Integration of RF passive elements in telecommunication

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Integration of RF passive elements in telecommunication

- Introduction
- Passive element libraries
- Electrical design, layout, simulation
- Supplier data
- Substrates
- Go 3D
- Components
- Time to market
- Conclusions

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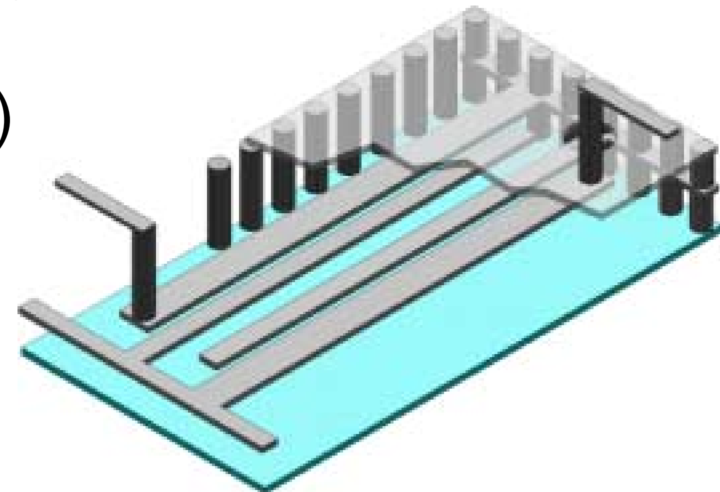
Introduction

- Passives growing in importance: MCM substrate much more valuable than just interconnect a number of chips.
- Total manufacturing cost, performance and size improved by integrating distributed RF elements (couplers, baluns, filters etc.) and discrete elements (capacitors, inductors and resistors) in the substrate



- Distributed elements can fulfill functions previously needing active elements
- The combination buried elements with active chips on top leads to very area efficient and well-performing solutions
- Focus on multilayer ceramic substrates for MCMs or SiP
- How to realize the promise the multilayer technology brings to RF and microwave products.

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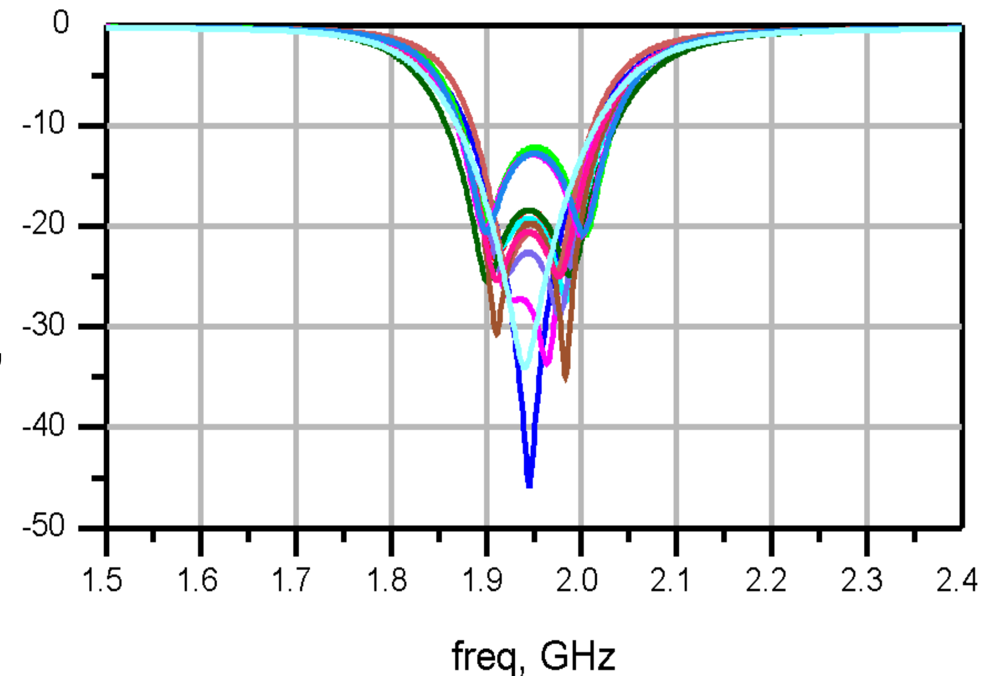
Passive element libraries

- Manufacturing develop => **design** need to follow pace and enable improved electrical performance and First Time Right designs
- **1** RF performance stabilized & characterized with fixed material set
- **2** build test circuits with elements using Design of Experiment parameters, measure and table for values and variance
- Avoid big library: capacitors, coils, resistors need to be listed with fixed geometries and optimized set of parameter values enabling designers/SW to extrapolate



- Include manufacturing tolerances, temperature- and humidity dependence and stability

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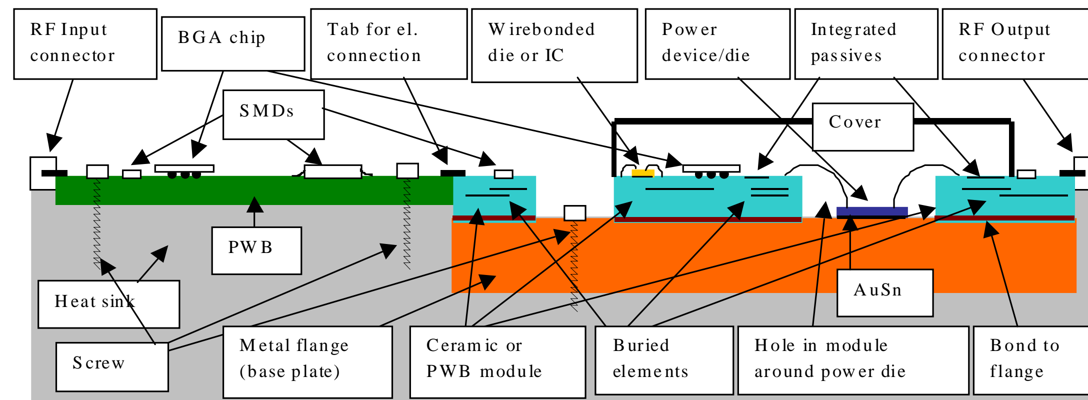
Electrical design, layout, simulation

- Structural approach: Specification -> Design -> Verification
- Design tool demands:
  - Input & output interoperability
  - Freedom of dimensions (3D)
  - Physical model extraction
  - Update and tool support



- Electromagnetic simulation tools
  - 2-, 2.5- and 3D
  - Library interaction
  - Comparison of different tools and analysis views
- To design and simulate a product EM simulation tools and RF design packages need to be used together. Better integration of tools for all levels of design and better correlation between different programs are on our wish list.

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Supplier data

- If manufacturing process not frozen library updating close to impossible
- New library for every alternative material set or subcontract manufacturer
- Too many, unstable libraries impossible to manage

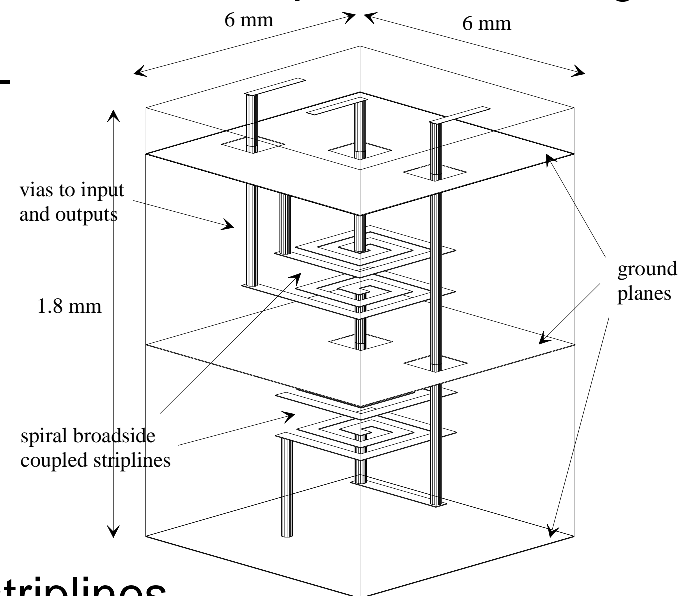
- IWPC building Internet based information network enabling designers to retrieve on-line material- and substrate-manufacturers' latest information to their design tool
  - Enabling to choose among manufacturers during the late design phase, a designer's dream
  - For suppliers a new tool to compete with focused information service
  - But need disciplined updating and standardized calibration
- Now building confidence material - module - OEM

Substrates

- Old thin- and thick film technologies develop and offer new performance - the integration of passive elements brings new life to MCMs and System In Package
  - Thick film technology sees a new life in multilayer ceramics like LTCC now seeing a growth
  - Improved thick film: Photodefined or etched
- In organic substrates passive integration limited:
  - inductances, low value capacitances and polymer thick film (PTF) resistors.
  - All organic based passive elements one order of magnitude lower stability than similar ceramic ones.
- Hence the interest in RF LTCC
- Line width and space not enough, tolerances essential for RF passives
- Manufacturing processes frozen
- Play with dimensional ratios, not absolute values

Go 3D

- Enhanced performance and size by 3D integration
- Designers need to go 3D for several reasons
  - The increasing integration of active devices together with the developments in electronics materials increases the electrical effects of interconnection length
  - Also boards, substrates, components and other mechanical parts close to each other increase interference in conductors
  - FlipChip and Wire-bond loops cannot be considered planar at the higher frequencies now employed in Wireless
  - The need for combining electrical simu-lation and 3D physical simulation (including thermal) based on layout
- Tolerance from hot elements



3D Balun by spiral broadside coupled striplines

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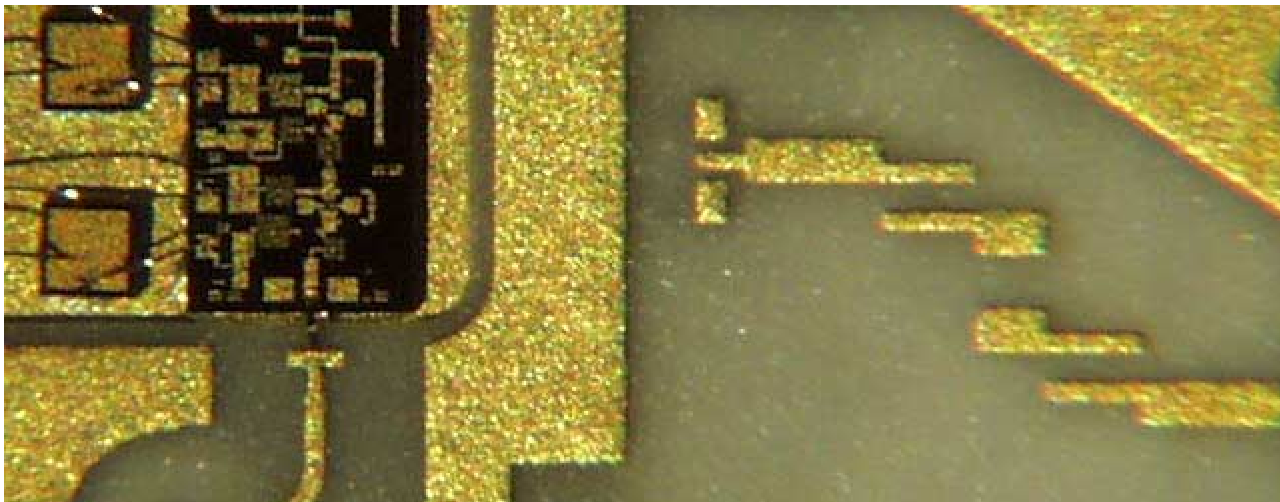
Components

- Some active chips replaced by passive elements but still need for semiconductor ICs
- Below 2 GHz difficult to get KGD
- Above 2 GHz difficult to get packed devices
- IC interconnects essential part of RF model, utilize their capacitance and inductance, make unbalanced paths extremely short



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Time to market

- RF engineers are used to build - measure - improve - build -....
- Time to market and limited resources in a price sensitive market makes First time Right an important goal for a design team
- To enable virtual building of subsystems using library elements improved design systems are needed
- These need to take into consideration not only material parameters and their dependence on environment and time but need also to consider unwanted interaction in the neighborhood of the elements and their interconnections
- An experienced designer is still the best "tool" as long as next product is close enough from previous ones
- Important to segregate process and design method development from fast product creation

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Conclusions

- Passives becoming more important
- More so in higher frequencies
- Microwaves and mm-waves in commodity products
- Multilayer ceramics promising for 3D passive & active integrated modules
- Material properties difficult to manage in design phase
- Holistic, 3D design and simulation on unit level needed
- Look for new technologies like thin film on glass or silicon, molded plastic constructions