filtronic
Innovation in RF technology

Moving up in Frequency

D-band the next frontier for Telecommunications XHaul

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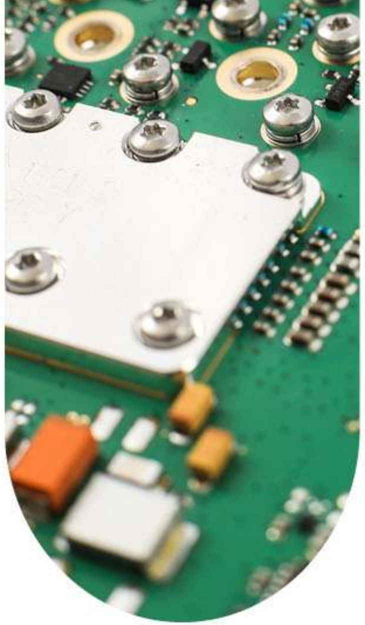
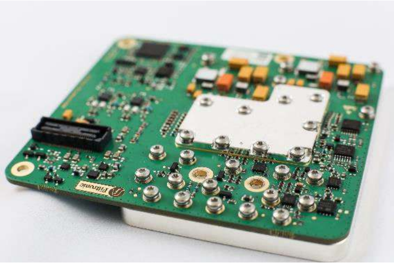



Introduction to Filtronic
Innovation in RF technology

- At the forefront of RF for > 40 years
- Experts in design, manufacture and testing of high-performance RF components and sub-systems
- Capabilities across the RF spectrum, but specifically microwave and mmWave.
- Our technologies:
    - Transmit & receive radio signals
    - Deliver passive & active RF conditioning
    - Provide integrated systems and sub-systems
    - Device packaging and hybrid assembly



Our Markets

Commercial in confidence

Why mmWave?

- Strong and demand for data driving adoption of higher mmWave bands for backhaul of data to the core network

- Terrestrial networks already scaling at E-Band, with congestion already driving work at W and D-Band

- Non-Terrestrial new data requirements driven by rapid scaling of LEO networks which will become an integral part of future 5/6G+ communications networks

- **Wireless Backhaul still Key**

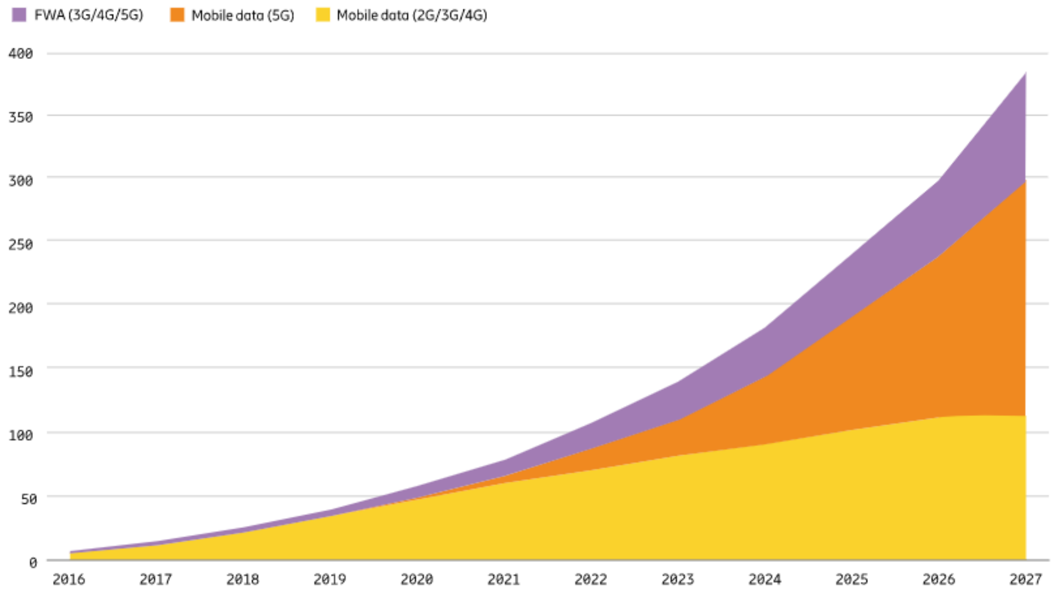


Figure 18: Global mobile network data traffic (EB per month)

Terrestrial

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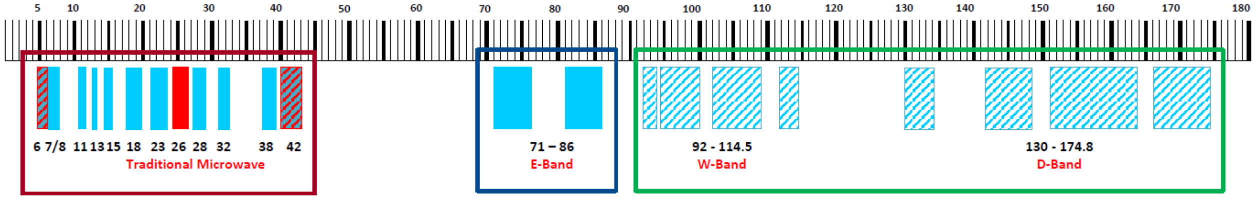
5G and Beyond –

With the roll out of 5G we have seen increased adoption of higher mmWave bands such as E-band to deal with the increased backhaul of data. As we move to 6G and beyond we expect to see use-cases requiring extreme performance, with extreme data rates.

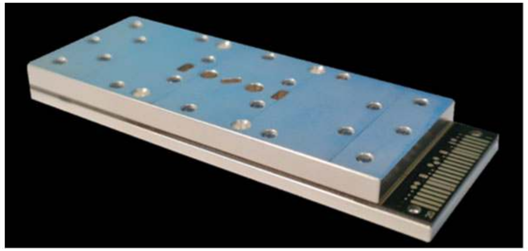
- W-Band, due to band assignment will offer similar channel bandwidth and performance as E-band (10Gb/s), simpler deployment

- D-band has the potential to support extreme data rates up to 100GB/s with 4x25GB/s MIMO, supporting extreme bandwidths for future applications.



Current State of the art – E-Band

- Filtronic have had products in the market since 2012, now on 3rd generation, higher levels of integration required to reduce cost.
- Filtronic chipsets allow performance advantage and price point.
- Recent introduction of ‘active diplexer’ for use with highly integrated silicon solutions



- Use as an extension of E-band, plan to use same form factor, allows re-use of investment at E-band with possibility to leverage existing modems
- Maximum 2GHz channel size
- Can maintain similar link lengths to E-band
- Accelerated deployment due to small shift in required architecture

Integrated Transceiver

W-Band	
Sub Band (GHz)	Net Bandwidth
92-94	3.5
94.1 – 100	5.5
102 -109.5	7.25
111.8 – 114.25	2

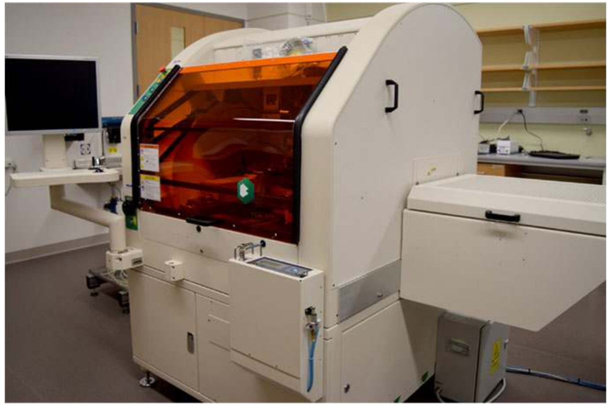
W-Band Manufacturing Challenges

- More incremental but not without challenge

- Push towards more integration of chipset, < interconnects & loss

- Increased placement tolerances, compatible with our current wire-bond/pick and place.

- Increased tolerances for manufacture diplexer – from current ±5um to ± 2um (possible but expensive at present)



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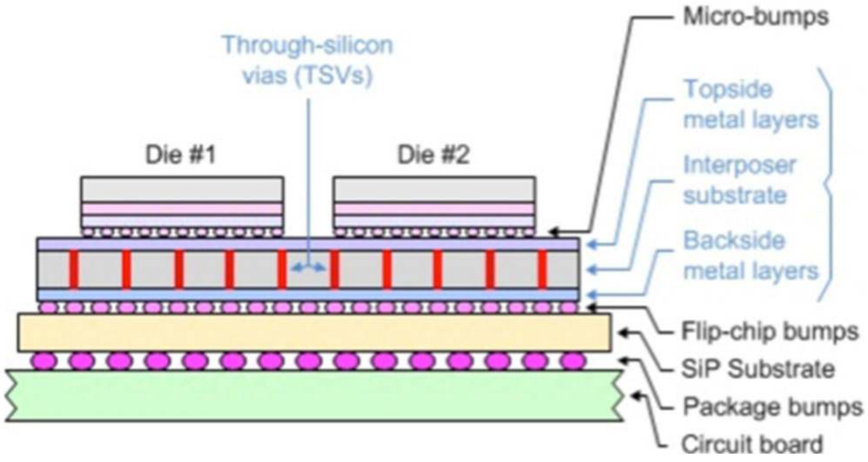
D-Band Product Form factor

- Form factor for D-Band will be very different, likely we will see a shift towards even **greater levels of integration** mixing **base-band** with **high frequency** using technologies such as SiGe
- Still require a **PA** and **LNA** for point to point links, interposer will be critical to accommodate multiple semiconductor technologies.
- **Complex assembly** issues in terms of **precision** of placement and **interconnects**.
- Possible move from **frequency** to **spatial** multiplexing due to narrow beam width.

Chip Scale packaging approach



*** From www.3DinCites.com**

*Note - Semiconductor Process still in development require 0.07um GaAs

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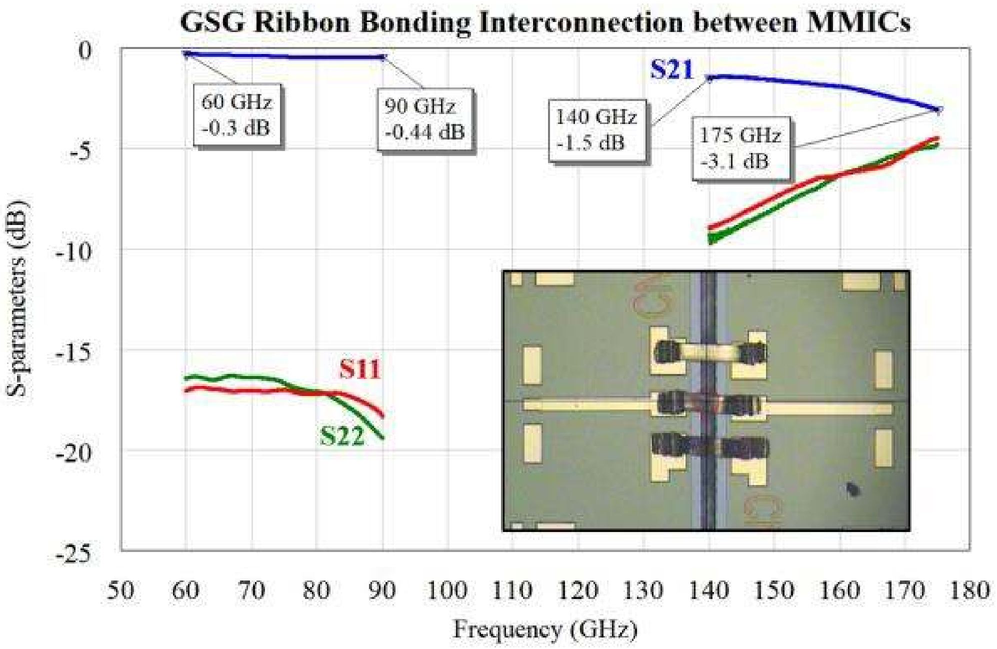
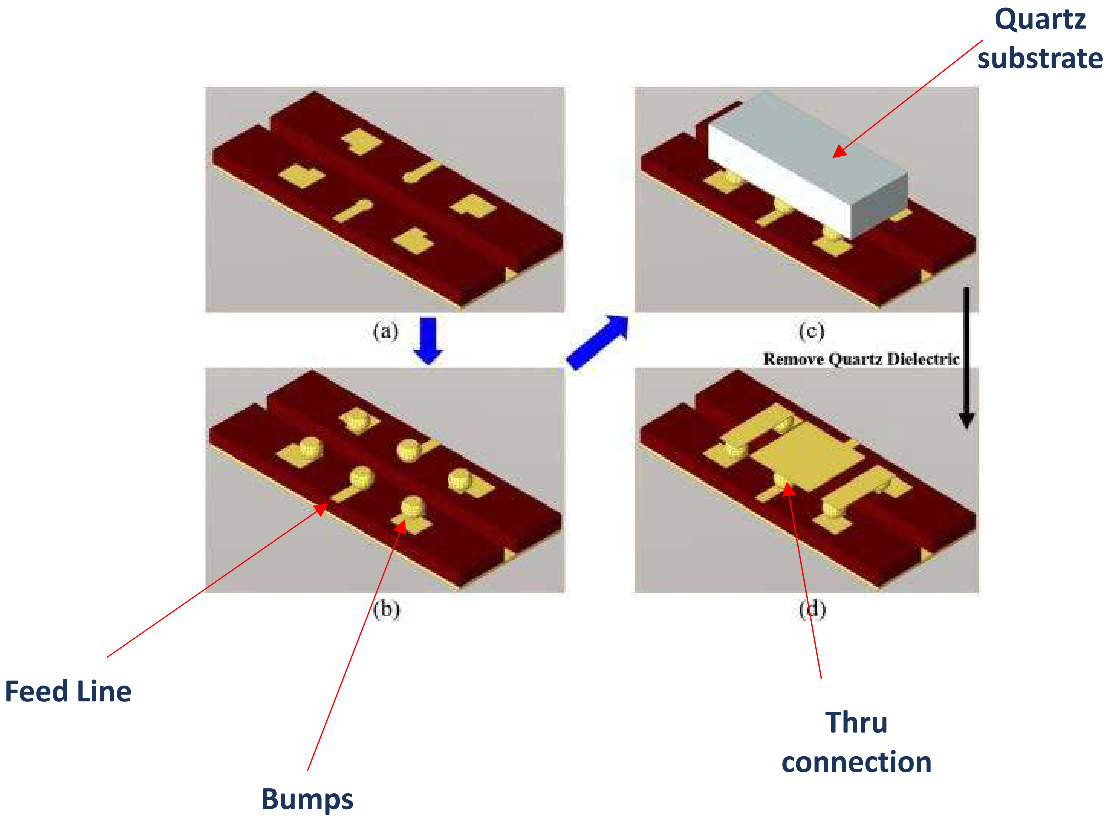
Manufacturing Challenges – Interconnects and transitions at D-Band

- A major constraint at D-band is interconnects between MMICs and transitions from microstrip to waveguide.
- While ribbon bonding is still relatively low loss at E-band but is no longer viable at D-band.
- New assembly methods required, four methods investigated in this work, two looking at microstrip to waveguide transitions and two methods considering MMIC to MMIC connections.



MMIC to MMIC Interconnect – Design

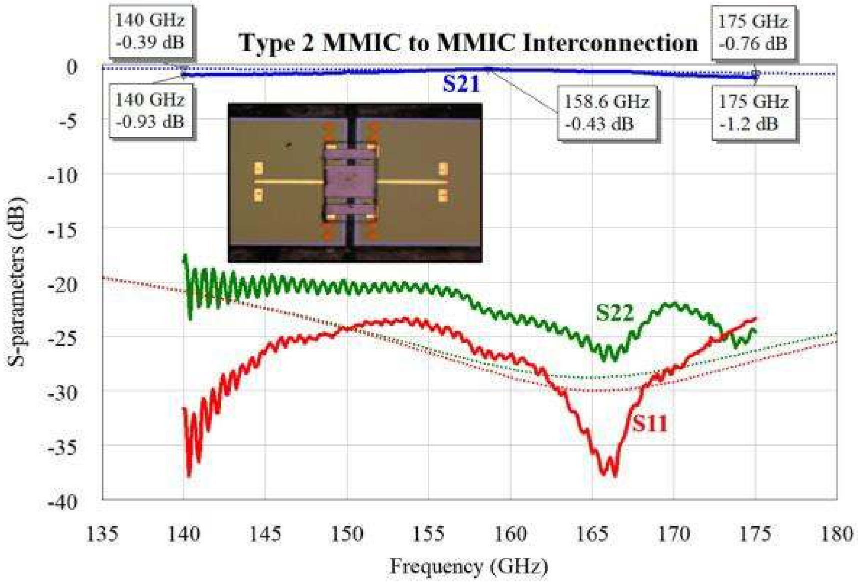


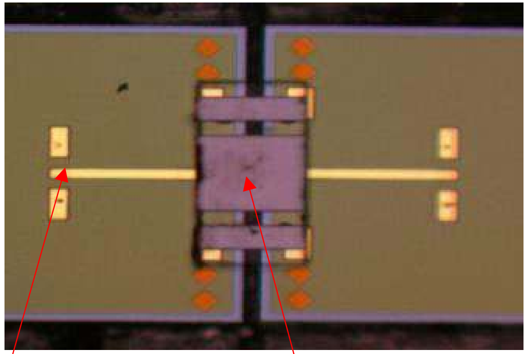
- Quartz Substrate with CPW tracks used for interconnection
- Low dielectric constant and transparent
- MIMICs are bumped
- Thermocompression bonding

MMIC to MMIC Interconnect – Design

- Loss of the structure is between 0.43 and 1.2 dB between 140-170 GHz

- Calibrated loss of just the interconnect 0.31 to 1.08dB



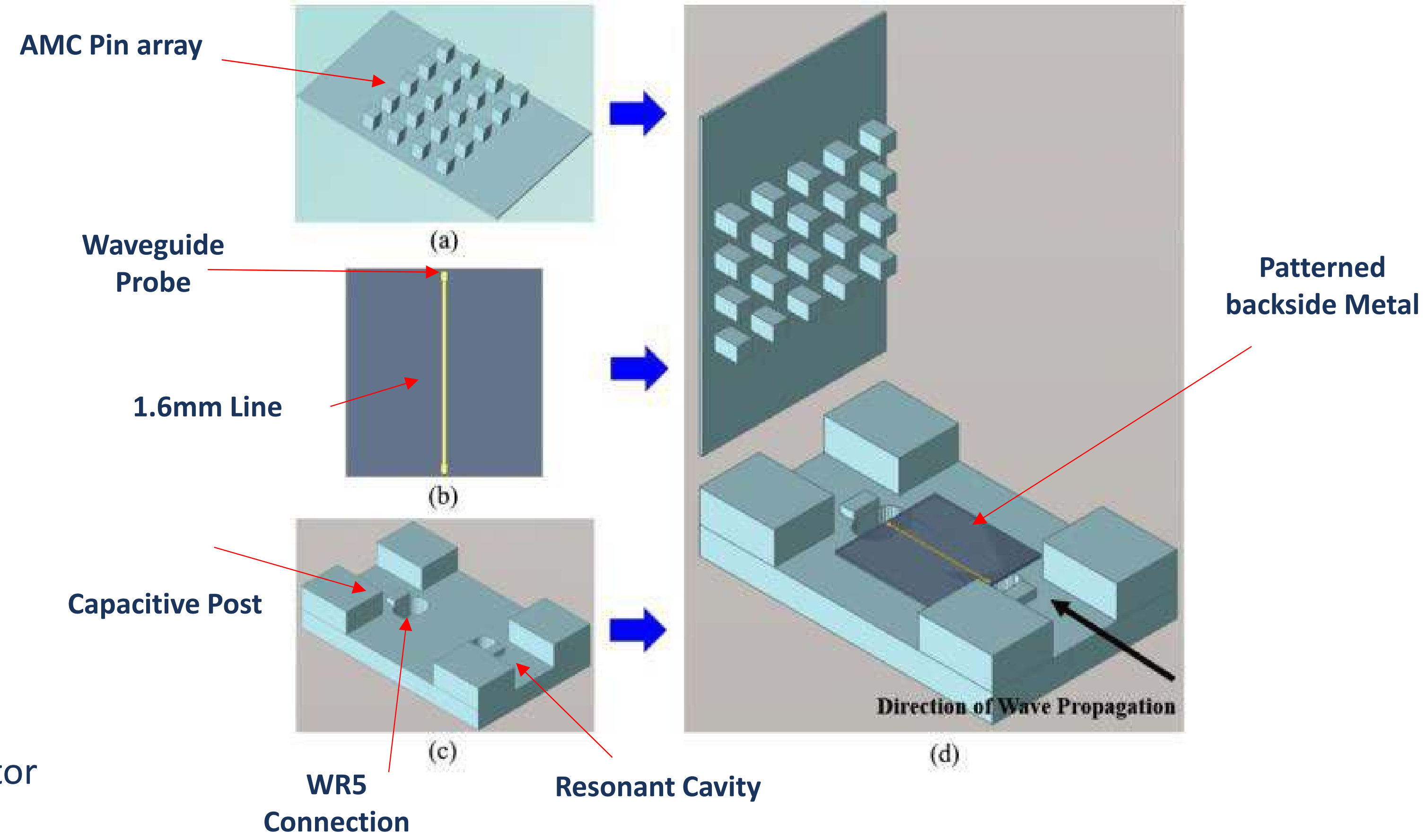


GSG Pads

Quartz substrate

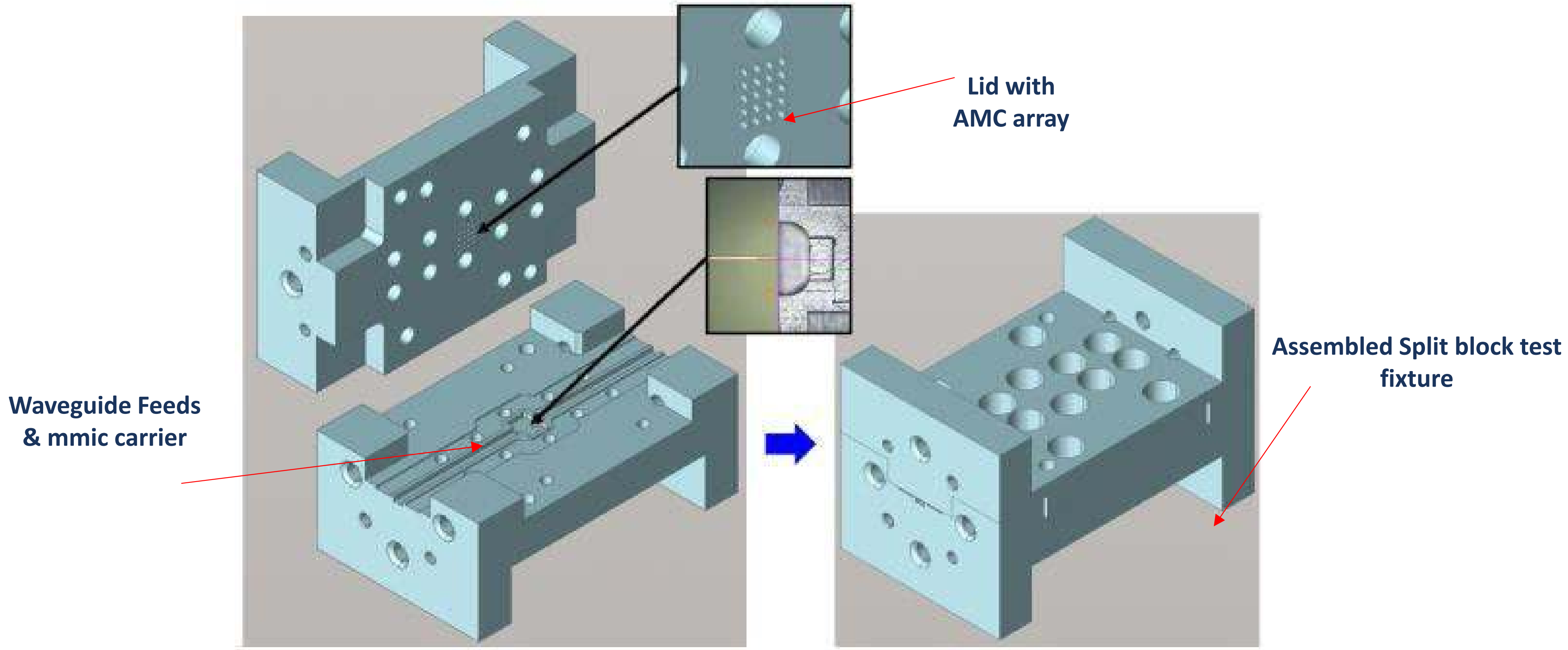
MMIC to WG Transition – Design

- Two resonant cavities, two capacitive posts and two WR5 waveguide connections.
- Wave propagation is parallel and coupled to waveguide probe thanks to the resonant cavity, capacitive post and AMC pin Array



AMC = Artificial Magnetic conductor

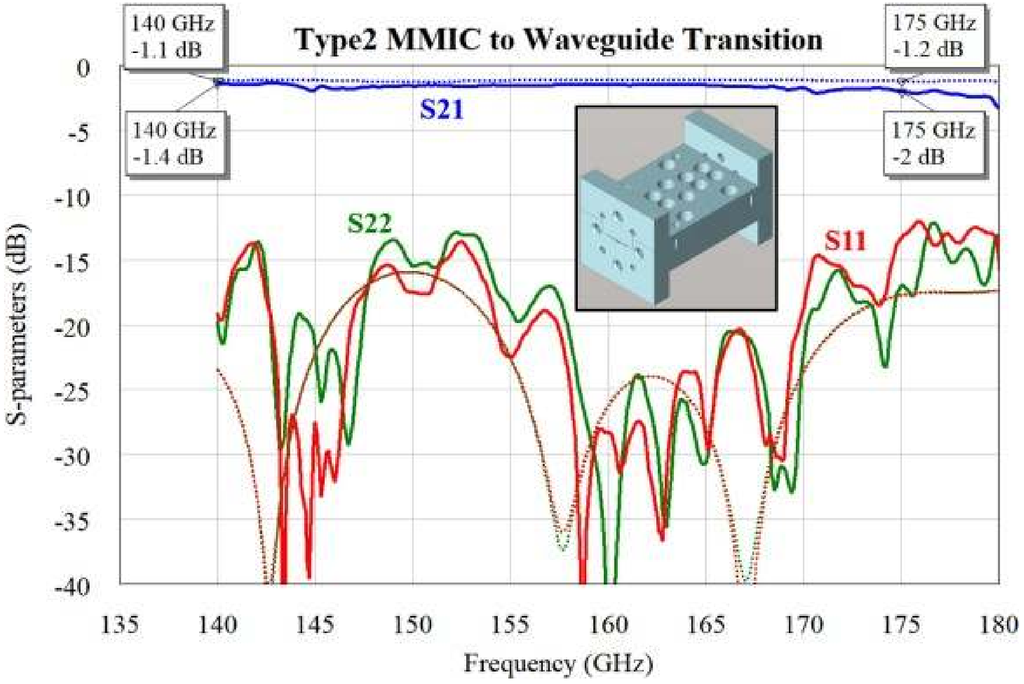
MMIC to WG Transition – Design



(a) (b)

MMIC to WG Transition – Experimental Results

- Overall loss of the structure including feeds between 1.4 and 2.0 dB between 140-170 GHz
- Measurements are de-embedded using s-parameter measurements of waveguide thru and on wafer microstrip line
- **Transition loss of between 0.32 and 0.62dB over 140-175 GHz**
- Very good agreement between measured and simulated performance



Conclusions

- Higher mmWave fundamental to future communication networks
- Terrestrial already rolling out E-band in Volume for 5G networks
- Move to W-Band to avoid spectrum congestion, no performance benefit, incremental but still difficult
- Move to D-Band for fundamental shift in performance 5G/6G+ many challenges remain