Communications Microsystems for Spacecraft – Current Research and Future Systems

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Outline

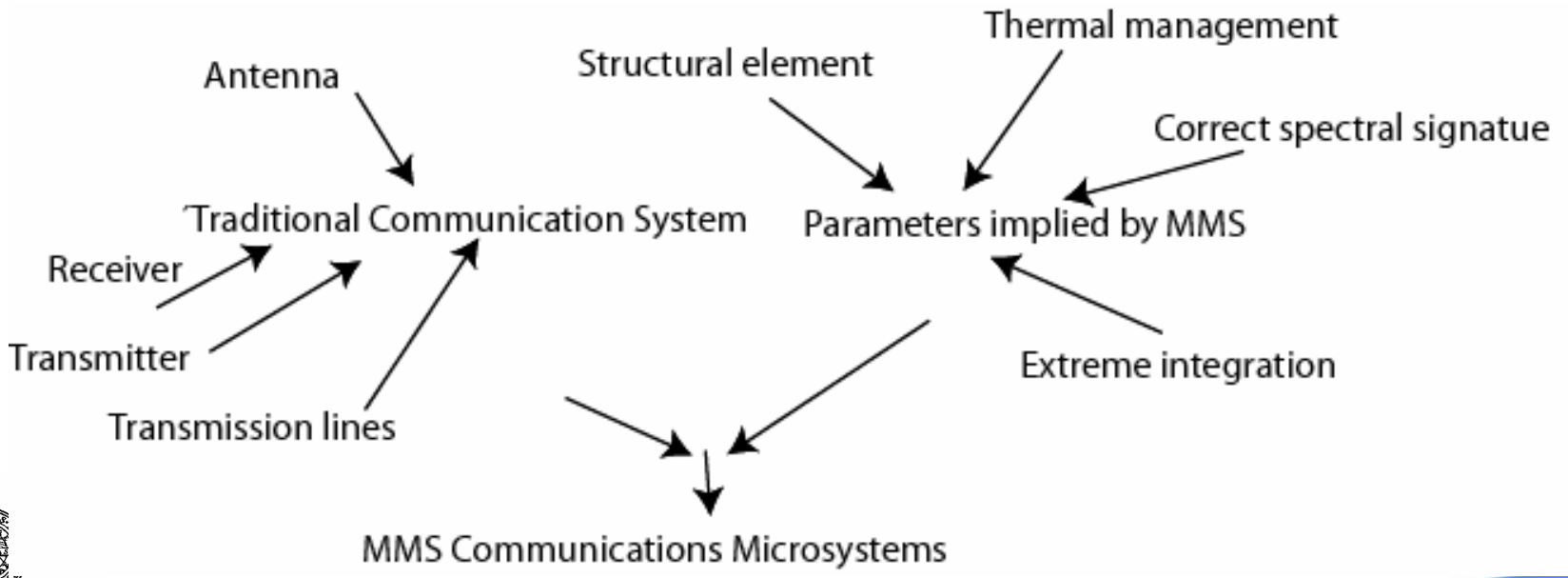
- Multifunctional Microsystems Applied on Communication Modules
- Current research at ÅSTC
- Front end of S-band module as an example
- Why silicon as a RF/mm-Wave substrate?
- Cross-disciplinary research
- Conclusions

Multifunctional Microsystem MMS – Applied on Communication Modules

Traditional RF system
- Separate parts connected toghether with transmissions lines

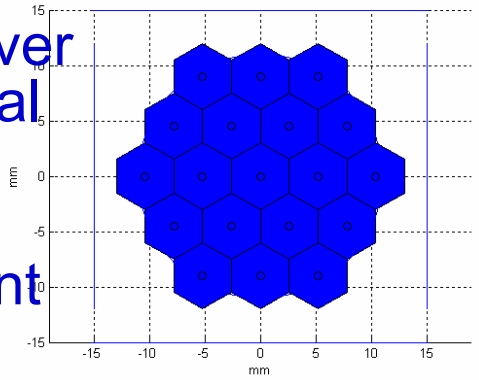
Highly integrated RF modules
- One RF module contains all necessary parts integrated

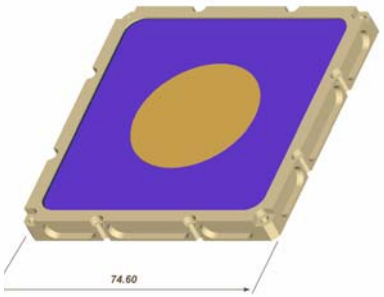
- MMS Applied on RF modules
  - Extreme minityrization
  - All necessary functions integrated
    - Thermal management
    - Communication module
    - Spectral admittance
    - And so on...



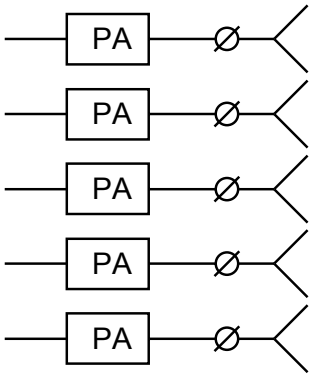
Current Research at ÅSTC

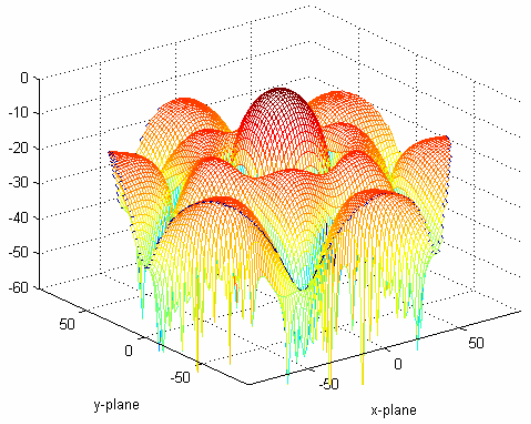
- S-band Transmitter and Receiver modules with integrated thermal management
- Ka-band phased array with integrated thermal management
  - Transmission lines on membranes
  - RF through vias
  - Phase shifters





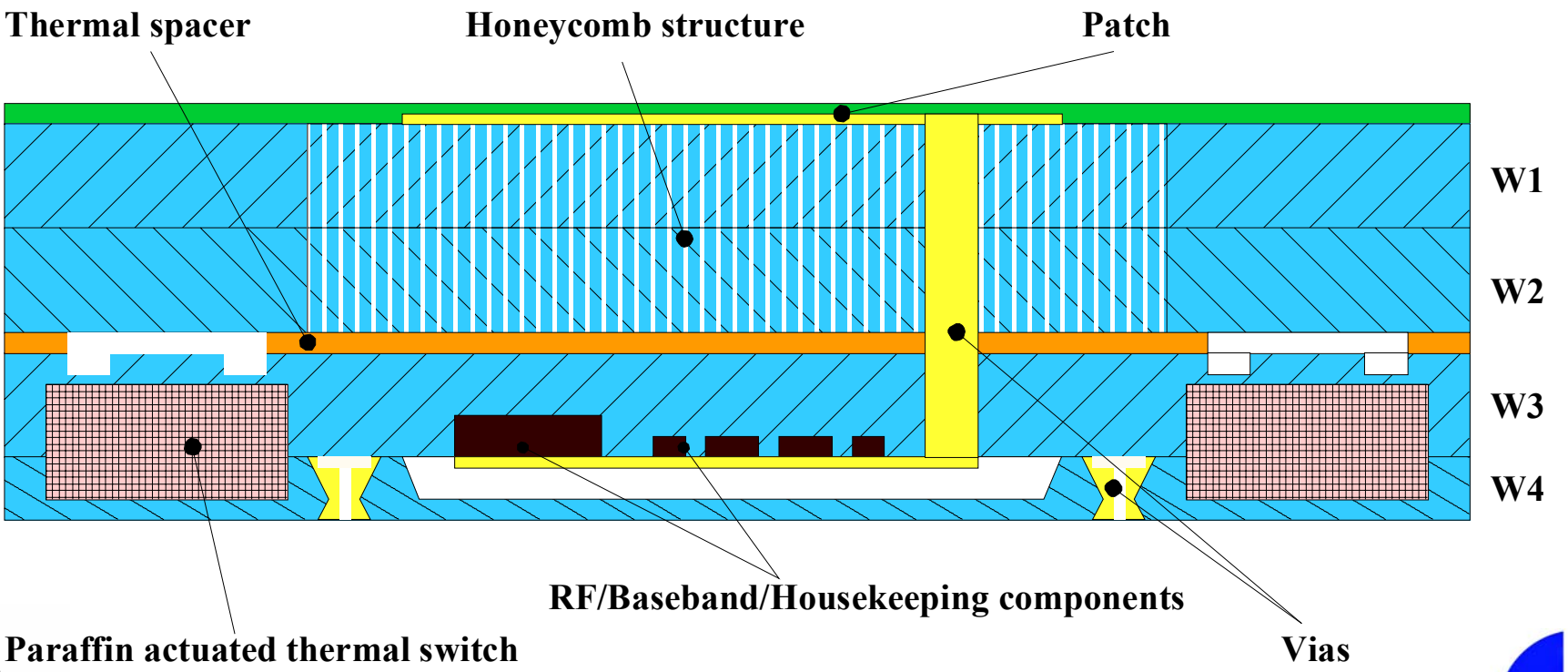
- Basic technology
  - Silicon as substrate
  - MST, MEMS
  - MMS





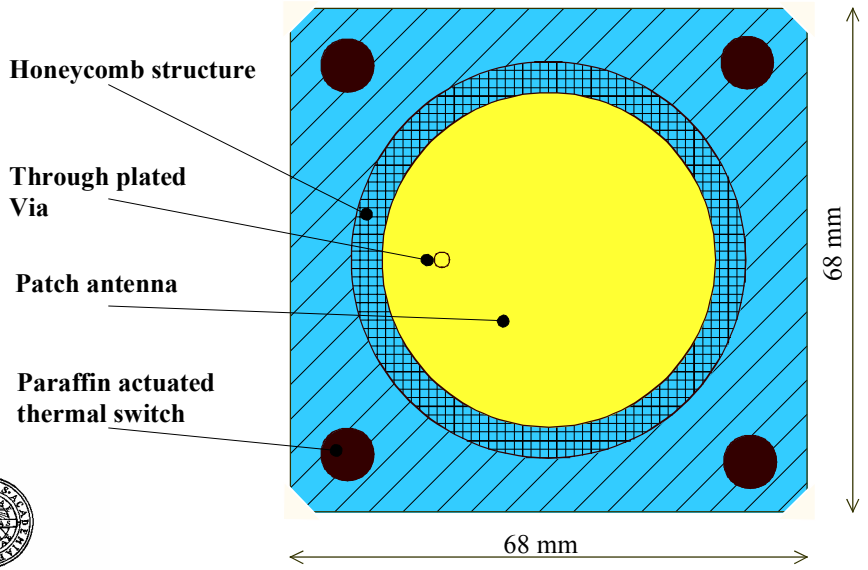
S-band Transmitter/Receiver with Integrated Thermal Control

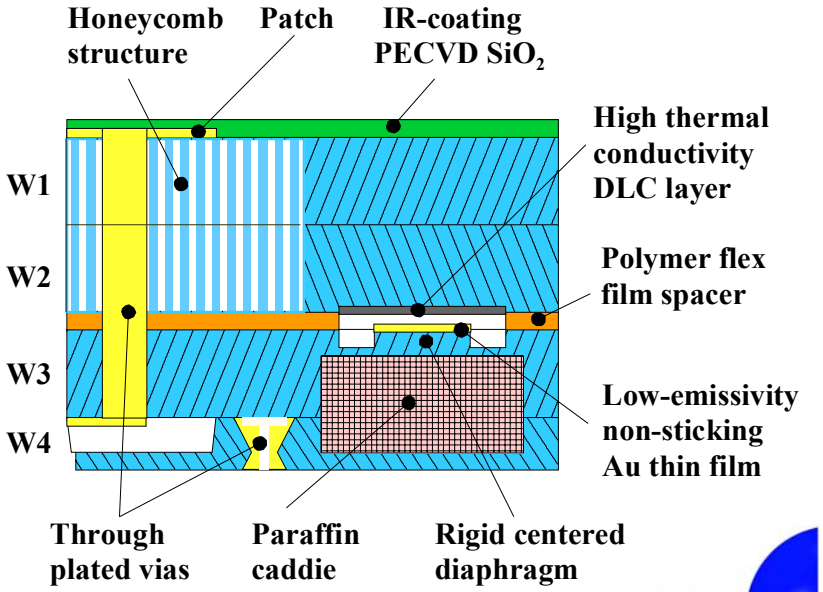
The system consists of a 4 wafer bonded silicon wafer stack



S-band Transmitter/Receiver with Integrated Thermal Control

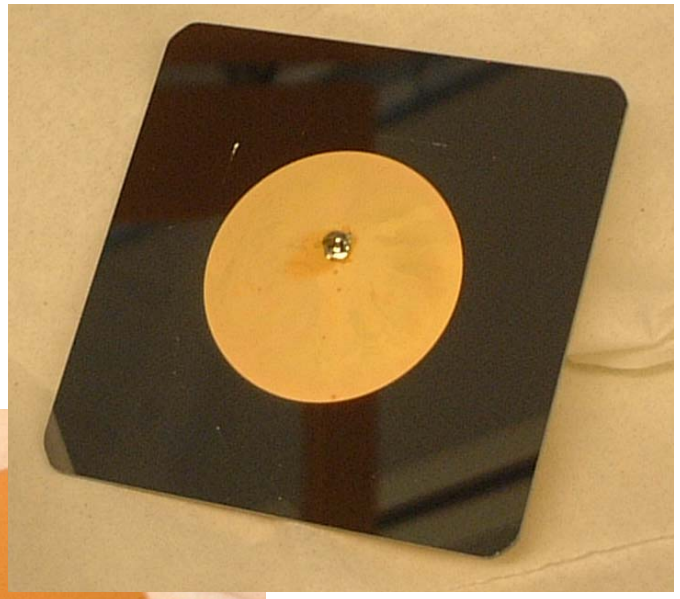
- Bulk thinned silicon, thermal coating, active MST heat management
- 20 grams, 68 mm square, 2 mm thickness
- Estimated RF-power 1.5W, Antenna gain 3.6dBi





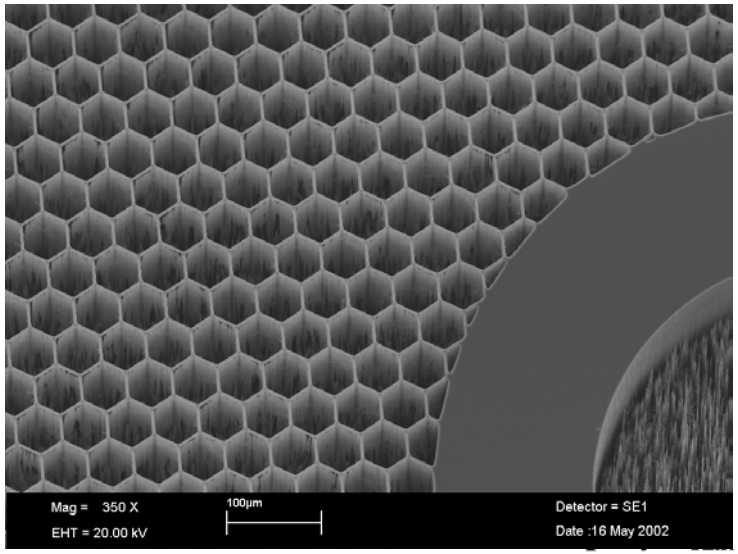
Bonded top wafers manufactured

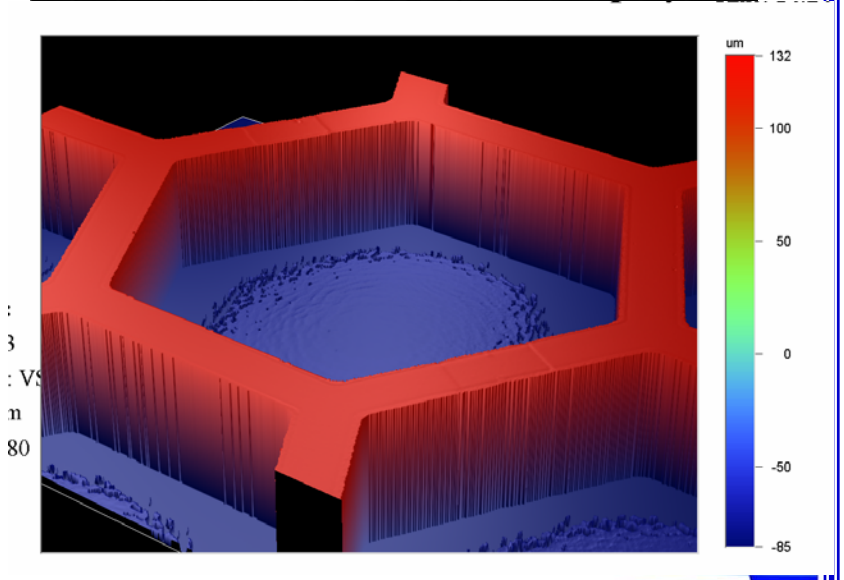
- Two bonded silicon wafers (each 525 µm thickness)
- Honeycomb support structure
- Simple SMA contact attachment for preliminary tests



Thinned Bulk Silicon Structure

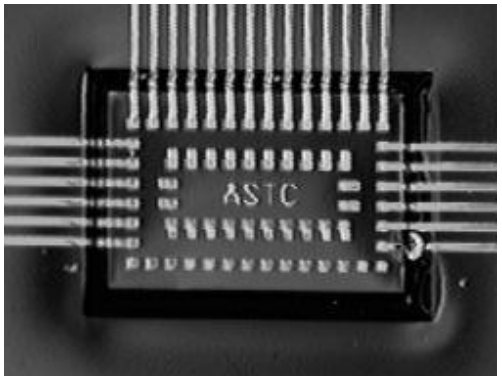
- Reduced losses
- Lower dielectricity constant → more broadband device
- MST process, DRIE etched honeycomb pattern
- Dielectric value reduced from 11.9 to 3.8!

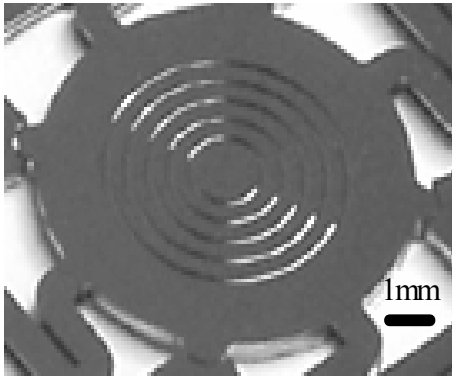




Integration of actuators and 'chips', or Why silicon?

- Well known micromechanical methods for producing very compact MCM modules using silicon as substrate
- E.g. Thin film connection of chips in etched pits (MCM):
  - Advantageous at high frequencies due to reduced parasitic impedances.
- Easy packaging (Si-Si bonding)
- Actuator integration
  - E.g. Paraffin as actuator in thermal switches in presented S-band module.





Cross-disciplinary Research

- Materials science
- Materials analysis
- Microwave technology
- Antenna analysis
- Device technology
- FPGA/microcontroller technology for stand alone ’smart’ microsystems
- and more...

Conclusions for future communications microsystems

- Low cost
- High redundancy
- New mission scenarios
- Few interconnects to outside ’world’ (spacecraft)

Thanks for your attention!

- Questions?

Smarter...
Smaller...
Lighter...
Multifunctional...

... are the keywords for
Communications
Microsystems
of the future

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