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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 ($\varepsilon_r = 2.63$), (normally called PDMS or silicone rubber)

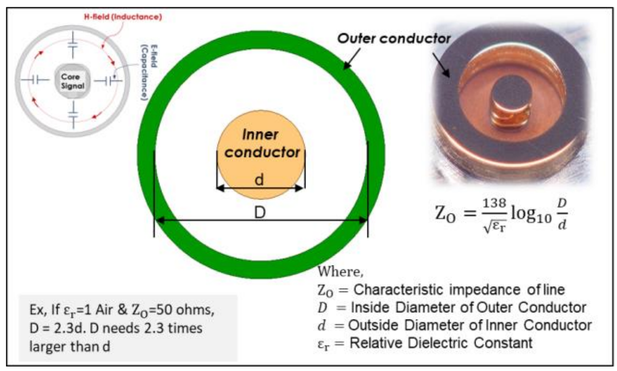


Fig1. Coaxial Impedance Theory

- 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.

▪ The Design of 3D MEMS Co-axial Structure

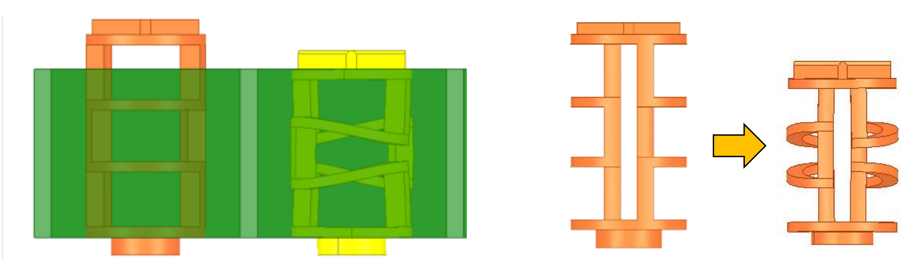
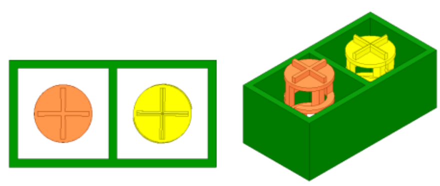
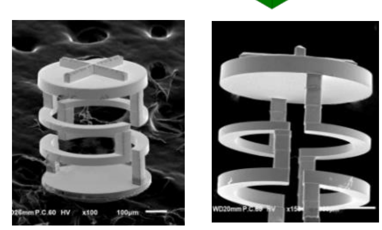
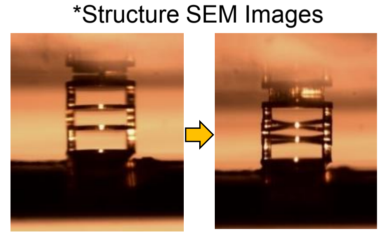


FIg2. Coaxial Probe Structure (normal vs compression)





*Structure SEM Images



*Structure Compression

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

Mechanical Characterizations

▪ Low Level Contact Resistance (LLCR)

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

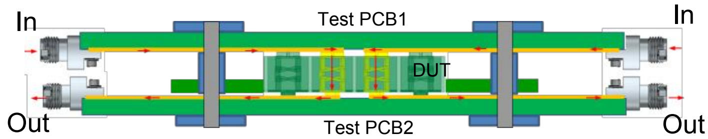


Fig3. LLCR test concept assembly

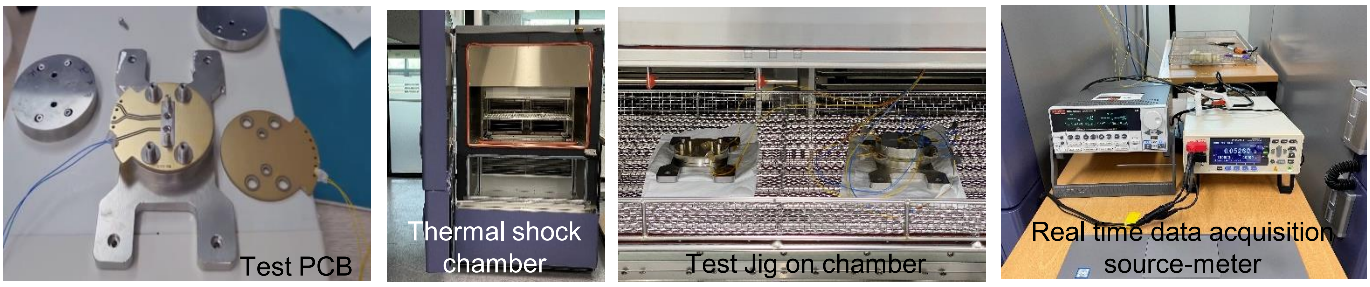
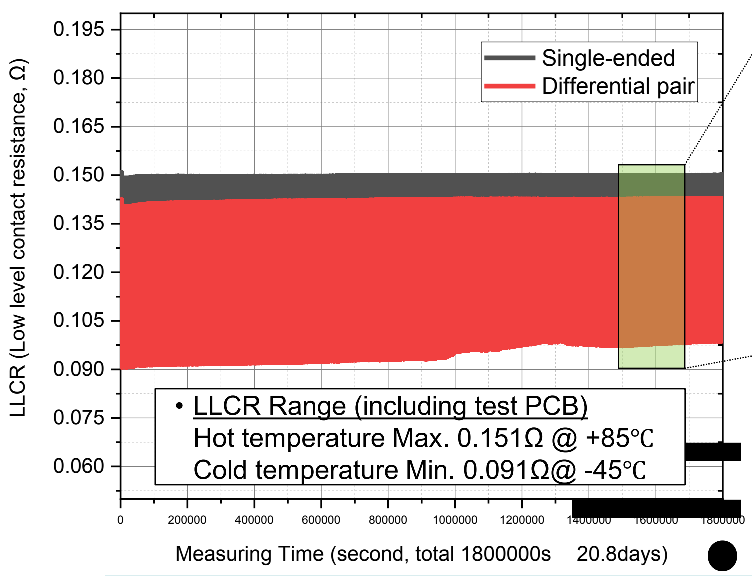


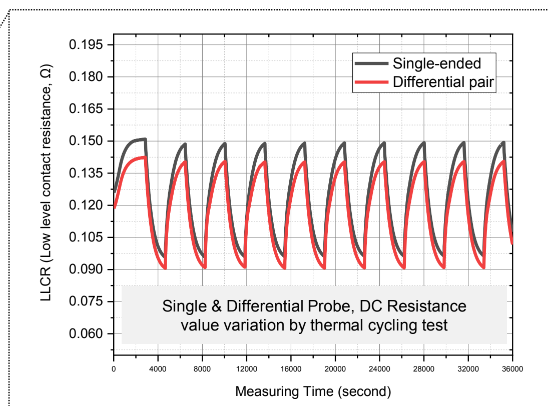
Fig4. Thermal Shock Test Measurement Setup (Dummy PCB, Jig, Chamber, Source-meter)

✓ Test Conditions

- Thermal temperature -45℃ (30mins.) ~ +85℃ (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 ↑ ➔ R ↑

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

R_{ref} = resistance at 20 ℃

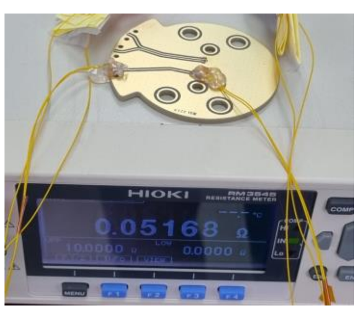
α = temperature coefficient of resistance

T_{ref} = reference temp. of α specified

Fig5. LLCR Thermal Cycling Test Result (Temp. -45℃, 30mins. ~ +85℃, 30mins.)

✓ LLCR Value for 3D MEMS Structure

- Cold Temp. @-45℃ : AVG. 0.012Ω (Range 0.005Ω)
- Hot Temp. @+85℃ : 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

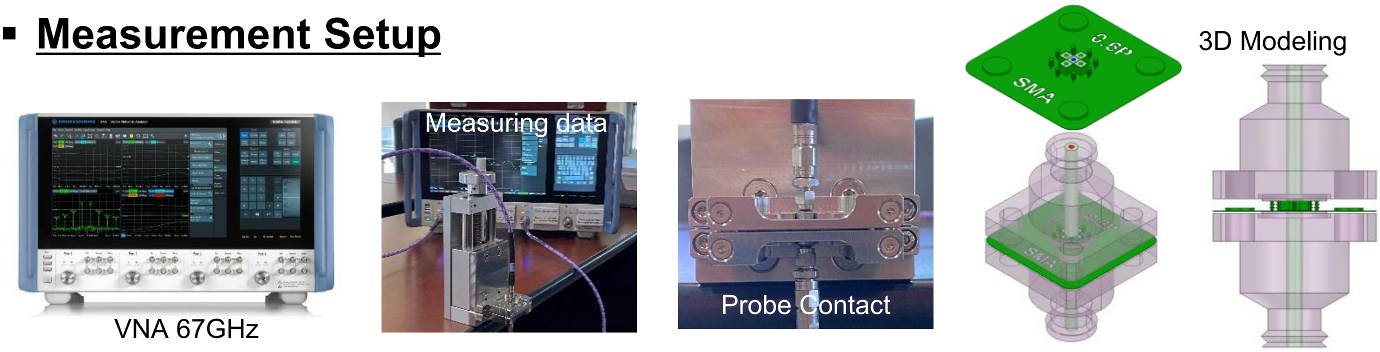


Fig6. 2ports SLOT Measurement Setup (VNA Rohde Schwarz 67GHz, Test Jig, SMA connector)

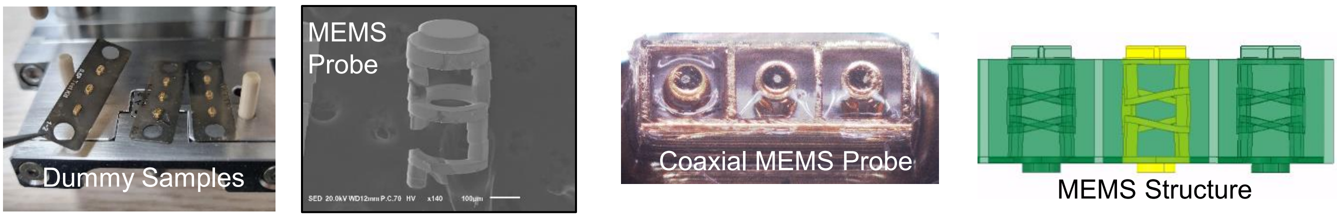


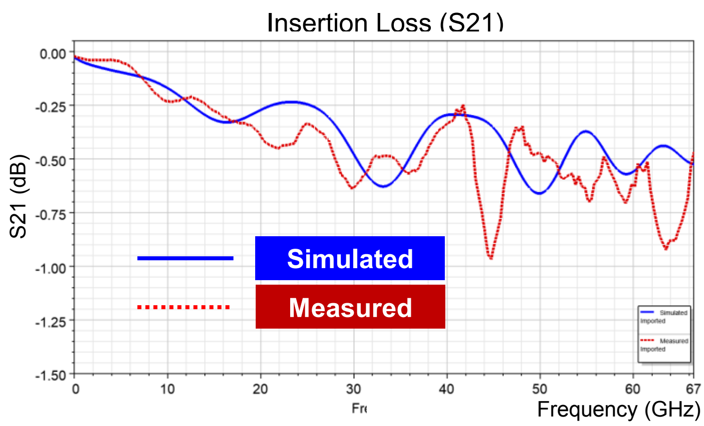
Fig7. 3D MEMS Coaxial Probe (Test Samples, SEM image, Coaxial Probe Structure image)

▪ Test Result

✓ **Insertion loss S21 :**

≤ -1 dB @ 60GHz

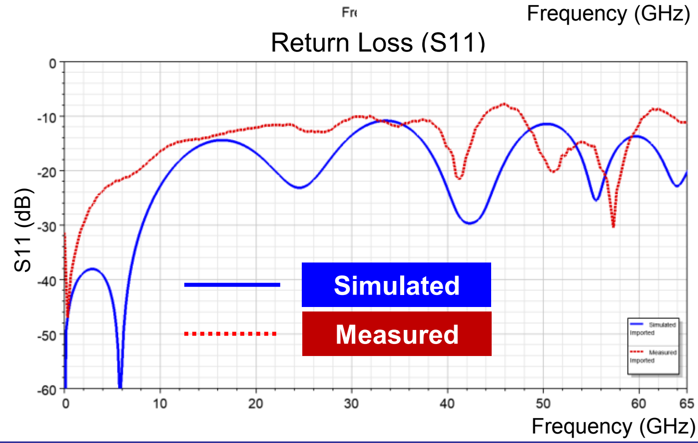
- Comparison of Measurement vs Simulation data
- Slightly different due to measuring contact sensitivity



✓ **Return loss S11 :**

≤ -10 dB @ 44GHz

- 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℃~+85℃
- Verification of electrical characteristics using VNA measurement
  ✓ High bandwidth test S21≤-1dB @ 60GHz for 3D MEMS coaxial structure