


**“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



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## Chosen by...

### Service Providers

### Municipalities

### Enterprise

### Government

### Healthcare

### Education

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## Introduction

- What is the problem?
  - Moore's Law => frequency and bandwidth
  - Interconnects limit performance
  - No existing solution
- 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

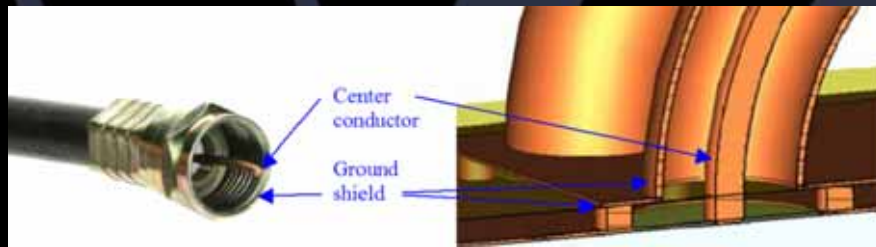
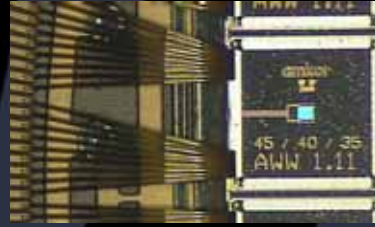
Source: Intel

Integrating Packaging + Silicon Technology is Essential

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## What is MicroCoax?

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



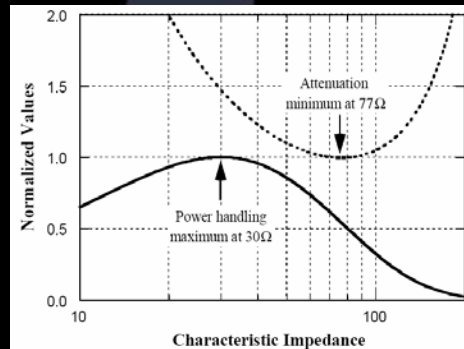
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## What is magic about 50Ω ?

- Historical optimization
  - Geometric mean is approximately 50Ω
- Vast majority of MMICs have this impedance value



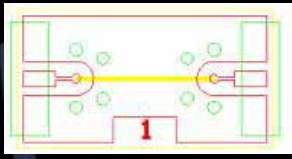
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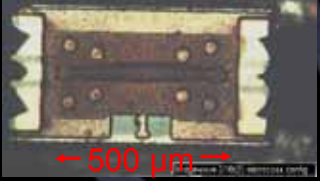


## MicroCoaxial Interconnect Characterization

- MicroCoaxial “Through’s” fabricated








Micro-coax through under test at probe station

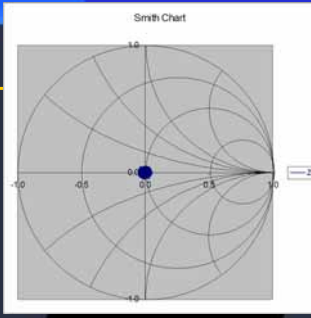
- Ranging in length from 500  $\mu\text{m}$  to 5 mm
- Longer and shorter are possible
- 15-25  $\mu\text{m}$  wirebond cores
- 75-100  $\mu\text{m}$  total diameter
- Polymer, ceramic, & metal based substrates
- MS, CPW, waveguide and leadframe I/O's


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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  $\sim 50\Omega$  characteristic across all frequencies



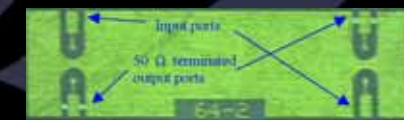
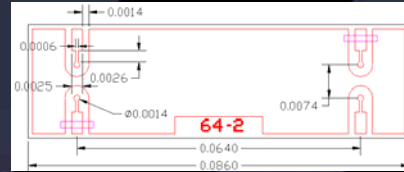
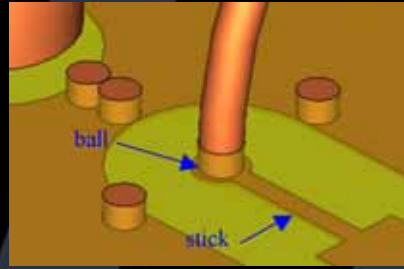
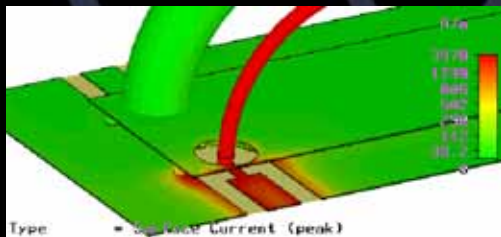


Measurement courtesy Motorola Embedded Systems



## MicroCoax Characterization – Cross Talk

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



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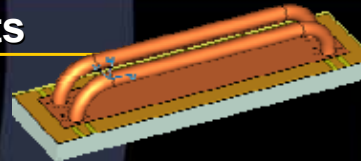
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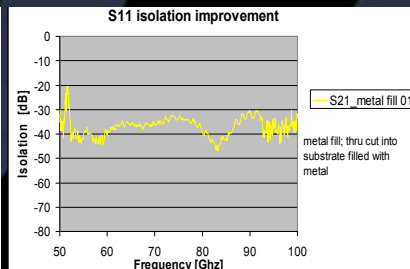
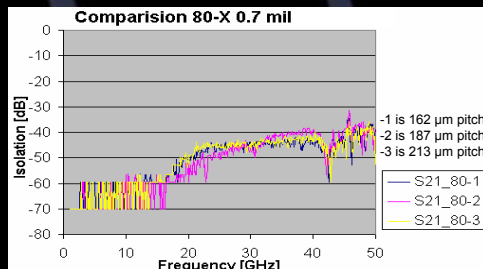
## Cross Talk - Measurements

### 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



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## 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

U/m  
274351  
553769  
3.3e5  
263189  
175086  
112874  
83587  
77954

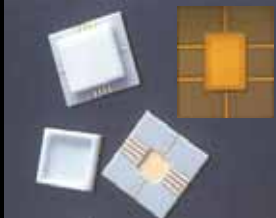
Type = 1-F-110 (mm)  
Mode Type = TEM  
Accuracy = 7.18e-10  
Beta = 1.794e7 U/m  
Wave Imp. = 231-124 Ohm  
S. Imp. Imp. = 49.853 Ohm

Plane at z = 0  
Frequency = 50  
Phase = 0 degrees

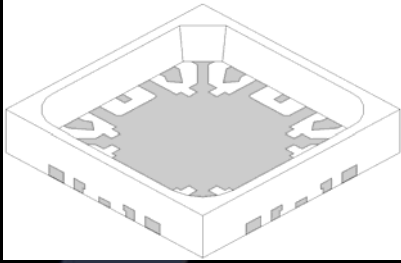
**10% offset => 0.6%**

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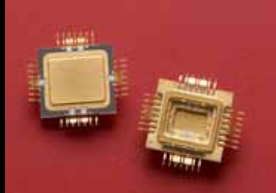


## Packaging for MMW



**Current Approach**




**BridgeWave Solution**

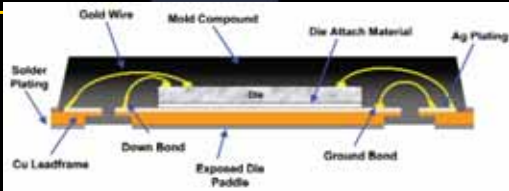
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## QFN Advantages


- 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



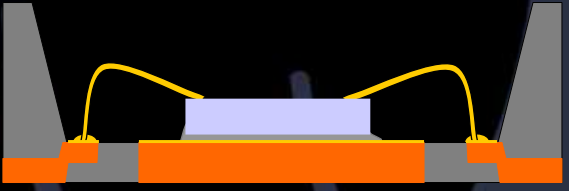
- Open Cavity QFN package with high frequency I/O design
- Apply conductive die-attach adhesive

**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

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## MicroCoax Package Process



- Accurate placement of active and passive components
- Wirebonding

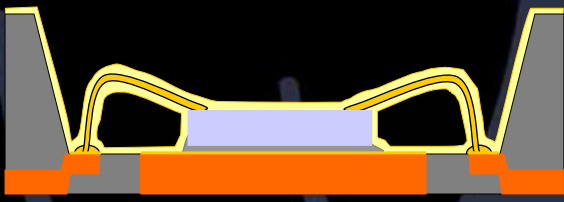
**Benefits**

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Shielding
- Chip scale
- Low-cost
  - Materials
  - Processes
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## MicroCoax Package Process



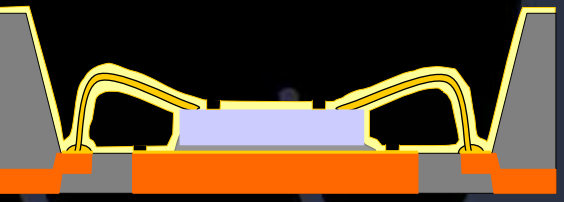
- Apply Conformal Coating

**Benefits**

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Shielding
- Chip scale
- Low-cost
  - Materials
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## MicroCoax Package Process



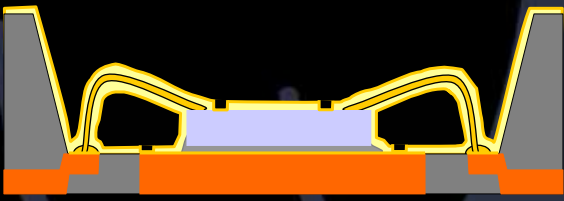
- Laser via for I/O ground and die ground
- Gentle plasma clean

**Benefits**

- Impedance matched
- Exceeds 50 GHz
- Metallic
  - Thermal dissipation
  - Shielding
- Chip scale
- Low-cost
  - Materials
  - Processes
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## MicroCoax Package Process




- Conformal deposition of metal
- Plate 3-5 microns additional metal

### Benefits


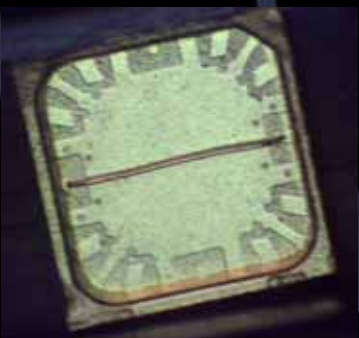
- Impedance matched
- Exceeds 50 GHz
- Metallic
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- Standard processes
- Flexible, low design NRE

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## 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

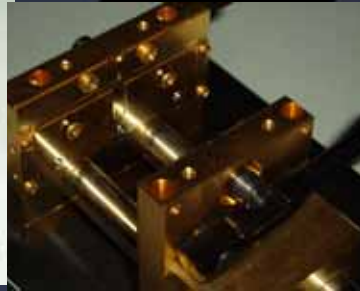


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## V-band Test Fixture

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



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## Package Test Configuration



Bottom of package

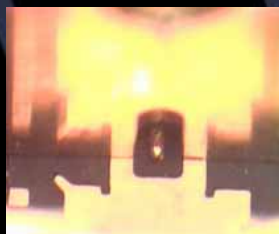


Closed



Open

Test fixture jaws

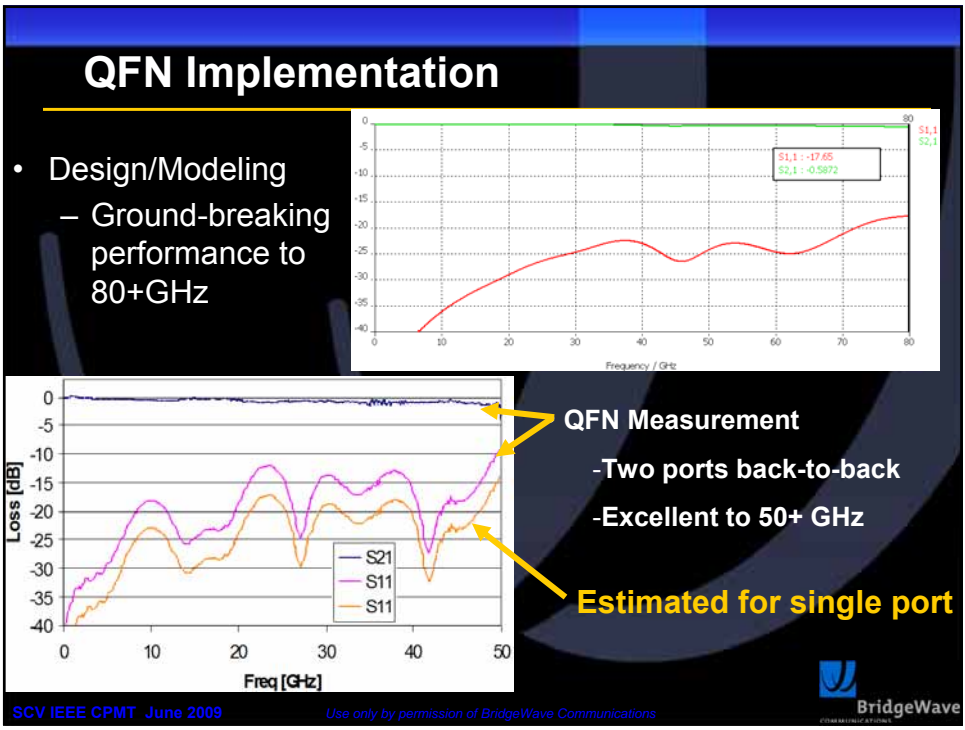
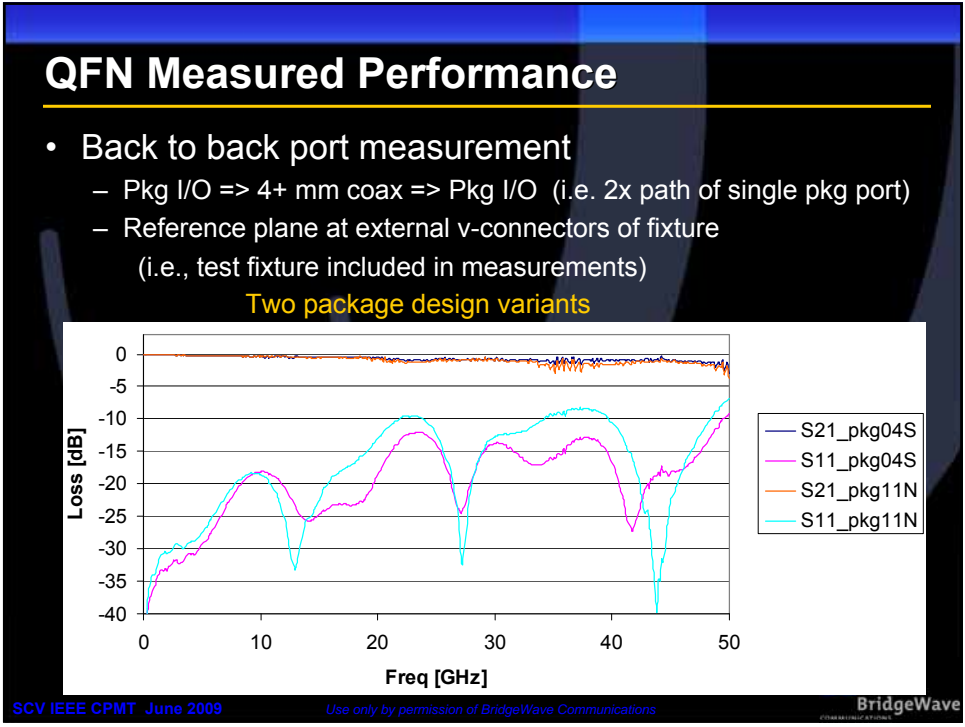


Package in fixture

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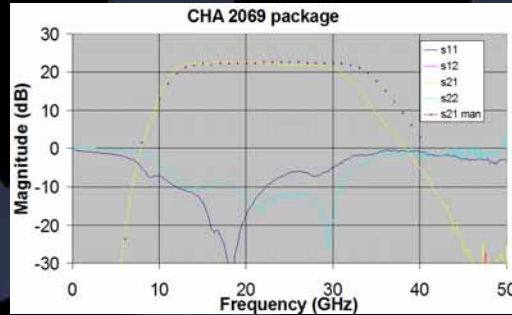
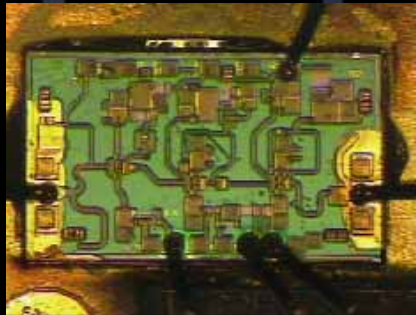
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## Packaged MMIC

- 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



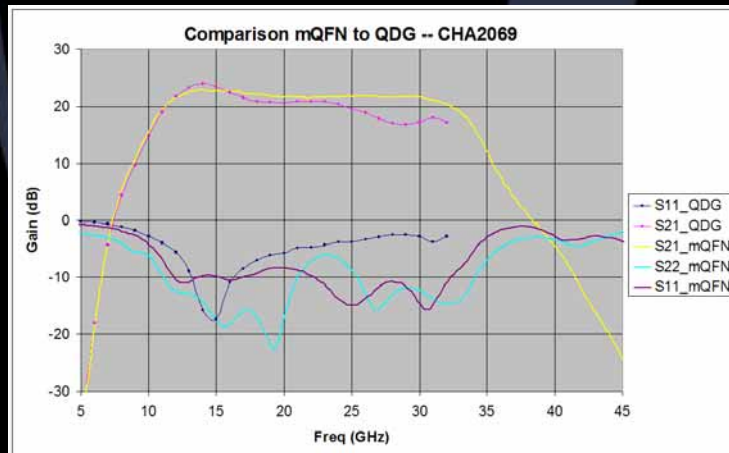
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## Commercial offering vs. MicroCoaxQFN

- 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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