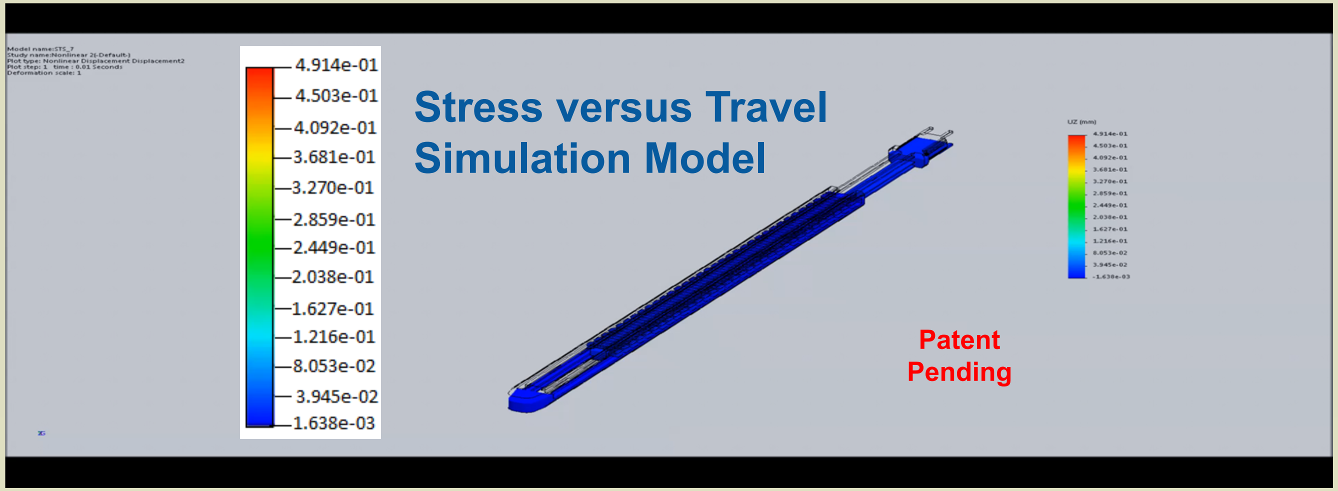
Micro Electronic Mechanical Systems

Micro-Composite MEMS Process:

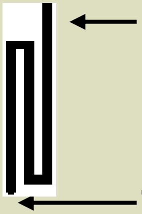
- Enables fabrication of probes for virtually any semiconductor test application.
- Produces 3D features/shapes with an additive layer build method.
- Combines multiple alloys to obtain optimal performance.
- Leverages a diverse materials pallet of both conductors and dielectrics.

Spring Stress Versus Travel

- The MEMS spring probe is a one-piece contact
  - Two-point interconnect.
  - Load board pads are not damaged by coil spring probe rotation on the load board pad. Simplicity of a buckling beam Cobra probe.
  - Force is linear, stress is linear.



Two-point contact

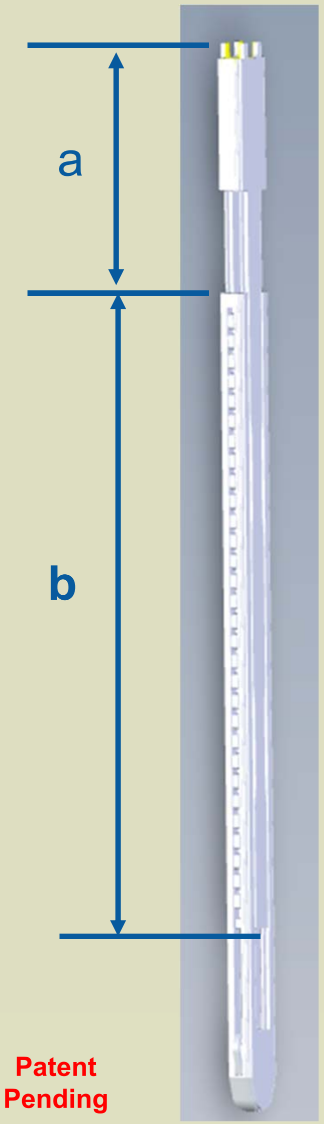


No Internal contacting surfaces

Pointing Accuracy Factors

- Pointing accuracy is defined as the radial target area in which a probe is expected to contact.
- The primary factors affecting pointing accuracy are determined by the probe design. These factors include:
  1. The extended length (a) of the plunger from the barrel.
  2. The retained length (b) of the plunger in the barrel.
  3. The working clearance between the plunger and the barrel.

- Other factors that determine pointing accuracy are the straightness of the drilled hole and the clearance between the drilled hole and the probe.
  – These factors will not affect the radial area where the probe can be expected to hit, however, these factors will shift the center point of this area.



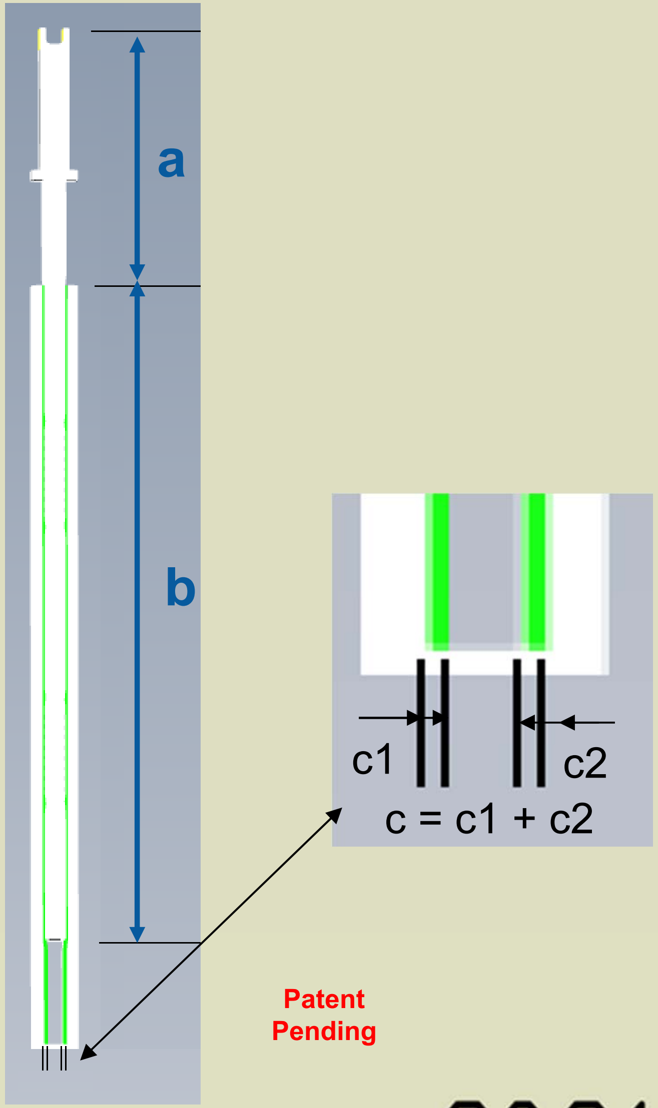
Patent Pending

Calculating Pointing Accuracy

- Pointing accuracy for most spring probes is calculated with the following formula:

$e = \frac{1}{2}c(\frac{a}{b} + .05)$ where:

  - e = pointing accuracy
  - a = extended length of the plunger
  - b = retained length of the plunger
  - c = working clearance between the plunger OD and body ID



Patent Pending

Calculating Pointing Accuracy

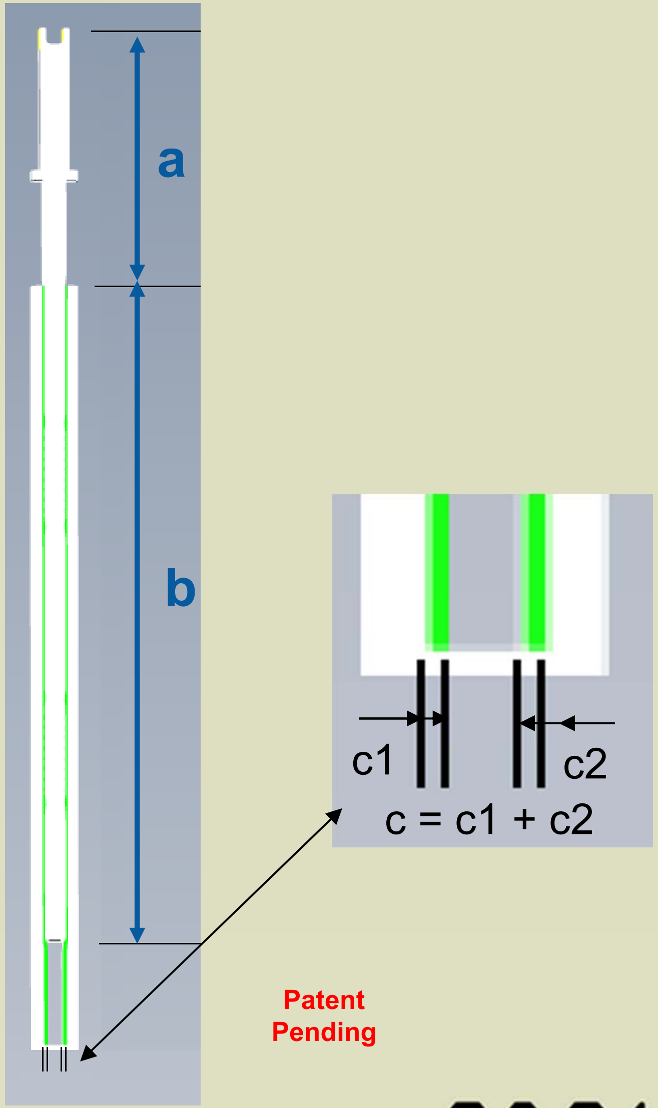
- Pointing accuracy for most spring probes is calculated with the following formula: $e = \frac{1}{2}c(\frac{a}{b} + .05)$

Description	Variable	Value
Pointing Accuracy	e	$\frac{1}{2}c(\frac{a}{b} + .05)$
Extended Length of Plunger	a	0.1mm
Retained Length of the Plunger	b	2.0mm
Working Clearance	c	0.001mm
Pointing Acracy	e	0.005mm

- The pointing accuracy e =

$$e = \frac{1}{2}(0.001)\,(\frac{1.0}{2.0} + 0.5)$$
$$e = 0.005\ * 1.0$$
$$e = 0.005mm$$

Values are for example only

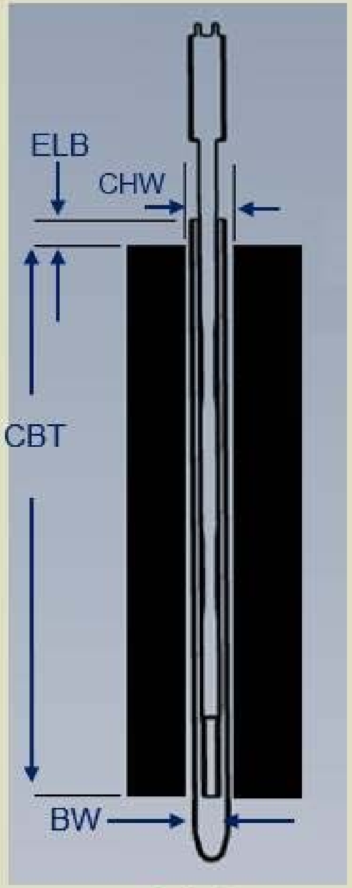


Probe/Receptacle Concentricity

Probe/Receptacle Concentricity
The probe/receptacle concentricity is defined as the offset or angle which occurs when the probe rests inside the body. The factors influencing pointing accuracy include:

- ELB: Extended Length of the Probe Body
- CHW: Contactor Hole Width
- CBT: Contactor Body Thickness
- BW: Body Width

Side View

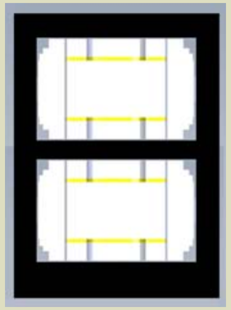


Patent Pending

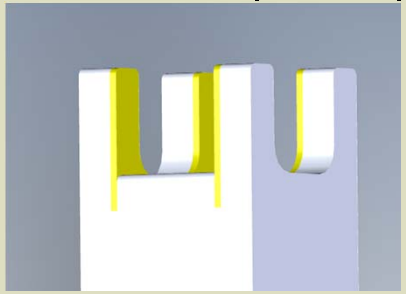
Repeatable Probe Alignment/Setup

- The rotation of round probes in round holes makes repeatable optical prober registration difficult.
- Rectangular probes in rectangular holes do not rotate.
- Rectangular probes in rectangular holes makes it easier for the prober to determine probe tip position (origin(X,Y)).

Illustrated top view of two MEMS probed in a probe head

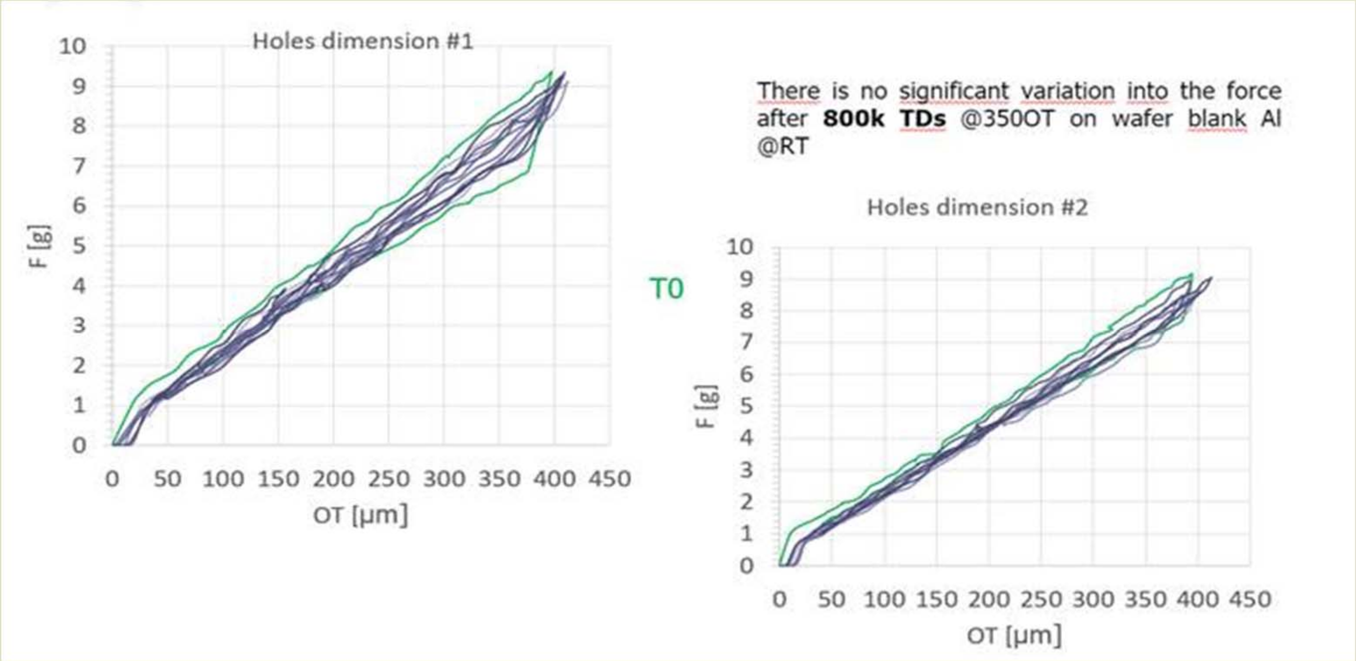


Illustrated view of a four-point crown MEMS probe tip

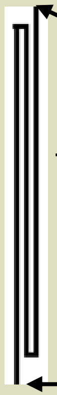


Patent Pending

Spring Pin Force and Deflection



Two-point contact



DUT Side Contact

Two-point uninterrupted current flow path

Mechanically, this is an on-center spring probe

Test Interface Board Contact

Patent Pending

- MEMS Serpentine Contact force vs. deflection is a linear relationship; as shown above.
- Fine pitch MEMS probes serpentine spring operates in the expansion mode when the tip is pushed into the body of the probe.

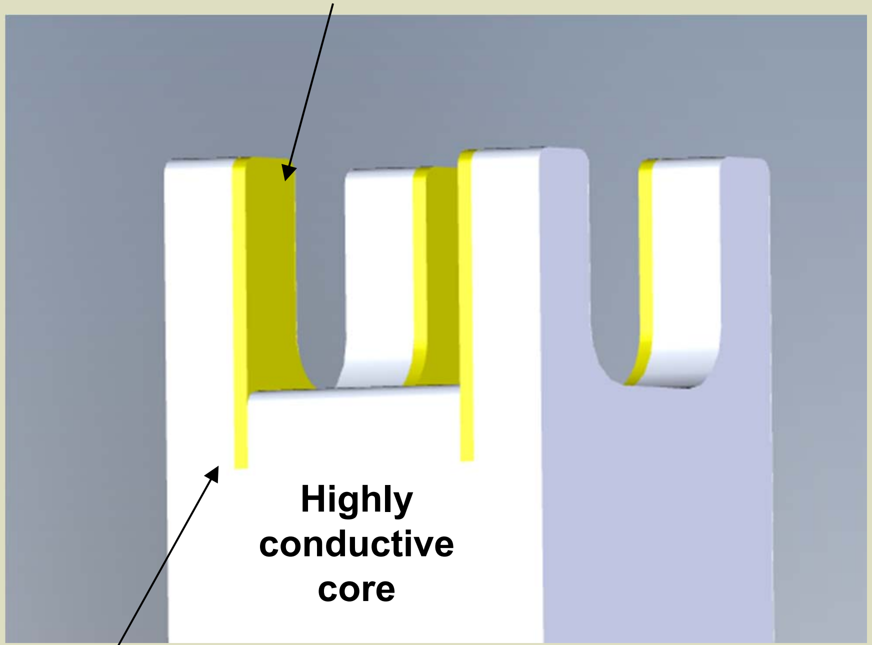
MEMS Tip Alloys

MEMS Plunger Tip

- Produced using the additive MEMS layering process.
  - Application specific materials.
- No sacrificial plating wears off due to use and cleaning.
- Continues surface to surface low Cres at the device-under-test.
- Homogenies MEMS will not bond with solder.

Three Dimensional Layers

Hard, homogenous tip alloy



Additive layer build up process to produce any 3D features/shapes while combining multiple alloys to obtain optimal performance

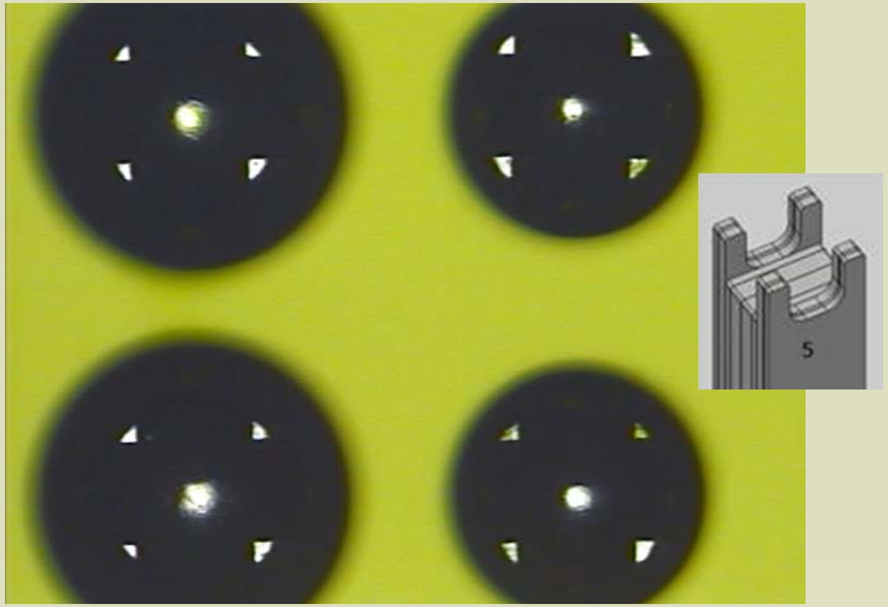
Contacted Solder Ball Witness Marks

Repeatable Probe Alignment

- 1 Touchdown

  Contacted Bumps

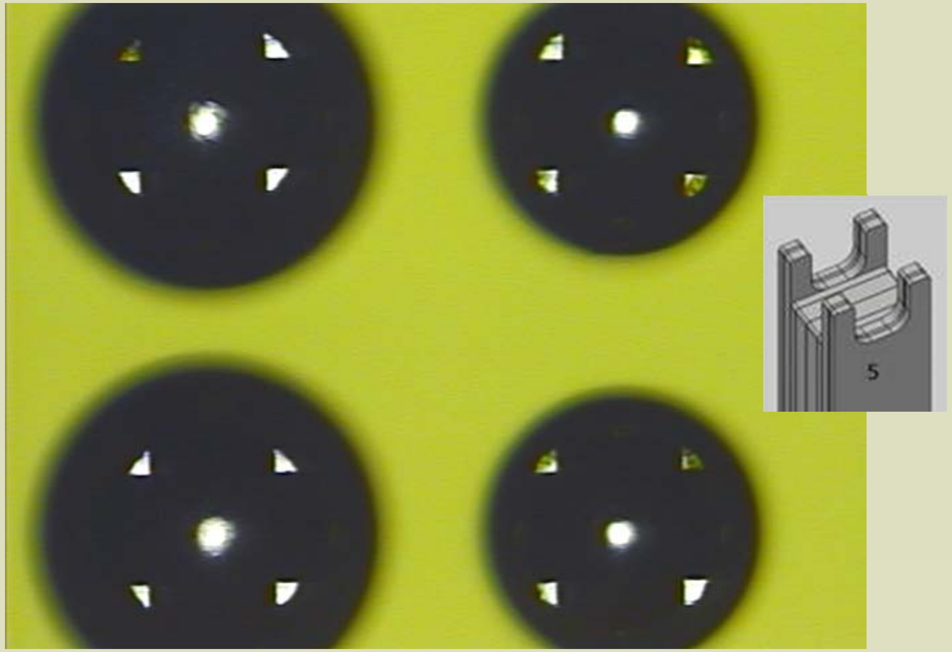
  Ø250µm Ø200µm



- 5 Touchdowns

  Contacted Bumps

  Ø250µm Ø200µm



Conclusion

- We live at a time of technological change that is unprecedented in its pace, scope, and depth of impact.
- MEMS opens exciting possibilities for the advancement of spring probe design, manufacture, and usage in WLSCP fine pitch and other test interconnect applications.
- Innovative work will continue to make this technology an increasingly effective means for increasing throughput at a lower cost in semiconductor test.

Contributors

- Arun Veeramani - Microfabrica
- Emanuele Bertarelli – Technoprobe
- Giulia Repossini – Technoprobe
- Mike Dang – Technoprobe
- Ming-Ting Wu – Microfabrica
- Nadia Paderno - Technoprobe
- Shaun Tran - Technoprobe

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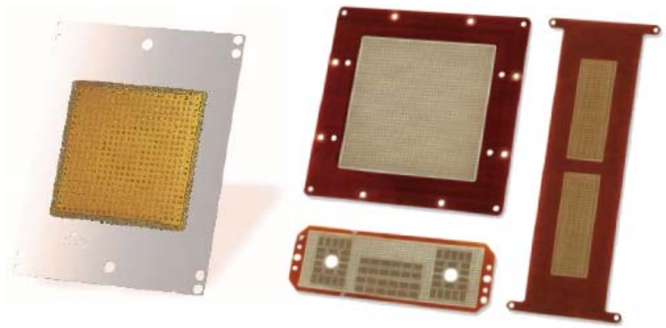
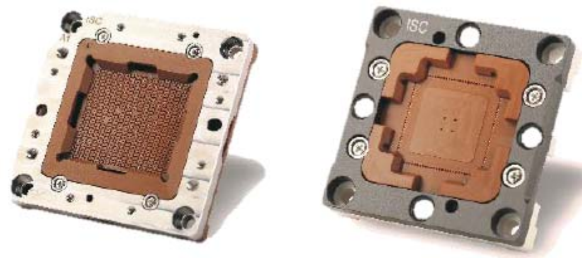


- High performance and competitive price
- High speed & RF device capability
- Various customized design to meet challenge requirement

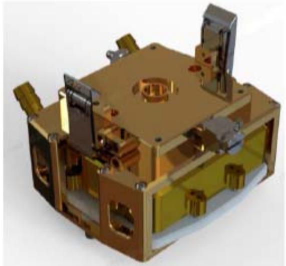
POGO SOCKET SOLUTIONS



- 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

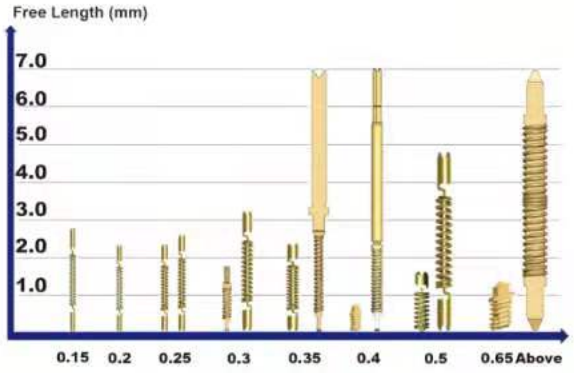
- Direct inserting on the board without soldering
- Higher performance BIB solution

CONTACT
ISC CO., LTD

ISC HQ	ISC International	Tel: +82-31-777-7675 / Fax: +82-31-777-7699
Seong-nam, Korea	Silicon-valley, CA	Email: sales@isc21.kr / Web: www.isc21.kr

IWIN Co., Ltd. The test probe for high signal integrity at extremely high speed test

Spring probe by stamping



250 kinds of spring probe pin

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

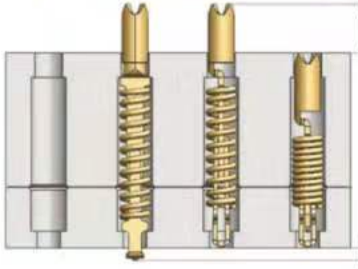
One piece spring probe

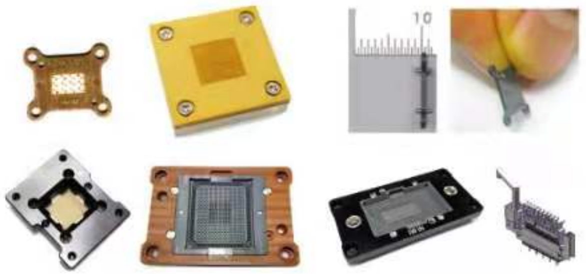
Three piece spring probe

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

Finest Pitch → 0.15mm Pitch

Spring probe by stamping



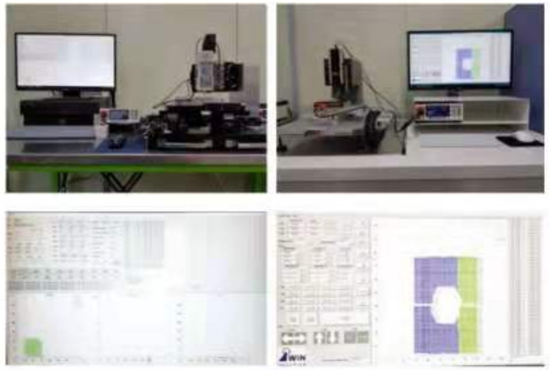


Patented

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

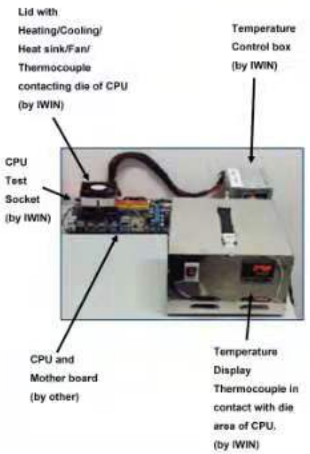
Pin assembly and Quality control



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.

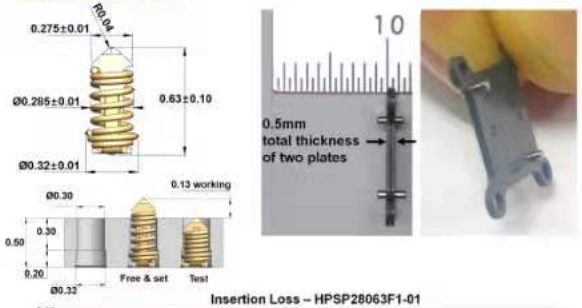
Spring probe pins for High speed

Extremely short spring probes by stamping

One piece spring probe

Three piece spring probe

Design approach



Homepage. www.iwinsn.com Tel. +82-10-6417-7580 E-mail. aj@iwinsn.com

High Performance Probe solution

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