Multi-wavelength Optical Beam Forming Network based on Wavelength Division Multiplexing for large-scale wideband Phased Array Antennas

C4 - Broadband Optical Beamforming Networks

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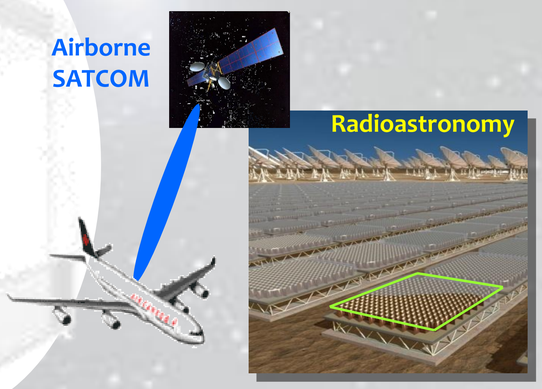
Wideband & low-signal power antenna arrays (WP A2)



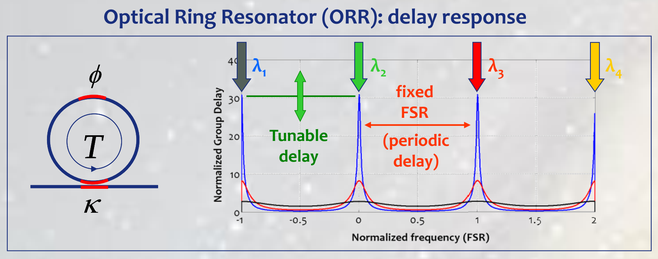
- Wideband phased array antennas (> 2 GHz) ➡ Beamforming in optical domain
- Low- signal power applications (SATCOM, radio astronomy) ➡ Large antenna arrays required ➡ Increased complexity of the antenna beamformer
- When the beamformer is realized in *integrated optical technology*, with thermally tunable parameters
  - Higher chip area occupation
  - Difficult heat dissipation
- Two possibilities of improvement:
  - System level: employ multiwavelength techniques to compact the design
  - Device level: improve the integration to reduce the footprint

System level: OBFN based on Wavelength Division Multiplexing (WDM)

Multi-wavelenght OBFN

- Optical ring resonators (ORRs) are used as true time delay (TTD) units in the integrated optical beamformer
- Ideal ORRs have a perfectly periodic frequency-delay characteristic

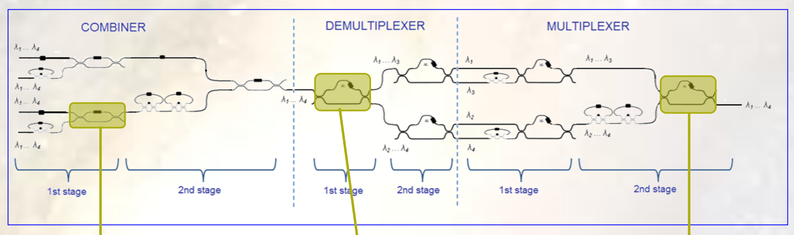
Optical Ring Resonator (ORR): delay response



- ORR periodicity can be exploited to multiplex signals originating from separate antenna elements on the same OBFN path (same waveguide) by the WDM technique
- Each ring resonator can be used to delay multiple antenna signals

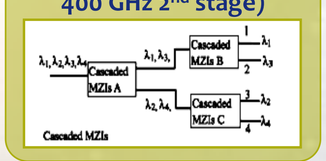
OBFN model

- A LabView model for the MWL OBFN has been implemented

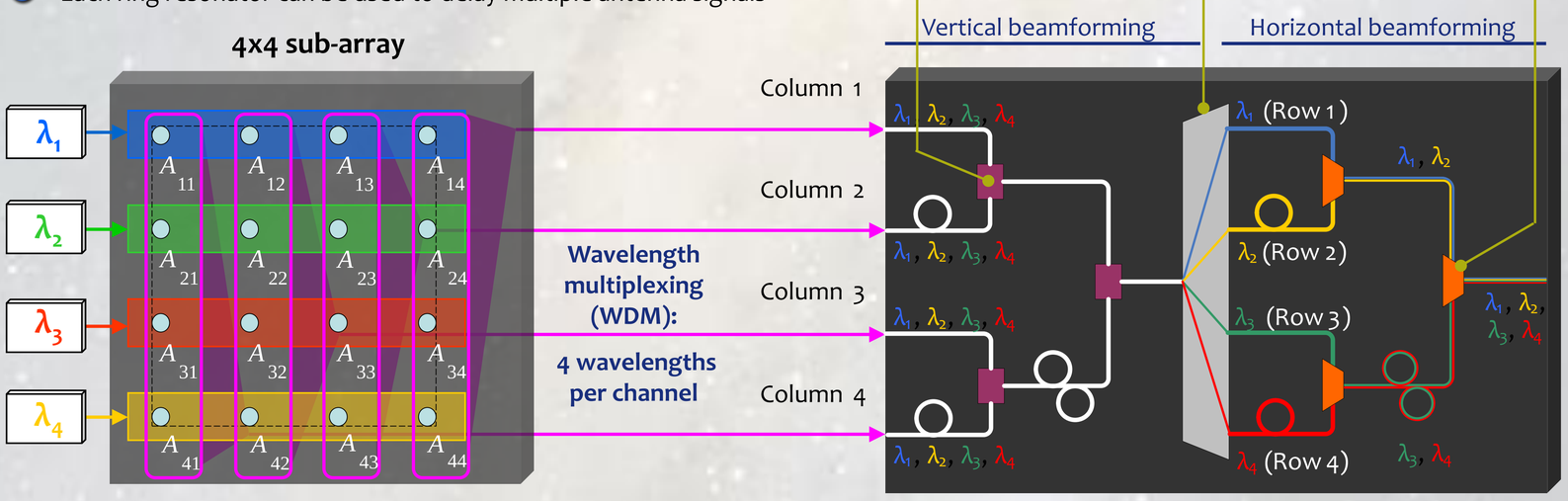


Combiner Symmetric MZI

1x4 DE-MUX Asymmetric MZI (FSR: 200 GHz 1st stage 400 GHz 2nd stage)

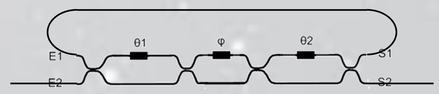


2x1 MUX Asymmetric MZI



Wavelength-independent MZI for frequency periodic ORRs

- Requirement: same delay at each period
- Non-ideal periodic behaviour of the ORRs has been characterized by measurements and modeled in LabView
- The non-ideal behaviour has been attributed to the wavelenght-dependance of the directional couplers used in the MZIs which connect the waveguide and the ring
- A new design for a frequency independent MZI has been implemented in the simulator



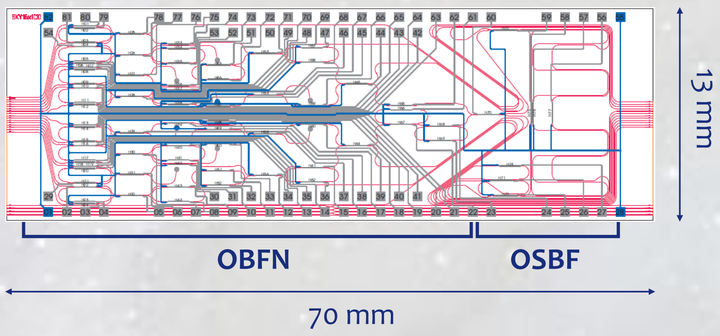
- When ϑ_1 and ϑ_2 are properly tuned, the coupling is flat with frequency **for all values of φ (and thus of κ)**

Limitations

- 2 MZI per ring => Smaller footprint needed to keep a small value for the round trip time *T*
- 3 heaters per ring => complex control and greater heat dissipation

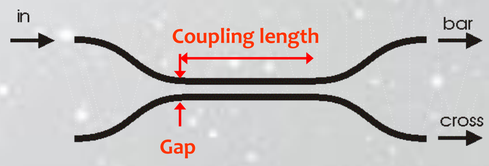
Device level: fabrication of novel TriPleX™ building blocks for footprint reduction (WP D2)

16 x 1 OBFN chip layout with current technology (`09)



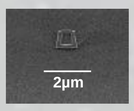
- With the current technology, only 3 (16x1) OBFN chips can fit on a 4" wafer
- Footprint reduction needed for OBFN upscaling
- Footprint reduction requires the increase of the index contrast of the waveguide

- The increase in index contrast requires a re-design of the directional coupler

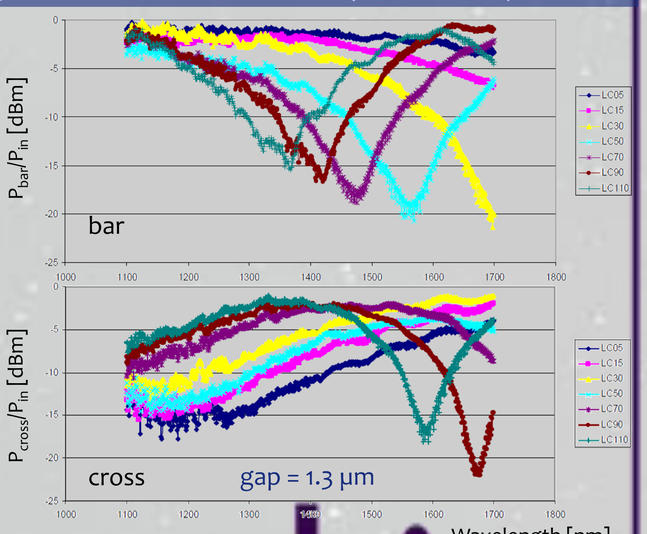


Set of structures fabricated and tested:

- Gaps: 1.3 – 1.7 µm
- Coupling lengths: 5 – 110 µm



TriPleX™ waveguide technology



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