"License to Speed: Extreme Bandwidth Packaging "

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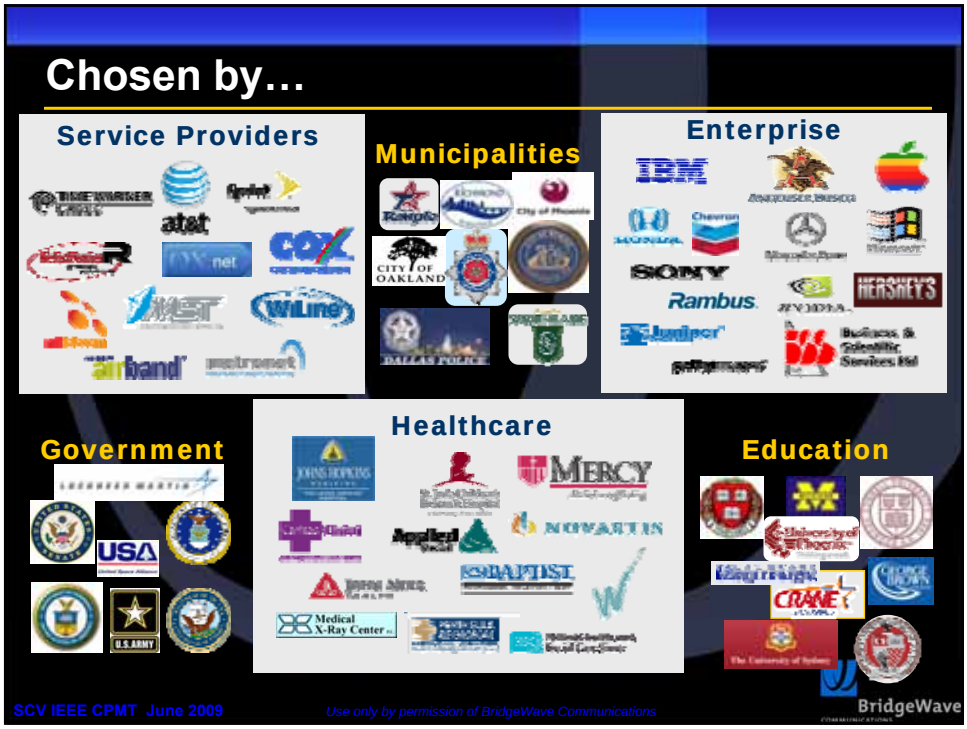
BridgeWave Communications

- Specializing in 60-90 GHz
- Providing a wireless fiber substitute
- 80% of all 2008 U.S. & U.K. FCC 70/80 GHz registrations

Corporate Headquarters: Santa Clara, CA

- Extensive product line
- Pioneered many "firsts" in this space
- Sales in Americas, EMEA, Asia/Pacific


Chosen by…
Service Providers
Municipalities
Enterprise
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Healthcare
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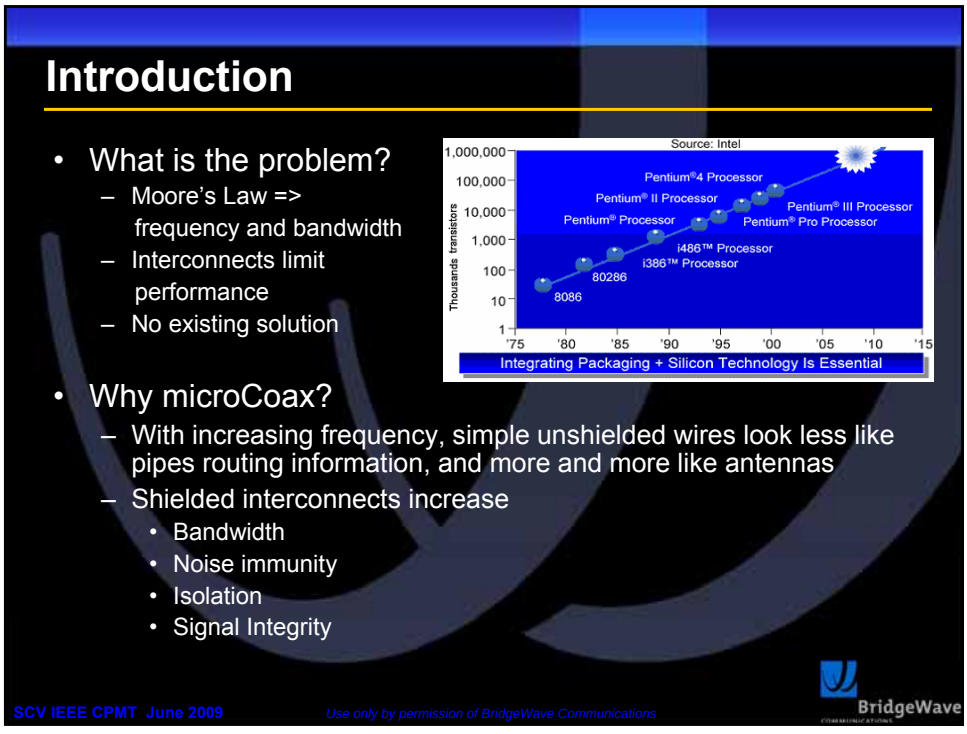
Introduction
What is the problem?
– Moore's Law => frequency and bandwidth
– Interconnects limit performance
– No existing solution
Source: Intel
Thousands transistors
1,000,000
100,000
10,000
1,000
100
10
1
8086
80286
i386™ Processor
i486™ Processor
Pentium® Processor
Pentium® II Processor
Pentium®4 Processor
Pentium® Pro Processor
Pentium® III Processor
'75
'80
'85
'90
'95
'00
'05
'10
'15
Integrating Packaging + Silicon Technology Is Essential
Why microCoax?
– With increasing frequency, simple unshielded wires look less like pipes routing information, and more and more like antennas
– Shielded interconnects increase
• Bandwidth
• Noise immunity
• Isolation
• Signal Integrity
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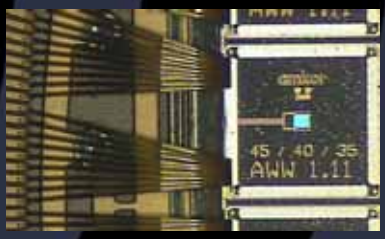
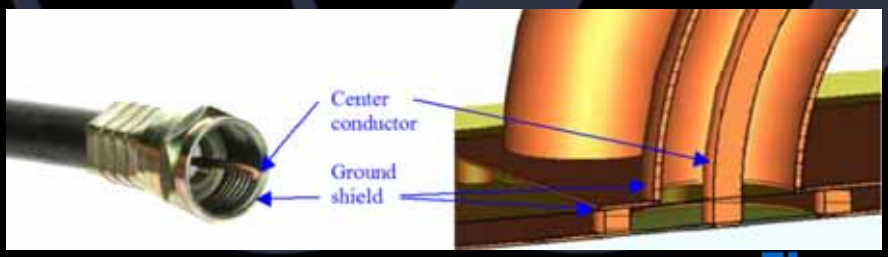
What is MicroCoax?

- Wirebonding based approach to producing high-performance interconnects with
  - over 110GHz of bandwidth
  - typical impedance of 50Ω





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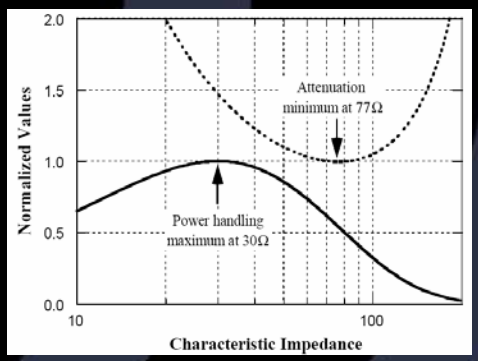
What is magic about 50Ω ?

- Historical optimization
  - Geometric mean is approximately 50Ω



- Vast majority of MMICs have this impedance value

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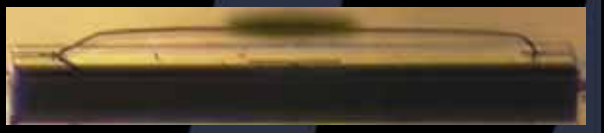
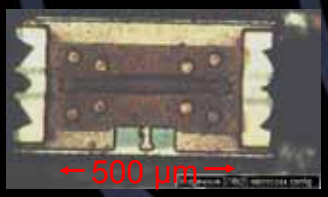
MicroCoaxial Interconnect Characterization

- MicroCoaxial "Through's" fabricated





Micro-coax through under test at probe station

– Ranging in length from 500 µm to 5 mm
– Longer and shorter are possible
– 15-25 µm wirebond cores
– 75-100 µm total diameter
– Polymer , ceramic, & metal based substrates
– MS, CPW, waveguide and leadframe I/O's

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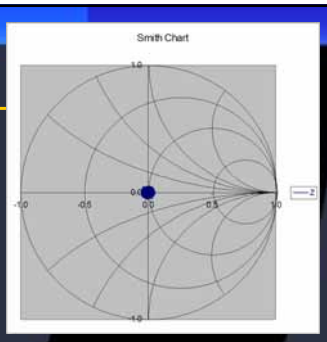
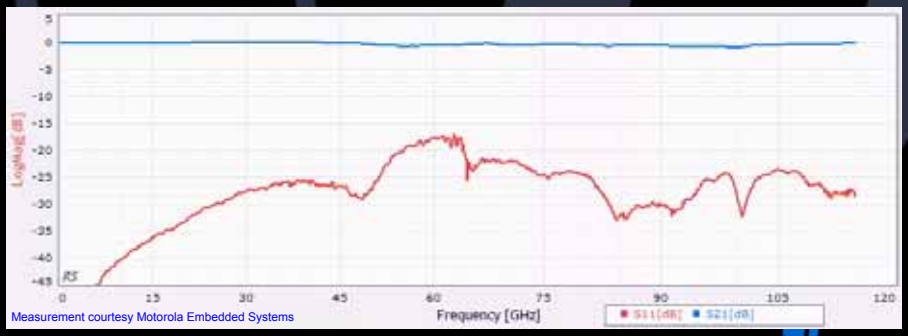
MicroCoax Performance

- Excellent Insertion loss – 0.75 dB over 2.2 mm
  - 0.34 dB/mm and even less at lower frequencies
  - Data includes Substrate-to-MicroCoax transitions
- Return loss <-25 dB over 0-50 GHz band
- S11 at center of Smith chart shows good ~50Ω characteristic across all frequencies





Measurement courtesy Motorola Embedded Systems

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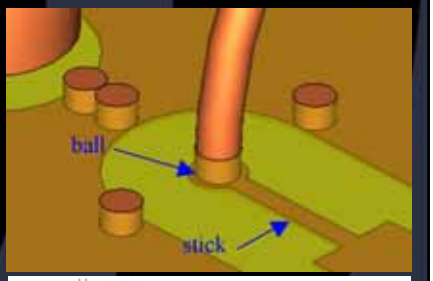
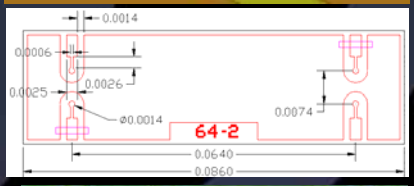
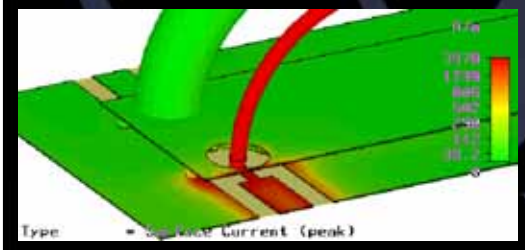
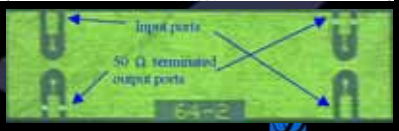
MicroCoax Characterization – Cross Talk

- **Cross Talk structure fabricated**
  - Two parallel MicroCoax wirebonds terminated to 50Ω load
  - Center-to-center MicroCoax spacing 160 microns



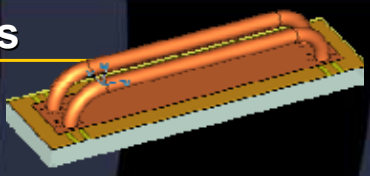




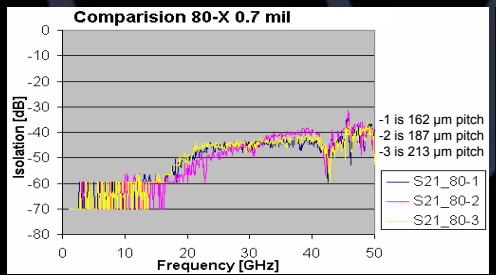


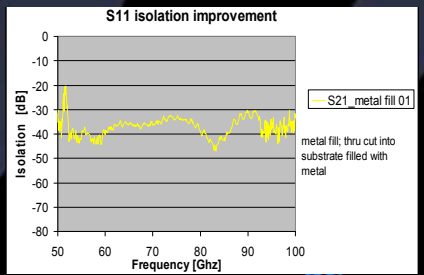
Cross Talk - Measurements

Isolation:
- From coax-to-coax & through the substrate
- 0-18 GHz better than noise floor of VNA (better than 70 dB)
- >18 GHz, diminishes due to dielectric substrate modes
  - Better than 40 dB from 18-50 GHz
  - Better than 30 dB from 50-100GHz with proper dielectric substrate design

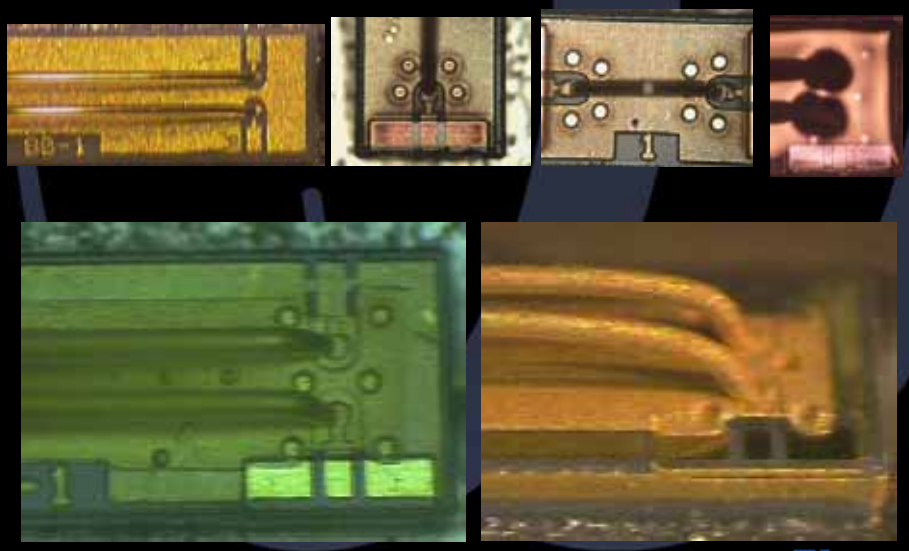


Cross-talk investigation structure





Test Structure – Process Flow



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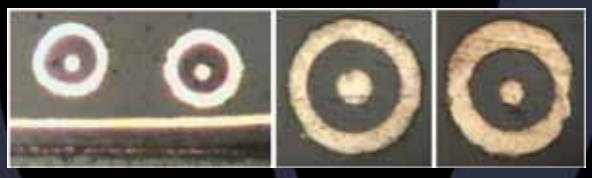
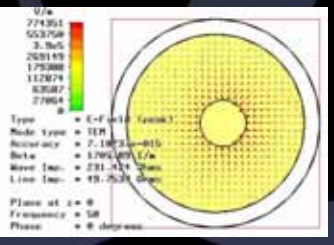
Process Variation

- Does center conductor offset produce performance impact?
  - 40% offset only produces 10% impedance change



% Offset	Impedance (Ω)
0	50.05
10	49.75
20	48.86
30	47.30
40	45.00
50	41.75



10% offset => 0.6%

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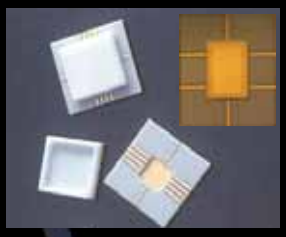
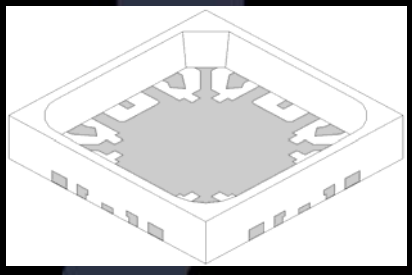
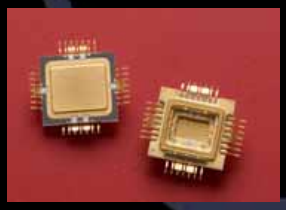
Packaging for MMW







Current Approach

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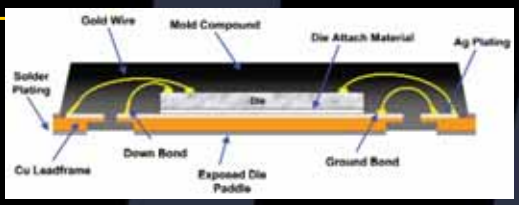
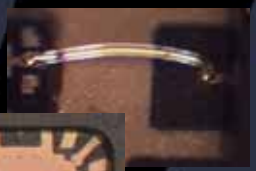
QFN Advantages

- Low cost
- Best thermal performance
- High I/O density
- Low NRE
- Stacked die / SIP capable



EVOLUTION



Open Cavity

Enhanced Bandwidth

MicroCoax

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MicroCoax Package Process

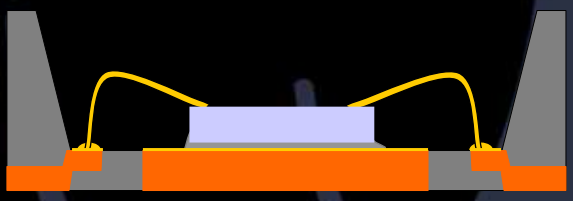
- Open Cavity QFN package with high frequency I/O design

- Apply conductive die-attach adhesive

Benefits

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Integral shielding
- Low-cost
  - Materials
  - Processes
- Pick-and-place high volume compatible
- Low capital costs
- Standard processes
- Flexible, low design NRE

MicroCoax Package Process



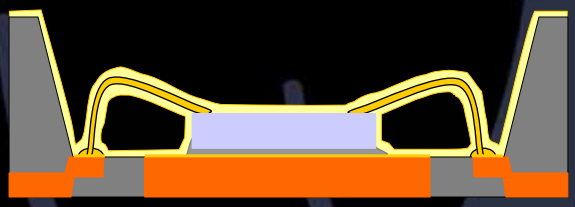
- Accurate placement of active and passive components

- Wirebonding

Benefits

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Shielding
- Chip scale
- Low-cost
  - Materials
  - Processes
- Pick-and-place compatible
- Low capital costs
- Standard processes
- Flexible, low design NRE

MicroCoax Package Process



- Apply Conformal Coating

Benefits

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Shielding
- Chip scale
- Low-cost
  - Materials
  - Processes
- Pick-and-place compatible
- Low capital costs
- Standard processes
- Flexible, low design NRE

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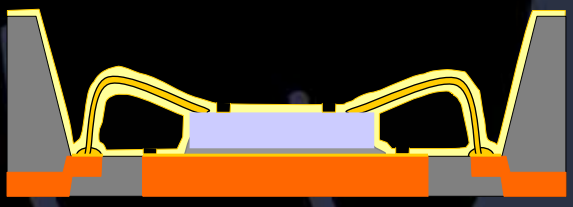
MicroCoax Package Process



- Laser via for I/O ground and die ground

- Gentle plasma clean

Benefits

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Shielding
- Chip scale
- Low-cost
  - Materials
  - Processes
- Pick-and-place compatible
- Low capital costs
- Standard processes
- Flexible, low design NRE

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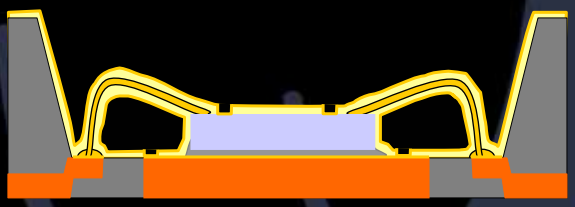
MicroCoax Package Process



- Conformal deposition of metal

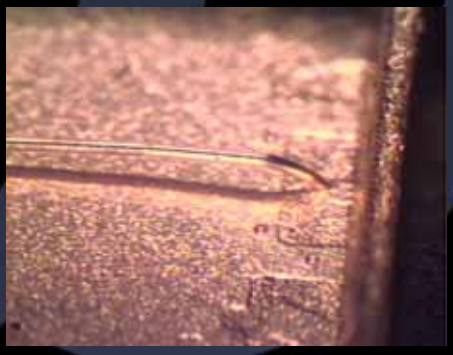
- Plate 3-5 microns additional metal

Benefits

- **Impedance matched**
- **Exceeds 50 GHz**
- **Metallic**
  - **Thermal dissipation**
  - **Shielding**
- **Chip scale**
- **Low-cost**
  - **Materials**
  - **Processes**
- **Pick-and-place compatible**
- **Low capital costs**
- **Standard processes**
- **Flexible, low design NRE**

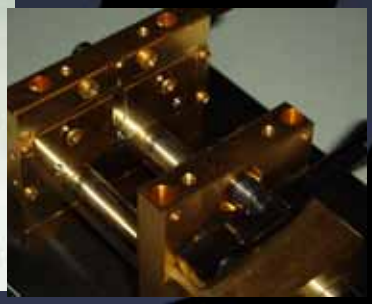
Coaxial Interconnect in QFN

- Open Cavity QFN – 5x5 mm
  - JEDEC compliant form factor
  - 4 high-frequency ports / 8 low-frequency ports
- 0.7mil core coaxial interconnect
  - 4+ mm long port-to-port through



V-band Test Fixture

- Wiltron - Model 3680V Universal Test Fixture
- I/O's consist of V connectors



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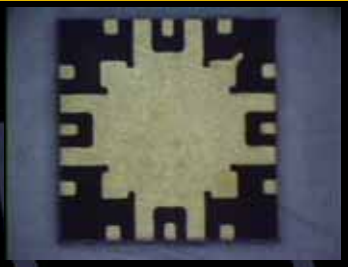
Package Test Configuration

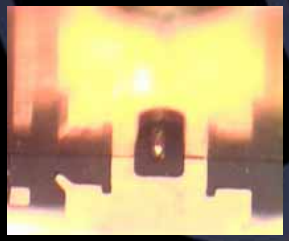


Bottom of package

Closed

Open

Test fixture jaws



Package in fixture

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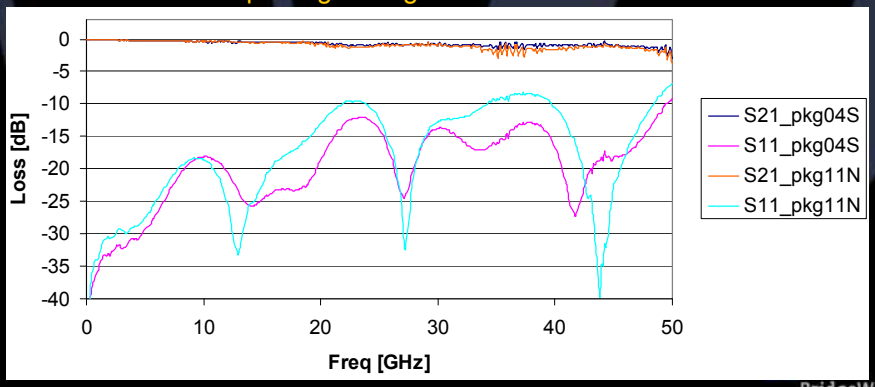
QFN Measured Performance

- Back to back port measurement
  - Pkg I/O => 4+ mm coax => Pkg I/O (i.e. 2x path of single pkg port)
  - Reference plane at external v-connectors of fixture
    (i.e., test fixture included in measurements)

Two package design variants



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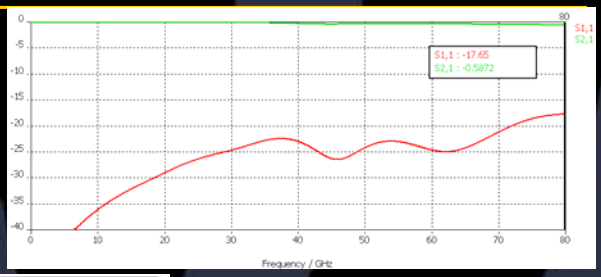
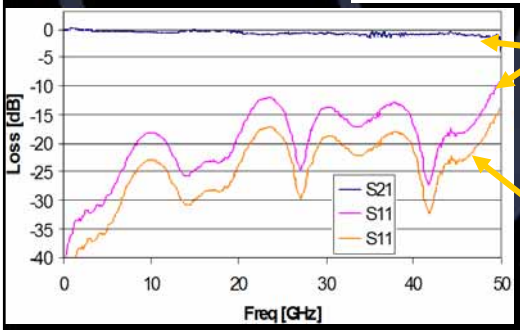
QFN Implementation

- Design/Modeling
  - Ground-breaking performance to 80+GHz





QFN Measurement

-Two ports back-to-back

-Excellent to 50+ GHz

Estimated for single port

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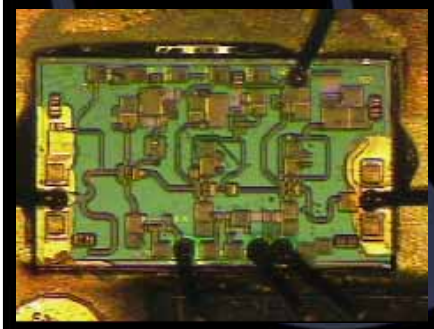
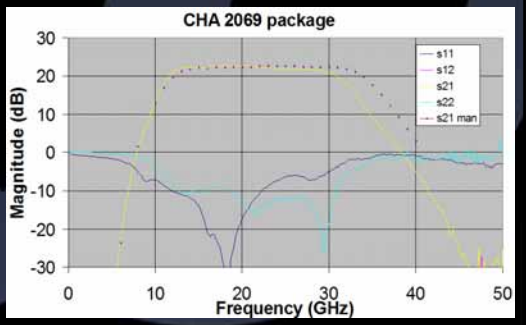
Packaged MMIC

- Essentially lossless packaging of UMS CHA 2069 18-31 GHz MMIC
  - Measured (yellow) vs. wafer probe data (dots) from manufacturer
- Early roll-off due to lack of expected 0.2 nH inductance at each I/O port
  - Coaxes don't have lumped inductance of a wirebond
  - MMIC's are designed to compensate for the expected inductance
- Selective removal of upper ground plane using 3D lithography and plating





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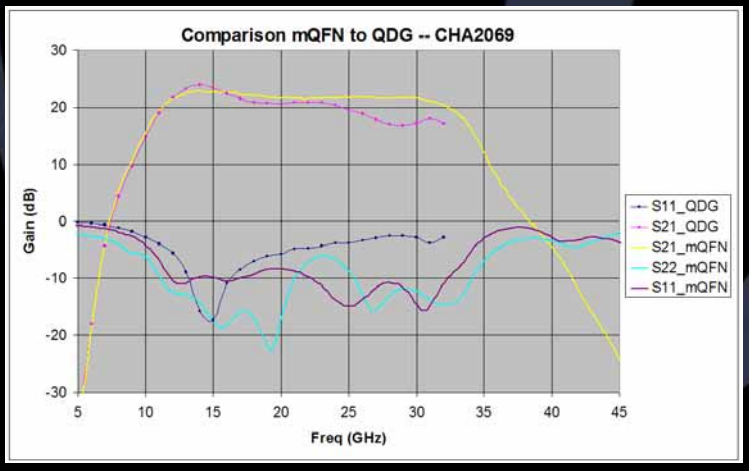
Commercial offering vs. MicroCoaxQFN

- QDG package data assumes reference plane immediately external to package and excludes connectors or board transmission lines
- mQFN package data includes connectors and board transmission lines



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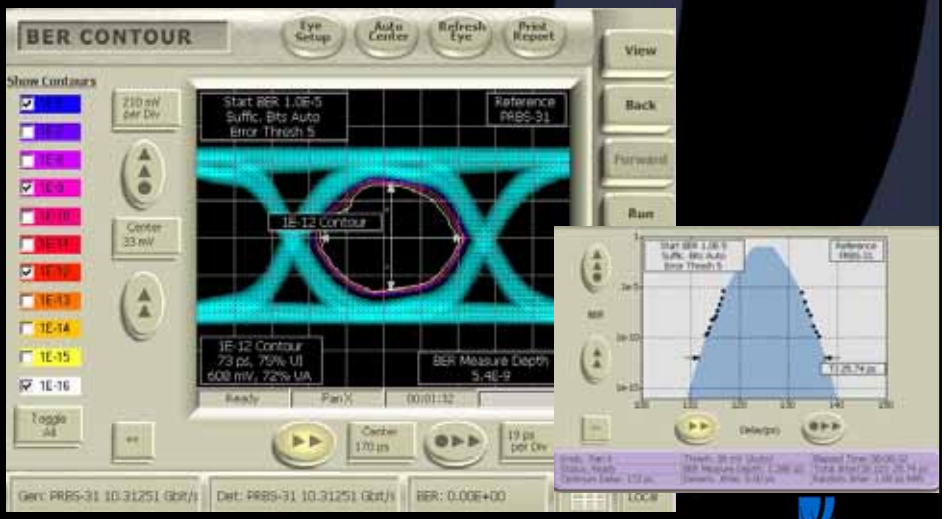
Digital Evaluation

- Test Performed by SytheSys Research



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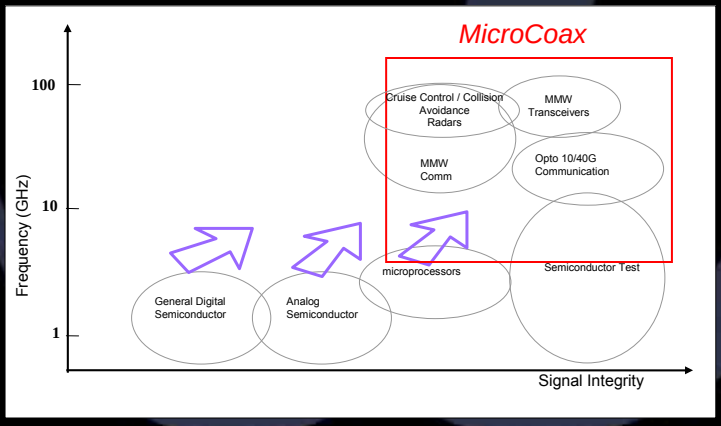
Where does MicroCoax play?

- Trends / Projections
  - Moore's law drive to higher frequency/bandwidth



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Conclusion

- National Science Foundation
  - Phase I and II SBIR grants
  - The Nation's venture capital arm
- Any Questions?

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