EIGHTEENTH ANNUAL
BiTS
TM
Burn-in & Test Strategies Workshop
March 5 - 8, 2017
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive – Session 2
© 2017 BiTS Workshop – Image: tonda / iStock

Copyright Notice

Session 2
Jason Mroczkowski
Session Chair

BiTS Workshop 2017 Schedule

Performance Day

Monday March 6 - 1:30 pm

Performance Prediction

"Coaxial Test Socket - Evolution & Optimization"
Frank Zhou - Smiths Connectors

"100G Testing Fixture Design and Verification"
Jackie Luo - Shanghai Zenfocus Semi-Tech

"Inductance Rise Due To Plating"
Gert Hohenwarter - GateWave Northern, Inc.

"Spring probe current-carrying capacity (continuous vs pulse) analysis and improvement"
Yuanjun Shi - TwinSolution Technology Ltd

Coaxial Test Socket

- Evolution & Optimization

Jiachun Zhou (Frank), Dexian Liu
Nhon Huynh, Kevin DeFord
Smiths Interconnect

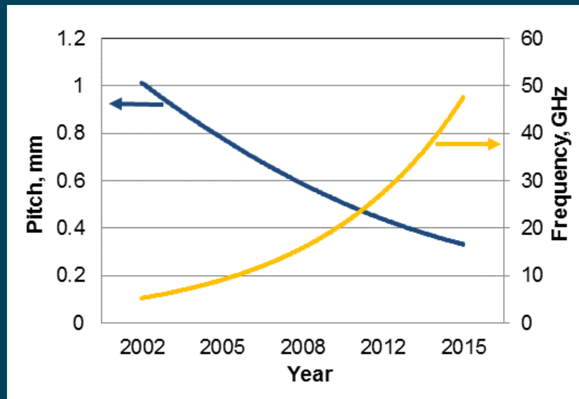
BiTS Workshop
March 5 - 8, 2017

Contents

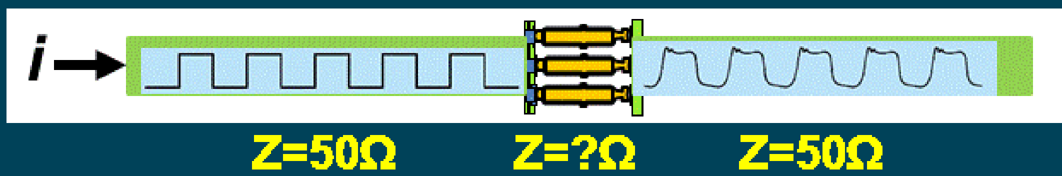
- Why Coaxial Connector Sockets?
- Coaxial Connector Basics
- Major Challenges in Coaxial Socket
- Coaxial Socket Evolution
- Performance Comparison & Continuous Improvements
- Summary

Why Coaxial Connector Sockets?

- Digital world moves to higher frequencies

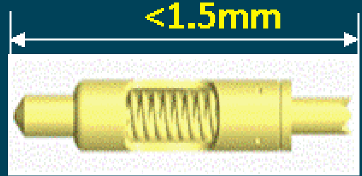


- Interconnects impact signal propagation significantly due to impedance mismatch by connector materials & mechanical structures

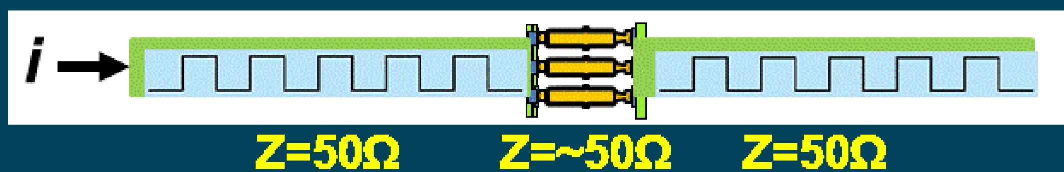


Connectors for High Frequency IC Test

- Shorter connectors, such as conductive elastomer
  - Limited compliance (mostly <0.20mm)
  - High force
  - Manufacturing complexity



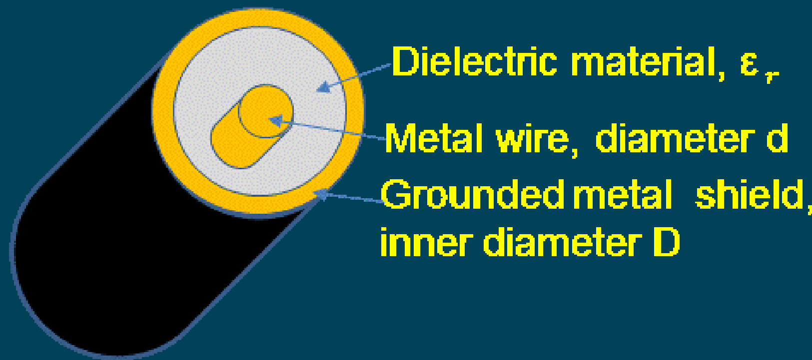
- Coaxial structure to control impedance
  - Long spring probe with more compliance (~0.5mm)
  - More reliable contact



Coaxial Structure Basics

- Impedance of typical coaxial cable

$$Z_o = \frac{138}{\sqrt{\varepsilon_r}} \log_{10} \frac{D}{d}$$



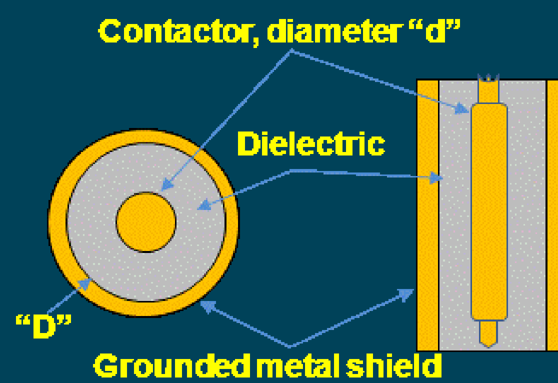
Where:

Z_0: Impedance

D: Inner diameter of grounded metal shield

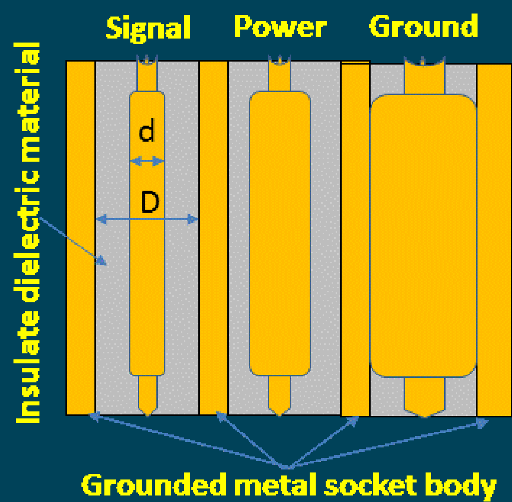
d: Diameter of metal conductor or wire

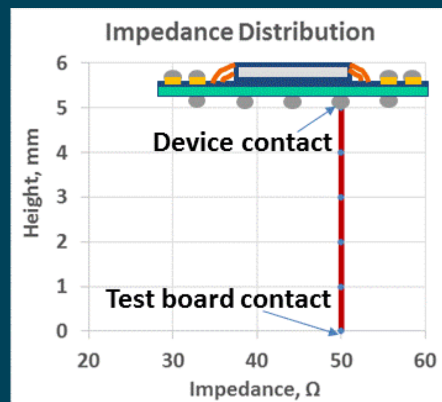
ε_r: Relative dielectric constant of insulator



Coaxial Structure Basics

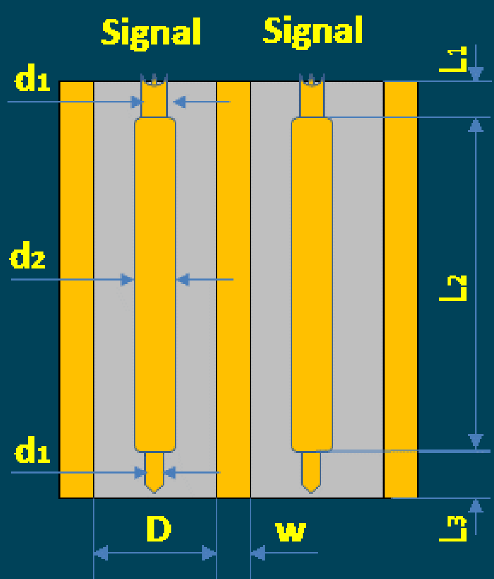
- Coaxial socket structure
  - Probes: signal, power, ground
  - Socket body: metal as conductive shield being grounded
  - Insulate dielectric material in cavities to avoid shortage of signal and power pins to grounded body
  - Diameters of signal pin & its cavity in socket body follows impedance formula
- Coaxial socket idea performance
  - Impedance match to IC package & test board
  - Perfect uniform impedance distribution between contacts from device to board

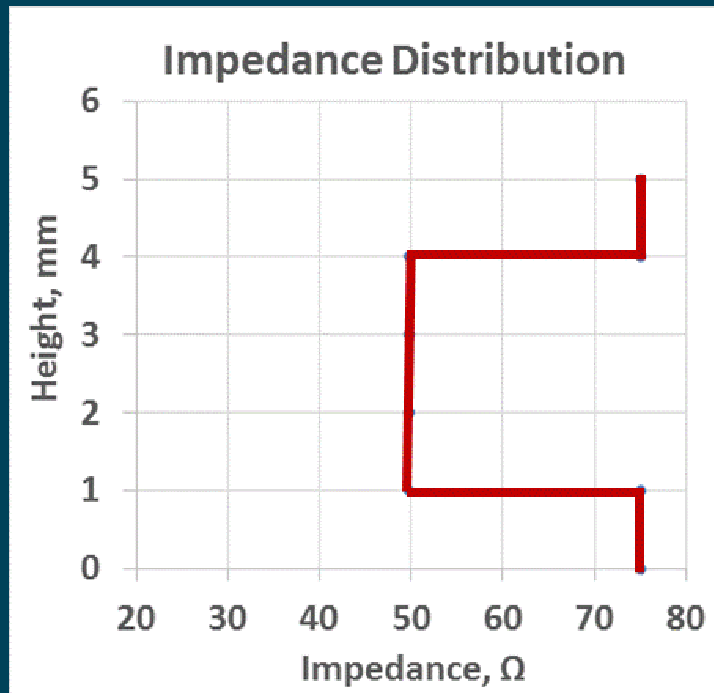




Coaxial Structure Challenges

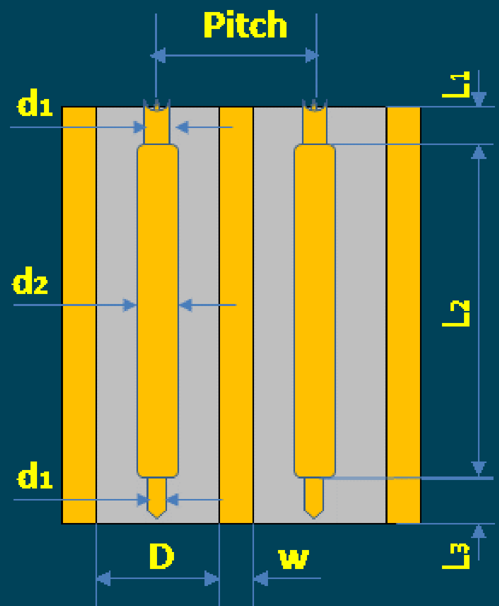
- Impedance, Z_o, variations along signal pin
  - Signal probe diameter variation, plunger vs barrel
  - Cavity inner diameter variation due to probe holding feature

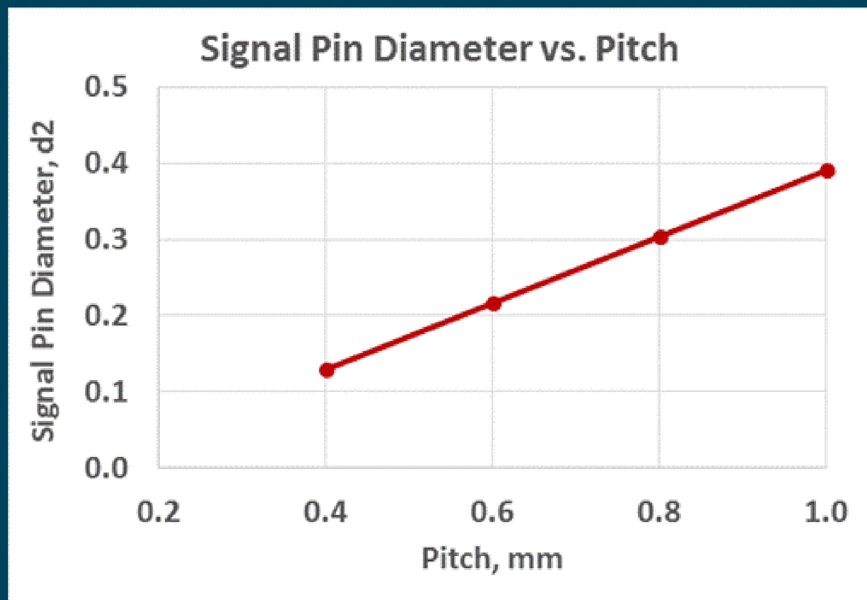




Coaxial Structure Challenges

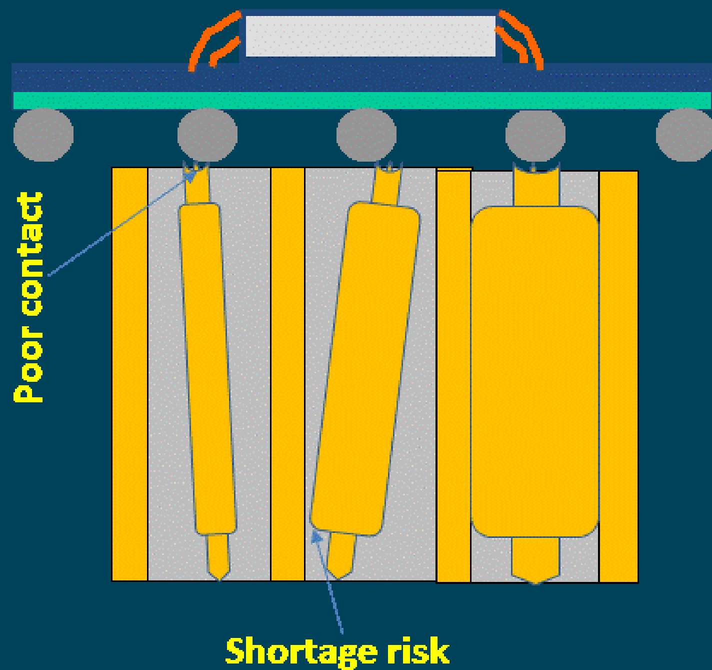
- Smaller signal pin diameter as pitch is reduced
  - Low force or long probe causes higher contact resistance (Cres)
  - More difficulties in probe manufacturing
  - More complex signal/power probe retention features in socket





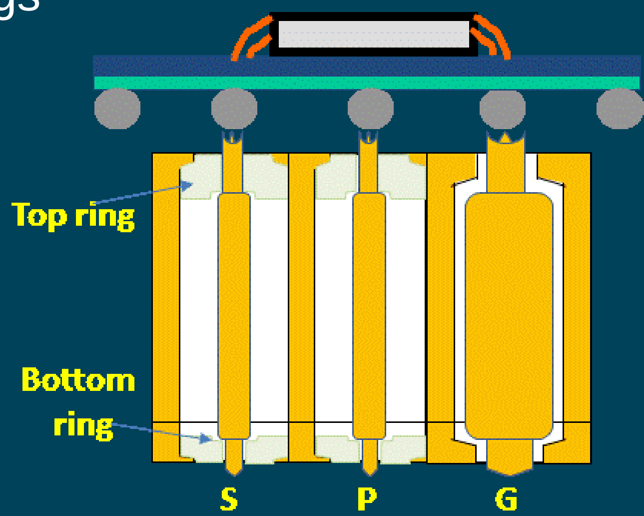
Coaxial Structure Challenges

- More challenges encountered in coaxial socket design
  - Reliable signal & power probe holding features in socket cavities to avoid any shortage to grounded socket metal body
  - Manufacturing and maintenance feasibility of small signal probes in their socket cavities
  - Keeping signal & power probes in the cavity centers to ensure reliable contacts to IC device
  - Ensuring socket body is grounded



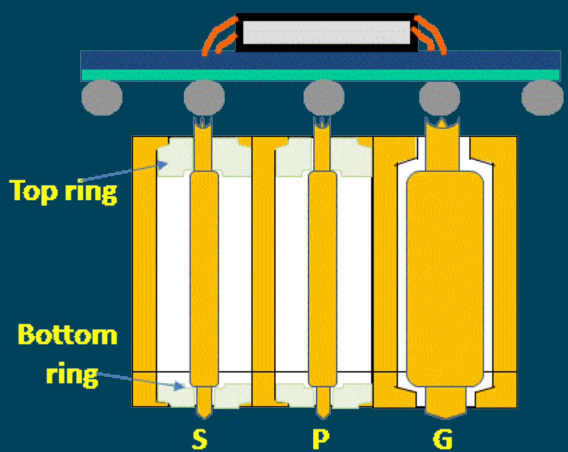
Coaxial Socket Evolution: G1

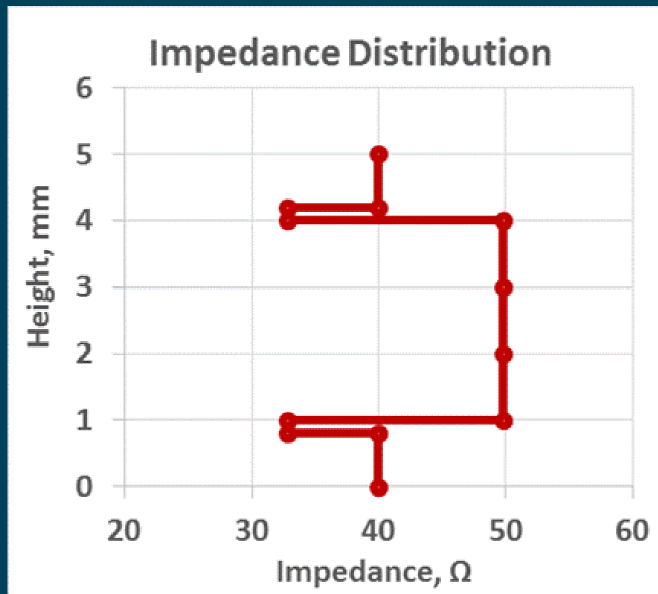
- Coaxial socket G1 basic structure
  - Most section in signal pin with ideal coaxial structure with air as dielectric ($\varepsilon_r = 1.0$)
  - Small rings on top/bottom to hold signal & power pins
  - Rings in compressive fitting into cavities (socket body & retainer)
  - Same probes for signal & power
  - Low dielectric constant material with proper mechanical properties for holding rings



Coaxial Socket Evolution: G1

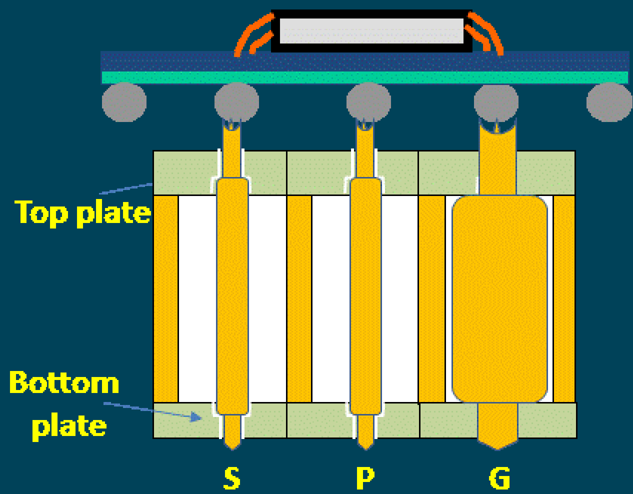
- Coaxial socket G1 performance & weakness
  - Most section in signal pin, Z_o = 50Ω impedance
  - Impedance variations in probe holding sections
  - Special process/fixture used in socket assembly/maintenance
  - Ring material impacts on Z_o
  - Two different probes in socket
  - Small rings for better Z_o distribution

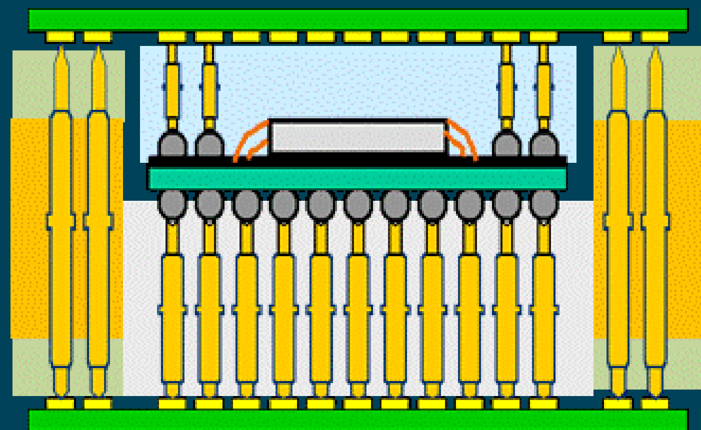




Coaxial Socket Evolution: G2

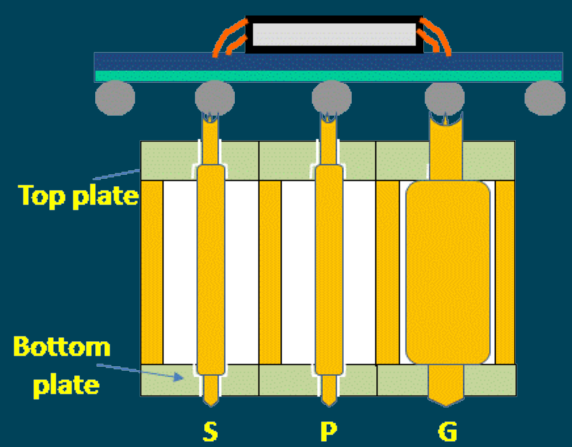
- Coaxial socket G2 structure
  - Sandwich structures with top/bottom to hold signal/power probe
  - Top/bottom plates by dielectric materials (general socket materials)
  - Feasible in HVM
  - Package on Package (PoP) socket return structure (long electric path) with G2 coaxial structure

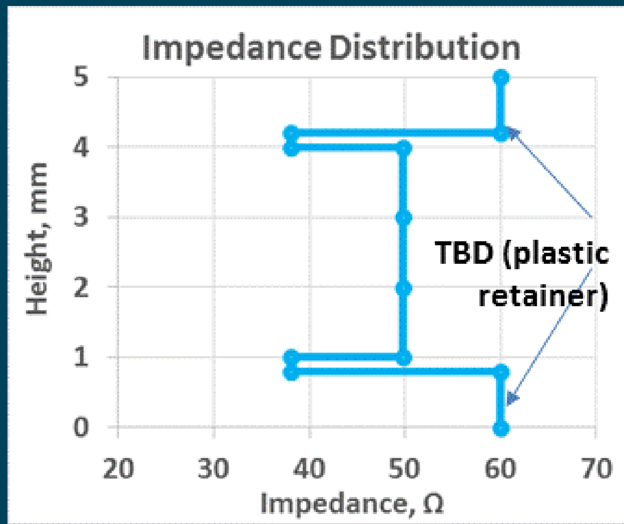




Coaxial Socket Evolution: G2

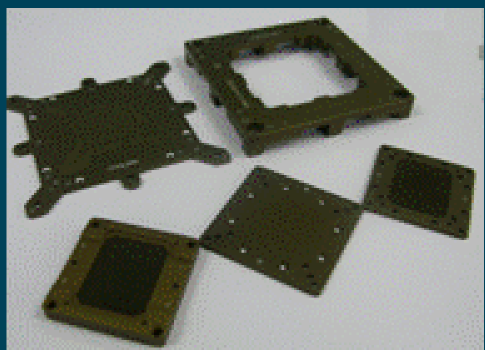
- Coaxial socket G2 performance, application & weakness
  - Top/bottom plates impacts on Z_o distributions
  - Top/bottom section impedances calculation same as general sockets
  - Signal/power pins mechanically more stable and reliable contact with devices
  - Concerns of electric shortage

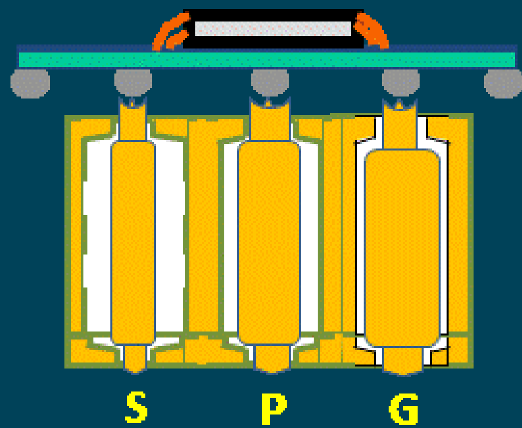


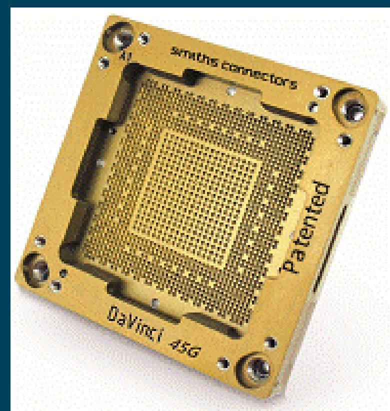


Coaxial Socket Evolution: G3

- Coaxial socket G3 (patented technologies)
  - Surface coated metal as socket body (IM material)
  - Special signal pin holding structures inside socket cavities
  - Same structure of power and ground probe

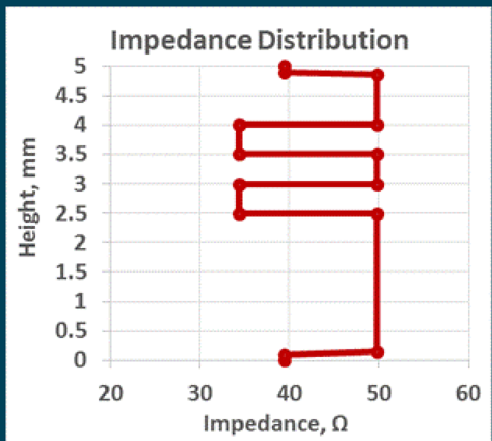


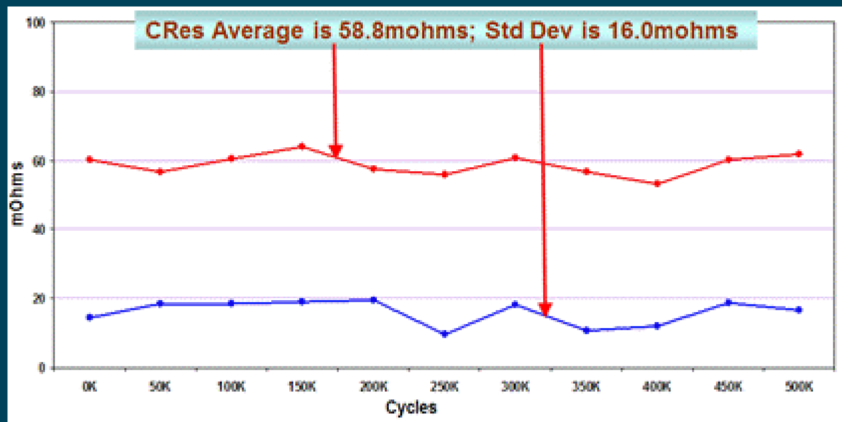




Coaxial Socket Evolution: G3

- Coaxial socket G3 performance, application & weakness
  - Avoid electric shortage of signal & power probe to grounded socket
  - Holding feature to ensure signal pin mechanical stability
  - More reliable contacts with device by much better alignment of signal/power probes to device
  - More uniform impedance distributions
  - Signal pins with low Cres
  - More reliable grounding of socket body

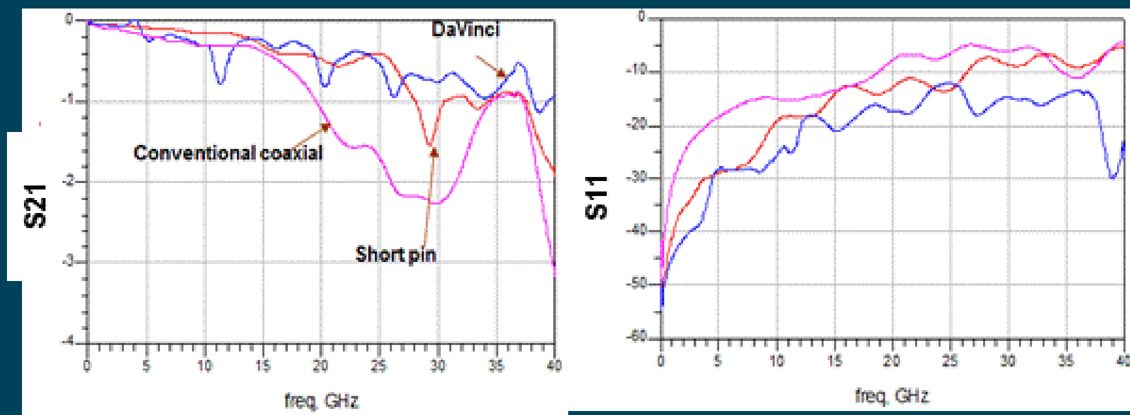




Coaxial Socket Evolution: G3

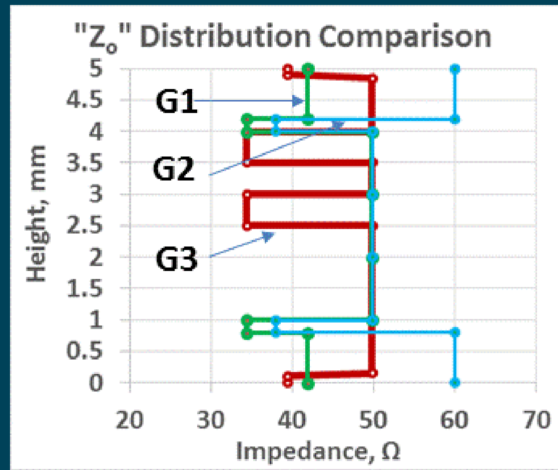
- Coaxial socket G3 performance, application & weakness
  - Improved signal integrity performance as in charts and table below:

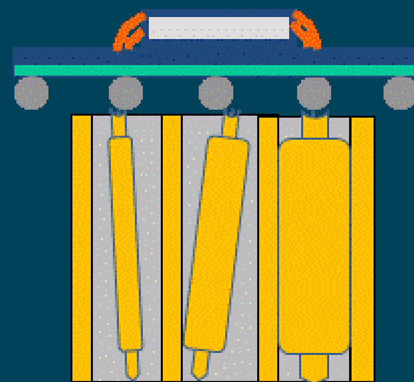
	IL, -1.0dB	RL, -10dB
DaVinci	>40GHz	>40GHz
Short pin: 2.15mm length	27GHz	27GHz
Conventional coaxial	19GHz	18GHz



Coaxial Socket Comparison & Continuous Improvements

- Impedance comparison
  - G1 has more uniform impedance
  - G3 is better than G2
- Mechanical stability
  - G3 is better than others in probe stability
  - G2 is better than G1
- Electric shortage
  - G3 socket avoid the electric shortage risk
- Continuous improvements
  - Improve probe holding structure to achieve more uniform impedance distributions
  - Coaxial structure in small pitch





Summary

- Coaxial structure has been successfully applied in test sockets through two decades' development
- Major challenges in coaxial sockets:
  - Keep uniform impedance distributions in complex mechanical structures
  - Proper structure to avoid electric shortage of signal/power probes
  - Retaining signal probe to ensure its mechanical stability
- Sandwich coaxial socket has weakness in RF performance in two holding plates
- Two major improvements in 3rd generation coaxial socket with patented technologies

*** Some information originally published in January-February 2017 issue of "Chip Scale Review"**