A Dual-Band Micromachined On-Wafer Probe with Integrated Diplexer for Ultra-Broadband Measurements to 220 GHz

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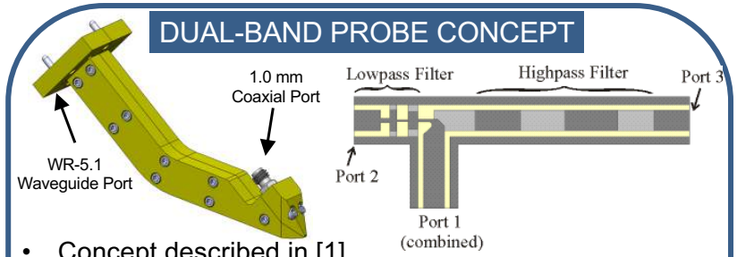
BACKGROUND AND MOTIVATION

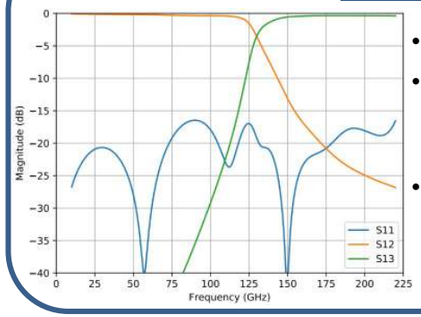
- Bandwidth of on-wafer measurement systems limited by single-mode propagation range of coaxial or rectangular waveguide interfaces
- Characterization over multiple frequency ranges is time consuming and introduces additional sources of error and uncertainty

DUAL-BAND PROBE CONCEPT



- Concept described in [1]
- Concatenate frequency ranges of existing hardware
- No need for novel broadband interface
- Integrated passive diplexer in probe to combine signals:
  - 1.0 mm coaxial input covers DC – 130 GHz
  - WR-5.1 waveguide input covers 130 – 220 GHz
  - Combined output to probe tips
- Keysight firmware seamlessly presents hardware as single-sweep two-port VNA

DIPLEXER DESIGN

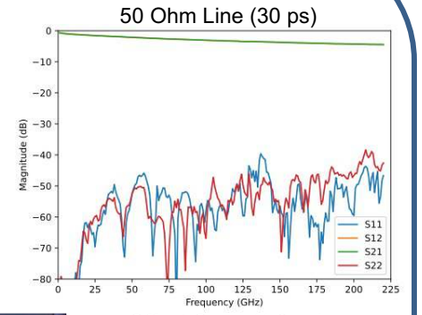


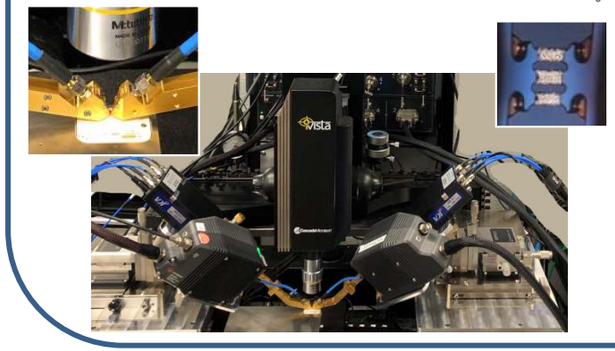
- Follows process outlined in [1]
- Diplexer implemented on 15µm silicon for integration with DMPI micromachined probe platform
- Complementary filters implemented as stepped impedance LPF and capacitively-coupled resonator HPF

ON-WAFER MEASUREMENTS

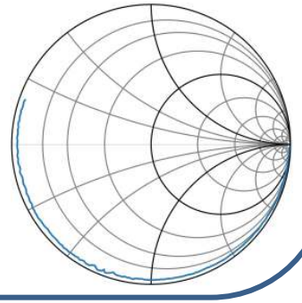
- Keysight N5291A PNAX w/ Broadband firmware
- Virginia Diodes (VDI) WR-5.1 extended band frequency extension modules
- FormFactor PA200 with with RFA probe arms and 45° dual frequency extender mounts
- LRRM or mTRL on-wafer calibration

50 Ohm Line (30 ps)

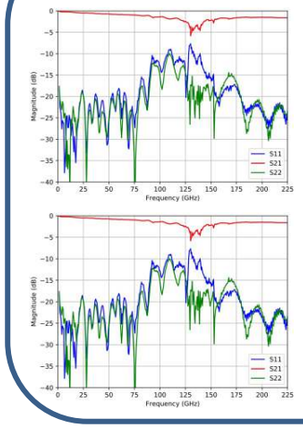




Offset Open (1.2 ps)



PROBE PERFORMANCE



- Maximum insertion loss of 6-7 dB, occurring at crossover frequency
- ~1.5 dB loss @ 220 GHz
- Return loss at probe tip >10dB, indicating complementary match of LPF and HPF filters
- Return loss > 15 dB away from crossover region

CONCLUSIONS & REFERENCES

- First dual-band on-wafer probe for ultra-broadband single-sweep measurements to 220 GHz
- Integrated diplexer enables extended measurement bandwidths without broadband connector interfaces

[1] F. Boes, et al., "Ultrabroadband Diplexers...," *IEEE TMTT*, June 2020.

This probe was developed in collaboration with Keysight Technologies, FormFactor, and Virginia Diodes.