

**MEMS**Land

*Cost Effective MEMS to Develop a Sustainable High Tech Business*



**Point-One**

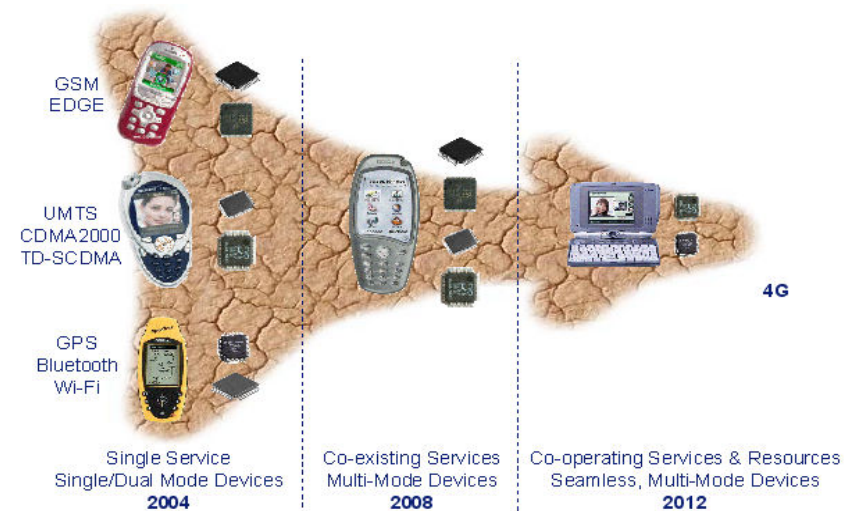
**Pole of innovative technology on nanoelectronics and embedded systems**

# Contents

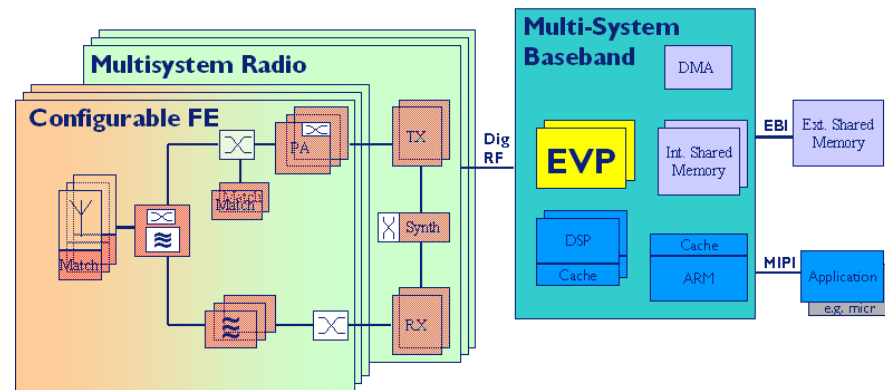
- Trends in the mobile market, challenges for future systems
- RF-MEMS capacitive switch
- MEMSLand partners working on RF-MEMS technology and applications
- Project status

# Multiple bands & modes present a challenge for the mobile industry

- Today's mobile terminals require increasing complexity in number of systems, bands and modes
- Consequently, subsystem components like Antenna's and PA/FEM's become more complex and specific
- Existing architectures do not provide a solution
- Re-configurable Front-Ends provide a solution and RF-MEMS is a key enabler



## Multi system challenges

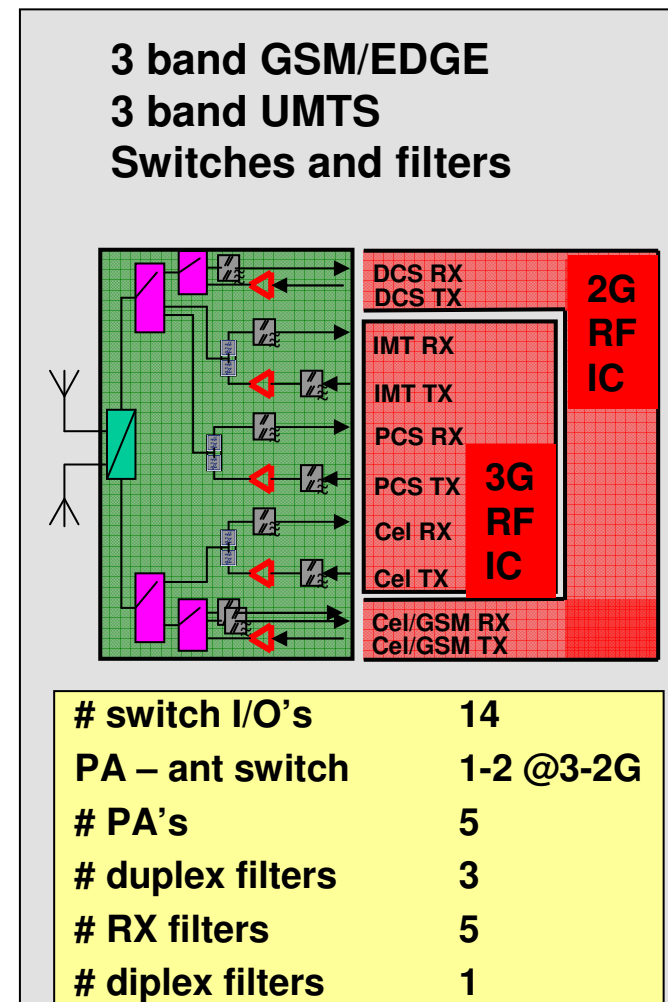


- 1) Increasing number of frequency bands and new requirements ask for **more and 'smaller' antennas**
  - Challenge: antenna size has theoretical limits leading to higher system losses and/or larger sized solutions
  
- 2) Increasing number of frequencies and operating modes require **more and higher efficient PA's**
  - Challenge: efficiency is optimized at peak power hence low efficiency at other modes & power levels
  
- 3) Increasing number of frequencies and duplex modes require **more and improved filters**
  - Challenge: today's filters are fixed frequency leading to large number of individual filters hence large size and cost

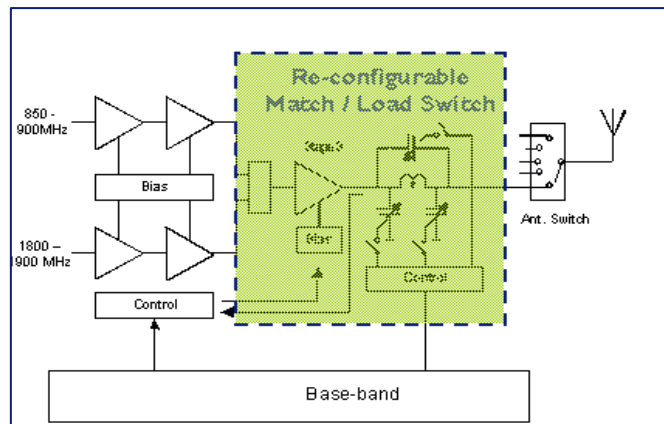
# Multi band challenge - example

evolution = combining antenna I/F + PA in multi TRX environment

- Rapid growth of Filters
  - 2G 1 RX filter / band
  - 3G 4 filters (1x Rx, 1x TX, 2x in Duplex)
- Growth in # PA's
  - Multi-band/mode
- More & Broader band Antennas
  - MIMO and diversity
  - Performance reduction
  - Increased antenna TTM
- Multiple RF interfaces

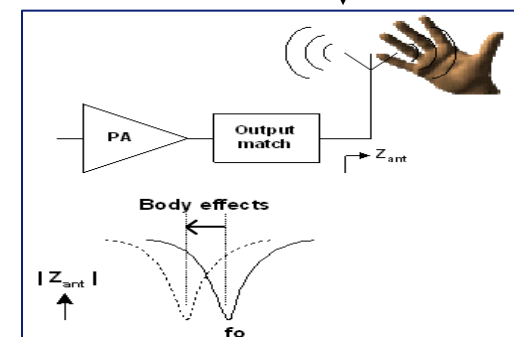
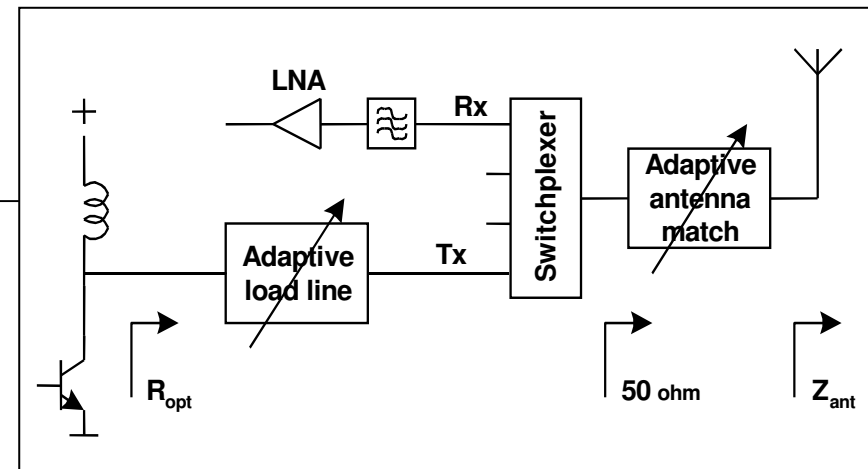


# Solution: Configurable RF front-ends ..... and RF-MEMS is the key enabler



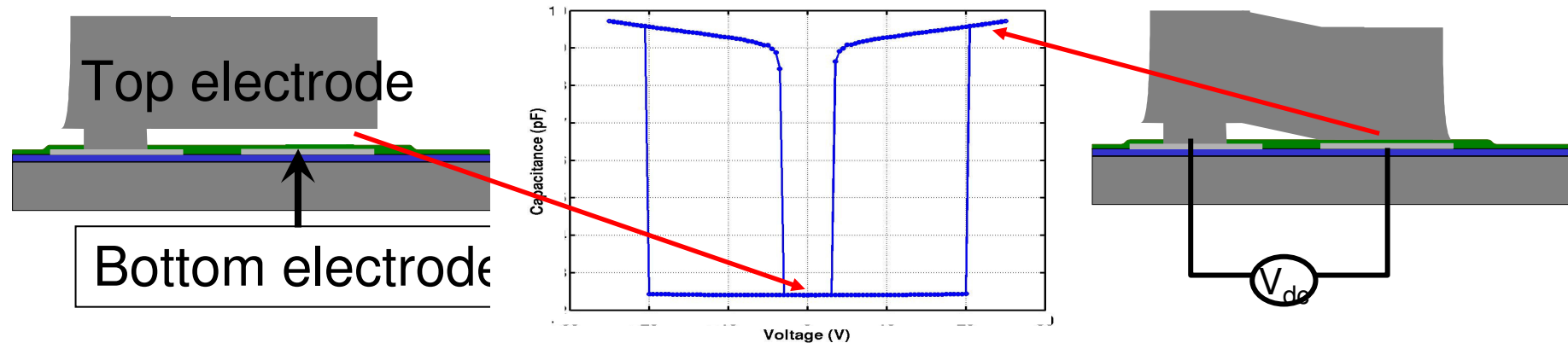
**Single line-up PA**  
*Benefits in size, talk time & cost*

**Adaptive antenna-match module**  
*Benefits in size & performance*  
*User interaction compensation*  
*Increased talk-time*



## RF-MEMS switch

- The RF-MEMS switch is a variable capacitor with a moveable top electrode.



- The RF-MEMS switch has excellent RF-performance:
  - High Con/Coff ration  $> 15$
  - Low losses : ESR  $< 100\text{m}\Omega$ ,  $Q > 100$
  - High power handling:  $P_{\text{max}} > 36\text{dBm}$
  - Very low harmonic distortion,  $H_{2,3} < -90\text{dBc}@34\text{dBm}$
  - Very low intermodulation distortion:  $\text{IM3} < -115\text{dBm}$

## RF-MEMS partners in MEMSLand



- NXP: design, model, process, library, system



Institut  
Siliziumtechnologie

- ISIT: wafer level MEMS package

**PHILIPS**

- AppTech: device simulation, test, reliability

**TU/e** technische universiteit eindhoven

- TUE: device/circuit simulation



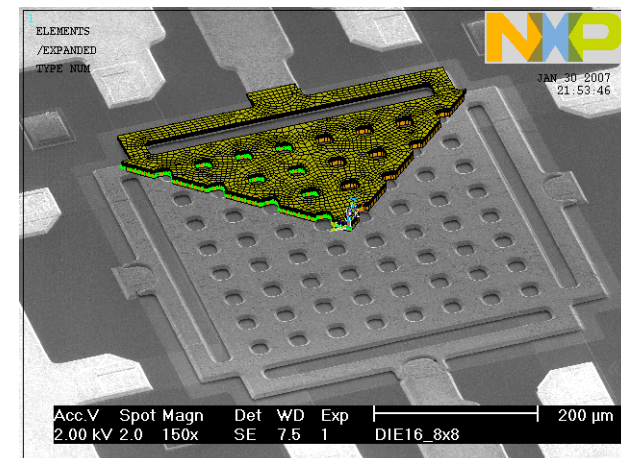
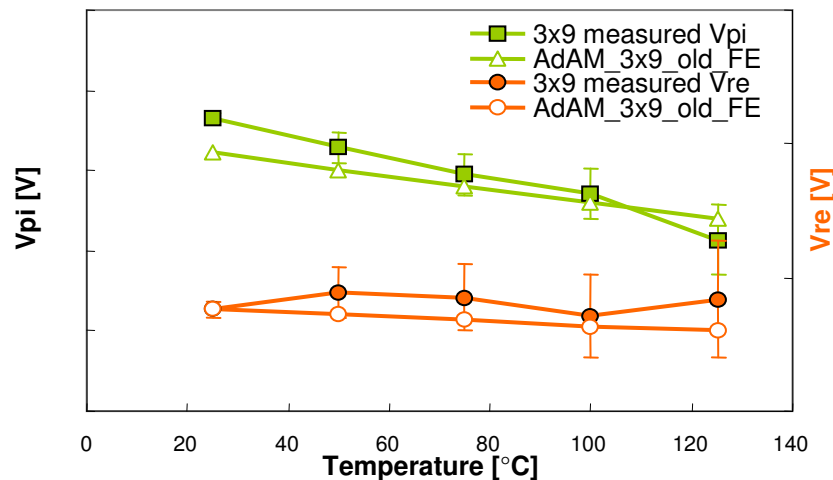
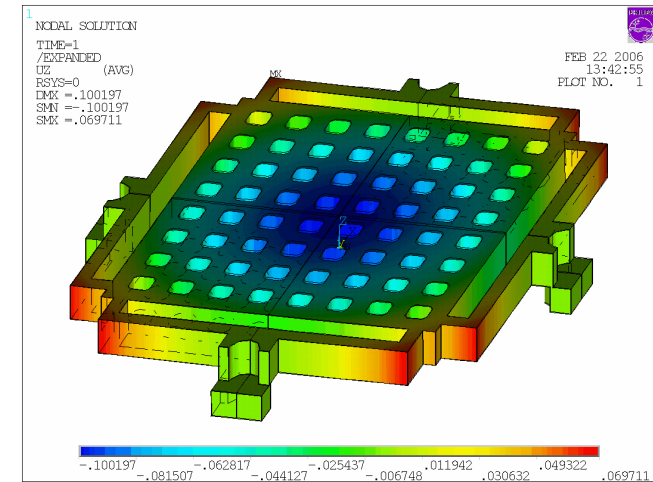
- TUD: material properties



- TUT: reliability

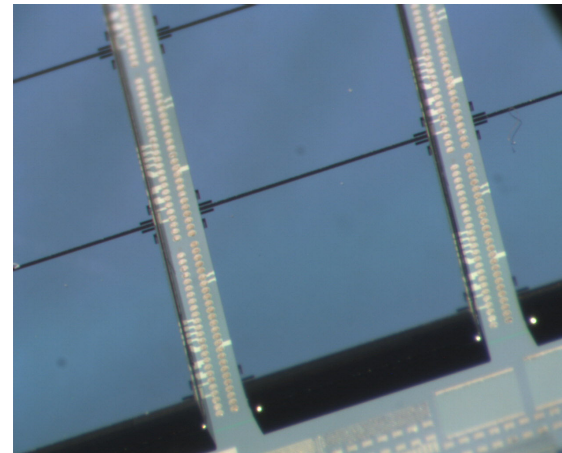
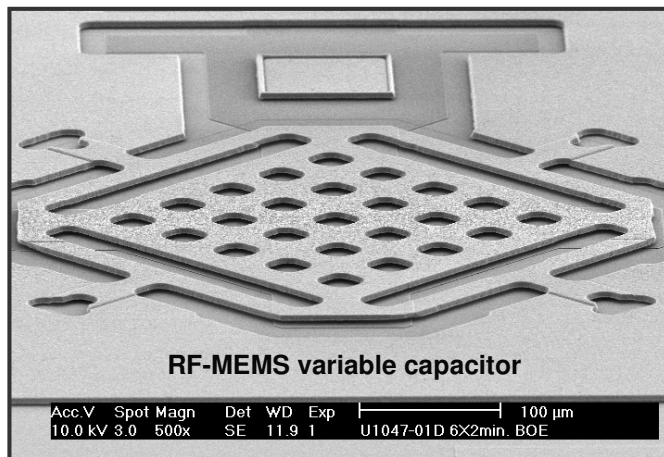
# Modeling (WP2)

- First versions available of models for device optimization and compact model for design kit
- Test structures available for model verification
- Static C(V) curve is well predicted over temperature range with FEM model
- Dynamic FEM model under construction



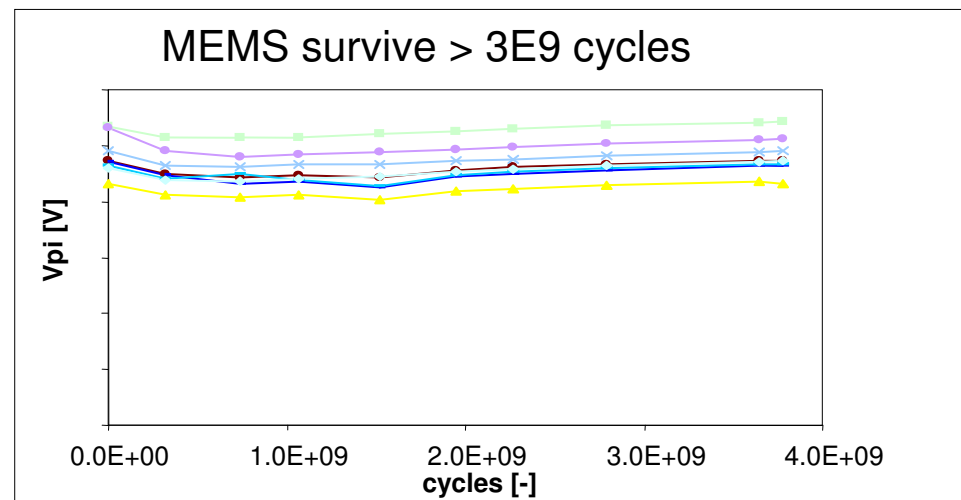
## Processing (WP3)

- Front-end process successfully transferred to 6” industrial line.
- Low cost hermetic capping route proven.
  - Multiple grinding & singulation routes under investigation.



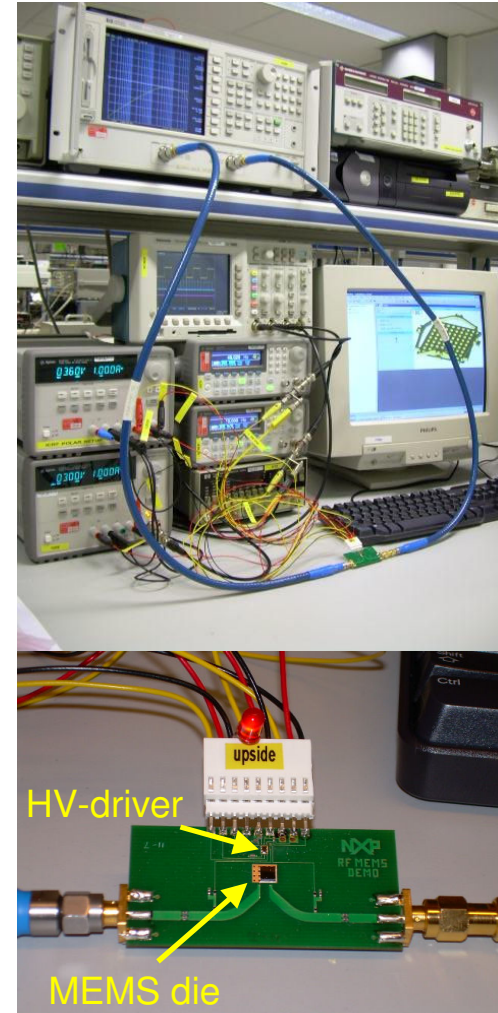
## Reliability (WP4)

- Dependence of mechanical properties on process settings & temperature budget investigated.
- Failure mechanisms investigated.
  - Acceleration factors to be verified on new hardware.
- Design rules for mechanical degradation available.



## Testing (WP5)

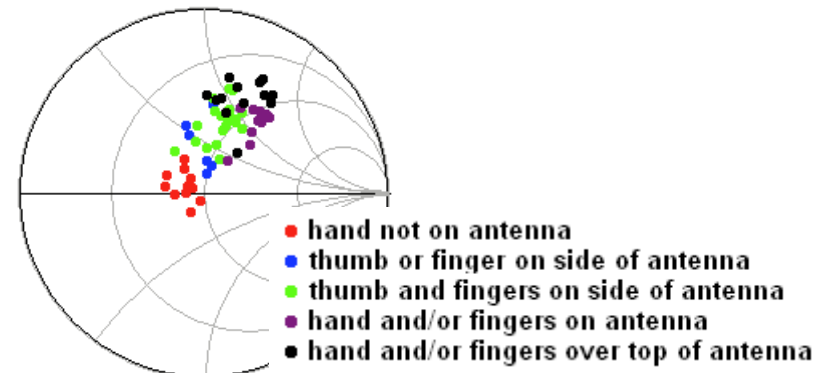
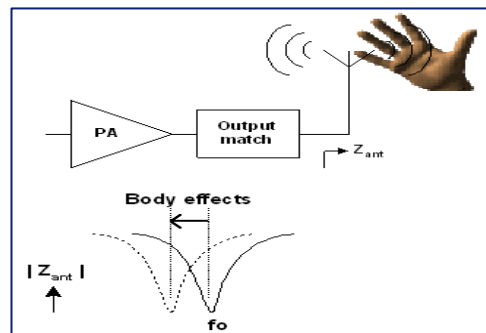
- Test moments selected on cost model.
- Device model available for modeling process faults.
- Evaluation program running on product level.



# Prototyping (WP6)

## Prototype Adaptive Antenna Match

Problem:



Solution:

