



Background & Organization

Motivations

- The RF MEMS devices were introduced 15 years ago and rapidly demonstrated highly attractive capabilities in term of insertion loss, isolation, power consumption and linearity.
- They are ideal candidates to create innovative reconfigurable front end architecture for RF and millimeterwave communication in different industrial segments such as mobile communications, aeronautic and space communications, radar applications and RF instrumentation.
- However, their industrialization has faced a very important issue concerning the reliability of these devices (sticking effect and material degradation)

Partners and Project Organization

- Thales Alenia Space** as end user (qualification procedures for MEMS devices)
- NovaMEMS (SME)** failure analysis for developing some standardization procedure and advanced knowledge on the Physics of Failure (PoF)
- CEA-LETI** acts RF-MEMS technology provider and it is interested in assessing the potentialities for space application
- ARMINES** (Ecole Nationale Supérieure des Mines de St-Étienne et le Centre de Microélectronique de Gardanne) has experience in material characterization and analysis
- LAAS-CNRS** has expertise in the field of RF MEMS failure analysis and modelling.

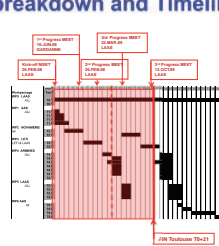
Objectives

Understand the fundamentals of these failure mechanisms in order to:

- Get a **standard in the methodology** to assess the RF MEMS reliability propose technological issues to minimize and/or overcome these effects
 - Develop **models** that will be implemented in the design to predict their life time
- The FAME project will focus on these three objectives and two types of RF MEMS devices :
- Ohmic switches**
 - Binary state capacitances/switch**

Failure analysis results will be exploited to design, fabricate and characterize RF MEMS demonstrators featuring enhanced predictable reliability behaviour.

Work breakdown and Timeline



- WP1 - Management (25.9 months)**
- Task 1.1: Project management (LAAS, 6 months)
 - Task 1.2: System and end user requirements (TAS, 6 months)
 - Task 1.3: System and end user requirements (TAS, 6 months)
- WP2 - Reliability platform set up (19.9 months)**
- Task 2.1: Design of the test vehicle (LAAS, 6 months)
 - Task 2.2: Characterization tests and methods (LAAS, 2 months)
 - Task 2.3: Test protocol (LAAS, 2 months)
 - Task 2.4: Test protocol (LAAS, 2 months)
- WP3 - Test vehicle fabrication (19.9 months)**
- Task 3.1: Test vehicle fabrication (LAAS, 6 months)
 - Task 3.2: Design of the test vehicle (LAAS, 6 months)
 - Task 3.3: Test vehicle fabrication (LAAS, 6 months)
- WP4 - Characterization and test (19.9 months)**
- Task 4.1: Structural failure modes evaluation (Novamems, 4 months)
 - Task 4.2: Structural failure modes evaluation (Novamems, 4 months)
 - Task 4.3: Failure modes and lifetime evaluation (Novamems, 4 months)
 - Task 4.4: Study of dielectric charging mechanism (LAAS, 4 months)
 - Task 4.5: Study of dielectric charging mechanism (LAAS, 4 months)
 - Task 4.6: Dielectric charging mechanism (LAAS, 4 months)
 - Task 4.7: Dielectric charging mechanism (LAAS, 4 months)
- WP5 - Failure analysis and modelling (19.9 months)**
- Task 5.1: Failure analysis and modelling (LAAS, 4 months)
 - Task 5.2: Failure analysis and modelling (LAAS, 4 months)
 - Task 5.3: Failure analysis and modelling (LAAS, 4 months)
 - Task 5.4: Failure analysis and modelling (LAAS, 4 months)

Scientific and Technological Achievements

Ohmic Switches --> Metal-to-Metal --> Microcontact degradation

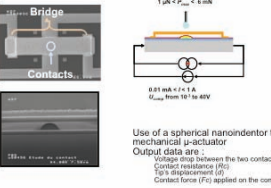
Two major failure mechanisms in RF-MEMS switches occur both at the mechanical contact

Capacitive Switches --> Metal-to-Dielectric --> dielectric charging

Technology

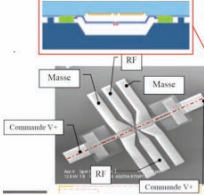
Test vehicle: Bridge with dimples (LETI/LAAS)

NOTE: same process as for actual device



Test vehicles: Ohmic switch (LETI)

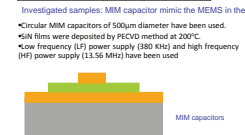
Cross section for the ohmic switch



Test vehicle: MIM capacitors (LETI/LAAS)

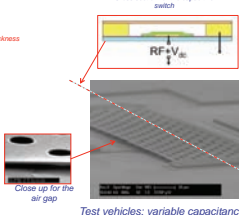
NOTE: same process as for actual device

Layer	Thickness
Top Electrode	Al
Dielectric	SiO ₂ 500nm
Bottom Electrode	Al
Substrate	Si 500µm



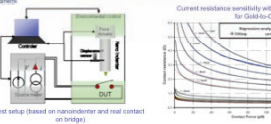
Test vehicles: Capacitive switch (LETI)

Cross section for the capacitive switch



Physics of Failure Component Level

Contact Resistance Test Bench @Novamems



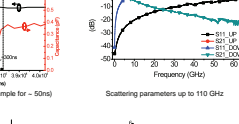
Contact Resistance Test Bench @Gardanne



Reliability platform for lifetime assessment (LAAS)

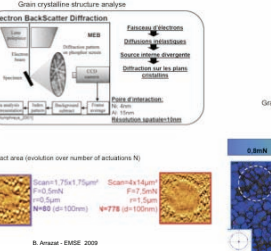


Test vehicles: variable capacitance/switch

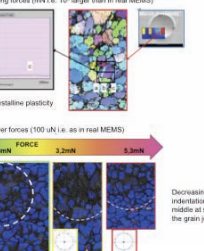


Physics of Failure Material Level

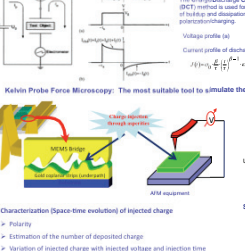
Metal contact wearing analysis by EBSD (EMSE)



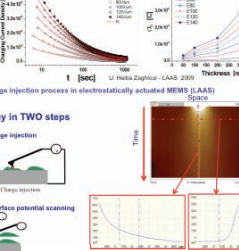
Texture analysis in different area of the contact



Charging - Discharging Transient Currents method for volume charging investigation (LAAS)



Methodology in TWO steps



Conclusions and Perspectives

- PoF associated to failure mechanisms have been studied at material and device level --> NEXT: Acceleration techniques implementation based on space application specifications (by TAS-F)
- Demonstrator (system level) based on the acceleration techniques will be developed in order to validate FAME methodology and approach

