# Design and Analysis of Advanced Hybrid Coaxial Socket for High Bandwidth Package Test

**TAEKYUN KIM**, YONGHO CHO, MICROFRIEND INC.
JONGGWAN YOOK, YONSEI UNIVERSITY

Virtual Event • May 11-13, 2020

# Contents

- Introduction
- Concept of Advanced Hybrid Socket
- High Speed Test Considerations
- Test Socket Comparison
- Proposal of Advanced Hybrid Coaxial Socket
- Characterizations
- Summary

# Introduction

- As better performance devices with higher memory bandwidth emerge in the automotive and the mobile industries, the demands for higher test speeds increase.
- Demands on high-speed, extremely small and dense packages have been steadily increasing in the semiconductor market.
- Due to the increasing data rate of the devices, the industries who provide the testing technology face more difficult challenges to meet the requirement.
- Signal/Power integrity issues increase : Crosstalk, Jitter, Skew, Inter-symbol Interference (ISI), PDN (power delivery network), Eye-diagram.

➔ **Needs High Performance Test Solution for analyzing IC Packages.**

# Concept of Advanced Hybrid Coaxial Socket

- **The Concept**

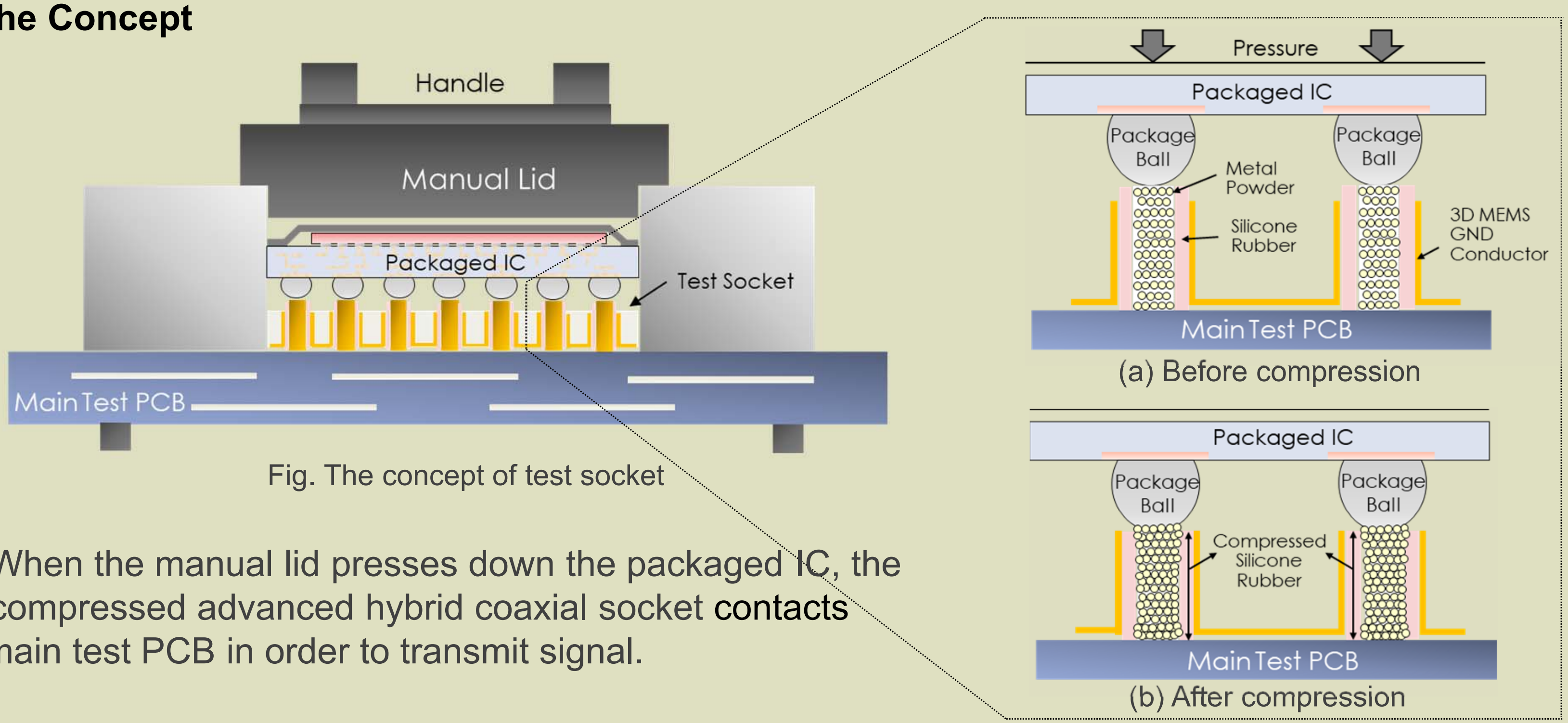



Fig. The concept of test socket

- When the manual lid presses down the packaged IC, the compressed advanced hybrid coaxial socket contacts main test PCB in order to transmit signal.

# High Speed Test Considerations

- **High Speed Design**

- Impedance mismatch
  - ✓ Transmission line signal loss and distortion
  - ✓ Reflection and bad signal quality
- Minimize impedance discontinuity
  - ✓ Stub, neck of via, connectors
  - ✓ Trae branch, test pads
- Balanced signal trace
  - ✓ Better topology design
  - ✓ Length matching

**➔ The better impedance matching, the better signal quality.**

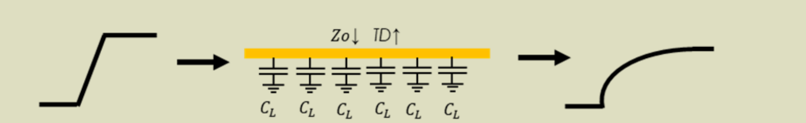



Fig. Signal effect by impedance mismatching

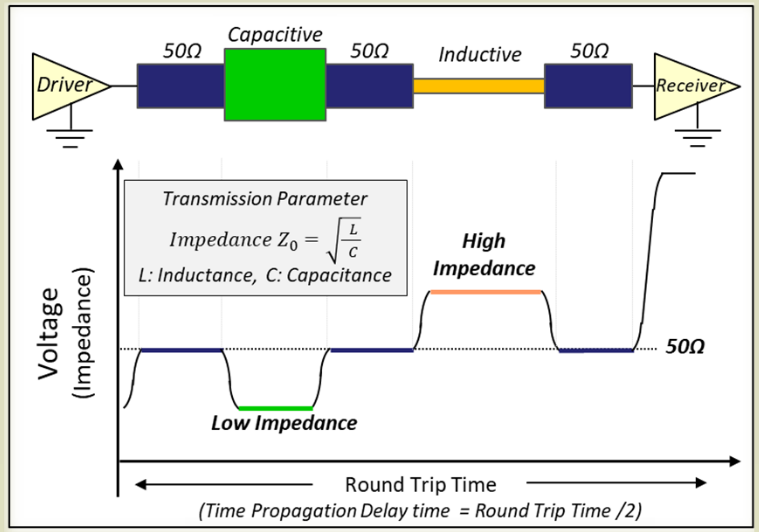



Fig. Transmission line impedance effect

# High Speed Test Considerations

- **Coaxial Case Study**

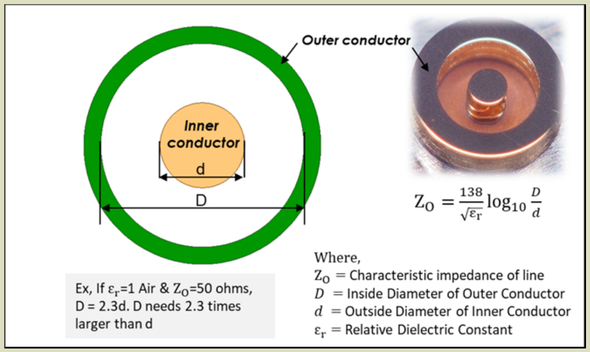
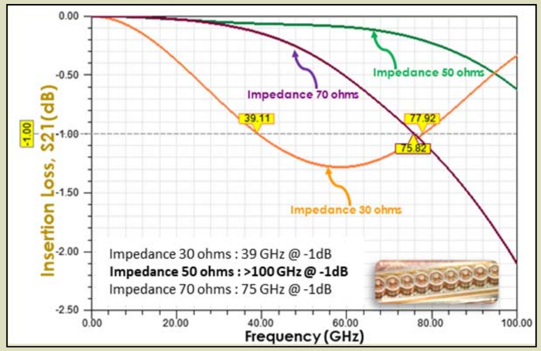
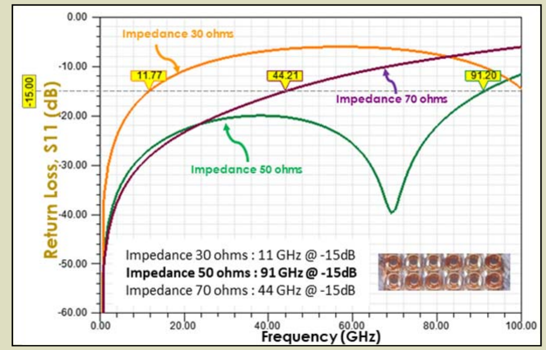



Fig. Coaxial impedance theory




(a) S21 for various impedance




(b) S11 for various impedance

- The analysis of electrical characterizations according to various coaxial Impedance.
- An outer ground shield protects the inner core signal from electrical field interference.
- The impedance matching is important for high speed test.

# High Speed Test Considerations

- **Comparison between Coaxial and Non-coaxial**

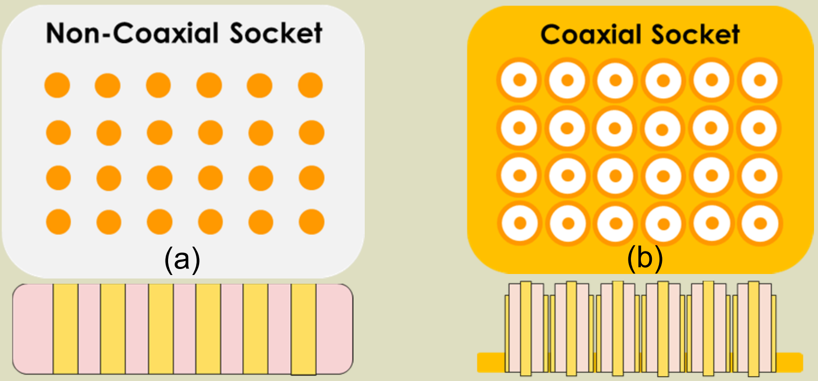
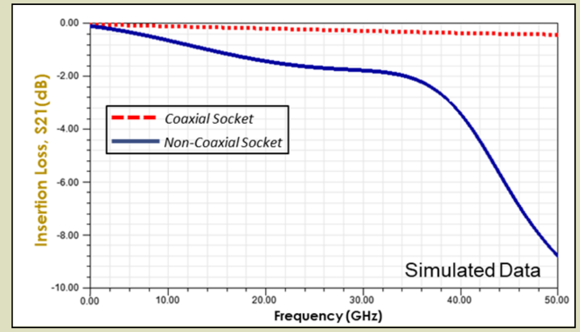
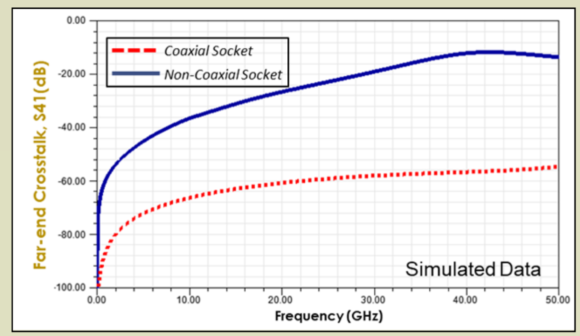



Fig. Comparison between the non-coaxial and coaxial socket
(a) Non-coaxial socket has multiple cylinders.
(b) Coaxial socket has an additional ground outer conductor.

- The electrical characterizations according to non-coaxial and coaxial socket. For S21, the coaxial has lower insertion loss and for S41, the coaxial has better performance.




(a) Insertion loss, S21




(b) Far-end crosstalk, S41

## High Speed Test Considerations

- **Comparison between MEMS and Hybrid Socket**

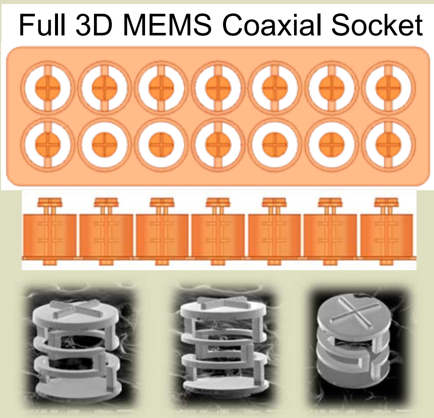



Fig. MEMS structure
(top & side view)

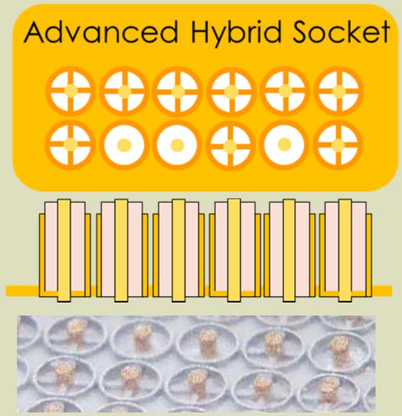
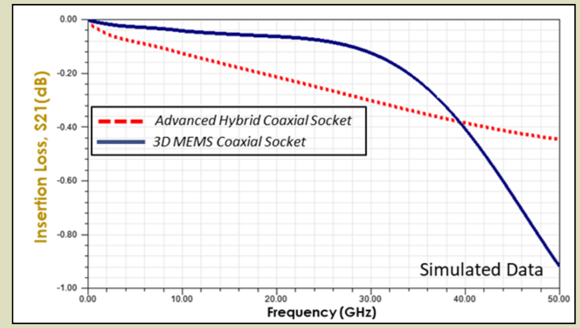
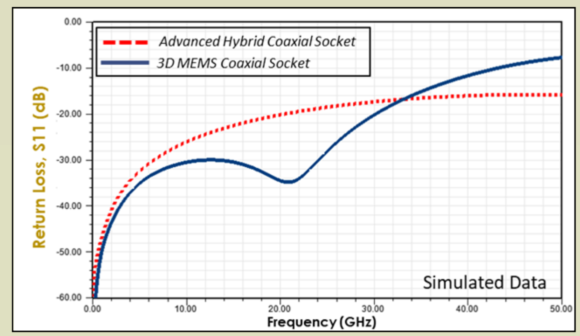



Fig. Advanced hybrid coaxial
socket (top & side view)




(a) Insertion loss, S21

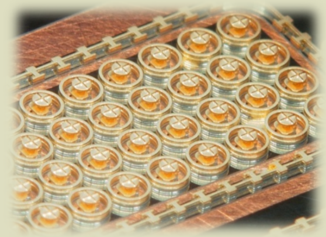



(b) Return loss, S11

- The illustrations above are the structural and electrical characterizations comparison of the 3D MEMS coaxial socket and the advanced hybrid coaxial socket.

## Test Socket Comparison

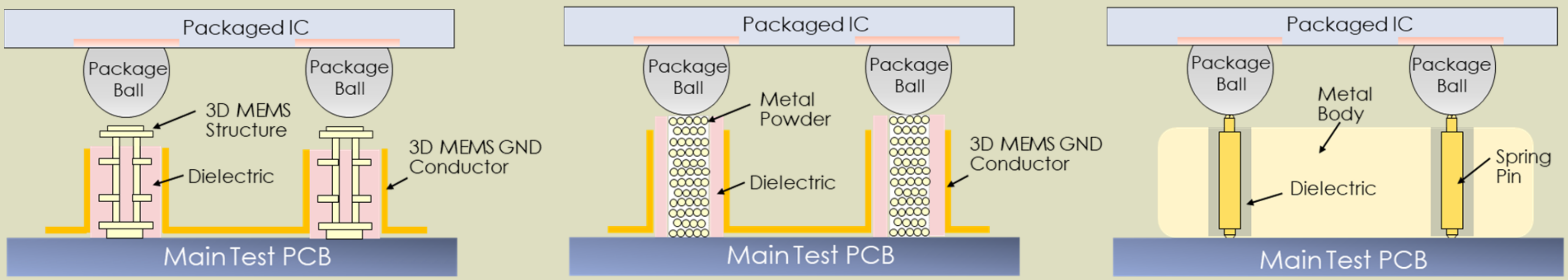
- **Various Type of Socket**

| | Spring | Rubber | 3D MEMS | *AHCS |
|---|---|---|---|---|
| **Figure** |  |  |  |  |
| **Pros.** | ▪ Height ≤ 6.0mm<br>▪ Stoke (controllable)<br>▪ Force (controllable) | ▪ Concept (simple)<br>▪ Less ball damage<br>▪ Delivery<br>▪ Cost | ▪ Fine pitch (coaxial)<br>▪ Position accuracy<br>▪ High pin counts<br>▪ Size (max. 300mm wafer) | ▪ High pin counts<br>▪ Price (reasonable)<br>▪ Less ball damage |
| **Cons.** | ▪ Complicated (coaxial)<br>▪ Fine pitch (coaxial)<br>▪ Cost (coaxial) | ▪ Fine pitch (Coaxial) | ▪ Cost<br>▪ Delivery<br>▪ Stroke | ▪ Fine pitch (Coaxial) |

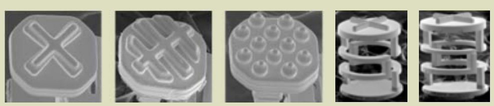
*__AHCS__ : **A**dvanced **H**ybrid **C**oaxial **S**ocket

# Test Socket Comparison

- **Coaxial Socket Contact Method**




(a) 3D MEMS coaxial socket (b) Advanced hybrid coaxial socket (c) Spring pin coaxial socket



| (a) | (b) | (c) |
|---|---|---|
| ▪ 3D MEMS Process | ▪ Adjusting MEMS outer shield | ▪ Outer metal housing |
| ▪ MEMS spring tension | ▪ An elastic rubber tension | ▪ A spring tension |
| ▪ Various contact tip shape | ▪ Metal powder contactor | ▪ Top / bottom plunger |
| ▪ BGA and LGA type | ▪ BGA type | ▪ BGA and LGA type |

# Proposal of Advanced Hybrid Coaxial Socket

- **Advanced Hybrid Coaxial Socket Definition**

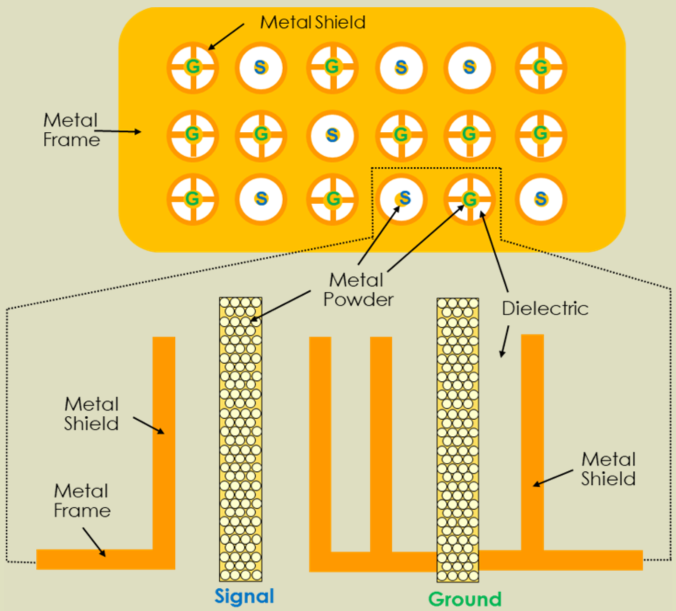



Fig. Cross-section view of AHCS

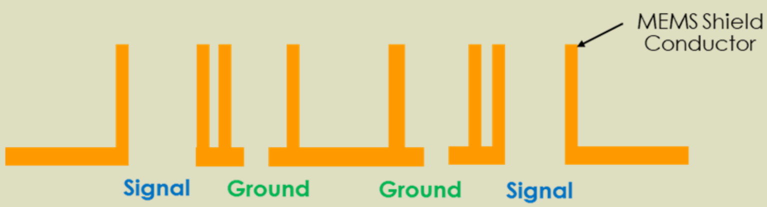
**Configuration**

(1) Coaxial outer shield conductor
- 3D MEMS manufacturing process
- Ni-Co based with Au coating
- Height ≤ 1.0 mm

(2) Core contactors (signal & ground)
- Dielectric : silicone rubber
- Core material : Au metal powder
- Signal : Isolated from ground
- GND : connected to outer conductor
- Stroke ≤ 0.4 mm

# Proposal of Advanced Hybrid Coaxial Socket

- **3D MEMS Outer Conductor & Ground Shield**



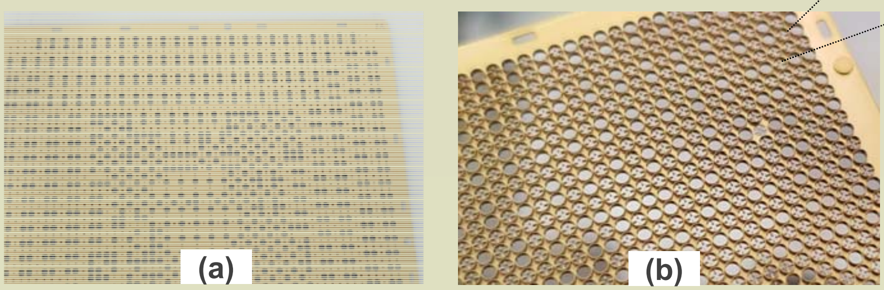




Fig. (a) Bottom view, (b) Top view

Fig. Outer conductor shield

**3D MEMS outer conductor shield**

- MEMS manufacturing process (Etching, Photo, EP, CMP)
- Outer conductor merged with whole frame as plane return current path
- MEMS Material : Ni-Co based with Au

* Hole size available up to 0.1mm pitch

# Proposal of Advanced Hybrid Coaxial Socket

- **Metal Core Contactor**

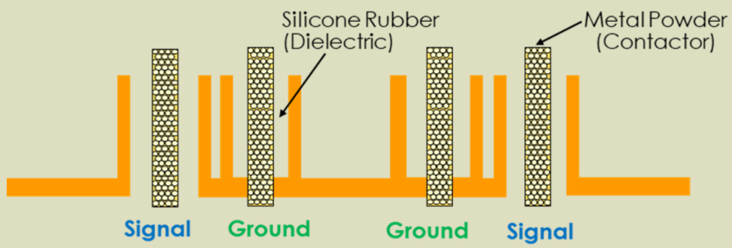
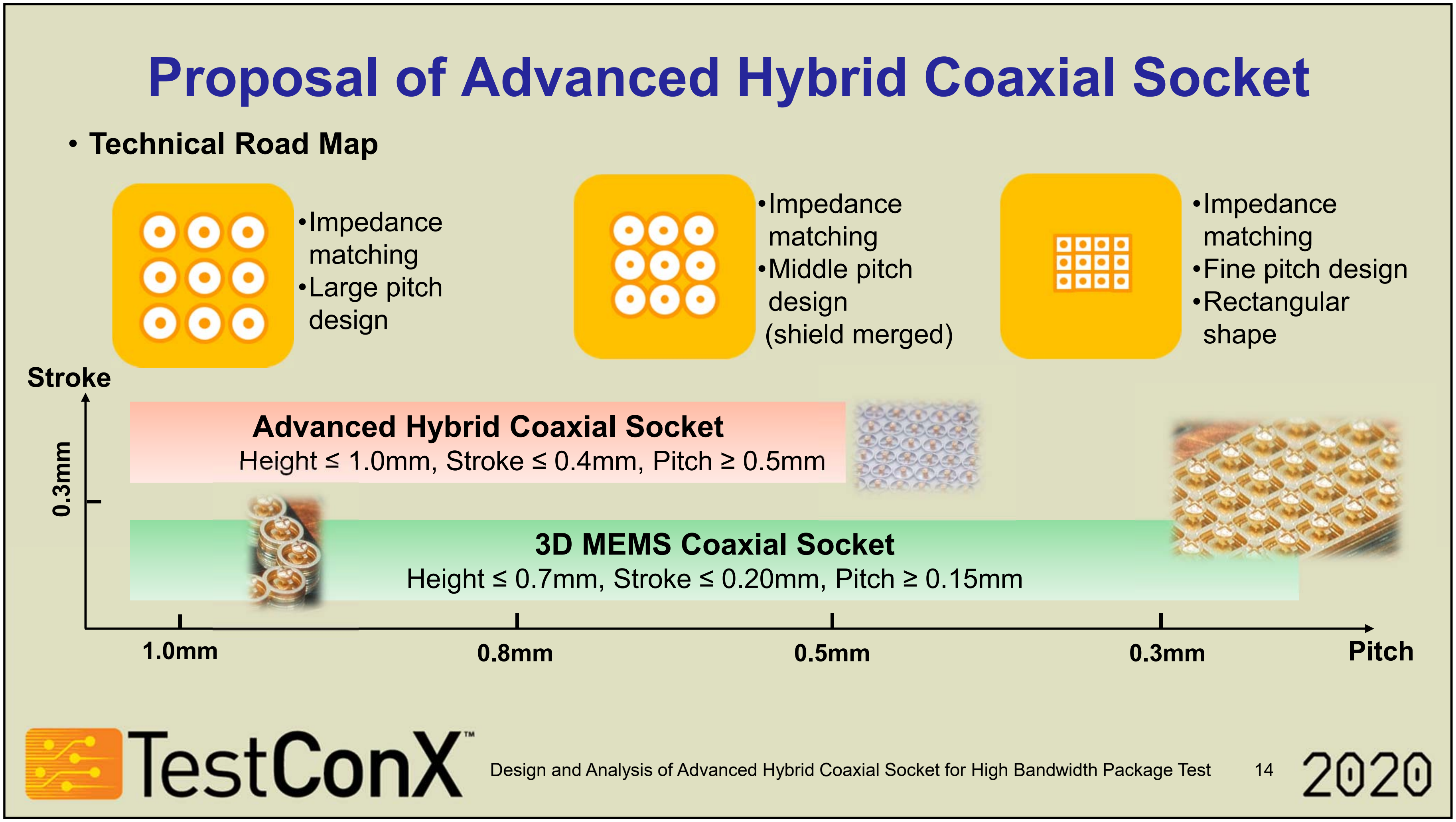



Fig. Advanced hybrid coaxial socket


Fig. (a) Bottom view, (b) Top view

**Metal core contactor**

- Stroke ≤ 0.4mm, Height ≤ 1.0mm
- The contactor : Metal powder Au
- Dielectric : Silicone rubber
- GND contactor is shorted with outer shield conductor as one.


Proposal of Advanced Hybrid Coaxial Socket
• Technical Road Map
•Impedance matching
•Large pitch design
•Impedance matching
•Middle pitch design (shield merged)
•Impedance matching
•Fine pitch design
•Rectangular shape
Stroke
0.3mm
Advanced Hybrid Coaxial Socket
Height ≤ 1.0mm, Stroke ≤ 0.4mm, Pitch ≥ 0.5mm
3D MEMS Coaxial Socket
Height ≤ 0.7mm, Stroke ≤ 0.20mm, Pitch ≥ 0.15mm
1.0mm
0.8mm
0.5mm
0.3mm
Pitch
TestConX
Design and Analysis of Advanced Hybrid Coaxial Socket for High Bandwidth Package Test
14
2020

# Characterizations

- **Pin Force and Contact Resistance**

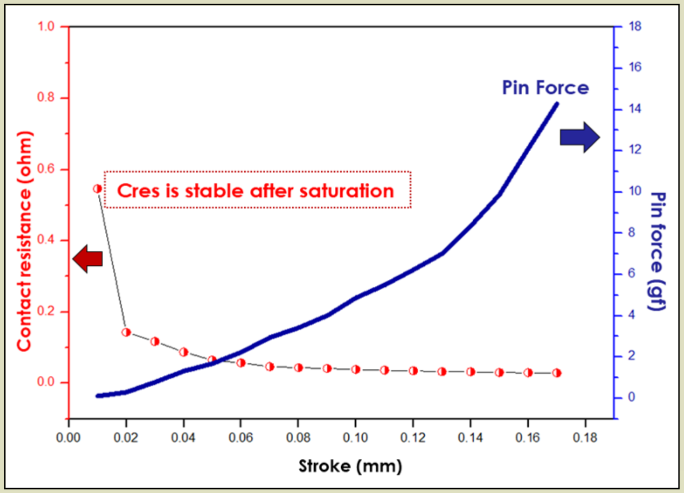



Fig. Pin force vs Contact resistance for stroke

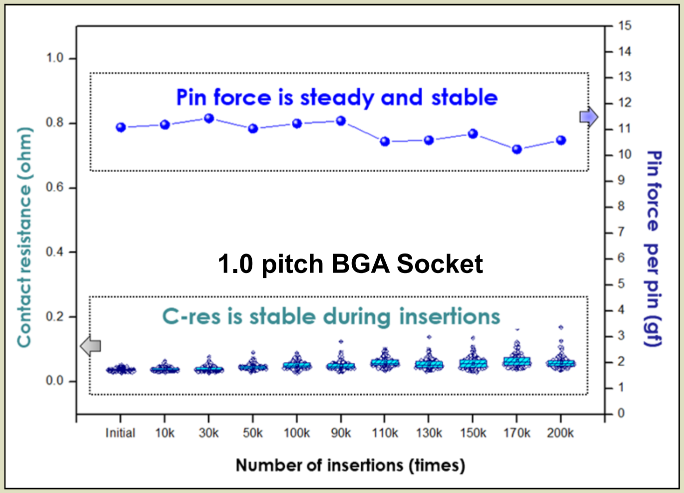



Fig. Pin force vs Contact resistance for insertions

➔ The mechanical characteristics of pin force and contact resistance have been measured by experimental study for increasing stroke and 200k touchdowns.

# Characterizations

- **Verification of the Advanced Hybrid Coaxial Socket**

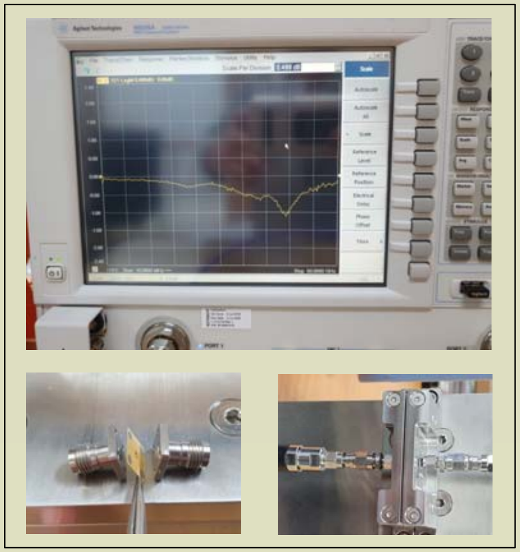


Fig. Measurement system

- Vector network analyzer (VNA, E5245A@Keysight)
- 1.85mm connector tested to 67GHz using test vehicles
- Measurement data with de-embedding fixture
- Analysis of frequency domain (S-parameter)
- Analysis of time domain (eye-diagram)

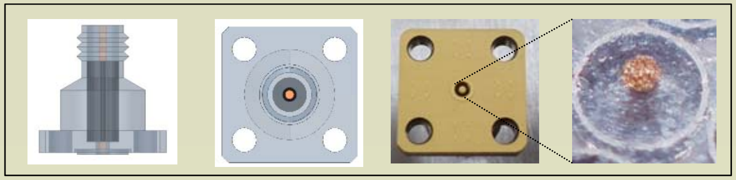


Fig. 1.85mm connector (67GHz) for test vehicle

➔ The measurement environment for experiment.
The universal connectors used for measuring test vehicle.

# Characterizations

- **Frequency-Domain Analysis :** S21, Insertion Loss & S11, Return Loss

Test vehicle

Pitch 1.0 mm

Height 0.75mm

Advanced Hybrid Coaxial Socket

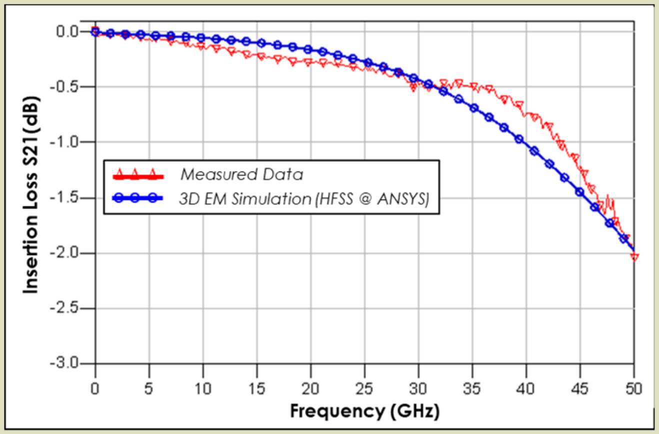



Fig. Insertion Loss, S21 for test vehicle

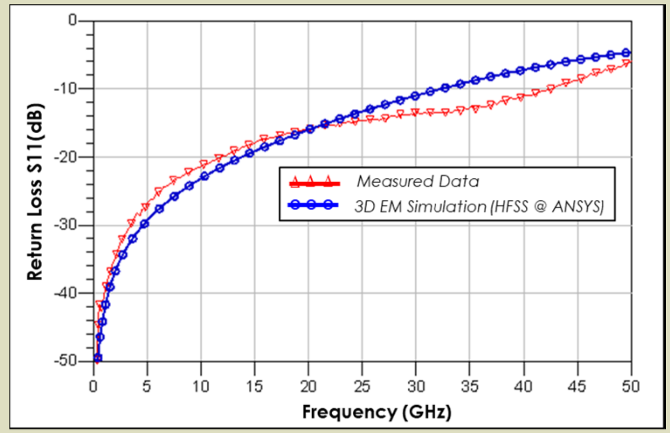



Fig. Return Loss, S11 for test vehicle

➔ The frequency-domain verifications have correlation up to 50GHz.
The insertion loss and return loss of test vehicle are obtained from the simulated data and measurement respectively.

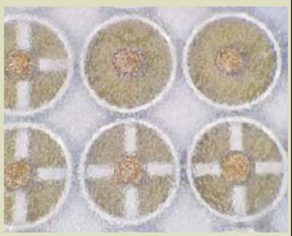
# Characterizations

- **Time-Domain Analysis :** Eye-diagram at a data rate of 50 Gb/s for advanced hybrid coaxial socket

Test vehicle

Pitch 1.0 mm

Height 0.75mm



Advanced Hybrid Coaxial Socket

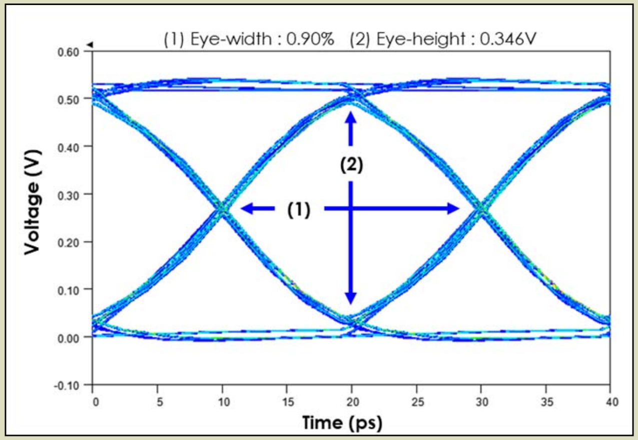



Fig. Measured Eye-diagram

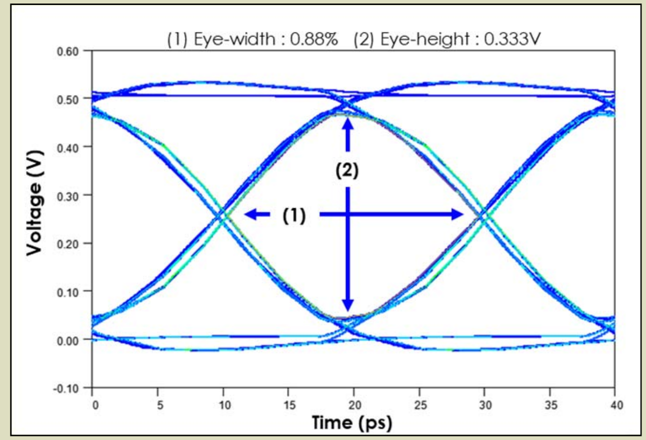



Fig. Simulated Eye-diagram

➔ The two eye-diagrams are compared respectively and the results of simulated model and measurement show similar tendency.

# Summary

- Proposed Advanced Hybrid Coaxial Socket for Package Test.
- Adopted New Coaxial Socket that is composed of 3D MEMS Outer Shield Conductor and Metal Core Contactor.
- Analyzed the Performance of Hybrid Coaxial Socket using Simulation Study and Experimental Measurement.
- Verified the Advanced Hybrid Coaxial Socket both Frequency-Domain and Time-Domain Method.

# Acknowledgements


- Special thanks for the management of their work & dedication in preparing data and review of this paper.

Microfriend Inc.

YONSEI UNIVERSITY

SHMT SAE HAN MICRO TECH CO., LTD. propin

- JOOYONG KIM
- JONGGWAN YOOK
- SANGHEE PARK

## COPYRIGHT NOTICE

The presentation(s)/poster(s) in this publication comprise the proceedings of the 2020 TestConX Virtual Event. The content reflects the opinion of the authors and their respective companies. They are reproduced here as they were presented at the 2020 TestConX Virtual Event. The inclusion of the presentations/posters in this publication does not constitute an endorsement by TestConX or the workshop's sponsors.

There is NO copyright protection claimed on the presentation/poster content by TestConX. However, each presentation/poster is the work of the authors and their respective companies: as such, it is strongly encouraged that any use reflect proper acknowledgement to the appropriate source. Any questions regarding the use of any materials presented should be directed to the author(s) or their companies.

"TestConX" and the TestConX logo are trademarks of TestConX. All rights reserved.

www.testconx.org