IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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New Probe Card Architecture – Ceramic without MLC

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Outline

- **MLC-free Probe Card**
- **Building "FI" Probe Card**
- **"FI" Probe Card Example**
  - CMOS Image Sensor
  - 300mm Full Wafer
- **Signal Integrity**
- **Summary**

“Make things as simple as possible, but not simpler”

Albert Einstein

MLC

- **MLC: Multi-layer Ceramic**
  – HTCC (High Temperature Co-fired Ceramic)
  – LTCC (Low Temperature Co-fired Ceramic)

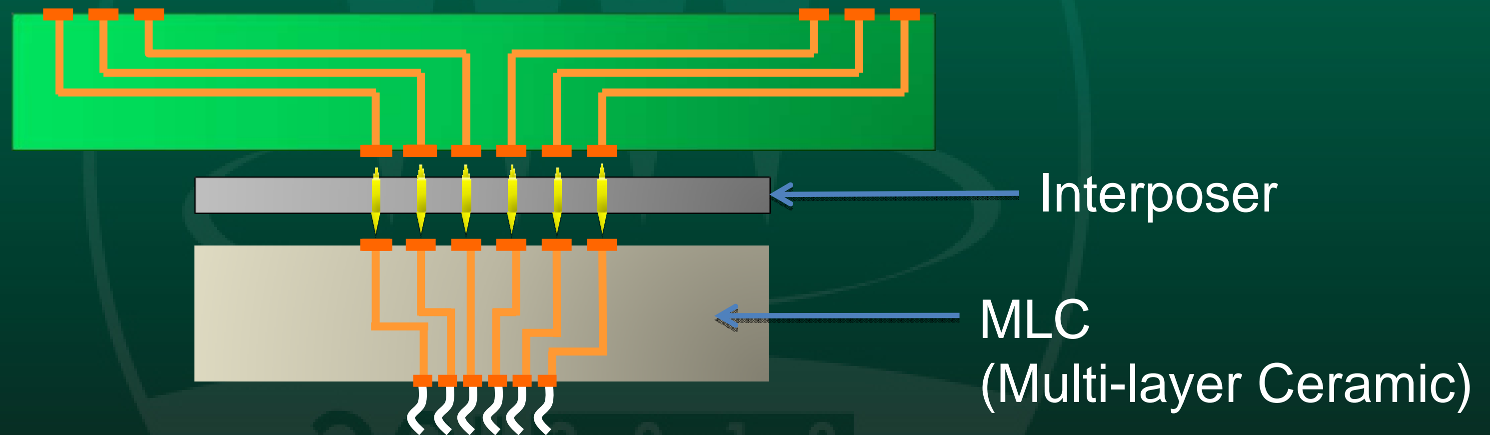
Probe Cards with MLC

- **Advantages**
  - Throughput
    - Due to increased parallelism
  - Yield
    - Consistent contact with device pads*
- **Challenges:**
  - Cost
    - Custom design & fabrication of MLC
  - Lead time
    - Multi-layer (as many as 20+) “green tape”

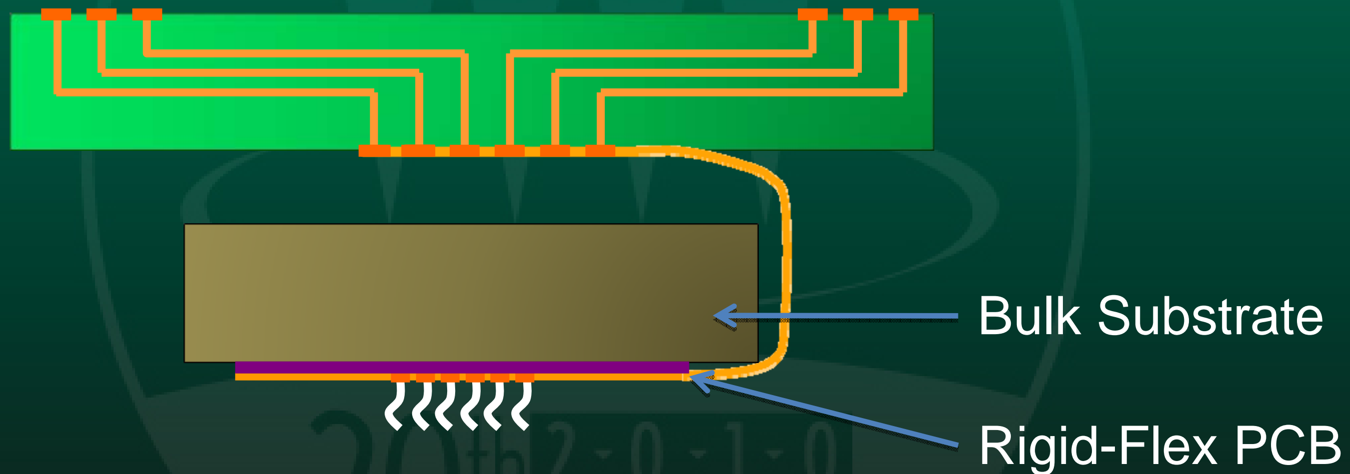
New Probe Card without MLC

- **Goal**
  - Maintain parallelism & reliability advantages, while overcoming cost & lead time challenges of the MLC-based probe card.

Typical Probe Card with MLC



"Fine Instrument" Probe Card - without MLC



- ✓ Bulk Substrate
- ✓ Rigid-Flex PCB

- ✓ No Interposer
- ✓ No MLC

"FI" Probe Card

- **Rigid Flex PCB**
  - Improved signal integrity
  - Modular construction
- **Bulk Substrate**
  - Wide selection of available substrates
    - CTE Match
  - Mechanical fabrication only
    - Lead time

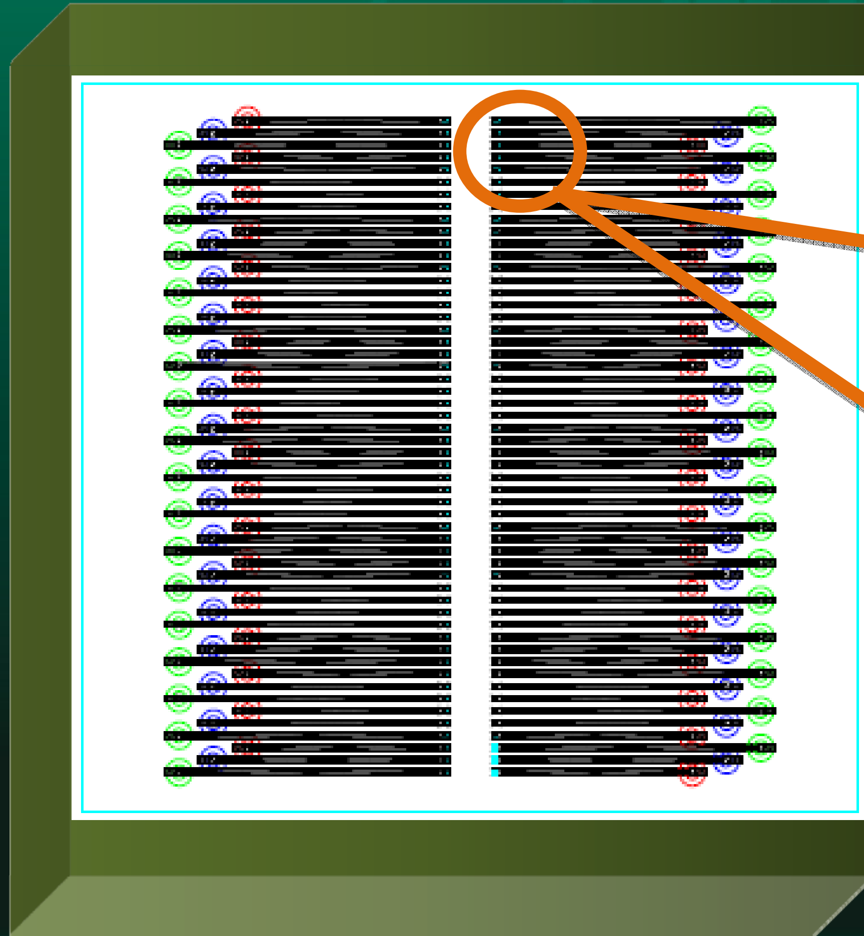
“FI” Probe Card

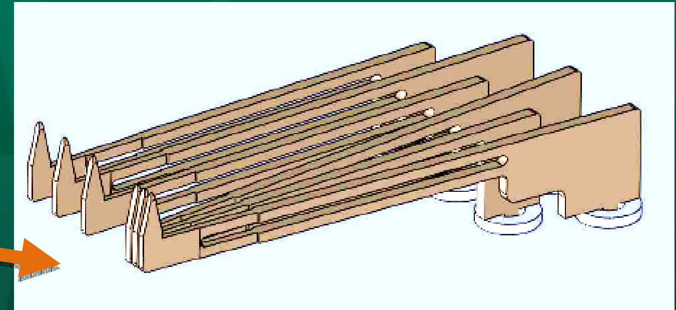
BUILDING “FI” PROBE CARD

Building "FI" Probe Card

- **Select Contact Material**
  - MEMS
  - Micro Cantilever: 2 – 3mm
- **Select Bulk Substrate**
  - Match CTE with wafer
- **Design Rigid-Flex Circuit**
  - PCB design & fabrication

Contact Selection





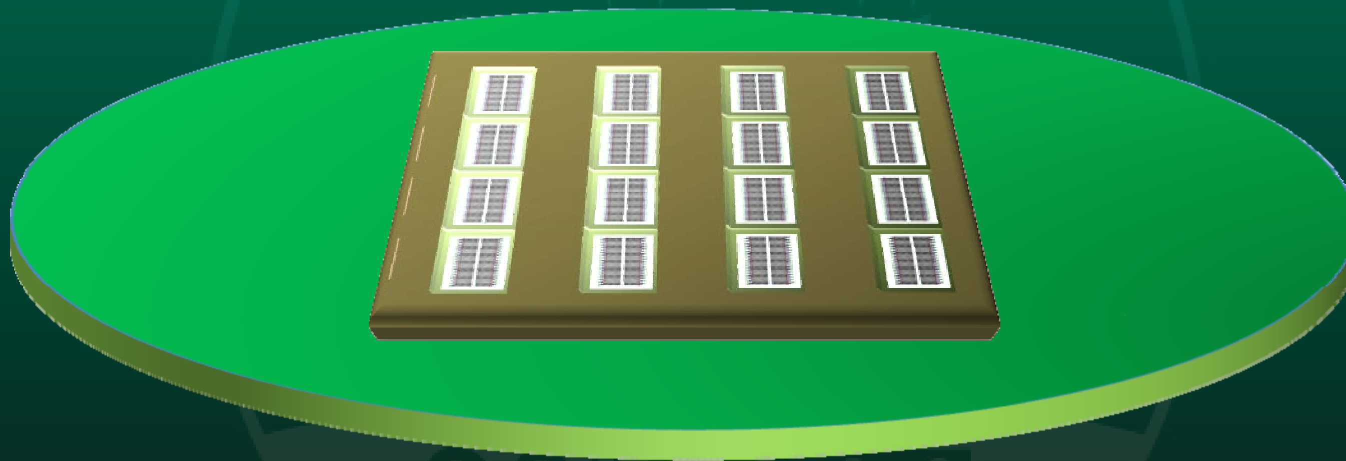
MEMS

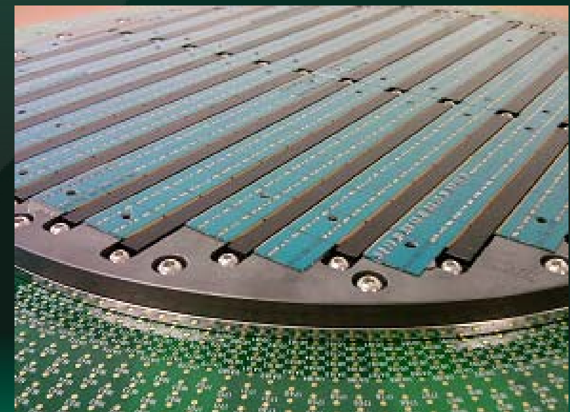
Micro Cantilever

Modular Site

Bulk Substrate – No MLC

Finished Probe Card – No MLC





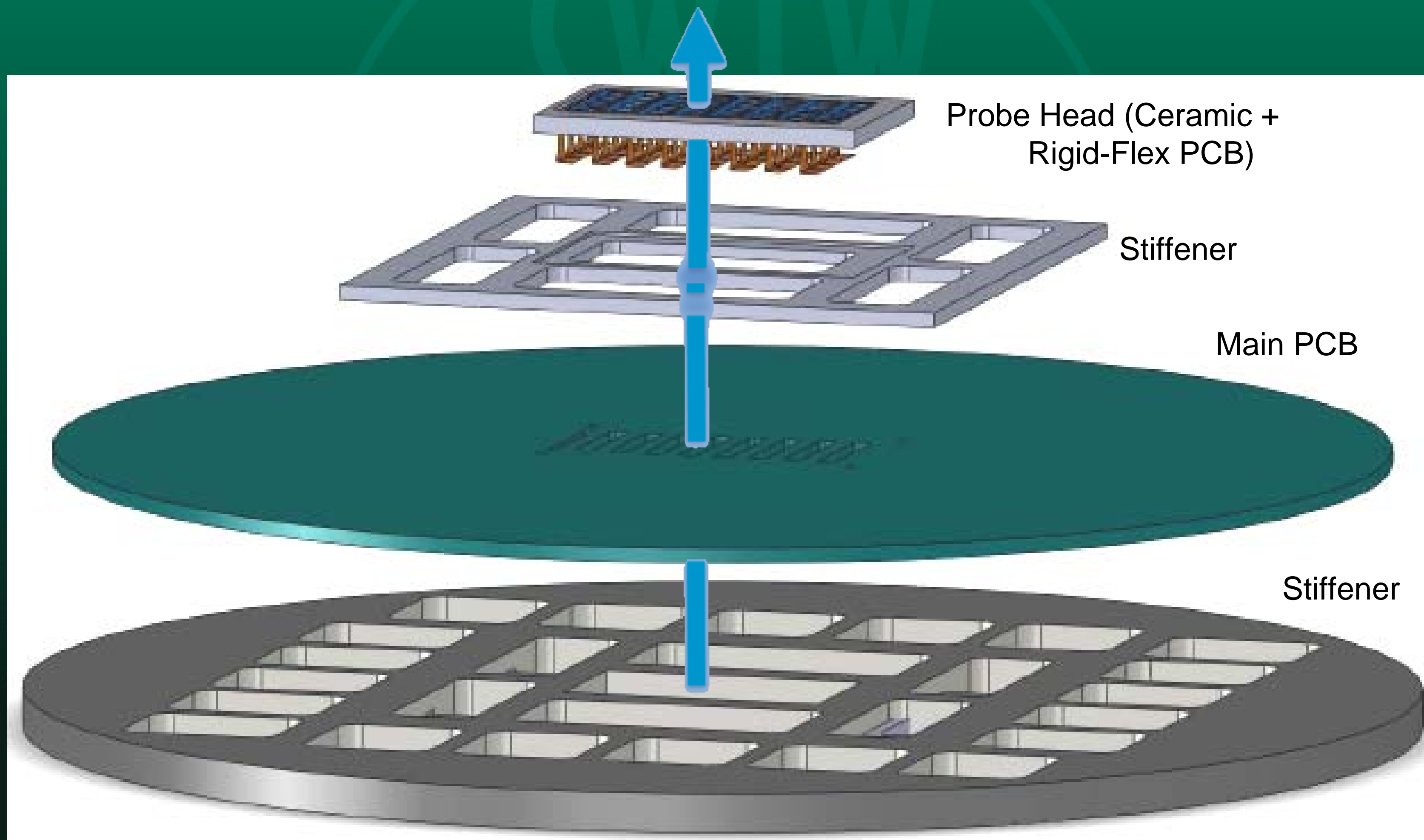
“FI” Probe Card Example

- **CMOS Image Sensor Probe Card**
  - Light port on each site (through-hole in the middle of each device location)
  - Multi-die: 32 devices in parallel
    - Higher parallelism, if ATE support is available
- **300mm Full Wafer Probe Card**
  - 1 touchdown (for flash); 4 touchdown (for DRAM)
  - Single probe card for both hot (90 deg C) and cold (-40 deg C)

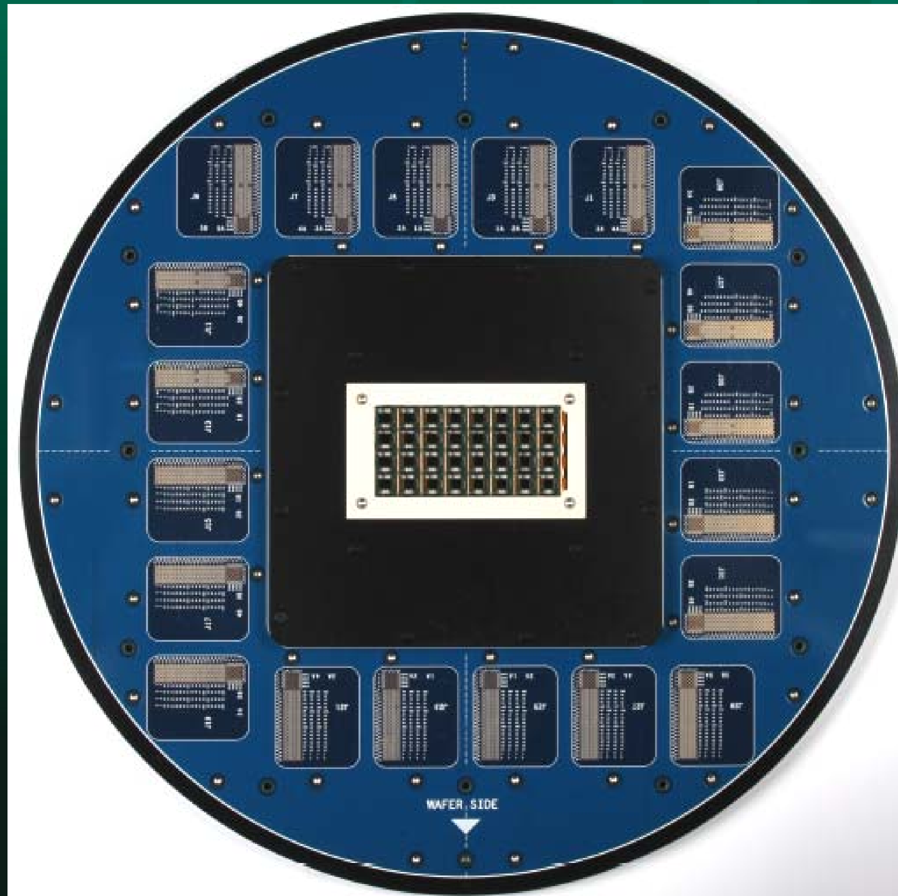
“FI” Probe Card Example

CMOS IMAGE SENSOR PROBE CARD

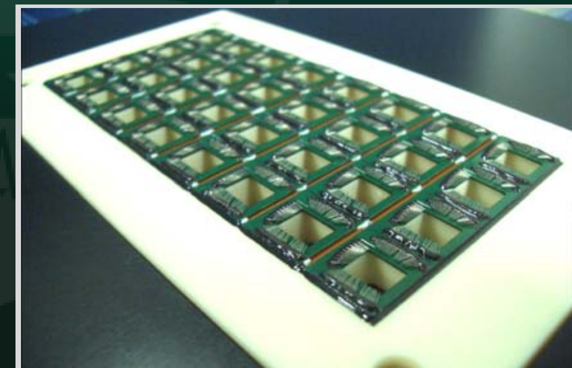
CMOS Image Sensor Probe Card



Probe Card for Image Sensor



- ✓ Multi-site: 32 (4 x 8)
- ✓ Light port on each site



“FI” Probe Card Example

300MM FULL WAFER PROBE CARD

Temperature vs. Probing Error

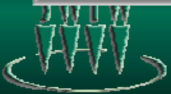
300mm Wafer

um
60
50
40
30
20
10
0
-10
-20
-30
-40

-40 -20 0 20 40 60 80 100 120

Temperature (deg. C)

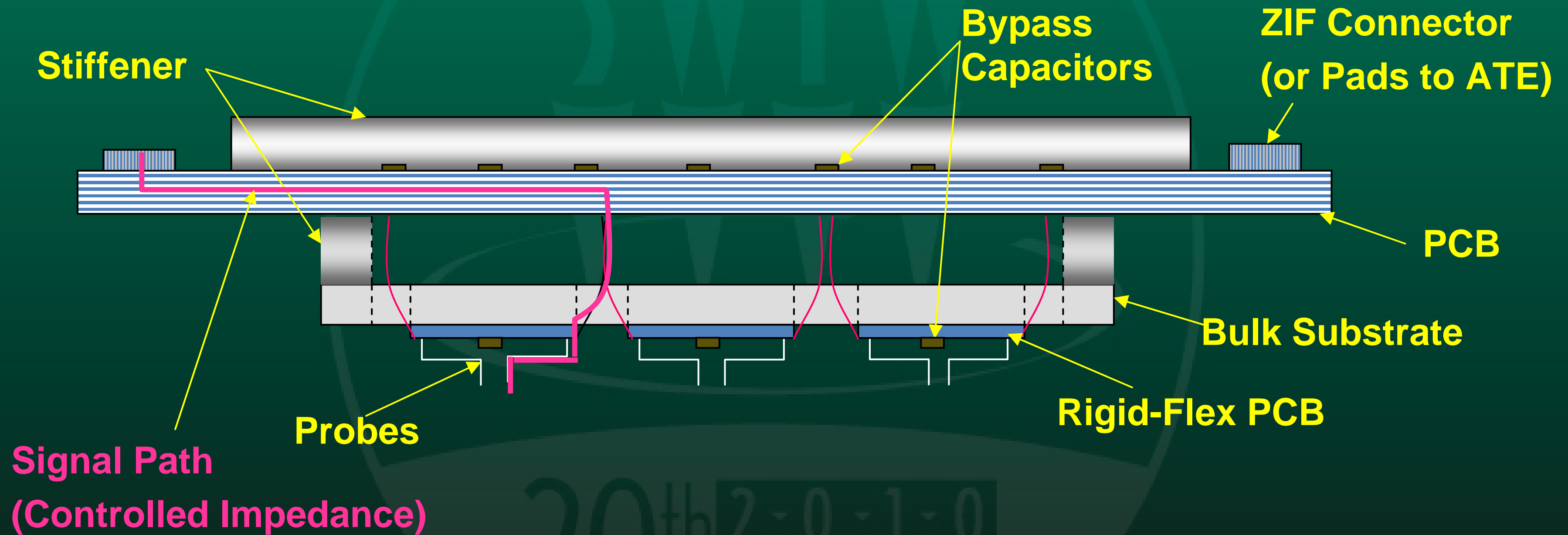
LTCC
HTCC
Aluminum
Nitride
Fine Instrument
Silicon Nitride



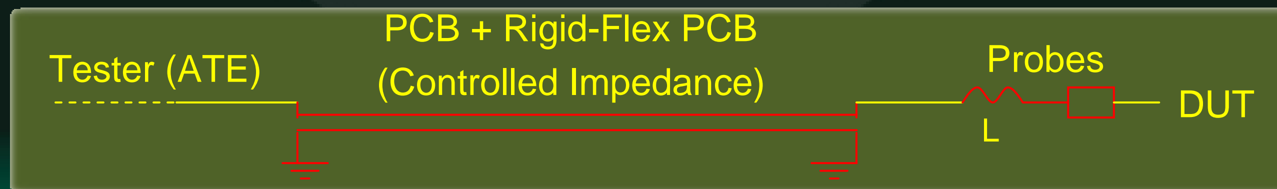
Substrates for 300mm Probing

- **Suitable for full 300mm application (good CTE match with wafer)**
  - Aluminum Nitride (AlN)
  - Silicon Nitride (Si_3N_4)
- **Limited (Localized or small temperature range) substrate application (due to CTE mismatch on 300mm wafer)**
  - HTCC (High Temperature Co-fired Ceramic, Al_2O_3)
  - LTCC (Low Temperature Co-fired Ceramic, Al_2O_3)

"FI" 300mm Probe Card Structure



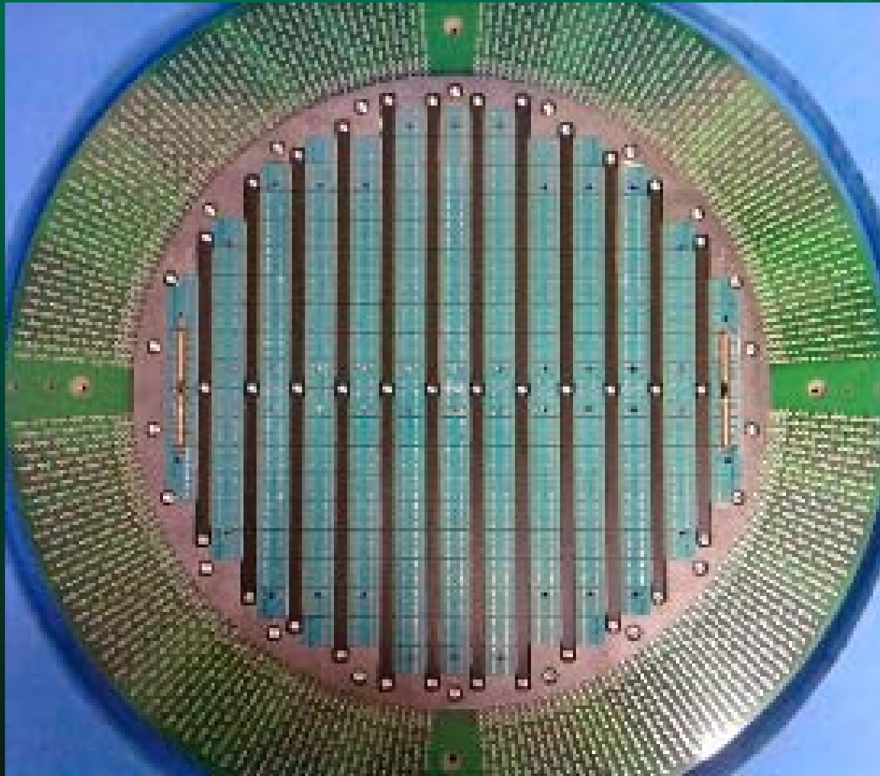
Signal path is fully impedance controlled



“FI” Probe Card

- **Impedance controlled signal path**
  - No interposer:
    - No extra inductance
    - No extra contact resistance
  - High speed / high signal integrity
- **Modular construction**
  - Readily scalable for high throughput (2x, 4x, etc.)
  - Selection of best CTE matched material
    - Single probe card for both hot (90 deg C) and cold (-40 deg C)

"FI" 300mm Probe Card – No MLC



- ✓ Full wafer, single touchdown
- ✓ 10,000+ contacts
- ✓ -40 deg C to +90 deg C

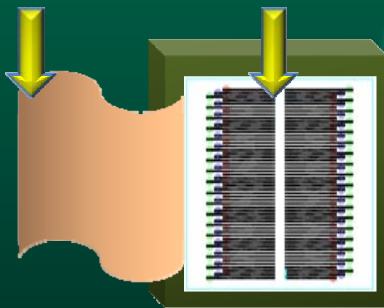
“FI” Probe Card Example

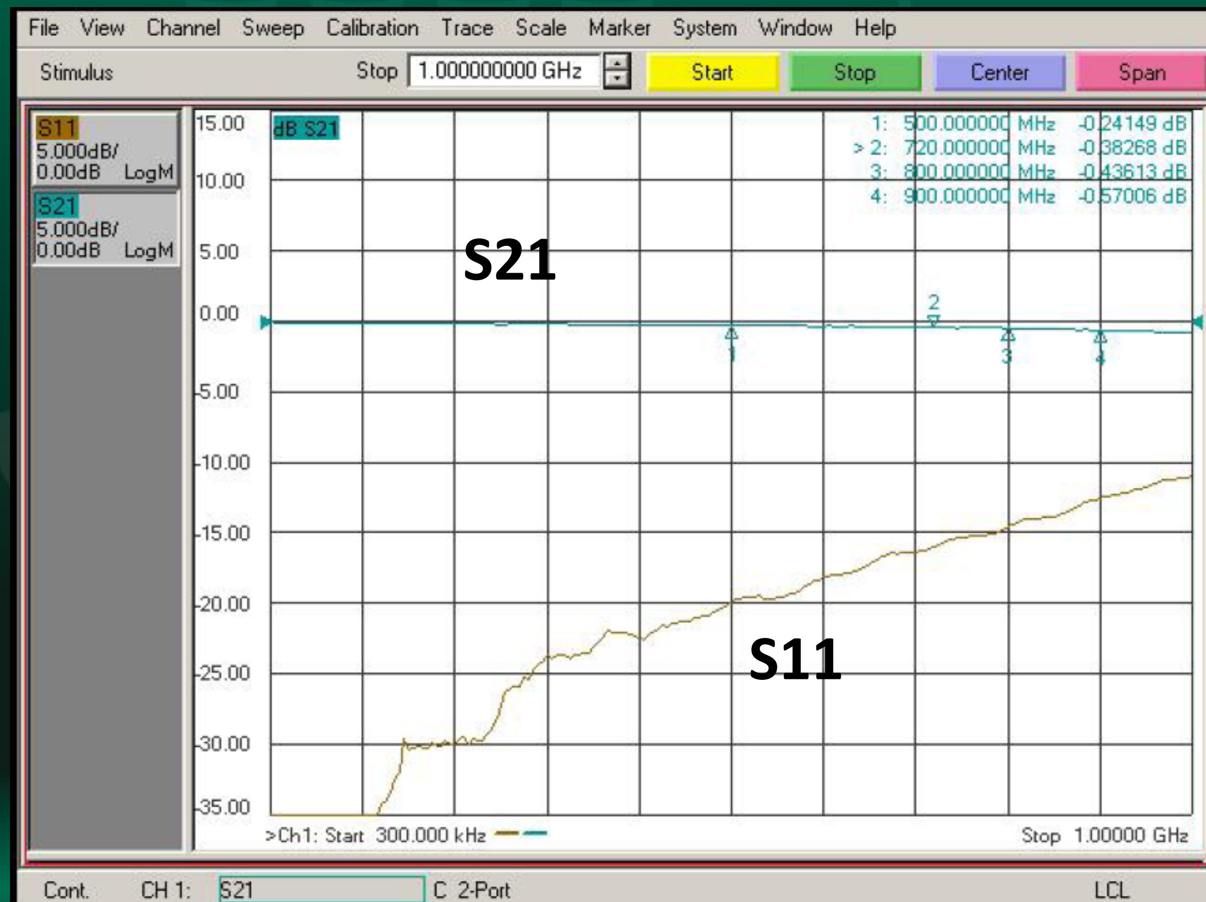
“FI” PROBE CARD SIGNAL INTEGRITY

Signal Integrity for Probe Block

Probe Block:

- S21 (transmission / insertion loss) **>> 900MHz** @-1dB
- S11 (reflection / return loss) > 500MHz @-20dB



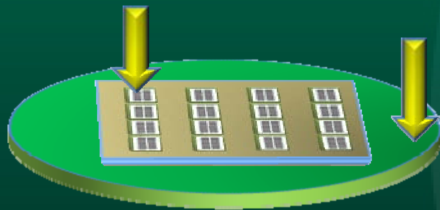


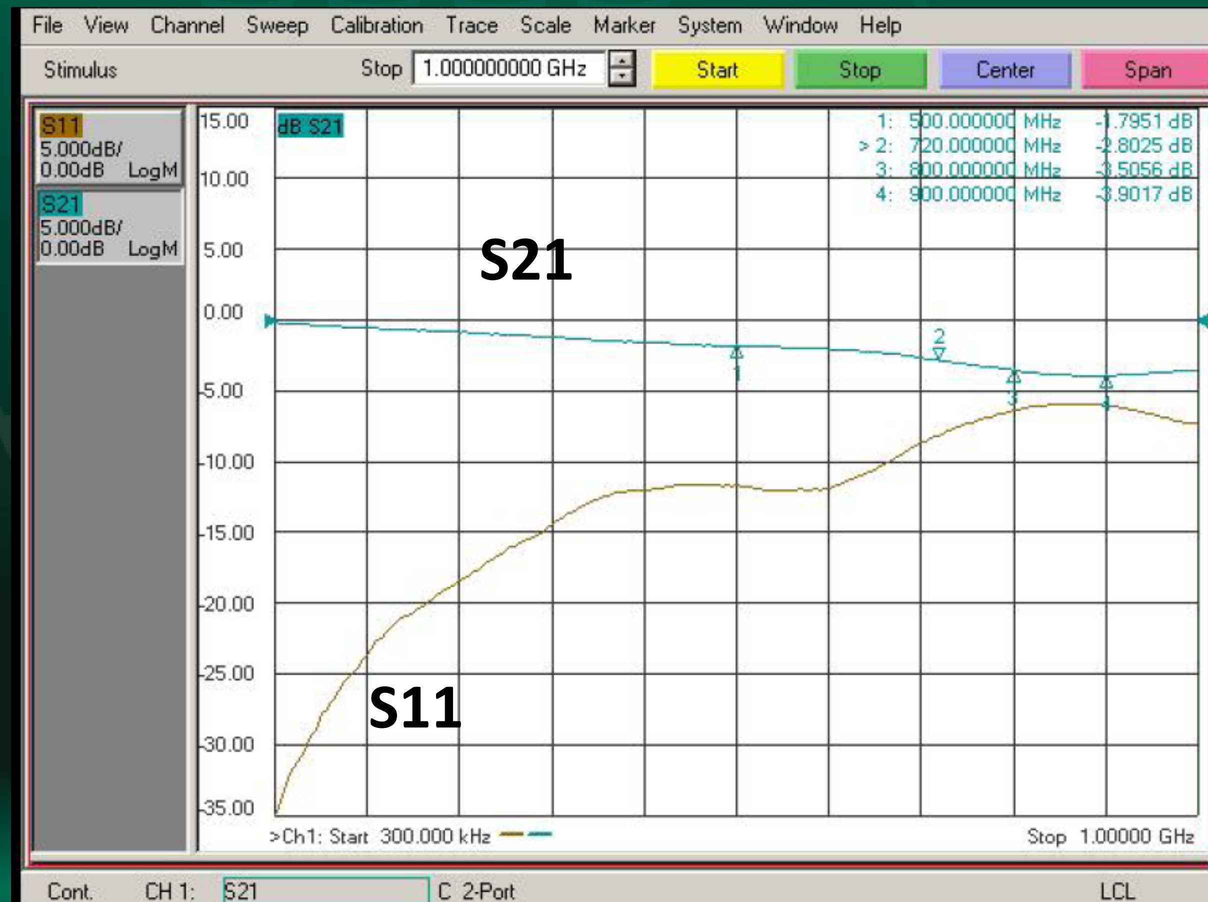
Signal Integrity for Probe Card

Probe Card:

S21 (transmission / insertion loss) **> 720MHz** @-2.8dB

S11 (reflection / return loss) > 400MHz @-15dB





"FI" Probe Card Capability

	Description
Alignment (X,Y)	+/- 10 um
Planarity (Z)	+/- 15 um
Working Temperature	-40 ℃ ~ 120℃
Pin Force	~ 1.2 gf/mil (selectable)
Tip Diameter	< 10 um
Minimum Pad Pitch	50 um
Impedance	50 Ω (customizable)

“FI” Probe Card

- **MLC-free, New Probe Card Architecture**
  - Bulk Ceramic Substrate
    - Choice of CTE matched material for full wafer contact
    - Shorter lead time
  - Rigid-Flex PCB
    - Signal integrity
    - Expandability (higher parallelism)
    - Shorter lead time
  - Probing contact
    - Choice of contact material
    - Repairable at individual pin & DUT

Summary

- **New probe card architecture, using bulk ceramic -**
  - – Overcomes challenges of traditional MLC probe cards.
    - Lead time
    - Cost
  - – Improves on advantages of MLC probe cards
    - Parallelism
    - Reliable contact

Appendix

PATENTS

Patents related to “FI” Probe Card

- **Patents have been filed or issued (Korea, Taiwan, International PCT):**
  - Manufacturing method of probe array
  - Probe assembly
  - Probe assembly and manufacturing method of probe card
  - Probe card and manufacturing method
  - Pin array frame used for manufacturing of probe card
  - Probe pin for probe card and manufacturing method