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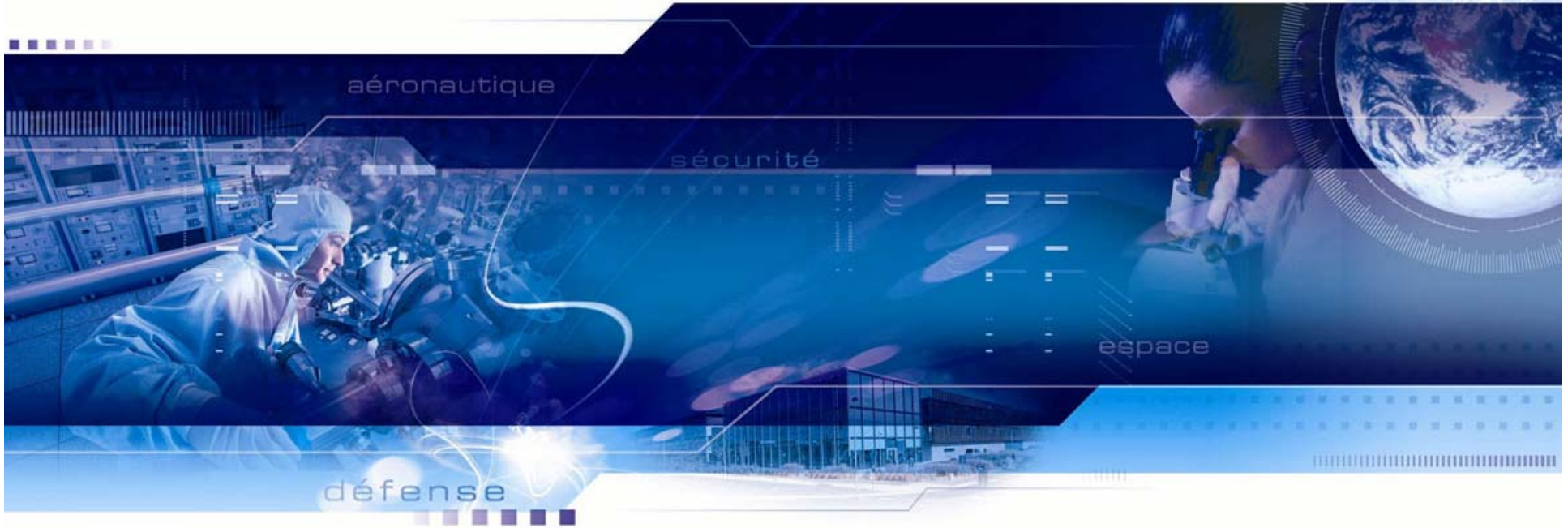

MiniMEMS

High-Reliability, High-Power & High-Speed RF Tuning Applications based on **Mini**aturised **MEMS** Switched Capacitors

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EURIPIDES EoI – October 10th, 2008 – Berlin

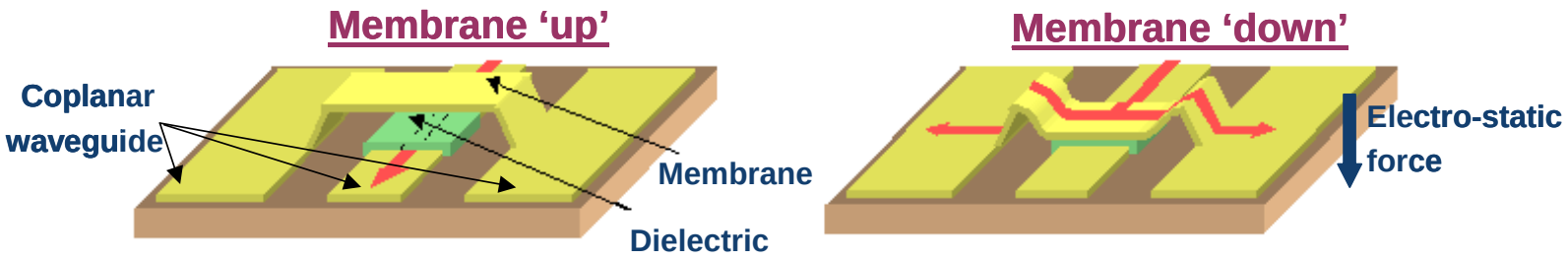
State-of-the-art of « standard » RF-MEMS

Reasons of enthusiasm for RF-MEMS

- High RF performances (wideband, low loss, high isolation, high linearity
- Very low power consumption

Two capacitive approaches

- Capacitive switch: Cr=30-200 ⇒ for routing purpose
- Switched capacitor: Cr=2-10 ⇒ for tunable/reconfigurable functions



Main current issue: long-term reliability (& high-power handling)

- Dielectric charging
- Temperature sensitivity of the fixed-fixed beam

And low switching time

- > 1 µs (to be compared to solid-state techno. < 0.1 µs)

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MiniMEMS Project Overview

New device of MEMS switched capacitors for RF tuning applications

- Mitigating dielectric charging effect and temperature sensitivity
- Allowing switching time in the order of 0.1 µs

Based on miniaturisation of standard capacitive MEMS switch

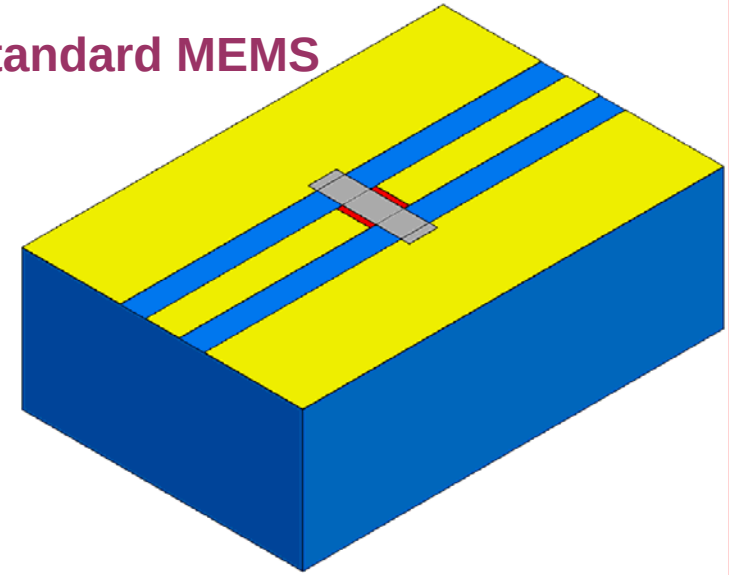
- Enhancing mechanical properties
- Leading to high-reliability, high-power and high-speed capabilities

Purpose of MiniMEMS

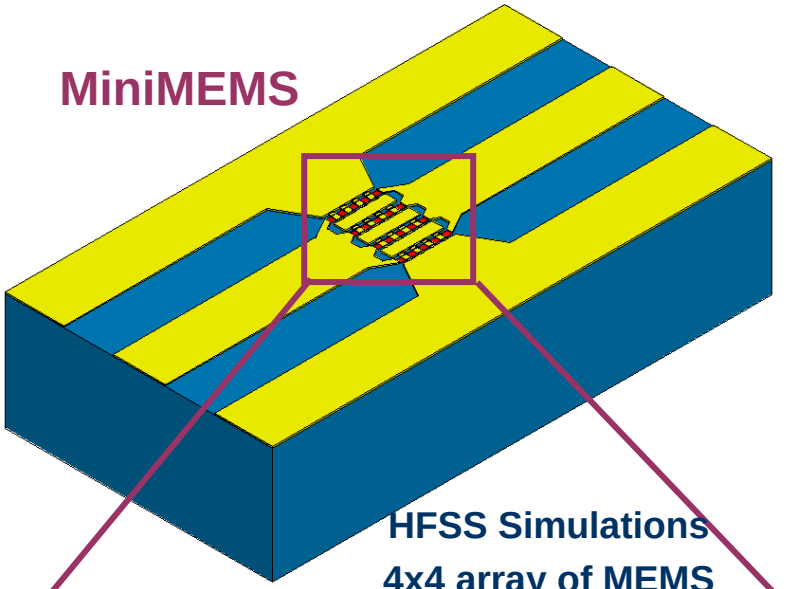
- Development of technological steps and methodologies to achieve fabrication of miniaturised switched capacitors
- Integration into elementary RF functions:
  - Tunable filters for adaptive receivers (X-Band)
  - 3-bit phase shifters for reflect array antennae (X-Band)
- Fabrication of demonstrators showing the benefits of the technology
  - Adaptive receiver for ATM applications
  - Partial reflect array for weather and wake vortex detection radars

MiniMEMS Project Innovation

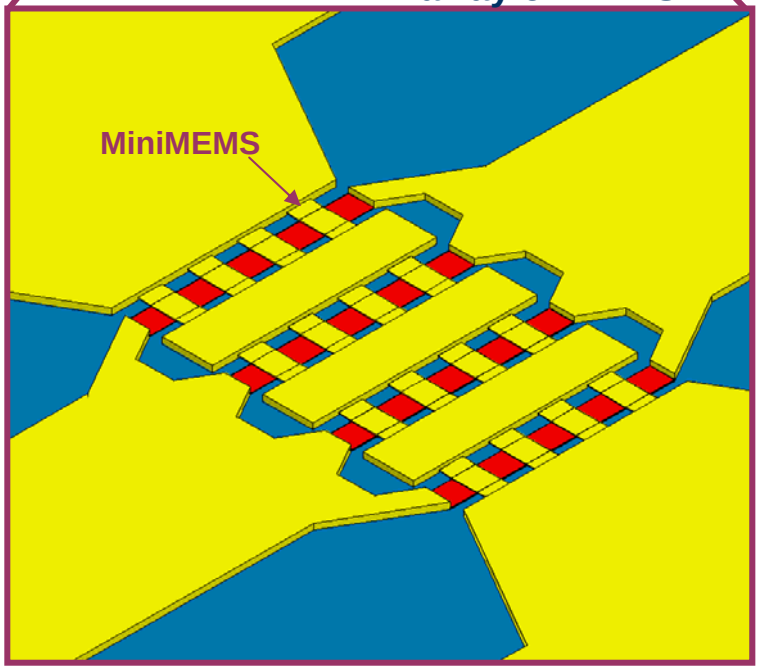
Standard MEMS



MiniMEMS



HFSS Simulations
4x4 array of MEMS



	Standard MEMS	MiniMEMS
Beam size	250x100 µm²	20x10 µm²
Gap	2 µm	0.25 µm
Capacitance ratio	30-150	3-30
Switching time	> 1 µs	200 ns
Reliability	$< 10^{10}$	$> 10^{11}$
Power handling	< 5 W	5 W

Enhanced mechanical properties thanks to the miniaturisation

- Spring constant ↗ but gap ↘ ⇒ pull-down voltage ≈ constant (30 V typ.)
- Gap ↘ ⇒ capacitance ration Cr ↘ (3 typ.)
  - Use of ZrO_2 or PZT instead of Si_3N_4 ⇒ aimed Cr ↗ by a factor 10
- Resonant frequency ↗ ⇒ switching time ↘
- Critical stress ↗ and residual stress ↘ by 70%
  ⇒ much more stable vs temperature variations (in terms of spring constant, Vp and capacitance)
  ⇒ can be packaged under higher T° conditions
- Pulling pressure ↗ ⇒ withstand higher charge density before failing in down state position ⇒ dielectric charging effect ↘

Array of MiniMEMS for 6-100GHz applications

- Capacitance value of 1 MiniMEMS too small (3-15fF) for RF applications
  - 6x6 array for X-Band
  - 4x4 array for Ku- & K-Band
  - 3x3 array for Ka- & Q-Band
  - 2x2 array for > 50 GHz

Risk evaluation

Nature of risk	Risk	Contingency Plan
Technical	At reduced scales, the planarity / roughness of the beam is critical	Use of chemical-mechanical planarisation techniques
Technical	Capacitance values not high enough to meet RF application requirements	Several dielectric layers will be used: Si_3N_4, $Zr0_2$, PZT Several devices can be built in parallel
Technical	Reliability not met due to packaging issues	3 types of packaging techniques will be studied in parallel
Market	Components and products developed by non European companies (USA are very active in this domain) with impact on European sales	Design methodologies and processes developed in MiniMEMS will allow industrialisation transfer to foundry (technology transfer to UMS at the end of the project)

Exploitation potential

Road Map MEMS for Reflect Array and ATM				
Application	Frequency Band	MEMS operation	Year	Market in number of MEMS
Data Link Satellite-Aircraft communications	X	5000 h	2012	10^7
Weather and wake vortex Radar	X	1000 h	2012	3.10^6

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Proposed Work Plan

Project duration: 36 months

- Phase 1: Component and system specifications (6 months)
- Phase 2: Design, fab. and test of packaged switched capacitors components (15 months)
- Phase 3: Design, fab. and test of tunable filters and phase shifters (9 months)
- Phase 4: Partial reflect array and adaptive receiver demonstration (9 months)
- Phase 5: Exploitation activities
- Phase 6: Project Management

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