Business from technology

LTCC for MEMS and Multi-Chip RF Integration and Packaging

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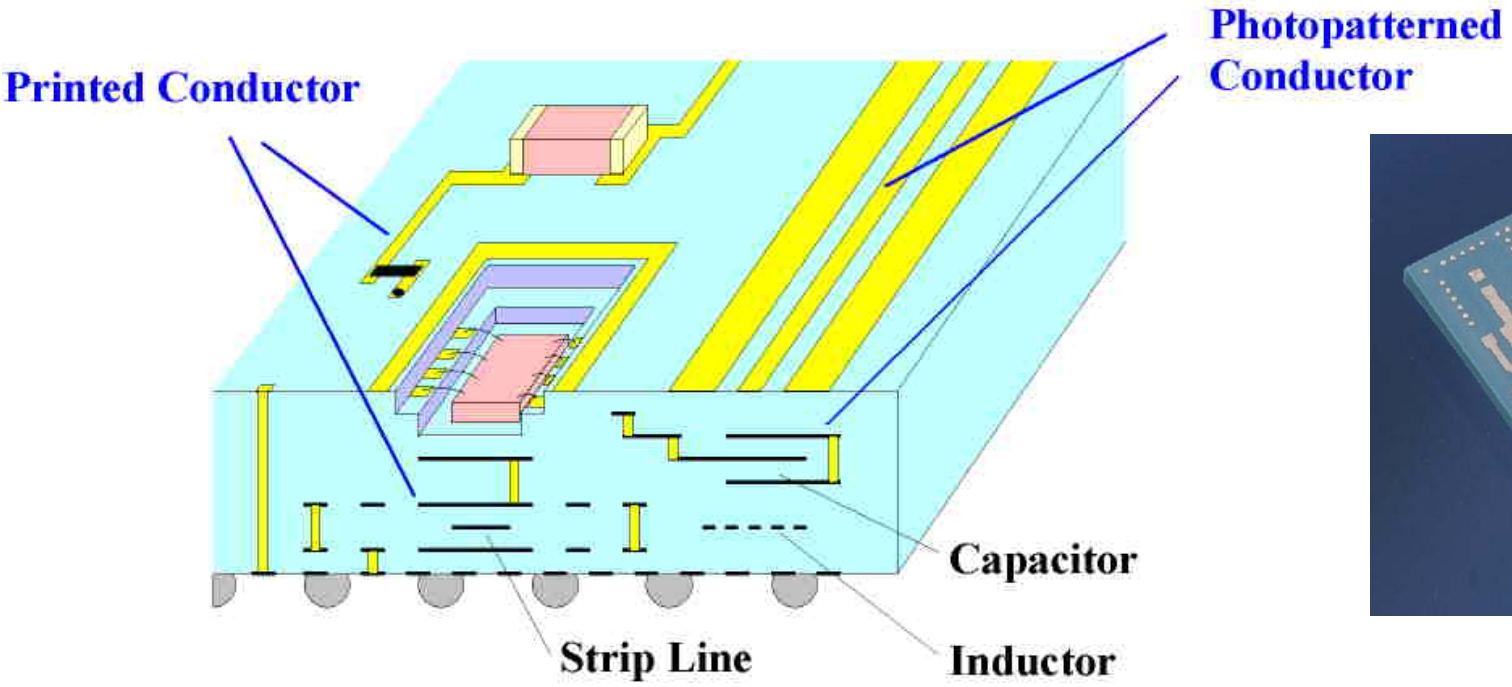
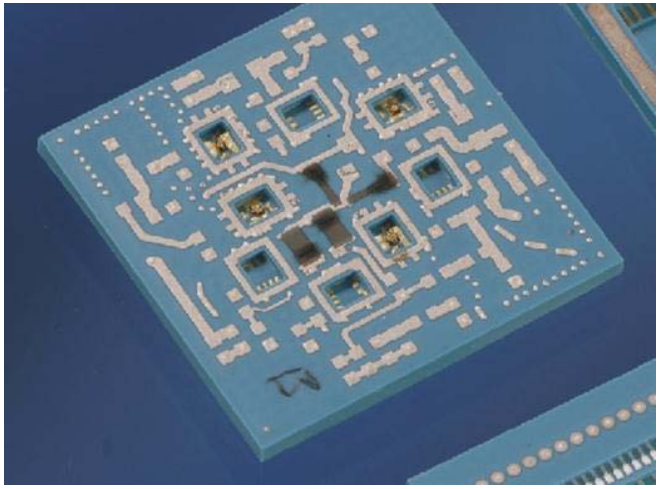
Outline

- Introduction to LTCC
- LTCC for wireless applications
- Experimental results
- Conclusions

LTCC:
Low Temperature Co-Fired Ceramics

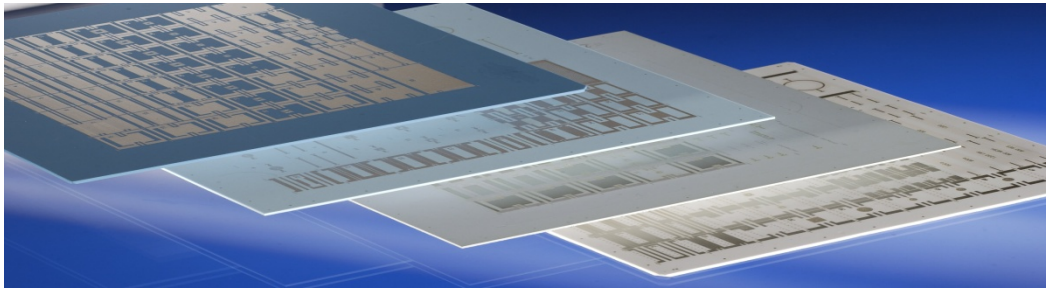
- Multi-layer technology platform for wide variety applications
  - Telecom&wireless, automotive, sersor&opto packaging, medical, chemical, defence, aerospace&space,…



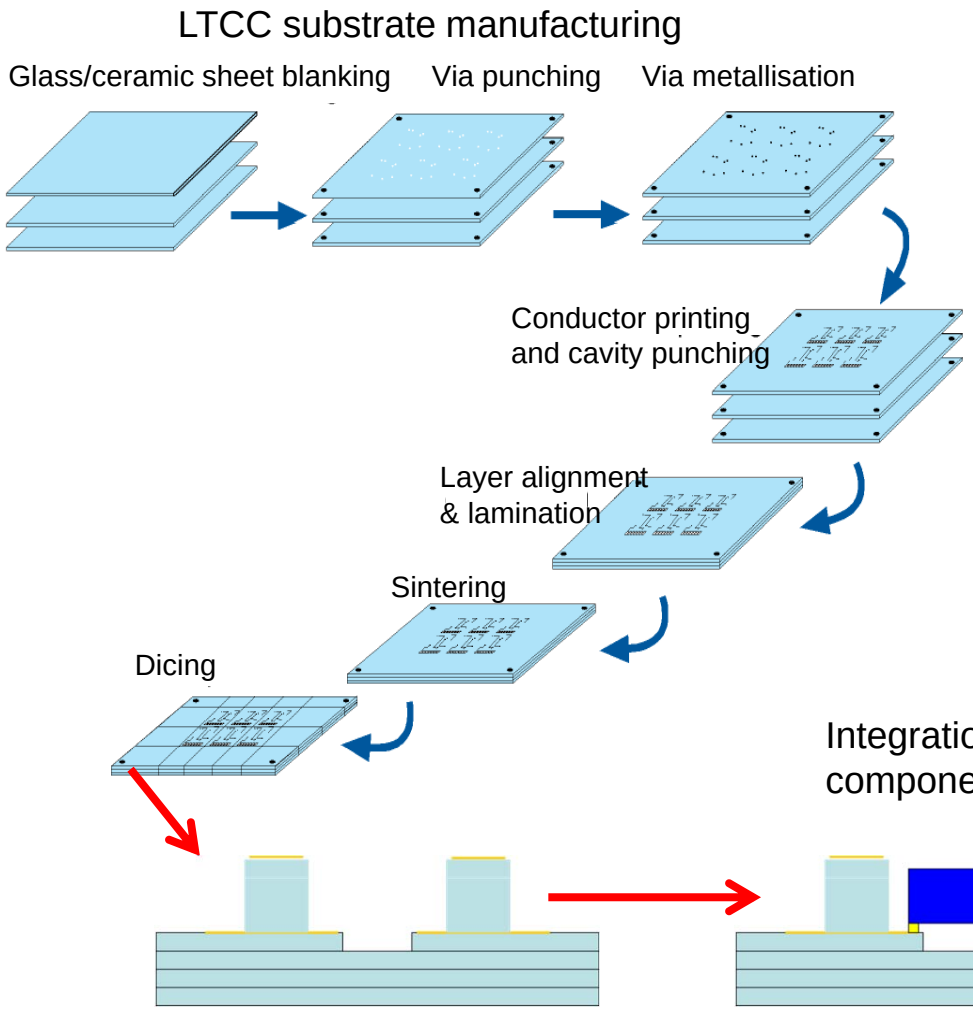


LTCC: Packaging and Integration Technology

- LTCC is used for packaging
- Additionally, it is a passive 3D integration technology with
  - High component density
  - Increasing functionality
  - High assembly yield
  - Good crosstalk and radiation management
  - Good stability and reliability
  - Low system cost



Typical LTCC process flow



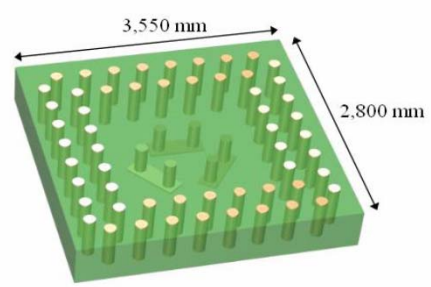
LTCC materials consist of unfired class/ceramic sheets onto which conductors are printed. The layers are stacked, laminated and co-fired at <900 °C to form a multilayer package. Cavities can easily be realised in the unfired state for assembly of components and they (e.g. MEMS) can then be hermetically sealed.

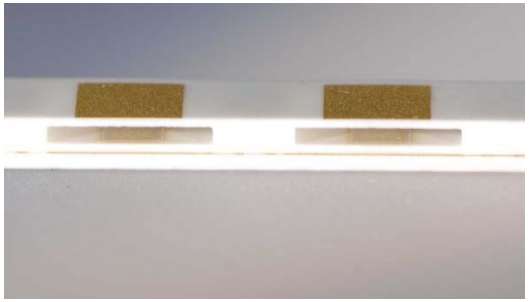
LTCC Properties

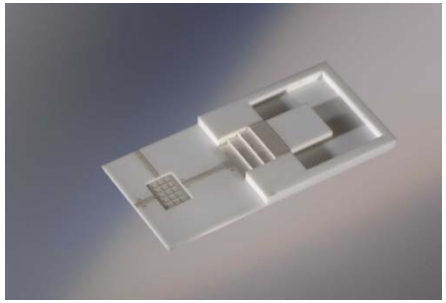
Parameter	Typical values with commercial manufacturer	VTT's typical min/max values
Min line width [µm]	150	50
Tolerances of linewidths [µm]	±20	±5
Layer-to-layer positioning accuracy [µm]	60	15
Min diameter of vias	150	100
Min spaces for vias	300	100
No. of layers	6-24	4-20

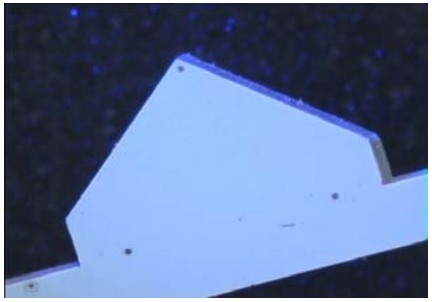
LTCC is a Real 3D System-in-Package Technology

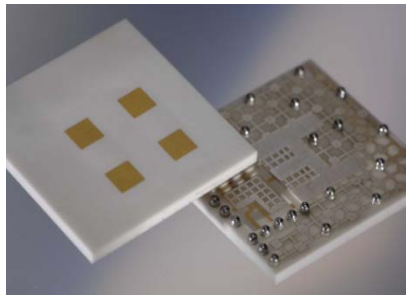
- Metallizations in several layers
  - Vias between layers
  - Vias used for formimg EM structures like substrate integrated waveguides, resonators
- Several dielectric layers
  - Can have cavities between the layers
  - Ceramic can be shaped to have 3D forms





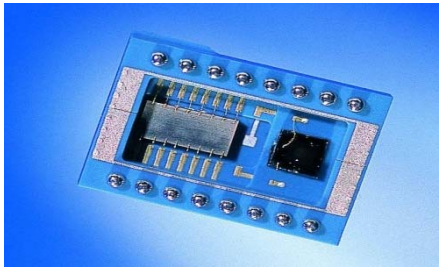




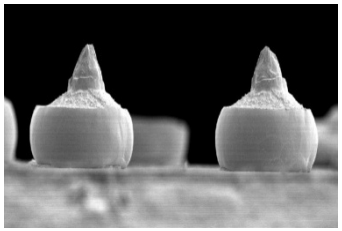


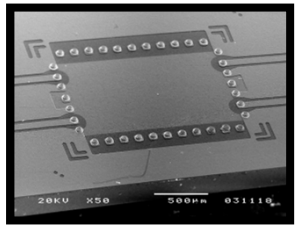
LTCC for Micro and MM-Waves

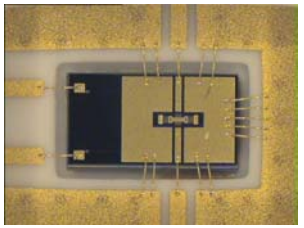
- LTCC is used for realizing high-Q passive component, multi-layer elements such as filters, matching networks, antennas, feed networks, etc.
- These are integrated with active components



- The whole system is packaged forming modules
- Following examples show how LTCC has been used as component technology, packaging technology, and module integration technology





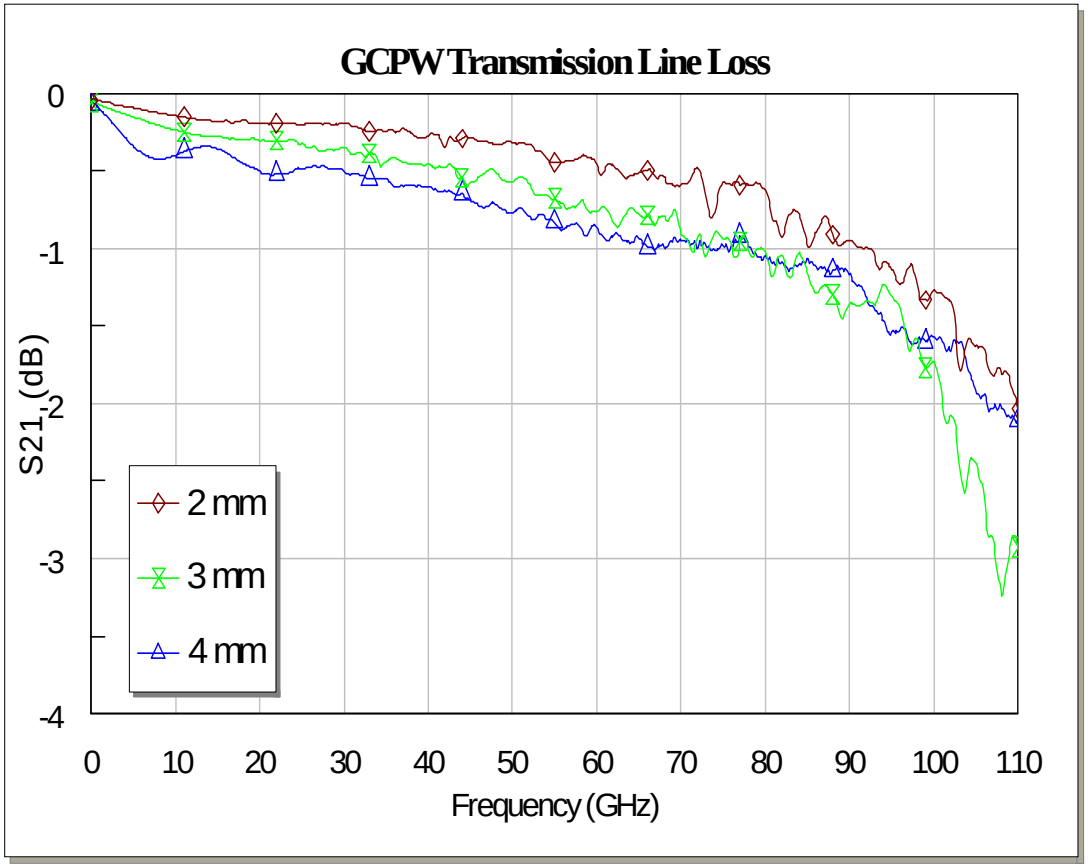


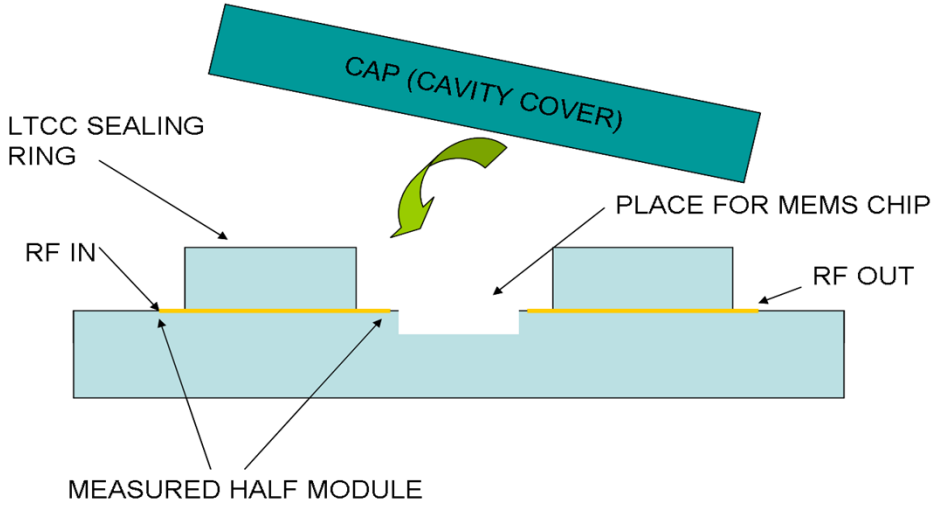
Development work for RF MEMS Packaging with LTCC at VTT

- Generally eutectic AuSn is used as soldering material for lid attachment
  - High melting temperature can degrade performance of MEMS components
    - VTT has studied low-melting temperature solder materials and found promising alternatives for hermetic sealing
- Vacuum packaging demonstrated to result in hermetic package
- Strains are much lower with low-T solder in comparison with AuSn
- Miniaturisation of packages by reducing sealing ring width and still maintaining hermeticity

RF Component Packaging with LTCC

- Transmission lines 2, 3 and 4 mm sealing rings, half module

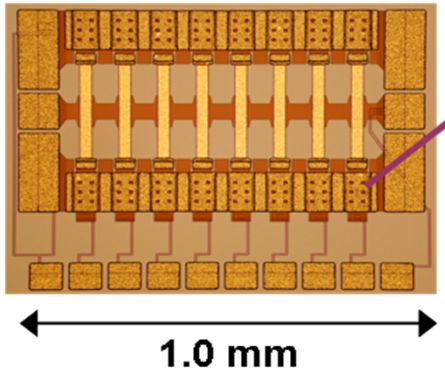




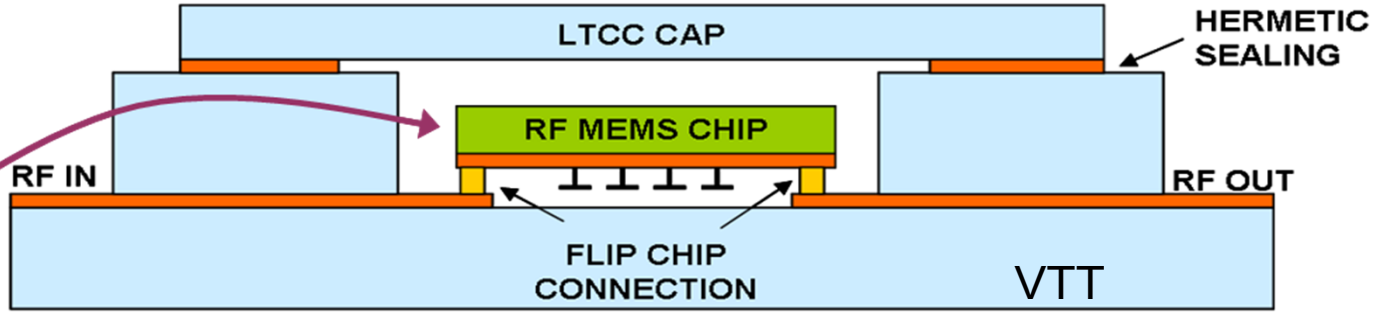
Loss < 1dB up to 90 GHz
with 2 mm sealing ring

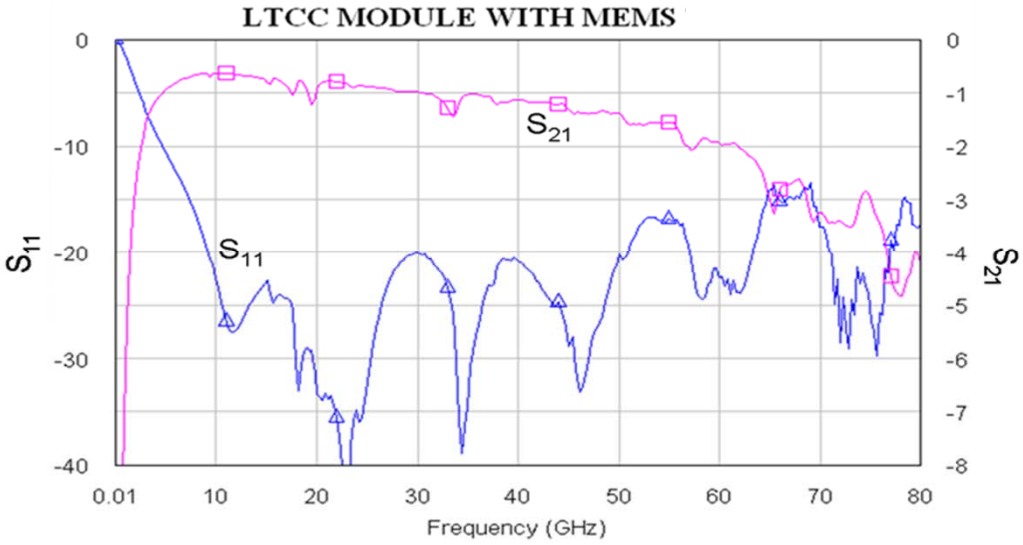
RF MEMS Packaging with LTCC at VTT

- LTCC can be used for packaging of sensitive RF MEMS components as a part of phased arrays and reconfigurable radio front-ends

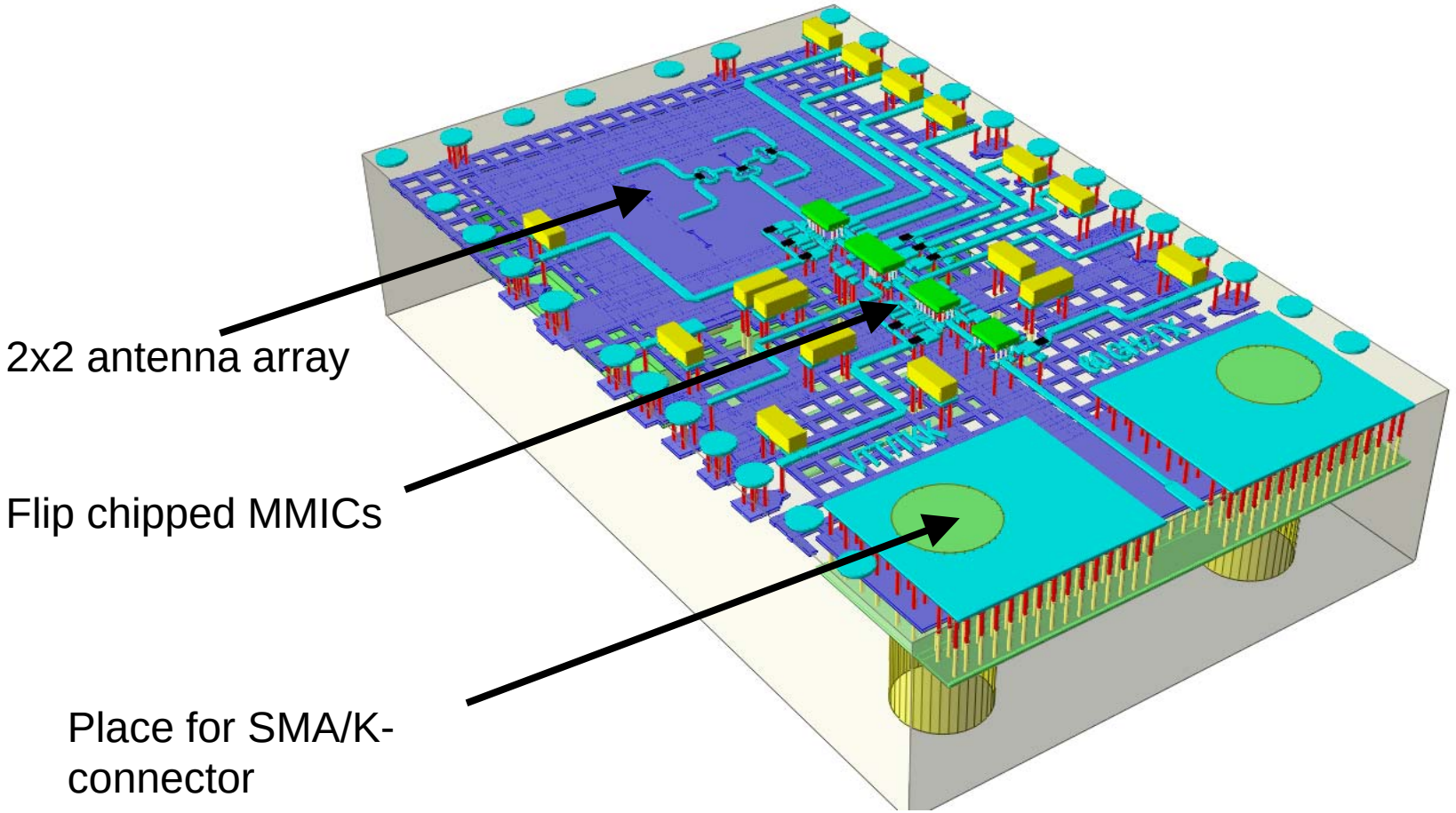


8-bit RF MEMS matching network with DC-blocks





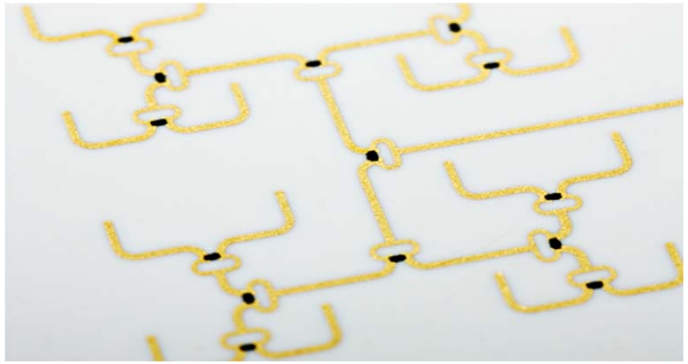
LTCC Modules for Hybrid 3D Integration and Packaging



Antenna Arrays for 60 GHz High Data Rate and Wireless Sensing Applications

- Aperture coupled 4x4 antenna array on LTCC developed at VTT
- Maximum gain: 18.2 dBi
- -10 dB impedance bandwidth: 5.8 GHz

4x4 array



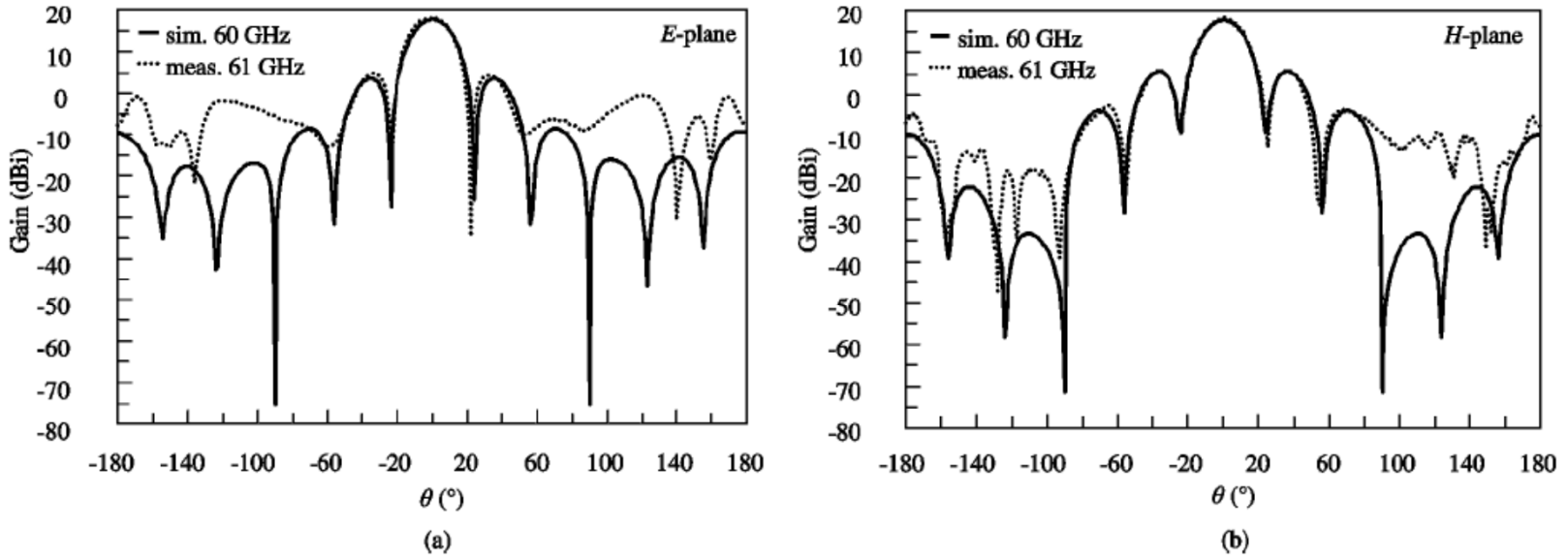
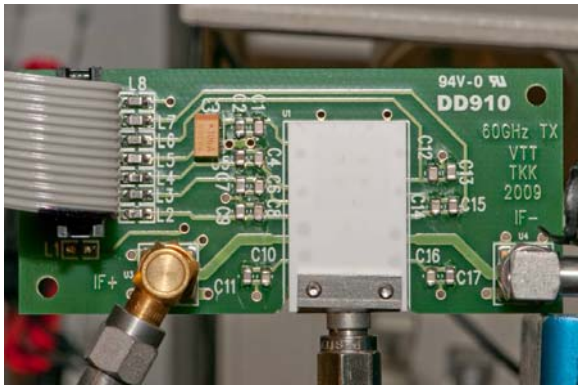


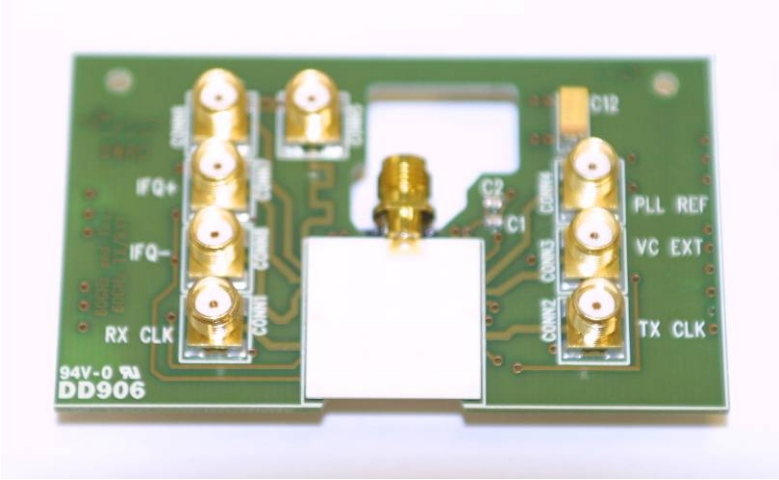
Fig. 17. Simulated (IE3D) and measured gain patterns for a 4 × 4 array with a large embedded cavity and Wilkinson feed network.

60 GHz Transceiver Demonstrators

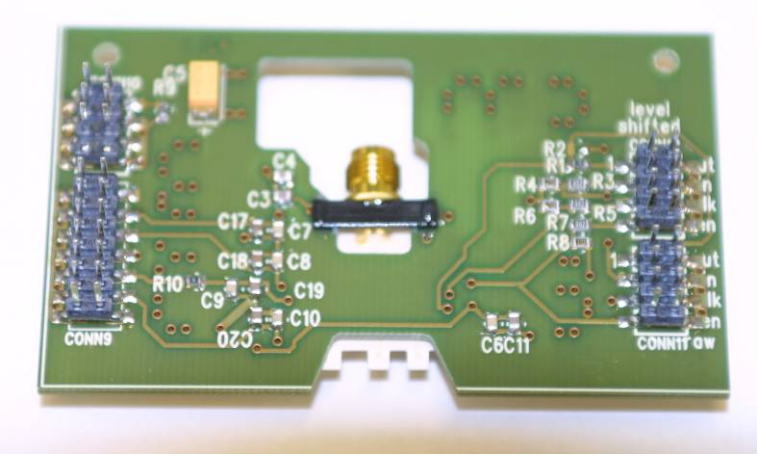
- Examples of 60 GHz CMOS transceiver demonstrators integrated with LTCC antenna arrays



60GHz TX with patch array antenna



Transceiver with TX & RX patch antennas



Transceiver with TX & RX end-fire antennas

Conclusions

- LTCC is a cost effective technology for RF modules
- Passive components such as filters, power dividers and antennas can be realized on LTCC
- LTCC modules have been demonstrated from DC to 100 GHz at VTT and example results were presented here

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