5G and mmW Applications

November 17, 2020

What does 5G mean for RF Front Ends?

- Current Active Antennas for 5G have split this, using a lot more PAs, filters, switches, mixers, and phase shifters in order to reduce individual power chain RF power
- Improved linearity with lower feed losses and lower power per component requiring higher quality measurements
- Large increase in the number of devices, dramatically increasing the number of DUTS that need to be tested

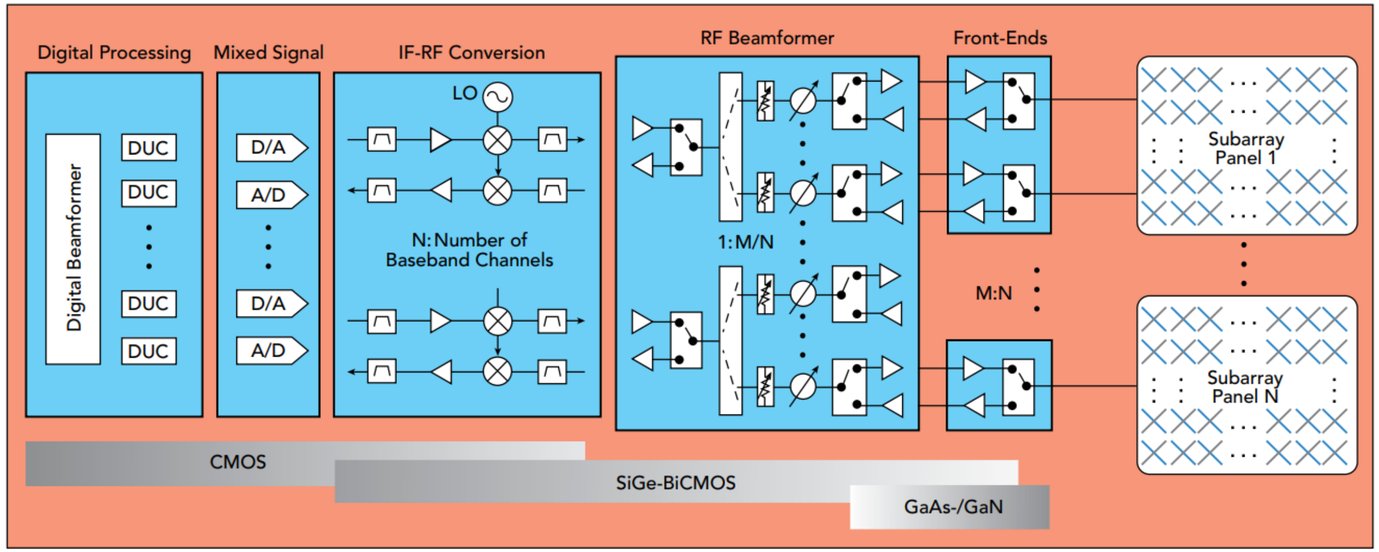


Fig. 14 Active array using hybrid beamforming.

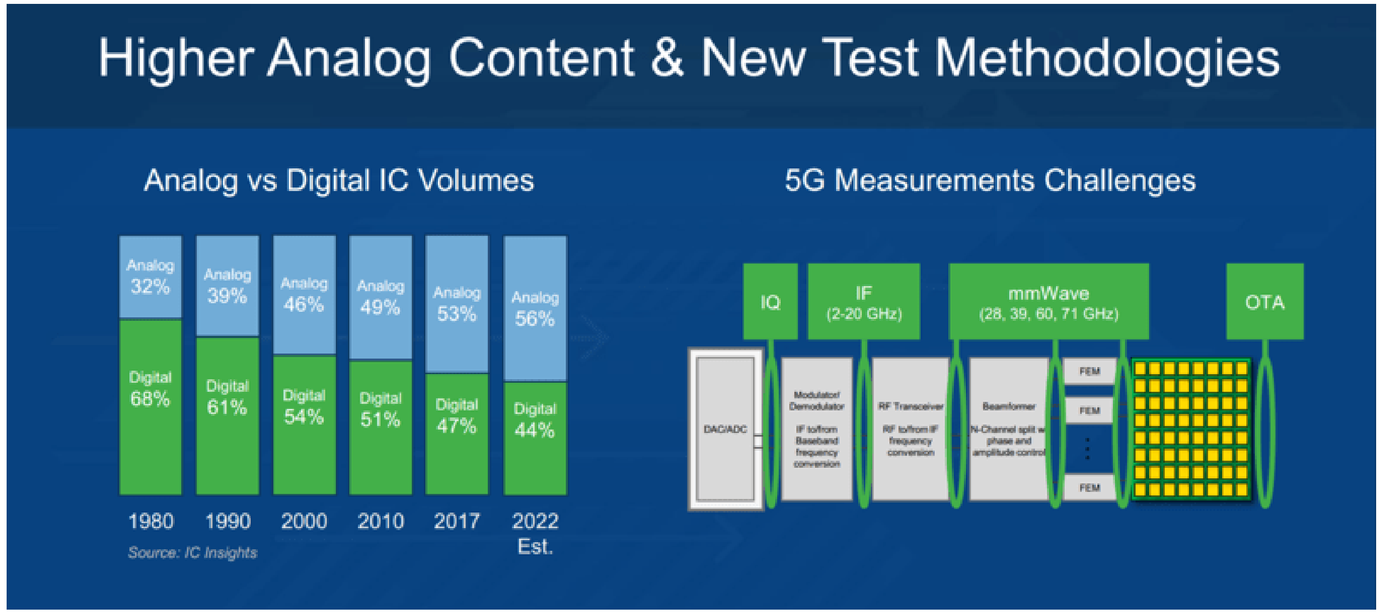
How the number of RF chips has been increasing

- Now what does 5G mean for Wafer test:
  - The share of analog to digital IC volumes have been shifting so that by 2022, about 56% of all chips being shipped will be analog, with RF taking up to about ¼ of the total analog
  - In particular, the increase in RF measurements will drive a lot of this, including how to test:
    - IF in 2-20 GHz
    - mmW in 28, 39, 60, and 71 Ghz
      - Capable of EVM measurements
    - OTA Measurements
    - SiPh, where are the high BW that

      Parts are moving will require RF wafer

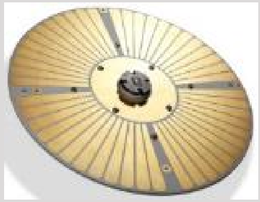
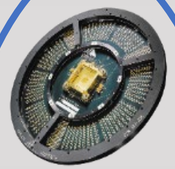
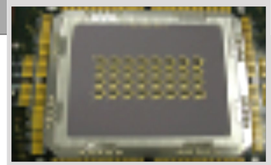
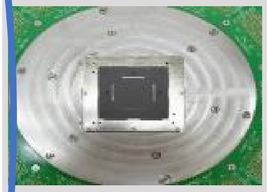
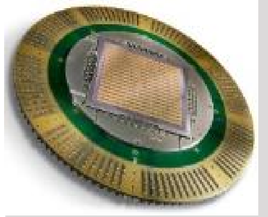
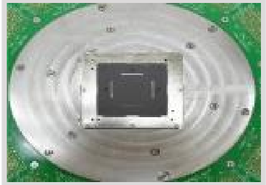
      Probing methods compared to traditional

      Wafer probing technologies



https://semiengineering.com/testing-5g/

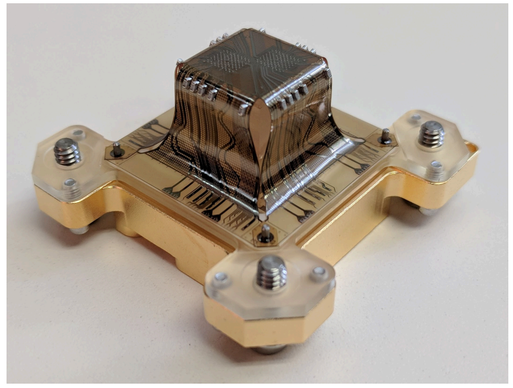
FormFactor Probe Card Product Portfolio -5G

PARAMETRIC	RF	SoC WLCSP	SoC Grid Array	SoC Optical IC	SoC Wire Bond	DRAM	FLASH
 Takumi	 Pyramid	 QiLin		 Hikari for Image Sensor	 TrueScale	 SmartMatrix	 TouchMatrix
 Pyramid	 Pyrana	 Katana	 Vx	 Akari for LED	 PH	 HFTAP	 PH
 Cantilever	 Katana Apollo				 Katana	 PH	

FFI 5G Solutions in Production

Pyramid

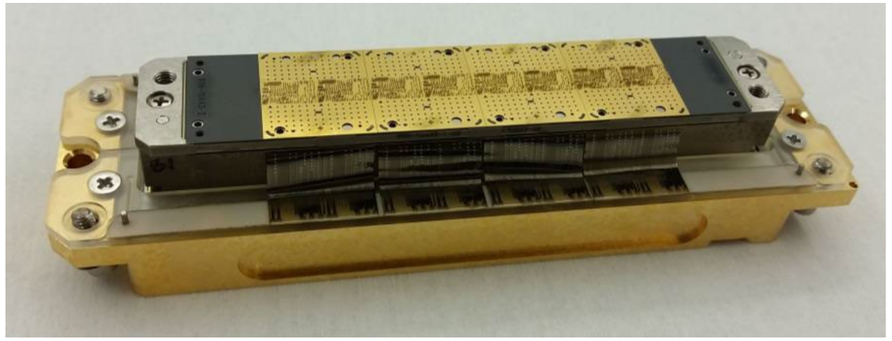
- mmWave performance to 80GHz +
- Lowest GND inductance
- Bypassing close to die
- Tight XY accuracy for small pitch
- Proven in production



Pyramid MSI x2 Probe Core

ePyrana

- High compliance, replaceable pins
- Large probe face for x8+ parallel testing
- Low probe force for small diameter Cu pillars
- Good RF performance to 45GHz

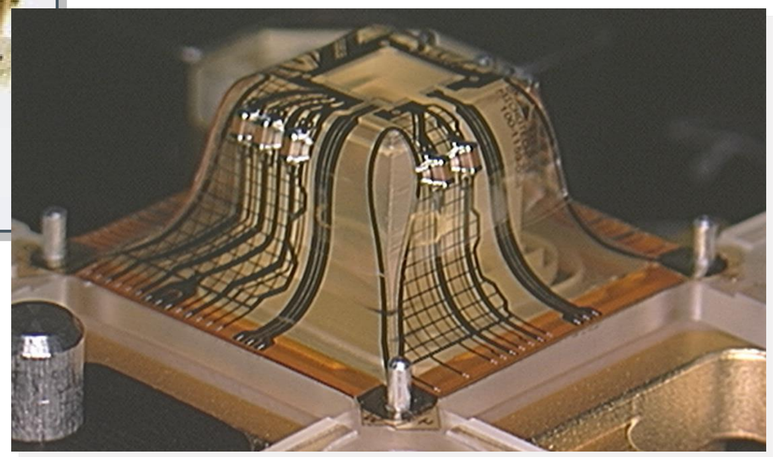


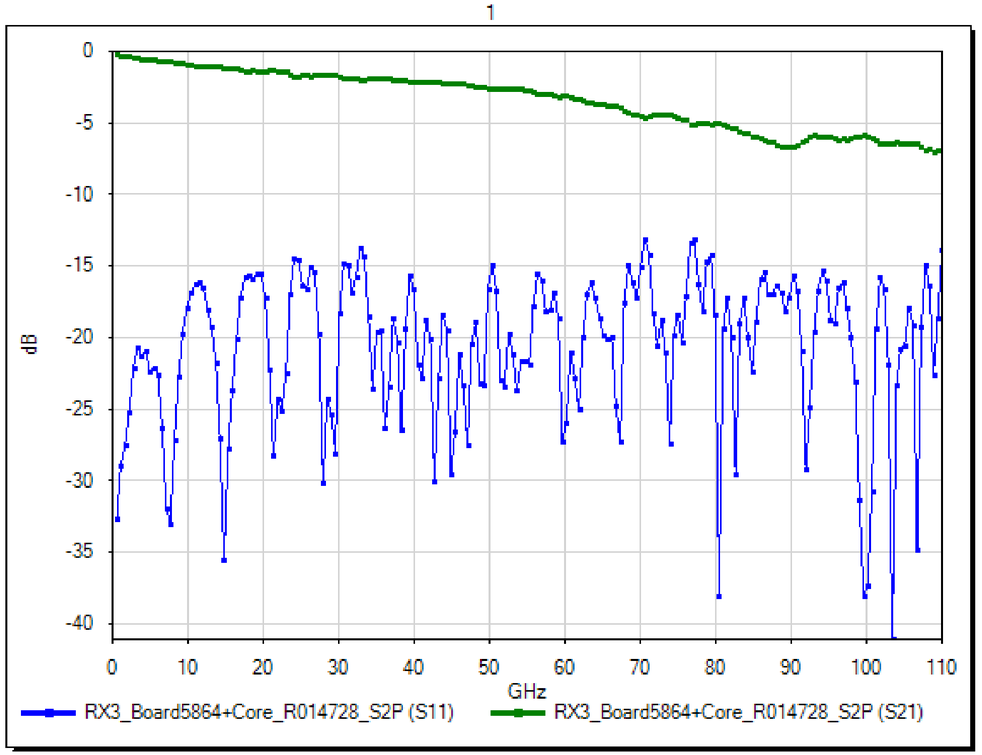
Pyrana PV75 x8 Probe Head

Pyramid Probe RF Measurements

Typical performance of Pyramid Probe is to have:

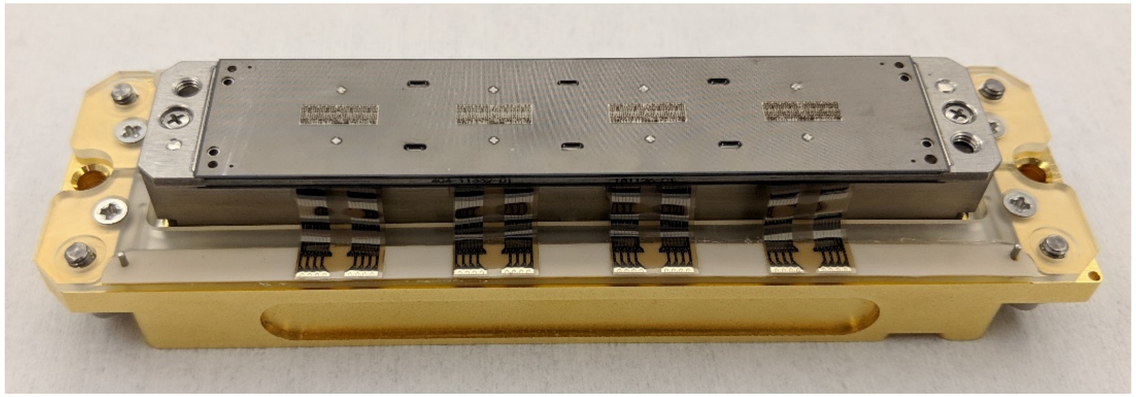
- Return loss better than -10 dB out to 81 GHz using 1 mm connectors
- Insertion loss of better than 6 dB at 81 GHz

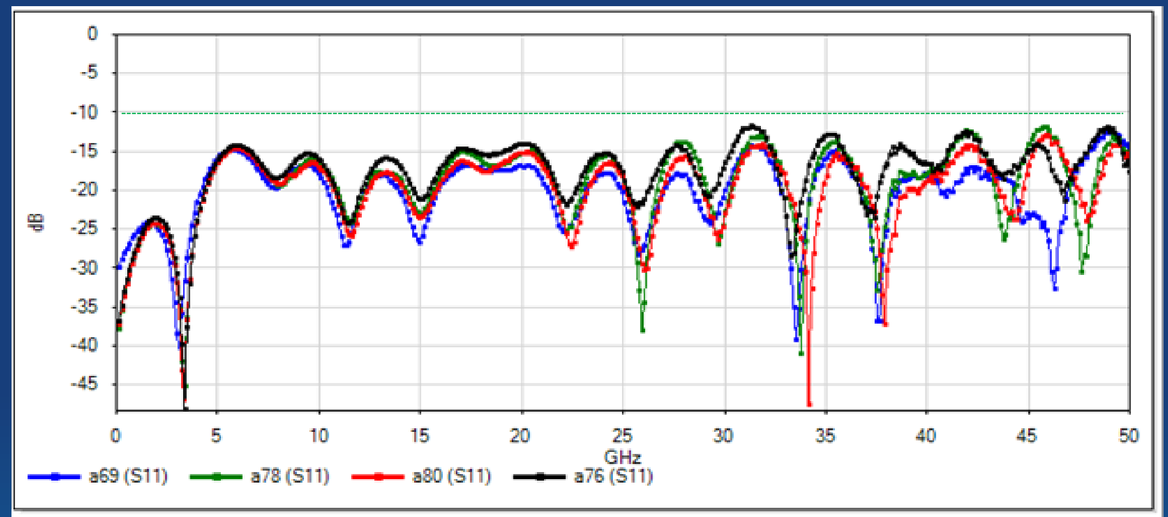




ePyrana RF Measurements

- High density CBI capable of 200+ mmWave interconnects on PV75
- Measurement from ISS through CBI breakout, inclusive
- Test vehicle based on customer design ball placement optimized for RF performance





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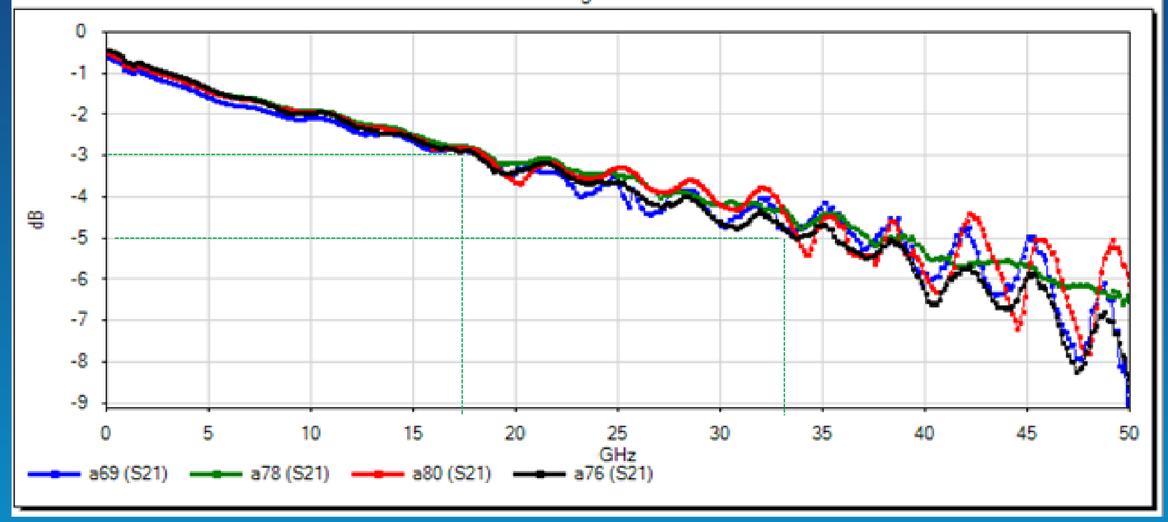
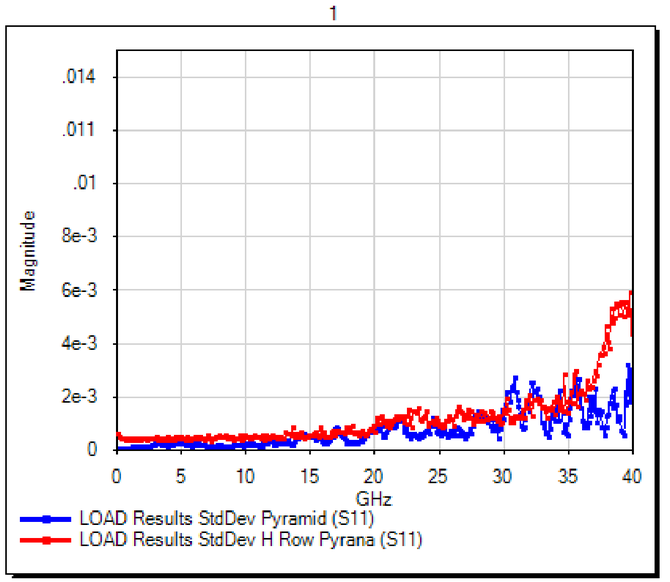
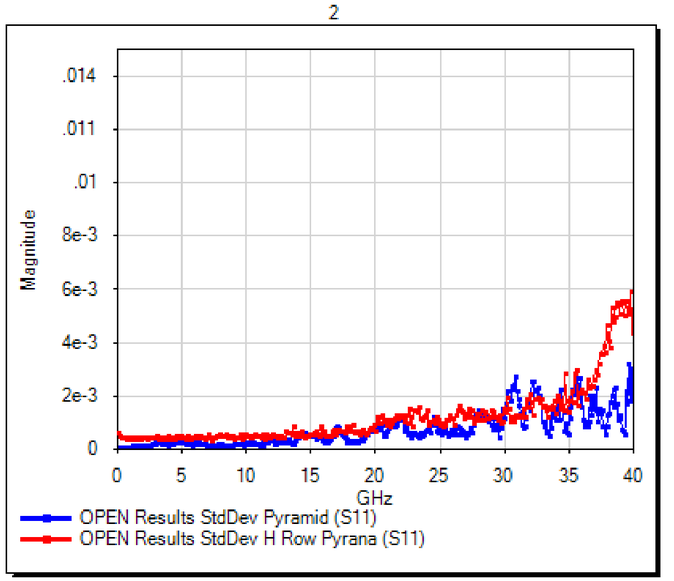
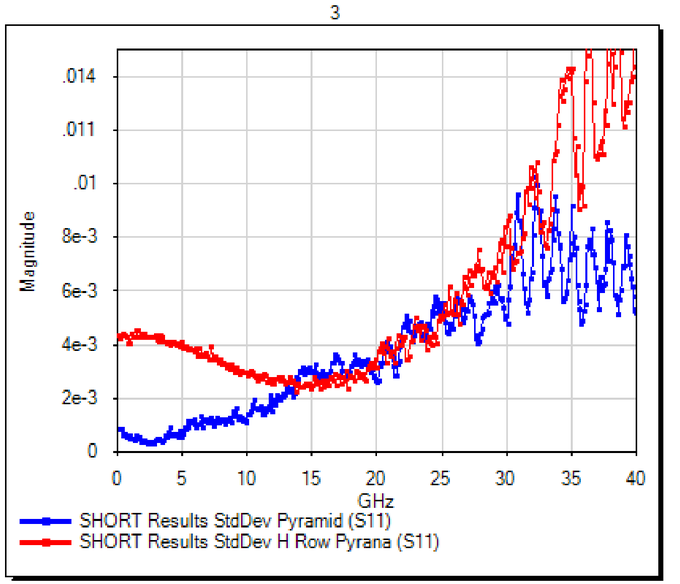


RF Measurement Repeatability

- RF TD to TD repeatability with an RF calibration is important for the test specifications
  - These measurements are done with a single SOL calibration, and then remeasuring all of the standards 10 times each
  - Each plot is the std dev of the measurements (Blue = Pyramid; Red = ePyrana)



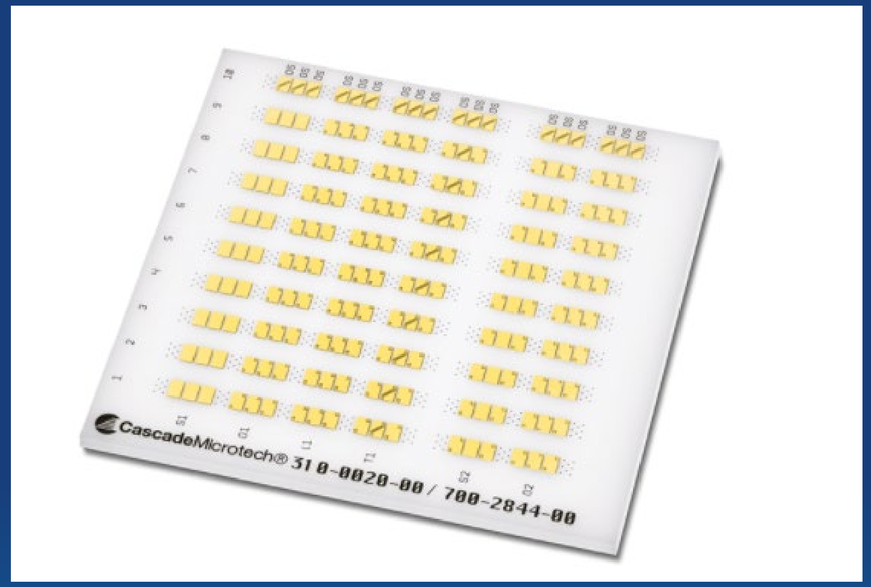


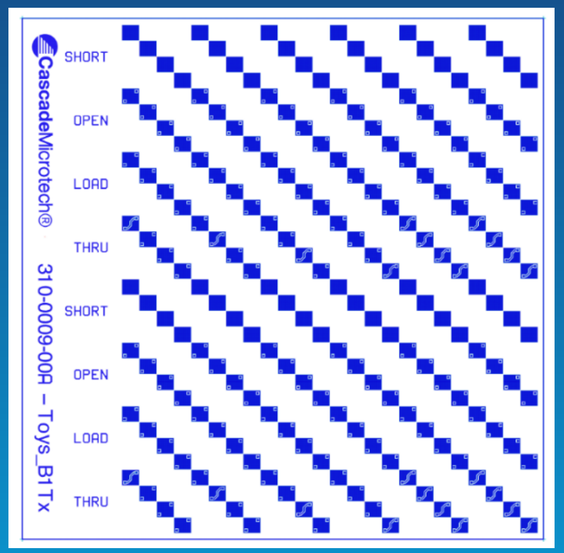


RF Calibration

Formfactor can provide a custom RF Calibration substrate

- Designed to exactly match the die layout
- Supports multi-DUT calibration
- Ability to control the RF impedance of all lines simultaneously for more accurate calibration
- Uncontrolled RF lines can resonate through excited currents and fields
- Standard 50Ω loads as well as non-standard loads are available
- Accuracy guaranteed to 1%
- Designed and built by Cascade. Ships in same box as the probehead





THANK YOU