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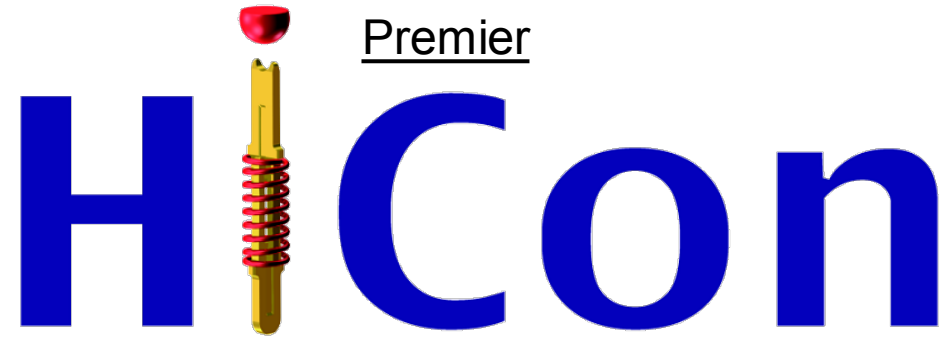
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3D MEMS Coaxial Structure for 0.6mm Pitch High Speed Connector up to 60GHz

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Introduction of Coaxial Theory

▪ Concept of Co-axial Probe

- Coaxial transmission geometry (outer ground shield) conductor forms a shield preventing external magnetic-field from crosstalk.
- The probe is composed of a core signal, an outer ground shield, and a dielectric material - polydimethylsiloxane ($\epsilon_r = 2.63$), (normally called PDMS or silicone rubber)
- High quality signal for high frequency due to the well-defined signal impedance.
- The shielding and specific dielectric keep the core signal separated to promote good impedance matching that results in the high signal quality.

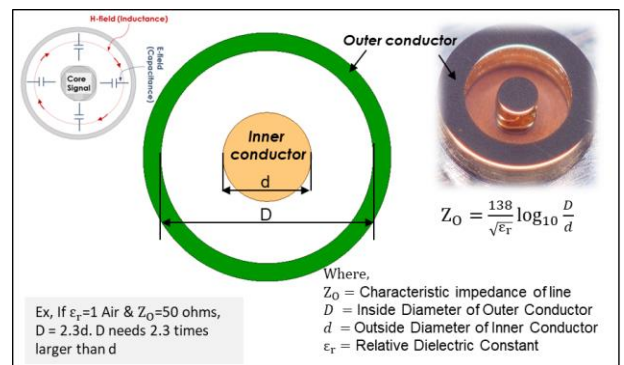


Fig1. Coaxial Impedance Theory

▪ The Design of 3D MEMS Co-axial Structure

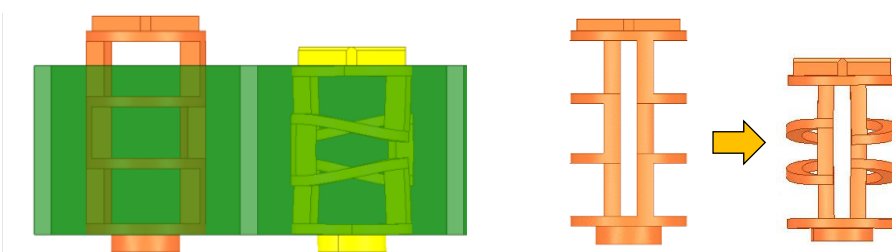
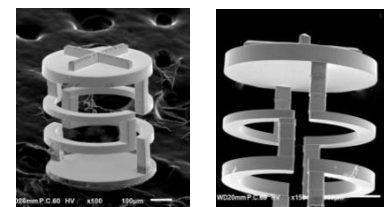
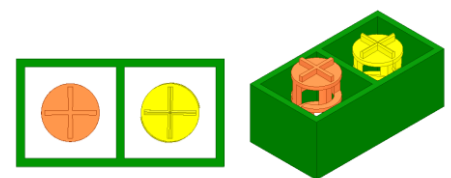
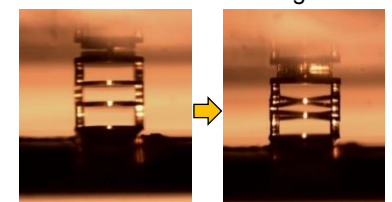


Fig2. Coaxial Probe Structure (normal vs compression)

- Coaxial probe stroke up to 150um
- 0.6mm pitch probe with square shaped outer shield
- Stable position with compression



*Structure SEM Images



*Structure Compression

Mechanical Characterizations

Low Level Contact Resistance (LLCR)

- LLCR Measurement Setup
- Input - Output (PCB1-DUT- PCB2)
- MEMS Probe connectivity

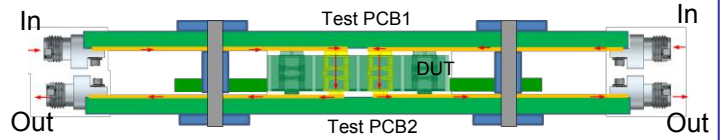


Fig3. LLCR test concept assembly

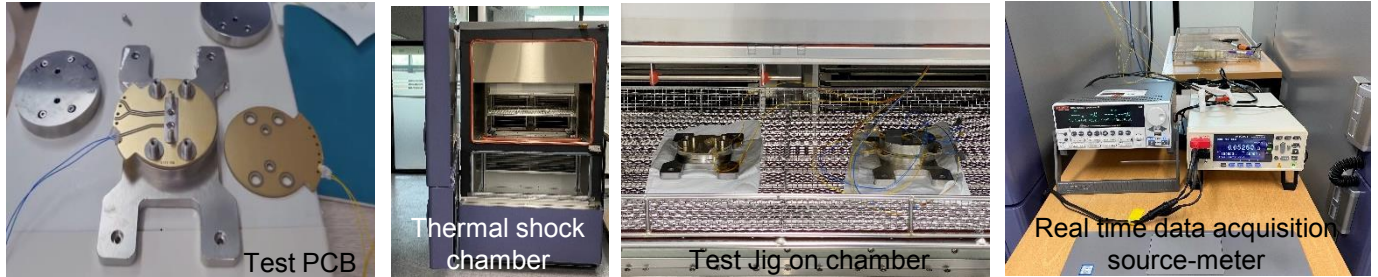
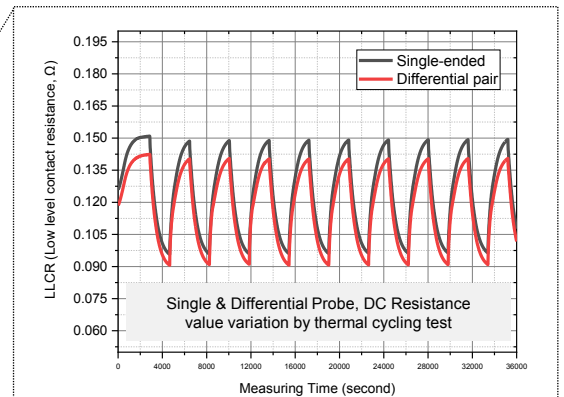
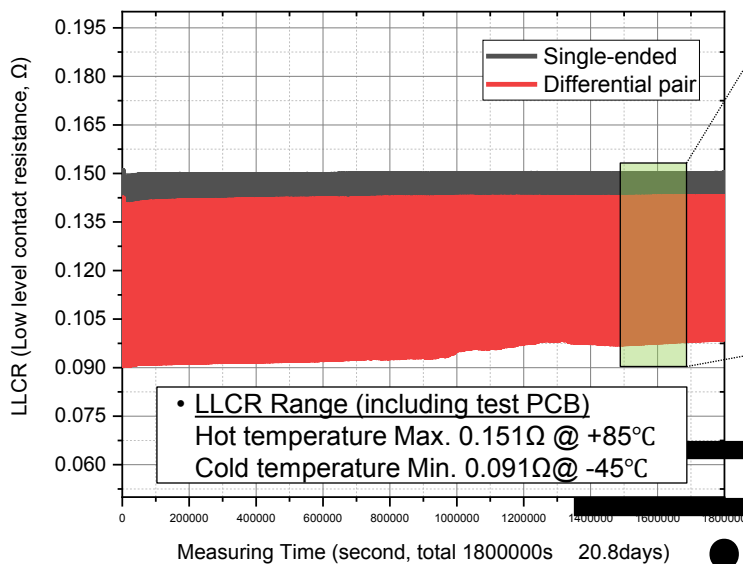


Fig4. Thermal Shock Test Measurement Setup (Dummy PCB, Jig, Chamber, Source-meter)

✓ Test Conditions

- Thermal temperature -45°C (30mins.) ~ $+85^{\circ}\text{C}$ (30mins.) : 1 cycle, 1 hour
- Total 500 cycles (≈ 21 days) by thermal shock chamber (ESPEC TSD-101)
- Real time data gathering (Keithley 2602B, HIOKI RM3545) contact resistance

Test Result



Resistance : $T \uparrow \rightarrow R \uparrow$

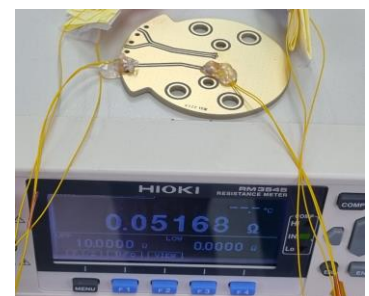
$$*R = R_{ref} + [1 + \alpha(T - T_{ref})]$$

R_{ref} = resistance at 20°C
 α = temperature coefficient of resistance
 T_{ref} = reference temp. of α specified

Fig5. LLCR Thermal Cycling Test Result (Temp. -45°C , 30mins. ~ $+85^{\circ}\text{C}$, 30mins.)

✓ LLCR Value for 3D MEMS Structure

- Cold Temp. @ -45°C : AVG. 0.012Ω (Range 0.005Ω)
- Hot Temp. @ $+85^{\circ}\text{C}$: AVG. 0.029Ω (Range 0.008Ω)
- Evaluation of 3D MEMS structure for repeatability & reproducibility by thermal shock cycling test



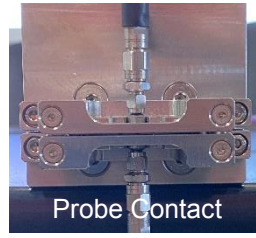
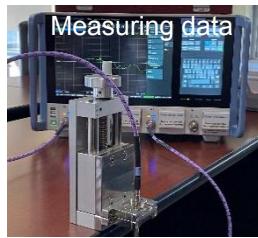
*Test PCB Self-R value

Electrical Characterizations

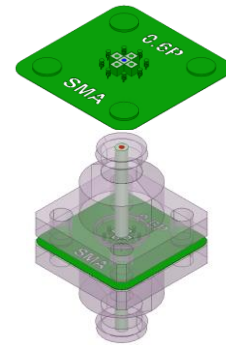
Measurement Setup



VNA 67GHz



Probe Contact



3D Modeling

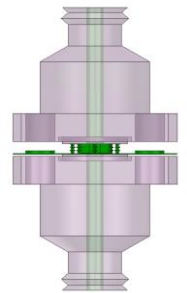
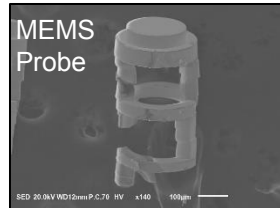


Fig6. 2ports SLOT Measurement Setup (VNA Rohde Schwarz 67GHz, Test Jig, SMA connector)

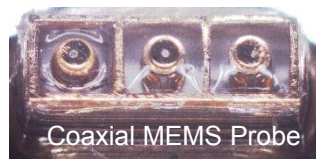


Dummy Samples

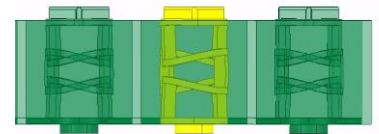


MEMS Probe

SED 20.0kV WD12mm P-C7.0 10µm x140



Coaxial MEMS Probe



MEMS Structure

Fig7. 3D MEMS Coaxial Probe (Test Samples, SEM image, Coaxial Probe Structure image)

Test Result

✓ Insertion loss S21 :

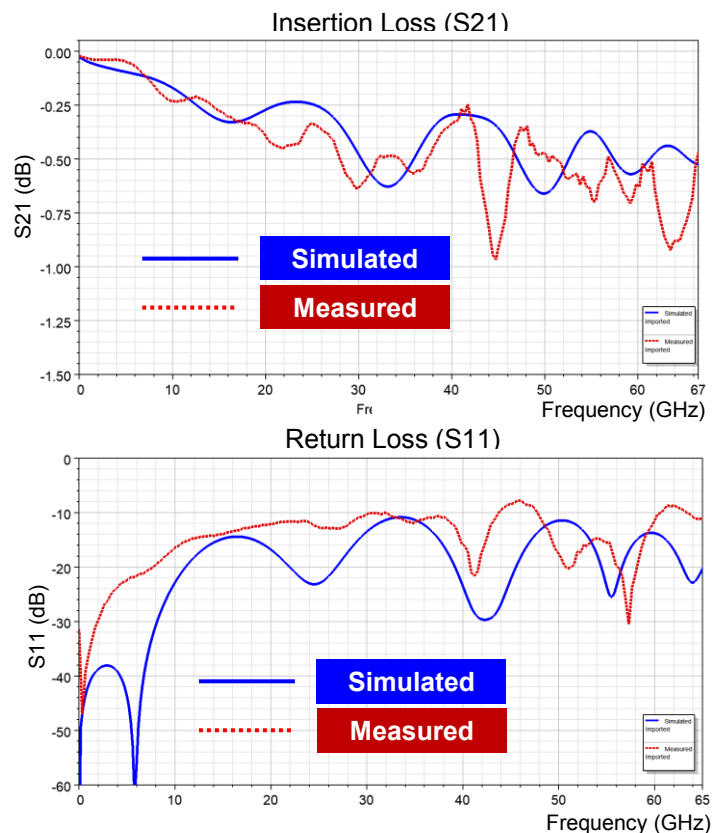
$\leq -1 \text{ dB @ } 60\text{GHz}$

- Comparison of Measurement vs Simulation data
- Slightly different due to measuring contact sensitivity

✓ Return loss S11 :

$\leq -10 \text{ dB @ } 44\text{GHz}$

- Showing a similar trend for high bandwidth up to 60GHz
- 2ports SLOT de-embedding from two fixture loss



Summary

- Proposal for coaxial structure for 0.6mm pitch connector up to 60GHz
 - ✓ 3D MEMS coaxial probe design and fabrication
- Evaluation of LLCR (Low level contact resistance) test
 - ✓ Repeatability and durability for thermal cycling test @ -45°C~+85°C
- Verification of electrical characteristics using VNA measurement
 - ✓ High bandwidth test $S21 \leq -1\text{dB @ } 60\text{GHz}$ for 3D MEMS coaxial structure