SW Test Workshop
Semiconductor Wafer Test Workshop

Optimization for Polyimide Circuit Design of Space Transformer on Probe Card

Sang-Kyu Yoo
Samsung Electronics

Tae-Kyun Kim, Yong-Ho Cho
Microfriend

Jong-Kwan Yook
Yonsei University

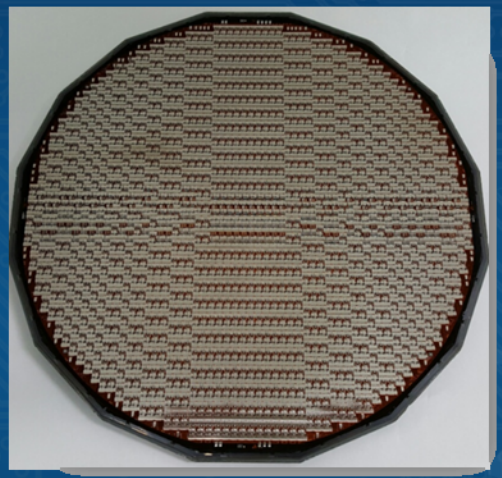
June 5-8, 2016

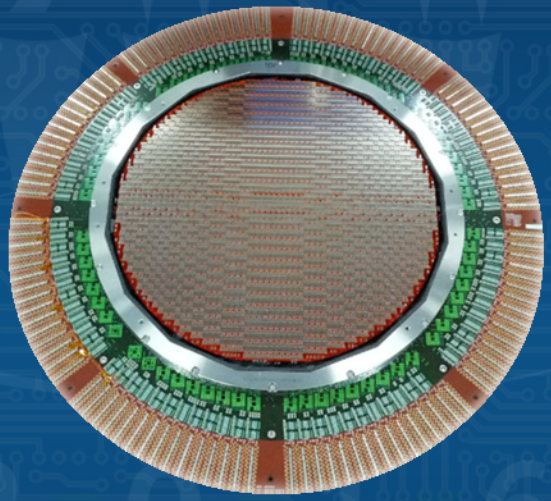
Overview

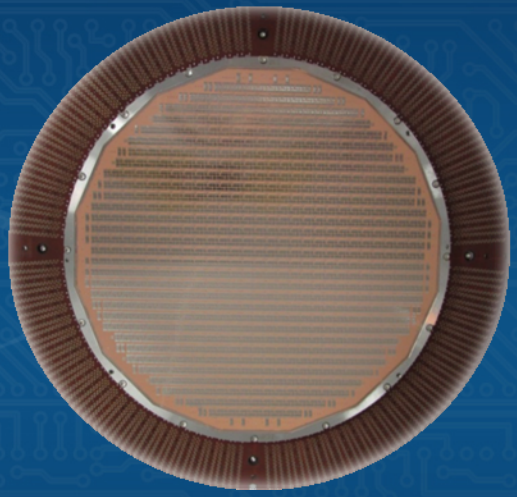
- Introduction of Probe Card Test
- Basic Study for Polyimide Circuit Design
- Signal Integrity on Probe Card
- Summary
- Future Works

Introduction of Probe Card Test

- **Probe Card needs for High Parallel, High Speed and High Density.**





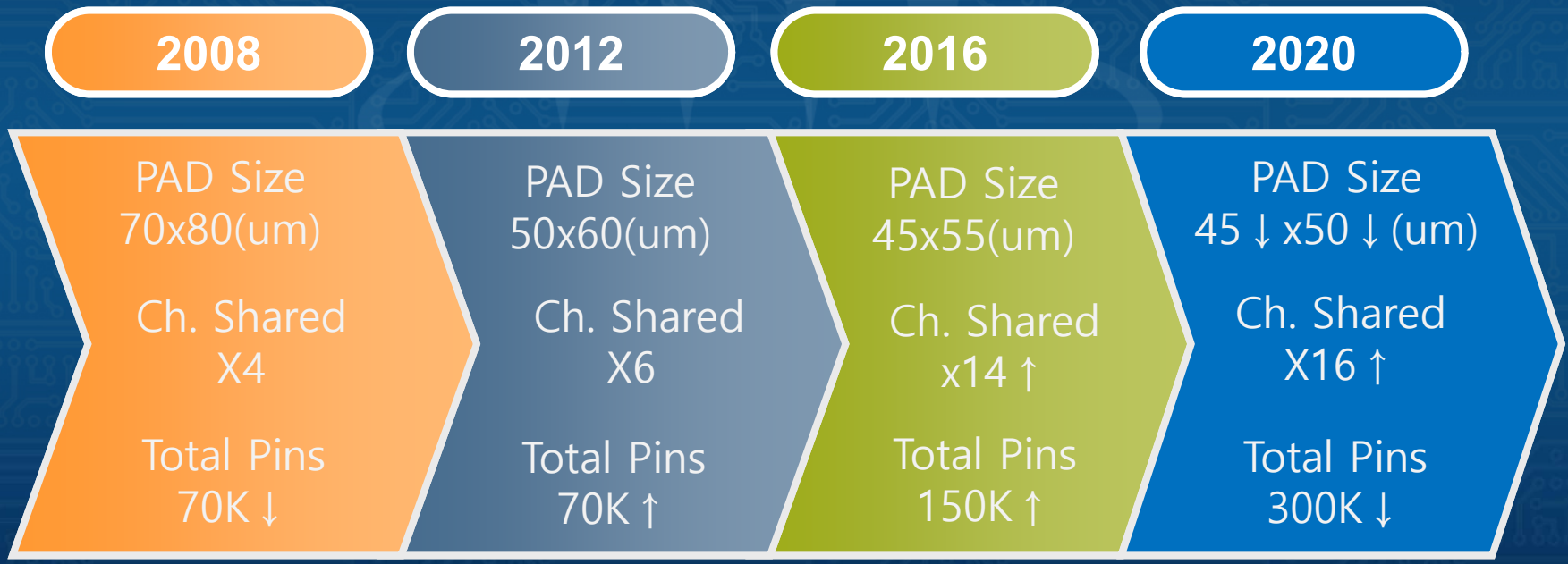


- Probe Card has a Function of Interface between ATE and Device.
- As Test Channels are Increase, Signal Integrity is getting more Important.
- It is necessary for High Parallel, High Density and High Speed on Probe Card.

Introduction of Probe Card Test

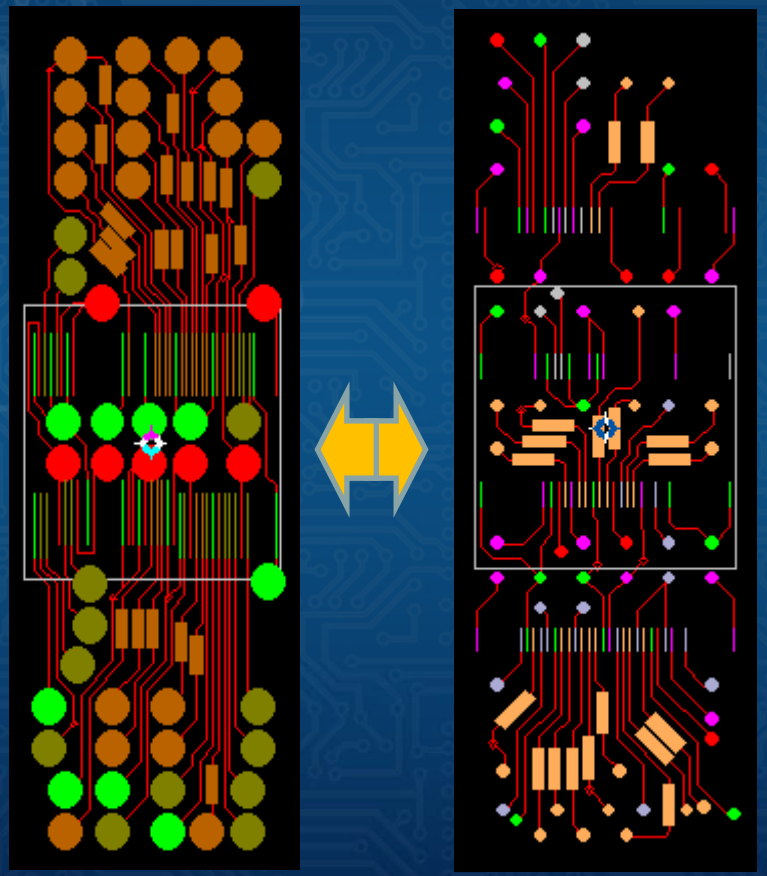
- **Test Trends**

- Smaller PAD Size & Fine Pitch and Higher Pin Counts
- Necessity of High Speed Testing Technology on Probe Card
- Higher Circuit Design Density



Introduction of Probe Card Test

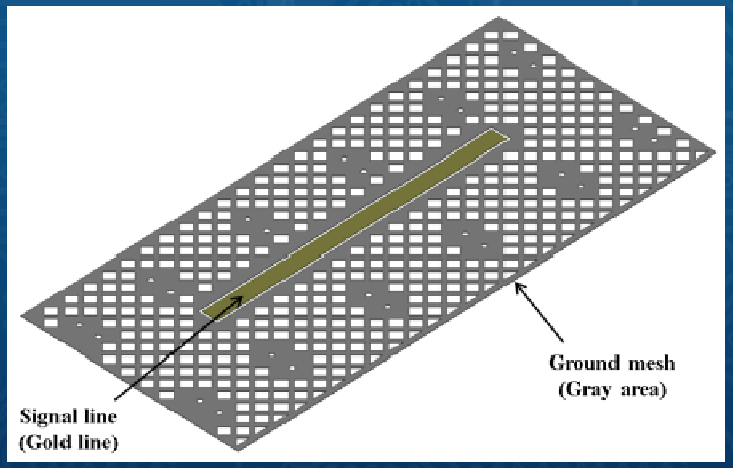
- **Advantage of Polyimide Thin Film**
  - Very Small VIA Hole
  - Highly Denser Circuit
  - Low Relative Dielectric Constant
  - High Propagation Velocity
  - High Speed Digital Circuits
  - Low Cost

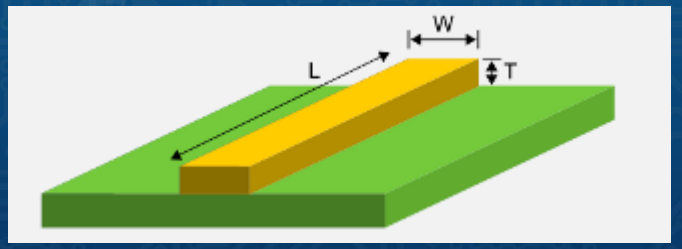


Basic Study for PI Circuit Design

- **Needs for Electrical Characteristics of Circuit Trace in Polyimide Thin Film**

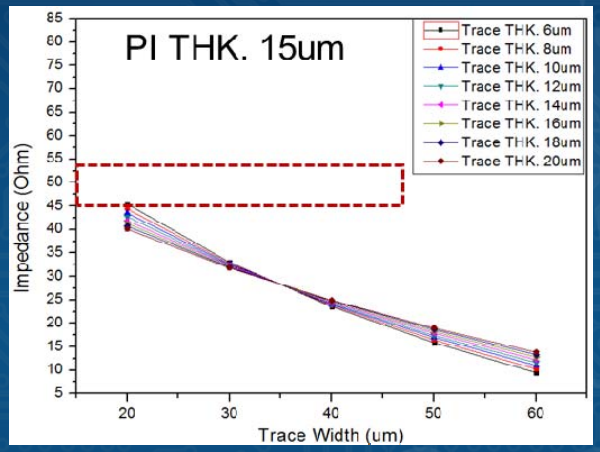
  - Dielectric Constant : 3.2
  - Impedance depends on Trace THK., Width, Material, Ground(Mesh & Plane)

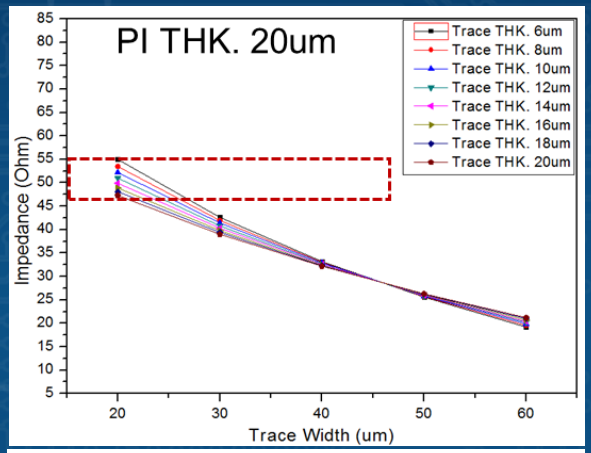


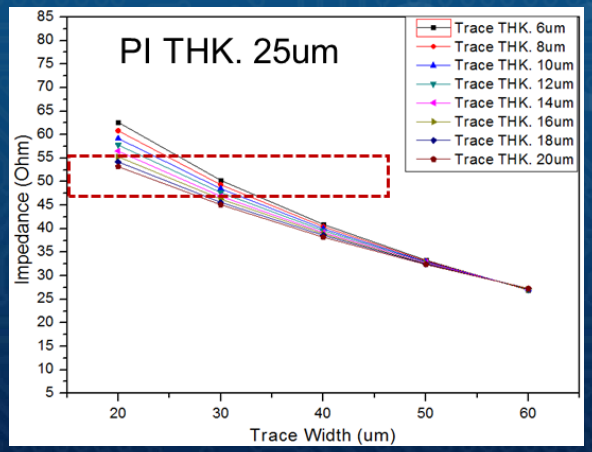


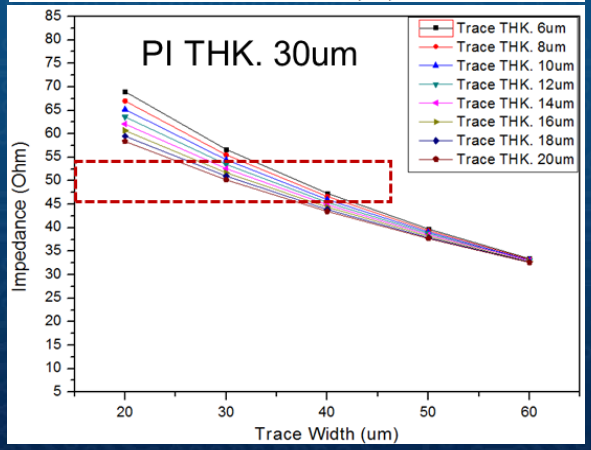
Basic Study for PI Circuit Design

- **Impedance depends on**
  Circuit Trace Width & Thickness and PI Thickness.



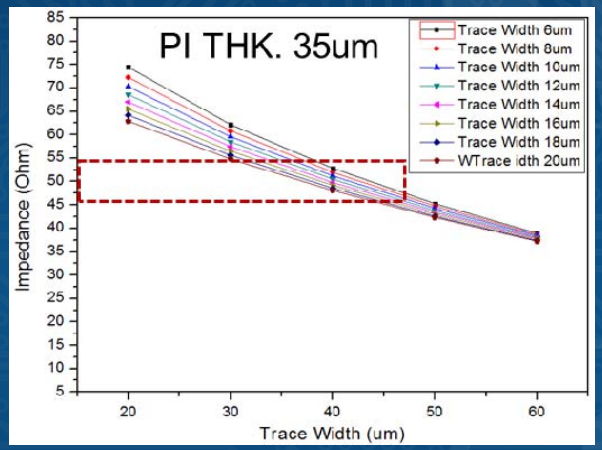


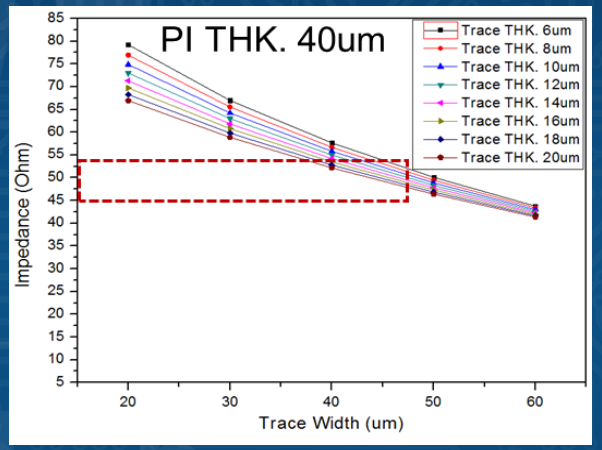




Basic Study for PI Circuit Design

- **Impedance depends on**
  Circuit Trace Width & Thickness and PI Thickness.

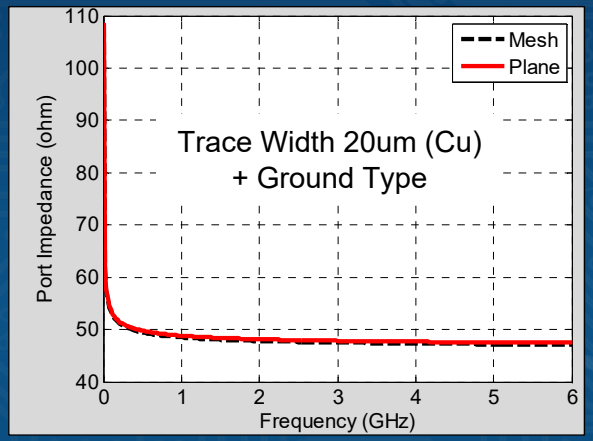


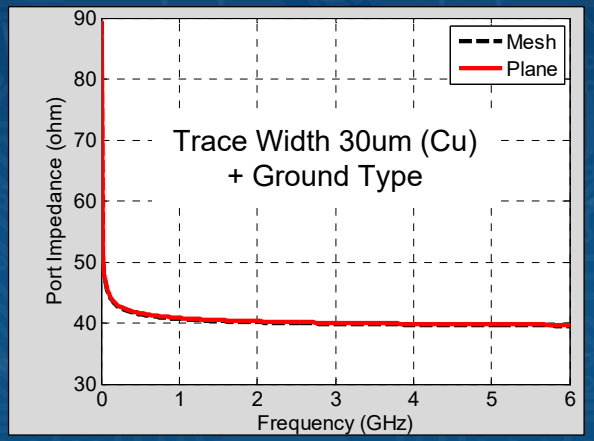


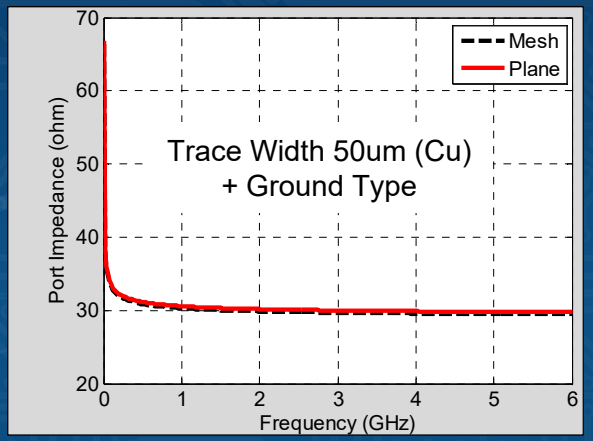
- **Circuit Design on Polyimide Thin Film**
  - Normally, Target Impedance needs for 50±10% Ohm.
  - Impedance mismatching affects poor Signal Quality.

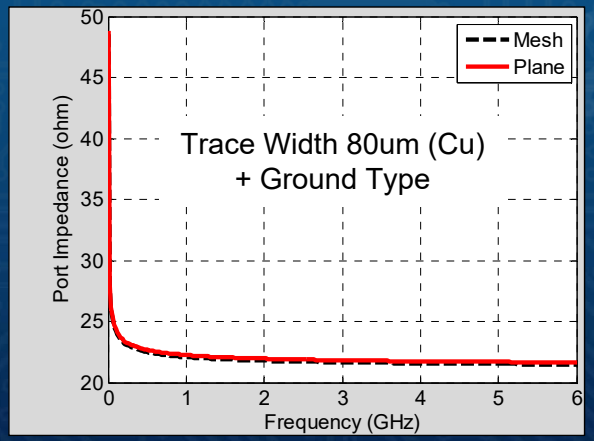
Basic Study for PI Circuit Design

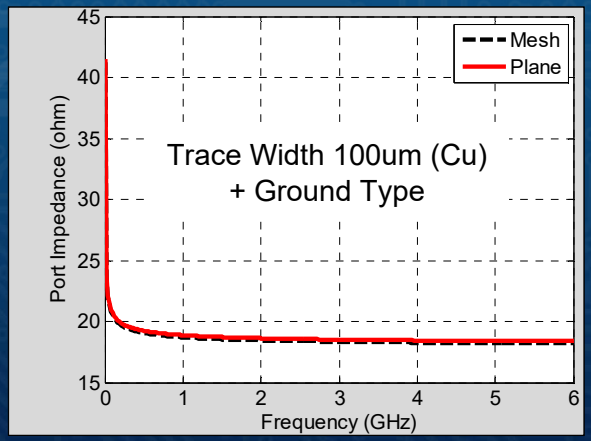
- **Analysis of Impedance for Trace Material (Cu), Width and Ground Type (Mesh or Plane)**

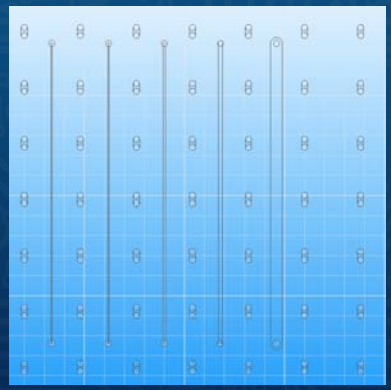






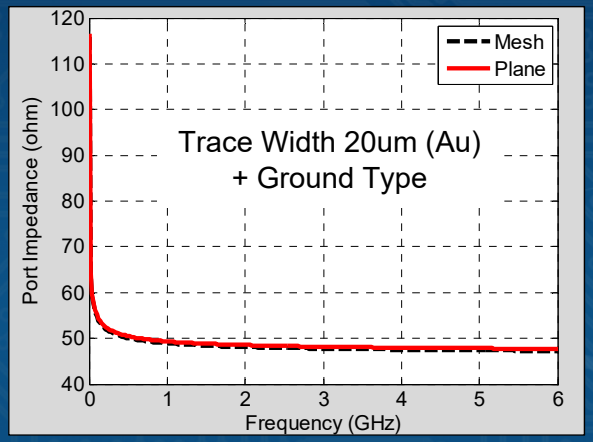


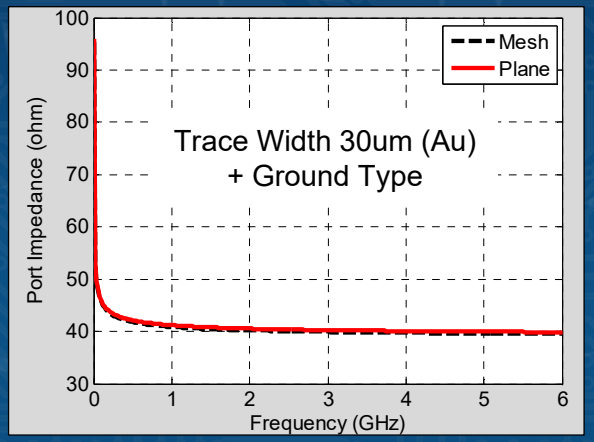


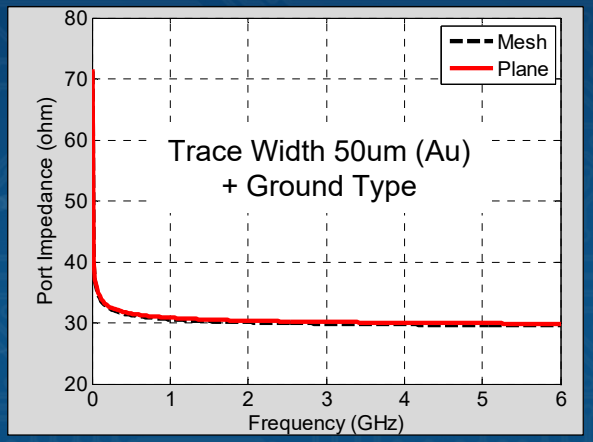


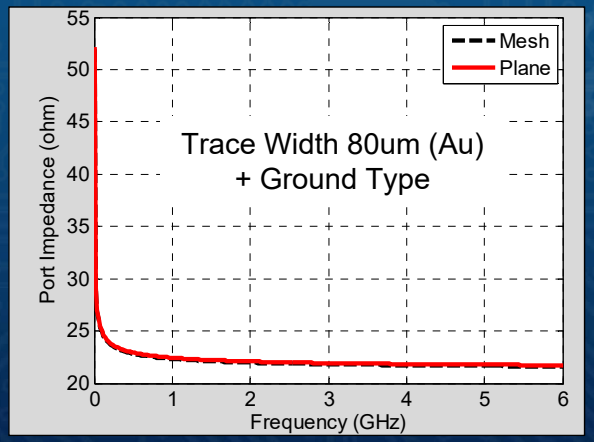
Basic Study for PI Circuit Design

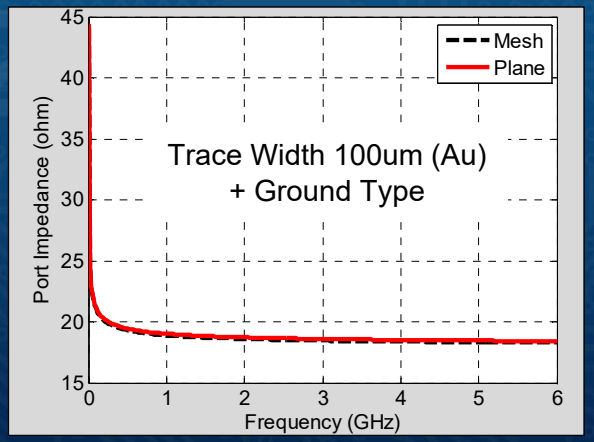
- **Analysis of Impedance for Trace Material (Au), Width and Ground Type (Mesh or Plane)**

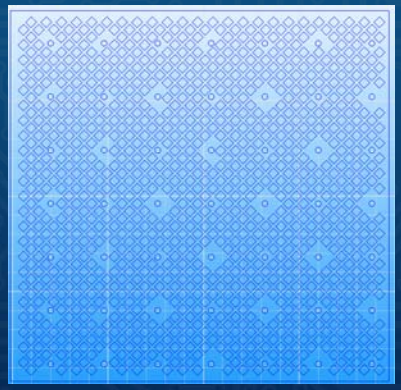












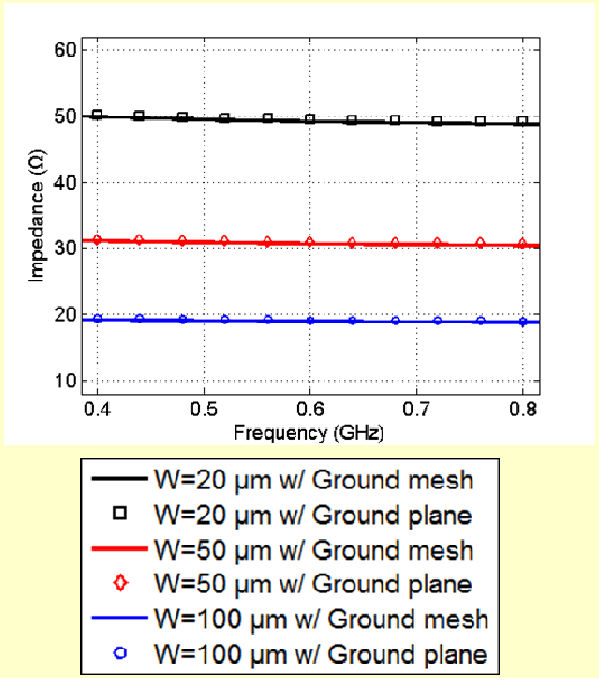
Basic Study for PI Circuit Design

- **Analysis of Impedance for Circuit Trace**

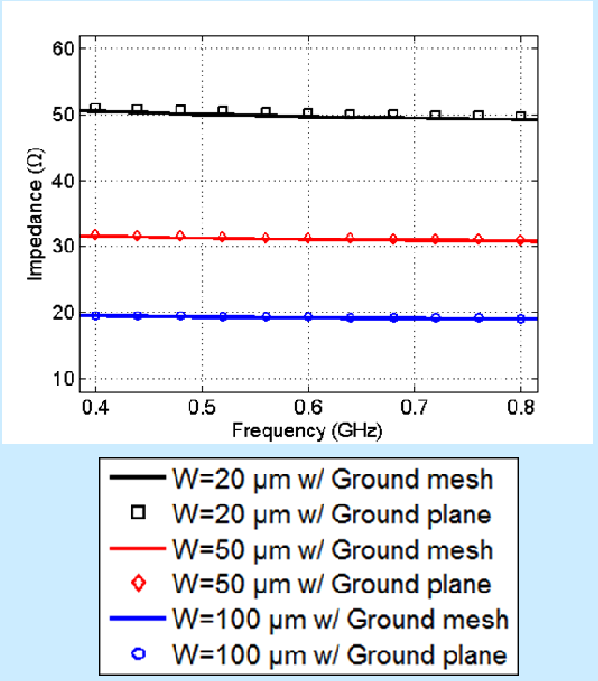
  - Depends on Circuit Material, Width and Ground Type

  - Copper (Cu) vs Gold (Au)

Copper (Cu)

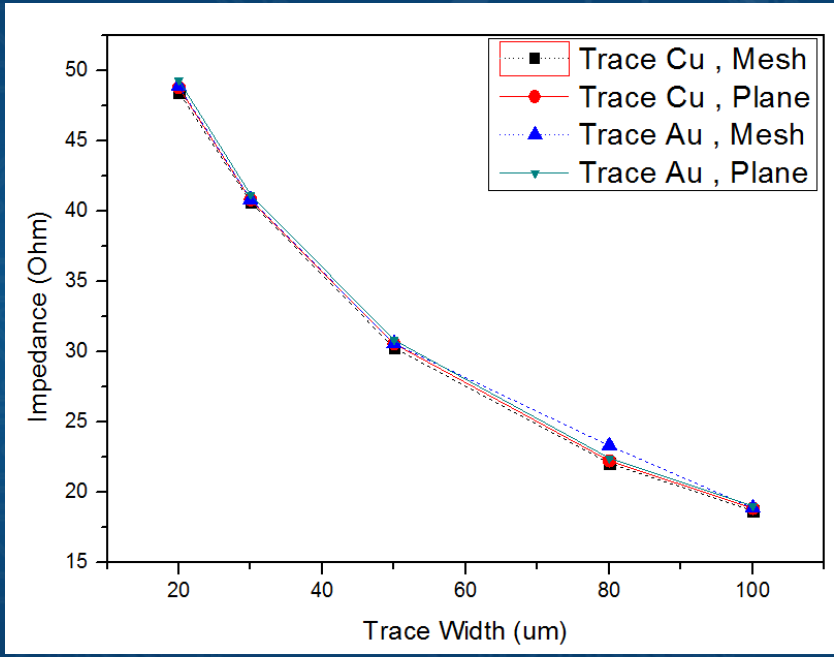


Gold (Au)



Basic Study for PI Circuit Design

- **Impedance Compared of Copper (Cu) with Gold (Au)**



Resistivity

Cupper (Cu)

: 1.68×10^{-8} Ωm

Gold (Au)

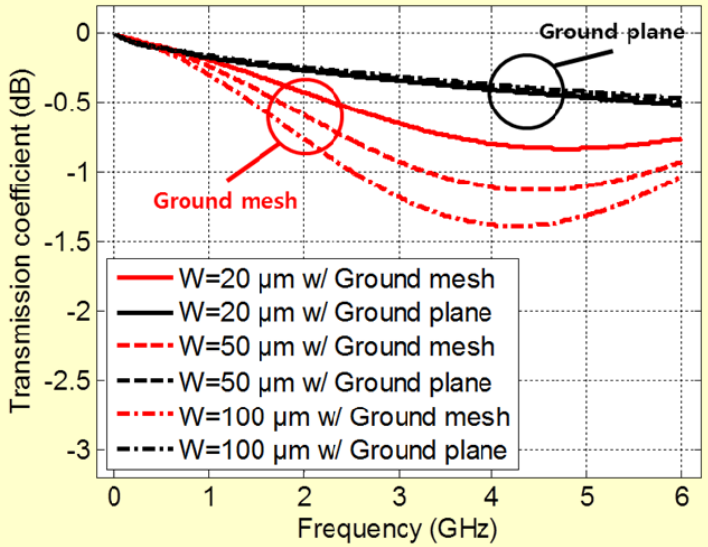
: 2.2×10^{-8} Ωm

- Copper (Cu) vs Gold (Au) , Mesh Ground vs Plane Ground

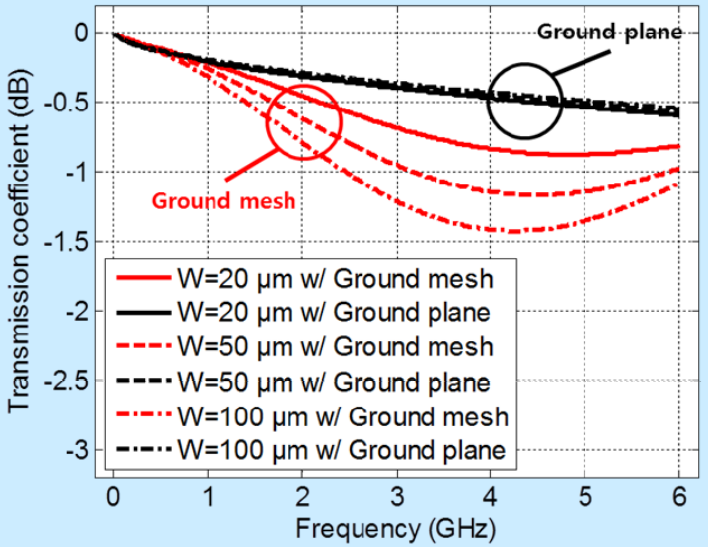
Basic Study for PI Circuit Design

- **Insertion Loss (Transmission coefficient)**
  - Depends on Circuit Material, Width and Ground type(Mesh & Plane)
  - Mesh Ground Insertion Loss Max. -1.5dB @ 4GHz

Copper (Cu)

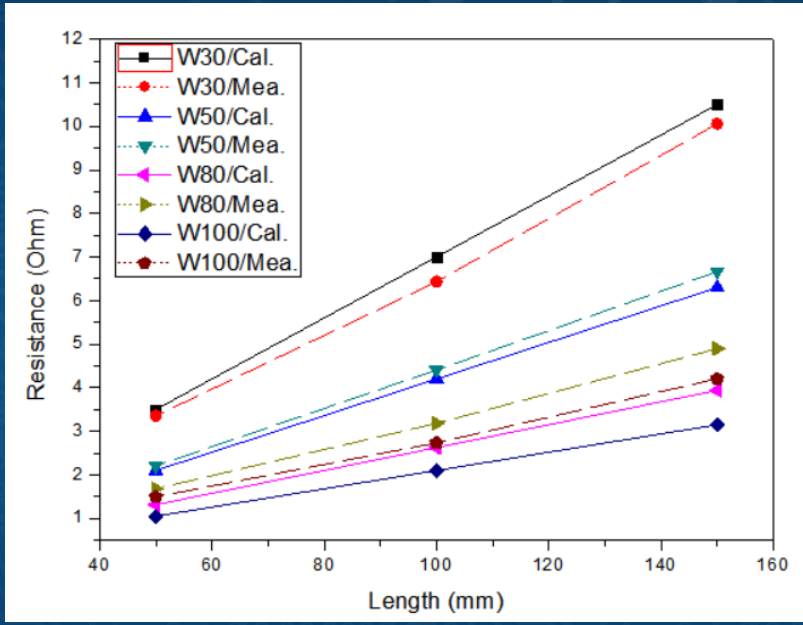


Gold (Au)



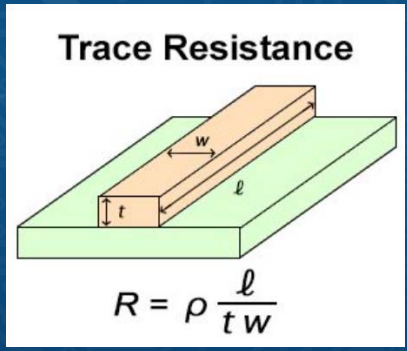
Basic Study for PI Circuit Design

- **Measurement vs Calculation (Trace)**



Copper Resistivity

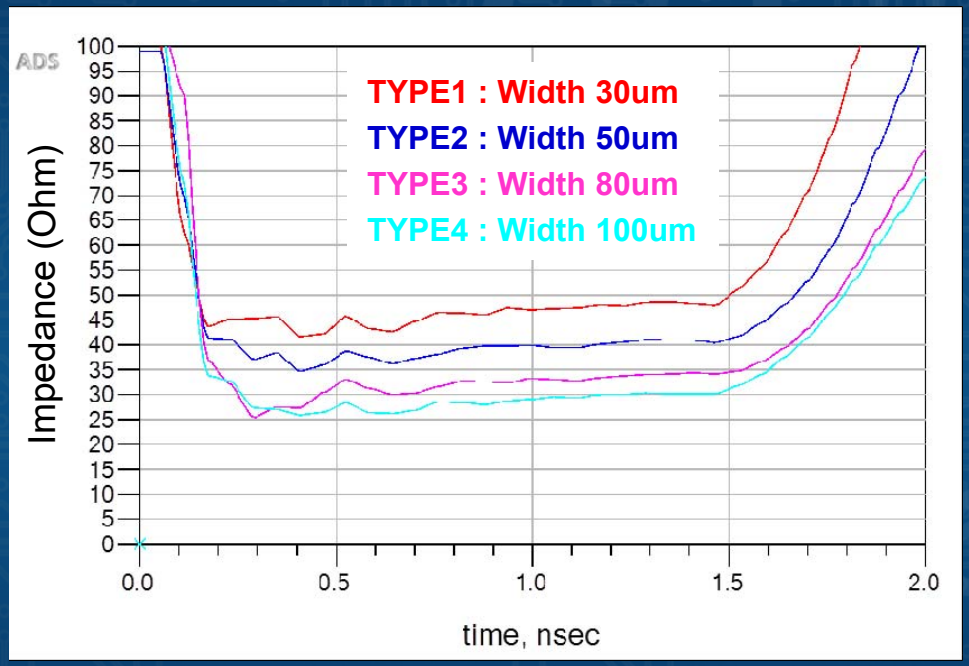
1.68×10^{-8} Ωm

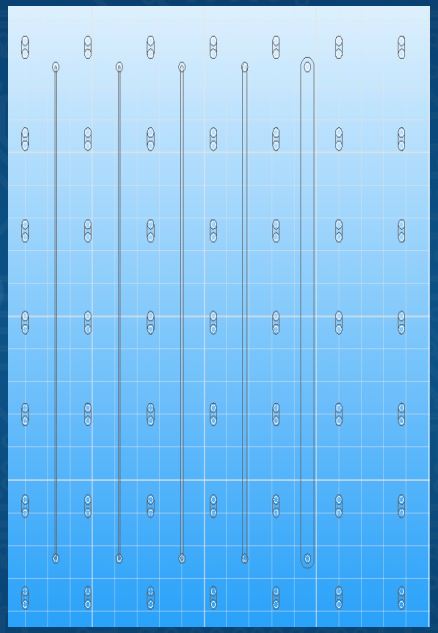


- As Trace Length is Large, the Resistance is getting Higher.
- As Trace Width is Large, the Resistance is getting Lower.

Basic Study for PI Circuit Design

- **Measurement (Impedance)**



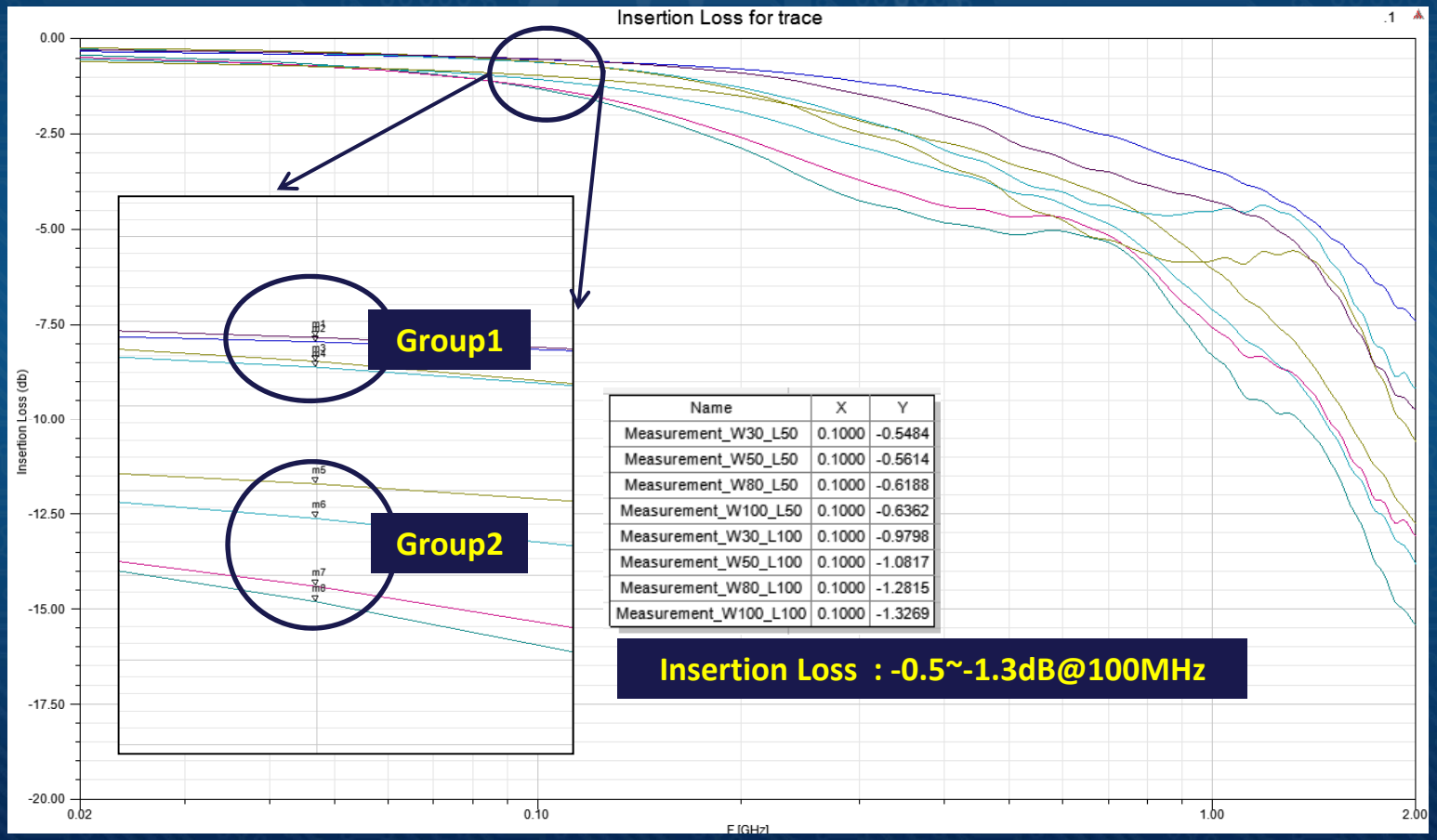


- As Trace Width is Small, the Impedance is getting Higher.
- Measurement shows impedance for Circuit Trace Width.

Basic Study for PI Circuit Design

- **Measurement (Insertion Loss)**

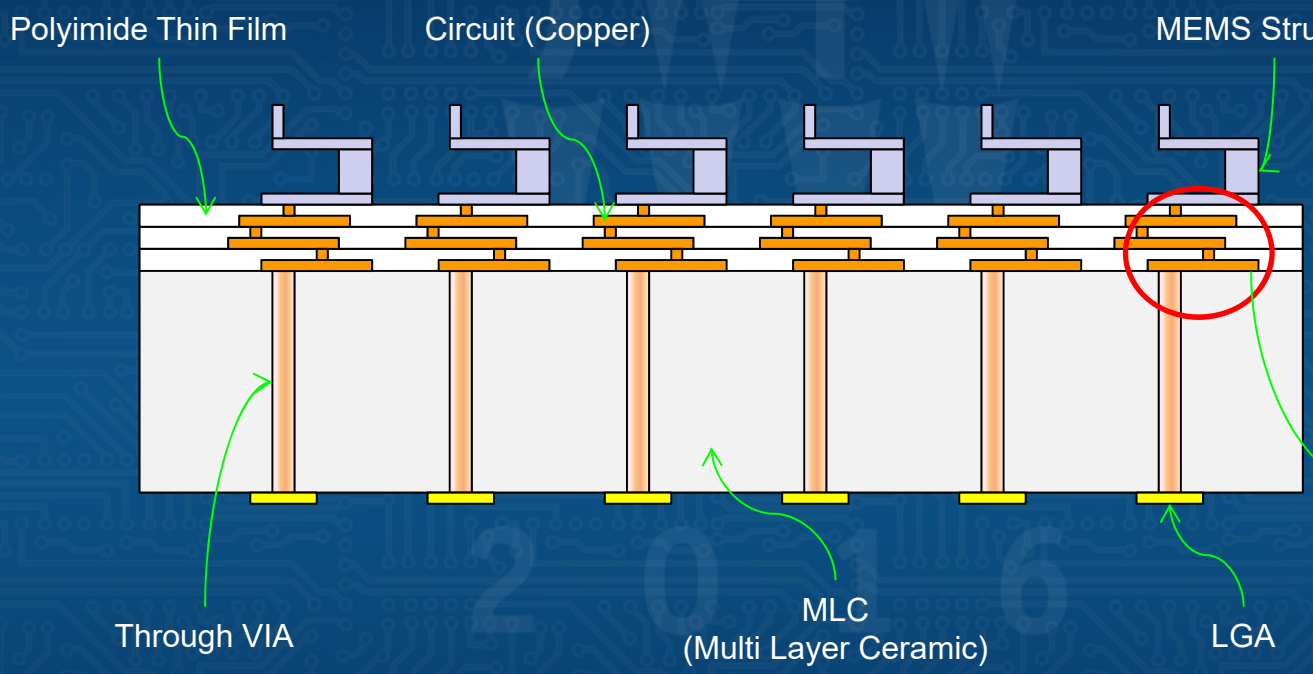
  - Analysis of Circuit Trace on Polyimide Thin Film

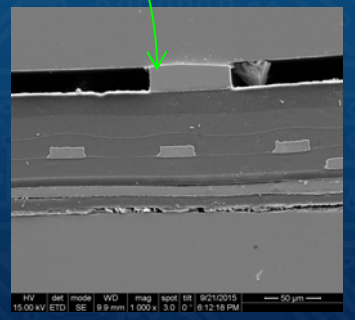


Name	X	Y
Measurement_W30_L50	0.1000	-0.5484
Measurement_W50_L50	0.1000	-0.5614
Measurement_W80_L50	0.1000	-0.6188
Measurement_W100_L50	0.1000	-0.6362
Measurement_W30_L100	0.1000	-0.9798
Measurement_W50_L100	0.1000	-1.0817
Measurement_W80_L100	0.1000	-1.2815
Measurement_W100_L100	0.1000	-1.3269

Signal Integrity on Probe Card

- **Concept of Circuit Design on Space Transformer (STF)**

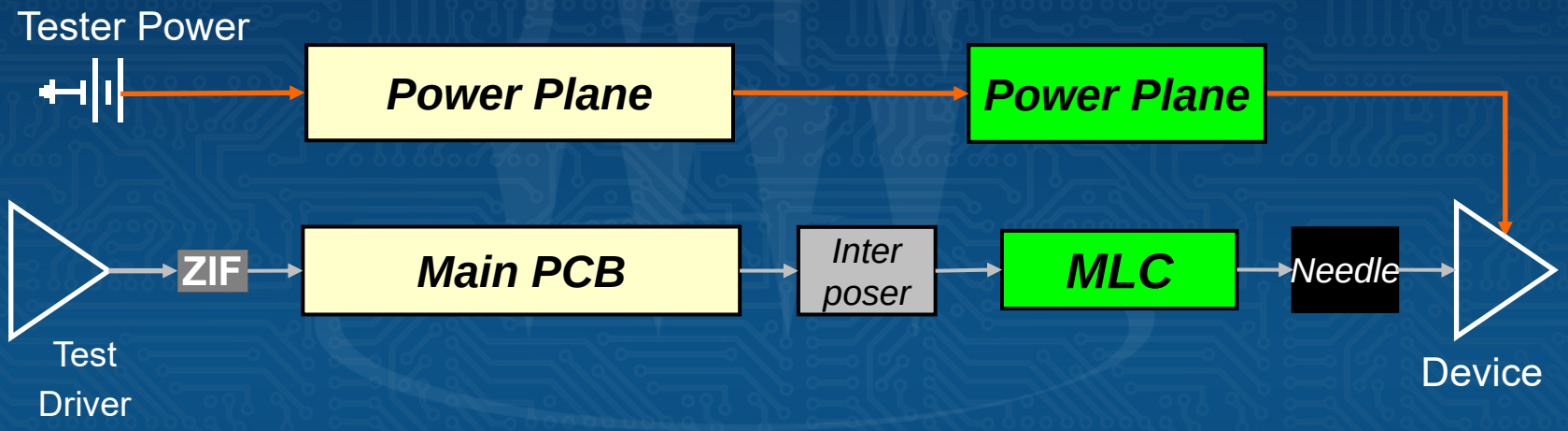




- STF consists of Universal MLC and Polyimide Thin Film.
- Polyimide Circuit is made by MEMS Process.
- MEMS Structure is stacked up after Polyimide Circuit Process.

Signal Integrity on Probe Card

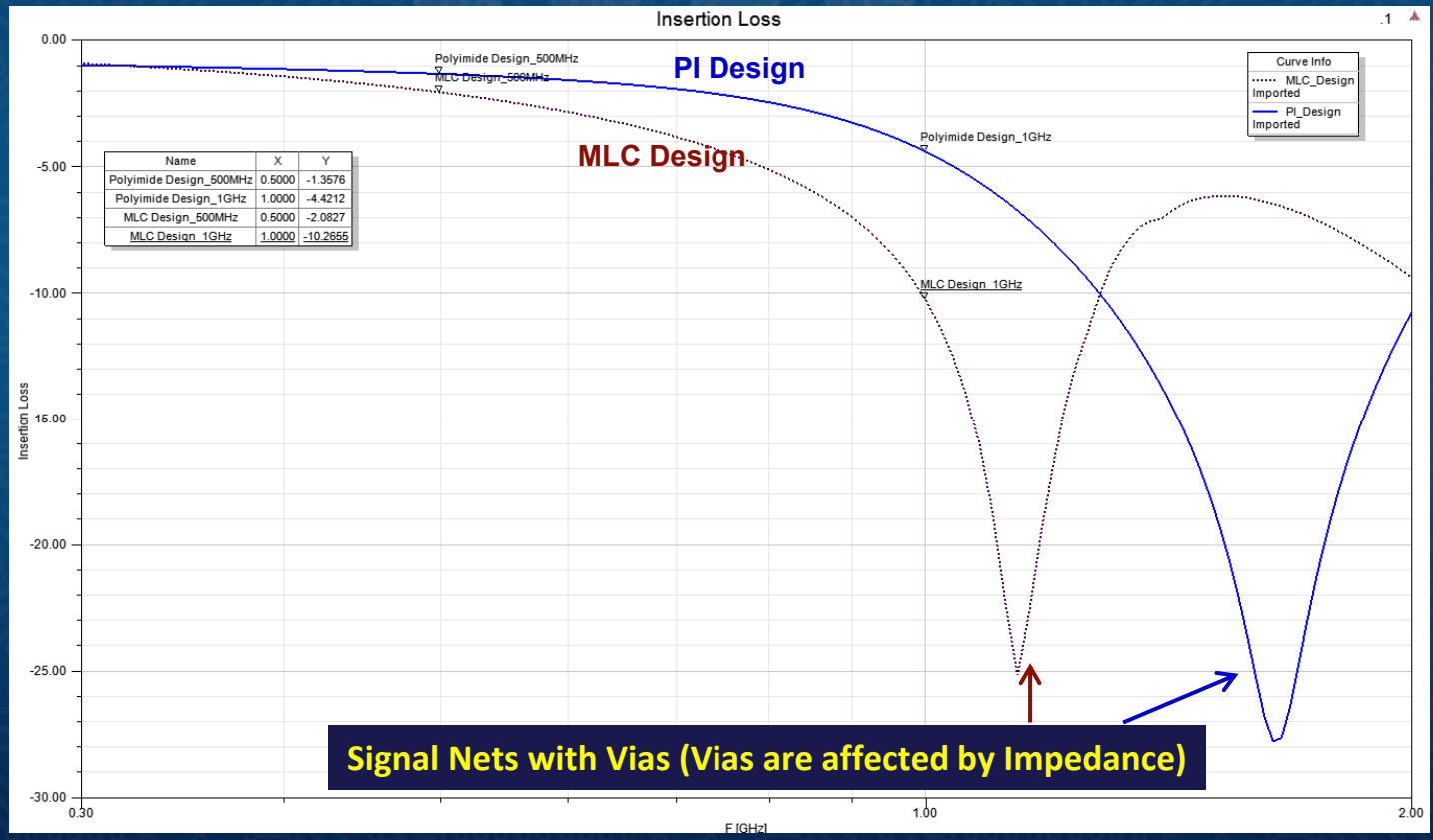
- **Simulation Conditions for Probe Card**



- Input Voltage : 1.1V
- Data : IO Ch.@Memory
- Data Rate : 100Mbps~1000Mbps (50MHz~500MHz)
- Factors : MLC Design vs PI Design on Probe Card
- Simulation Tool : SI Designer @ ANSYS

Signal Integrity on Probe Card

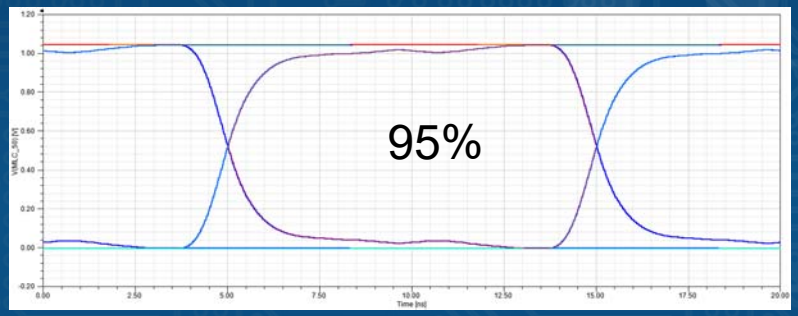
- **Insertion Loss (Simulation)**
  - Analysis of MLC Circuit Design vs PI Circuit Design on Probe Card
  - MLC Circuit Design -2.08dB vs PI Circuit Design -1.35dB@500MHz



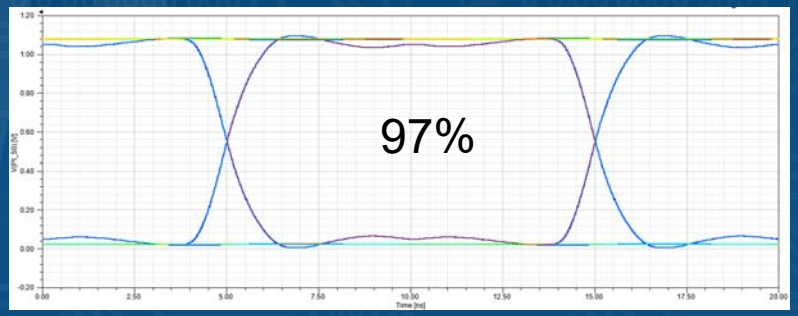
Signal Integrity on Probe Card

- **Eye Diagram (Simulation)**
  - Analysis of MLC Circuit Design vs PI Circuit Design on Probe Card
  - Eye-Opening : 95%~97%@50MHz, 93%~95%@100MHz

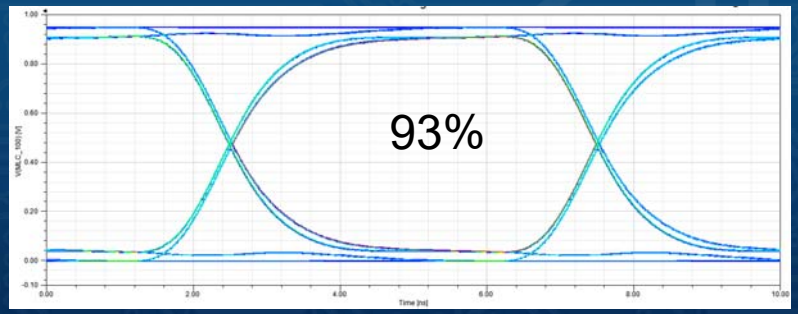
MLC Design : 50 MHz



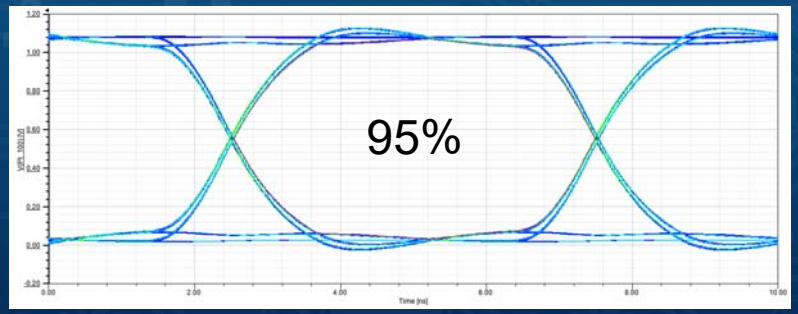
PI Design : 50 MHz



MLC Design : 100 MHz



PI Design : 100MHz

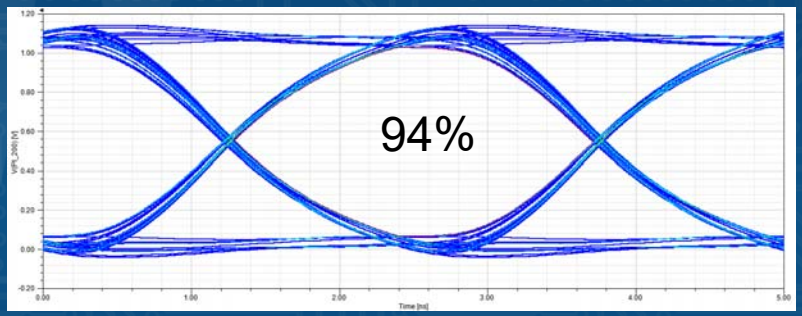


Signal Integrity on Probe Card

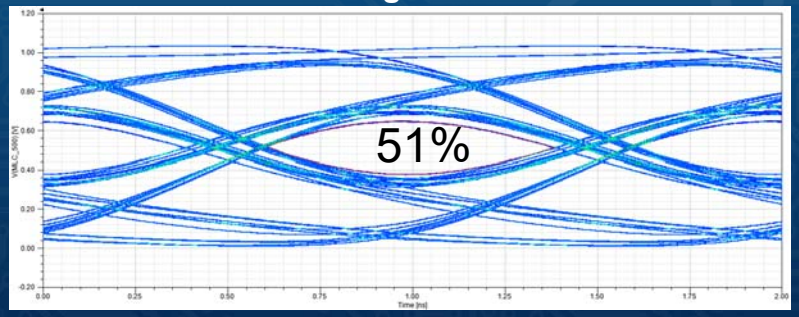
- **Eye Diagram (Simulation)**
  - Analysis of MLC Circuit Design vs PI Circuit Design on Probe Card
  - Eye-Opening : 90%~94%@200MHz, 51%~61%@500MHz

MLC Design : 200 MHz

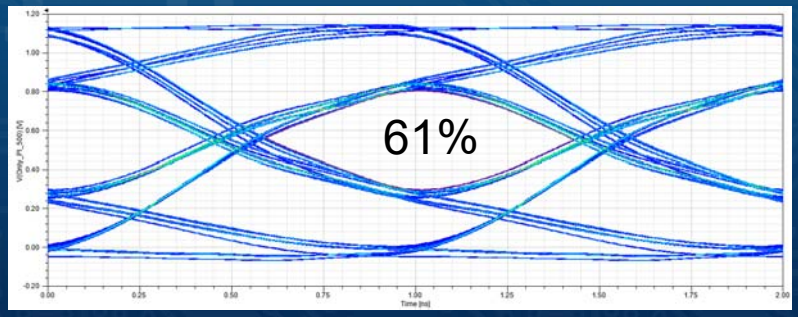
PI Design : 200 MHz



MLC Design : 500 MHz



PI Design : 500 MHz



Summary

- Basic Study for Polyimide Circuit Design was Performed and its Electrical Characteristics have been checked.
- Impedance of Circuit Design using Polyimide Thin Film can be Controlled by changing Trace Geometry.
- Signal integrity was analyzed using two kinds of Design Concept on Probe Card.

Future Works

- The Electrical Characteristics for Power integrity on Probe Card

  - Analysis of Power impedance using Polyimide Thin Film
  - Analysis of Effect for Decoupling Capacitor
  - Analysis of Power Noise as Ground Type(Mesh & Plane)

Acknowledgements

- Sang-Kyu Yoo
- Joon-Yoon Kim

- Yong-Ho Cho
- Sung-Mo Kang

- Jong-Kwan Yook

Thanks for Your Attention !