

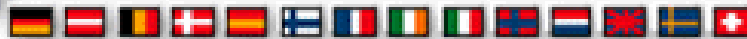
# RF MEMS Switches Built on LTCC

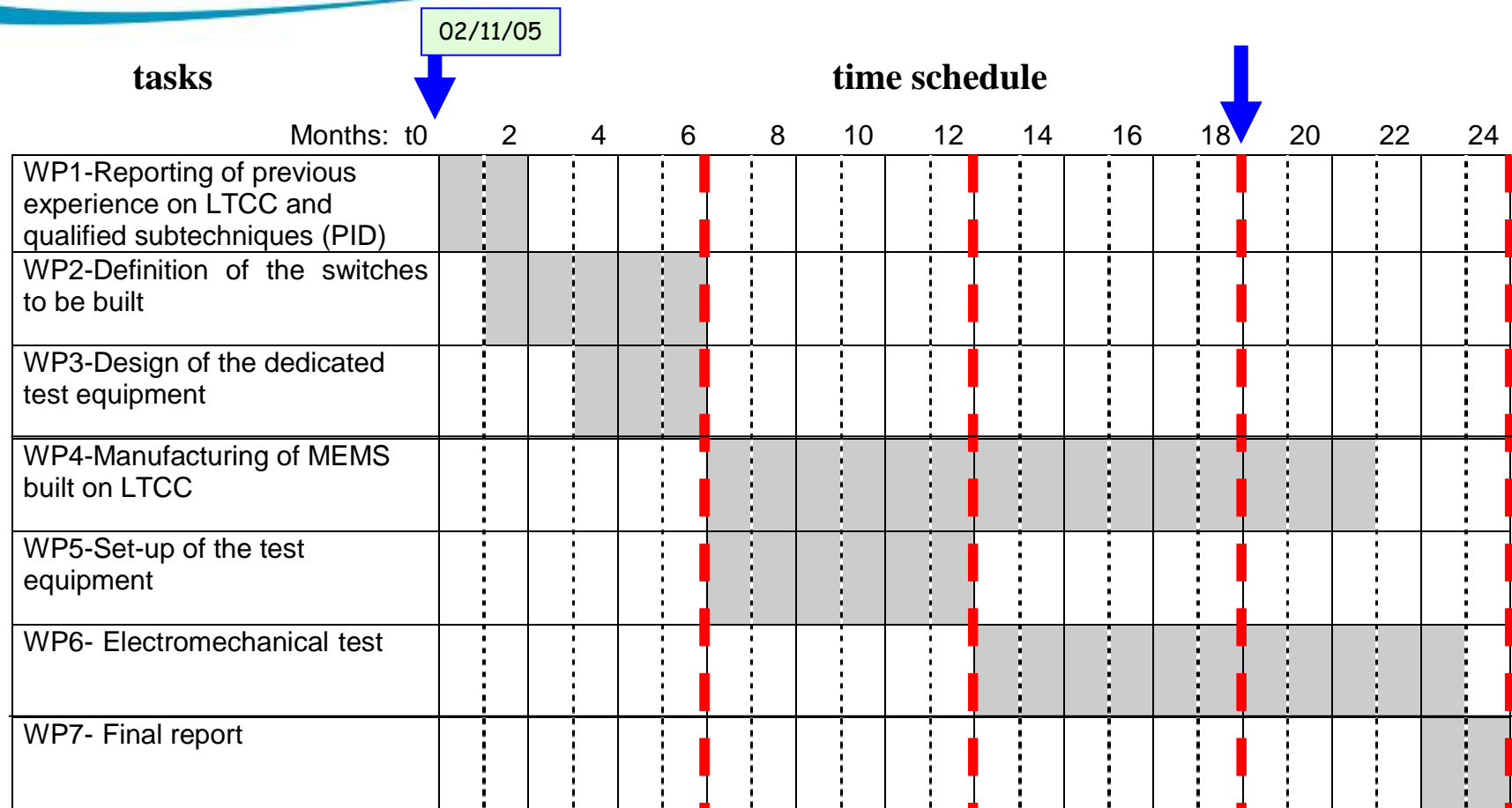
*(DAD 3.10.05; Activity Responsible: S. Di Nardo)*

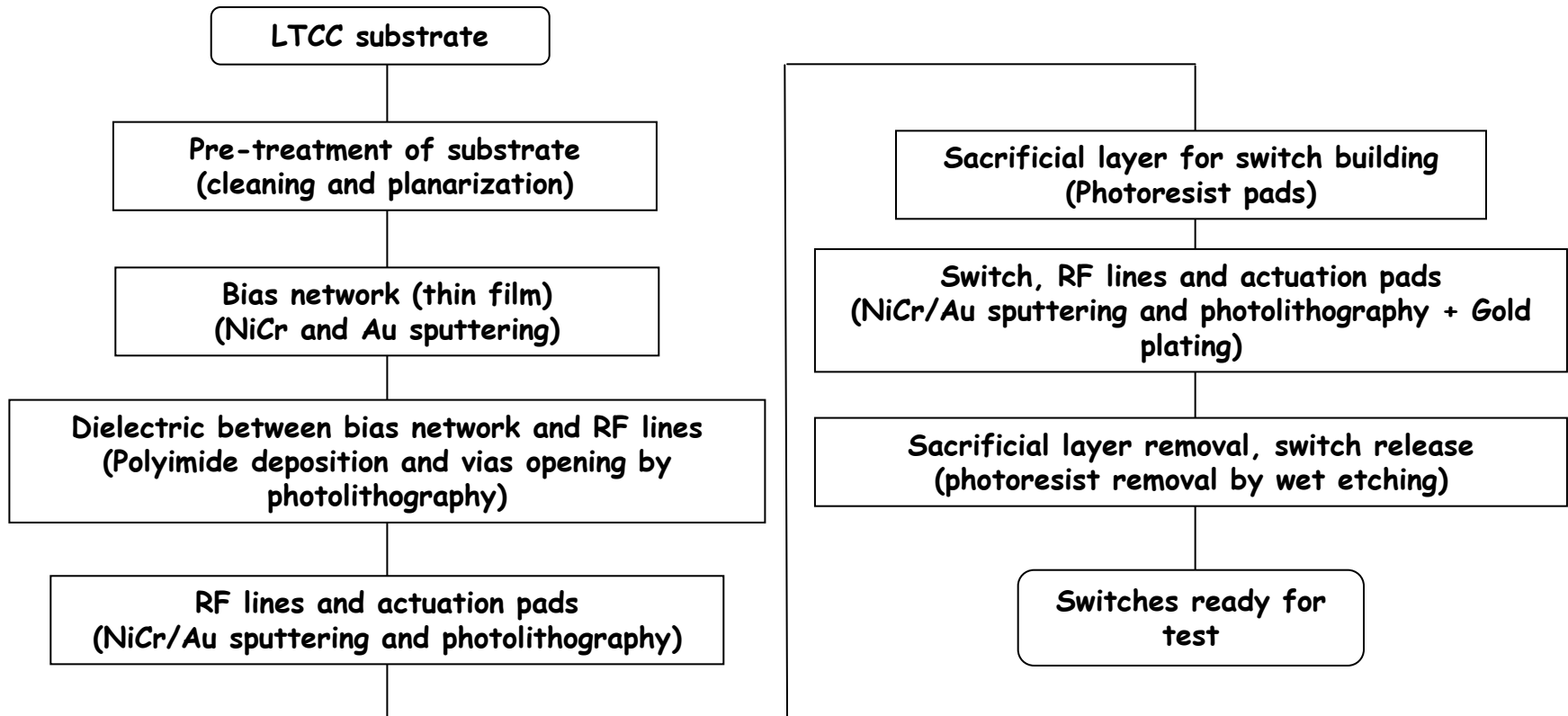
## 4<sup>th</sup> Technical Presentations Day

CTB Working Group on Hybrids, MCMs, interconnection and micropackaging

ESA/ESTEC, Noordwijk, 22 May 2007

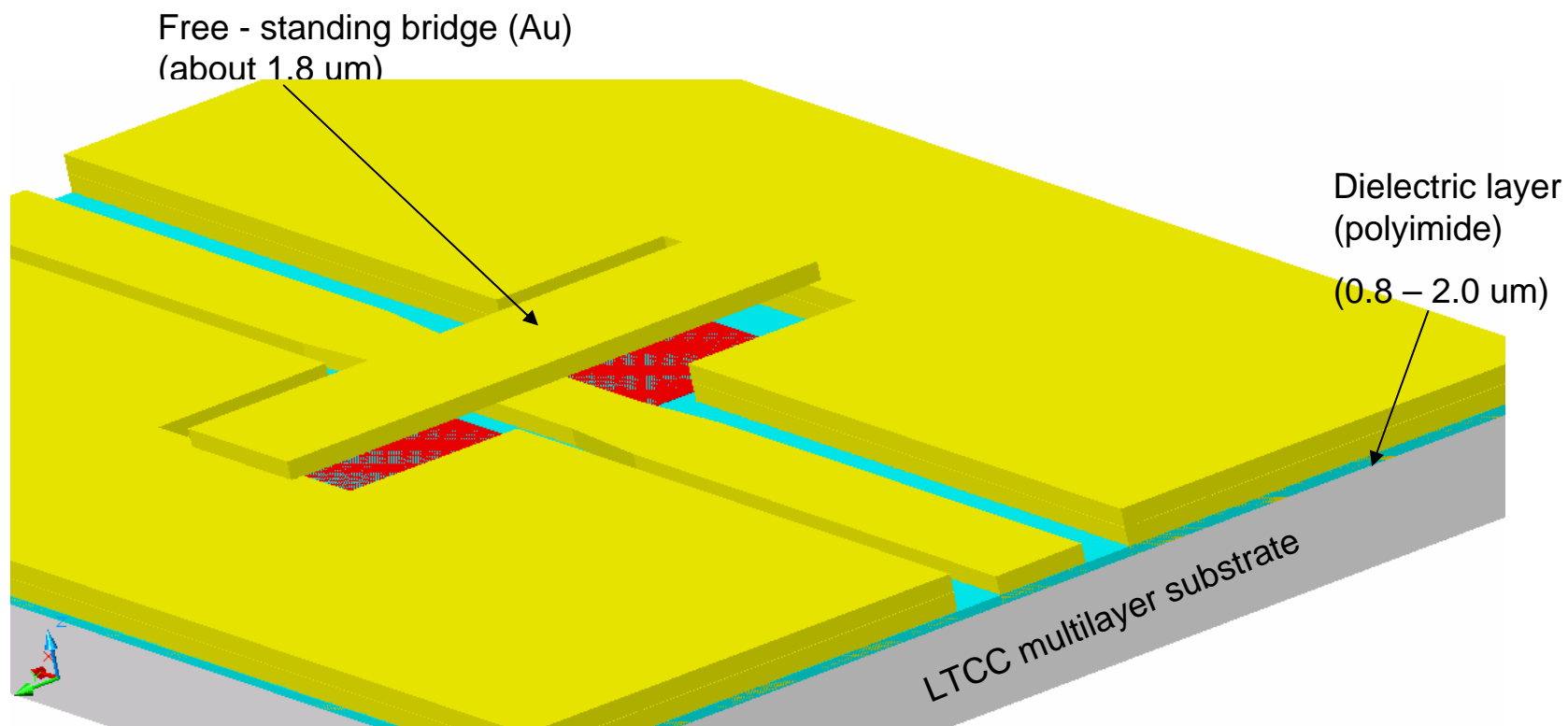






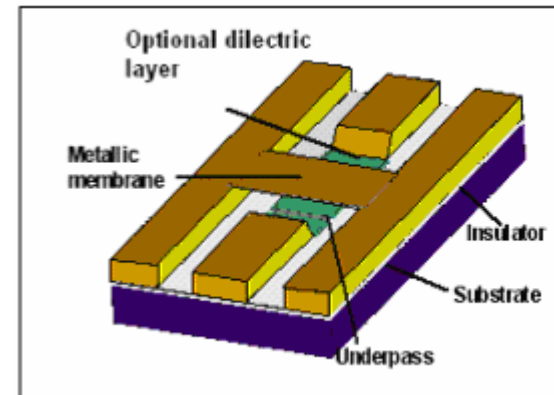
## Manufacturing flow

## MEMS switch design

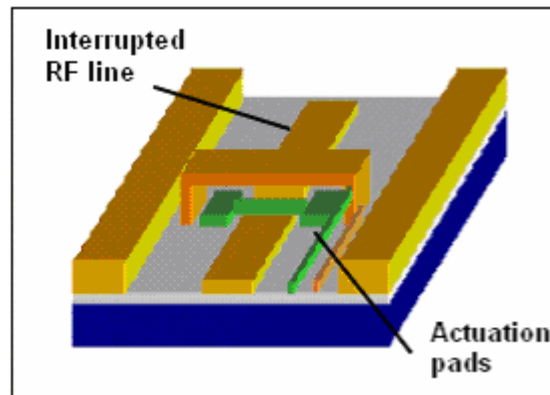


## Switches types developed

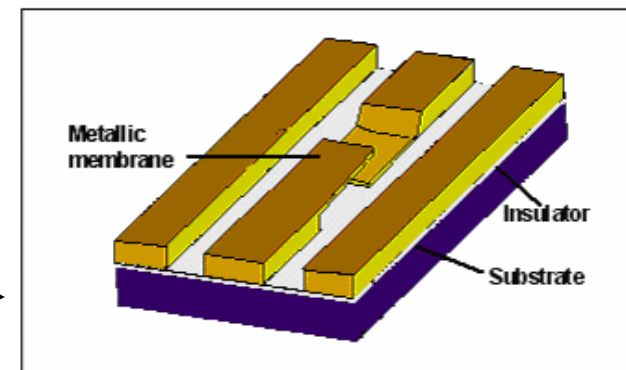
1) Ohmic contact Shunt Bridge



2) Series Bridge



3) Series Cantilever



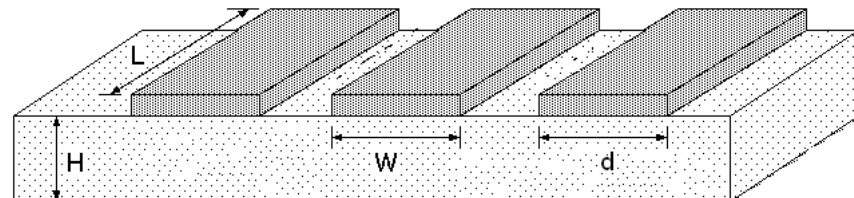
## ACTIVITY STATUS

- ✓ kick-off meeting ESTEC/Contract No. 19135/05/NL/PA: **02/11/2005**
- ✓ WP1 - Reporting of previous experience on LTCC Technology: **completed 02/01/06**
- ✓ WP2 - Definition of the switches to be built: **completed 14/03/06**
- ✓ WP3 - Design of a dedicated test equipment: **completed 14/03/06**
- WP4 - Manufacturing of MEMS built on LTCC: **in progress**
- ✓ WP5 - Set-up of the test equipment: **completed 07/04/06**
- WP6 - Electro mechanical test: **in progress**
- WP7 - Final report

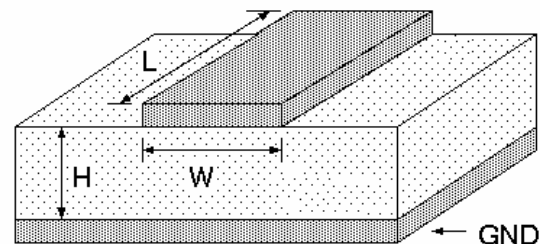
## **WP4** - Manufacturing of MEMS built on LTCC - LAYOUT:

By the RF point of view the MEM Switches have been manufactured on two different waveguides configurations:

- **Coplanar waveguide (CPW)**

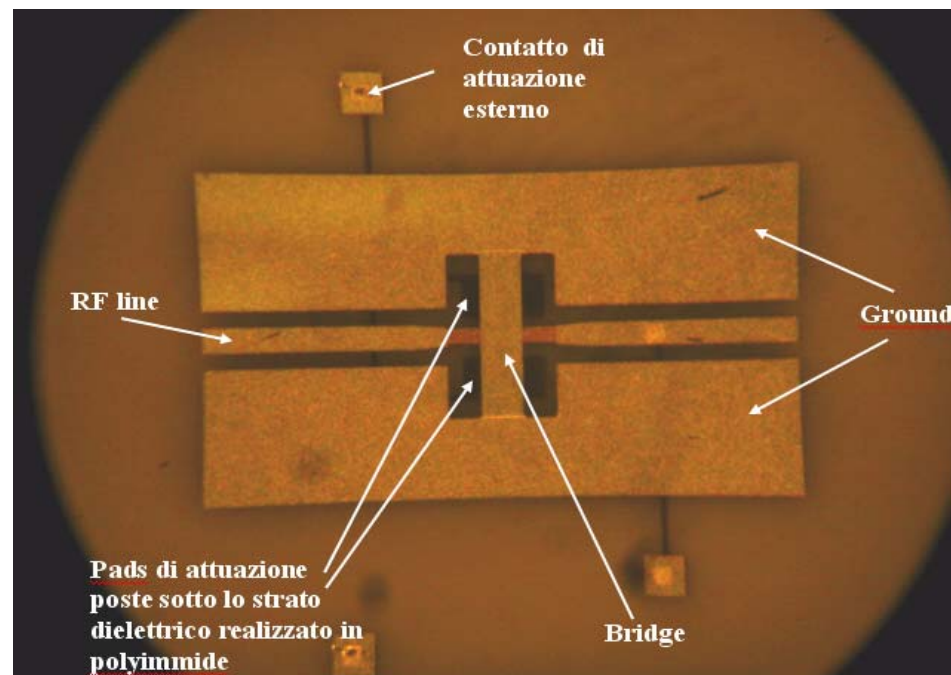


- **Microstrip (MS)**



## WP4 - Manufacturing of MEMS built on LTCC :

**CPW configuration:** the MEMS shown in the picture represented a bridge standing over a RF line of a coplanar waveguide.

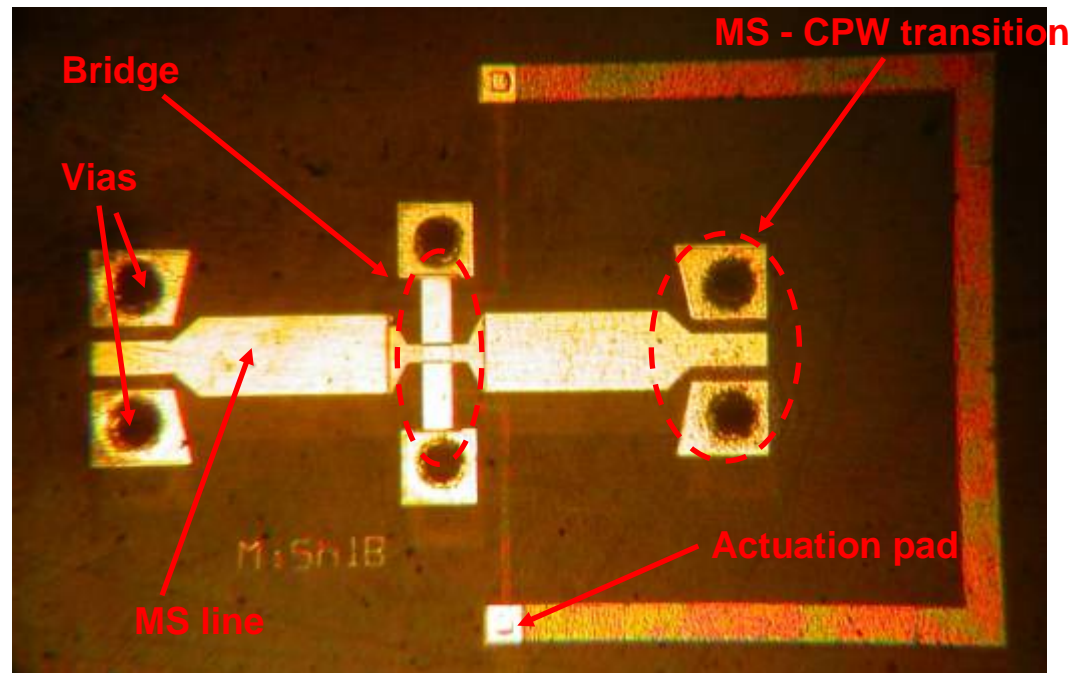
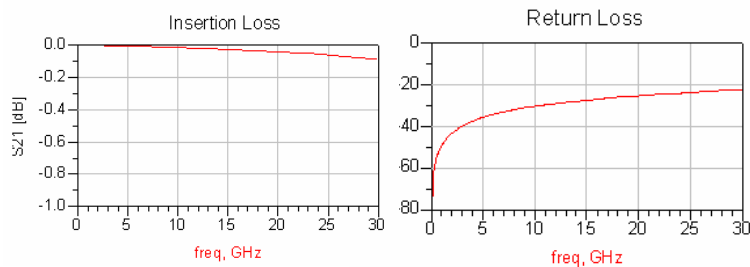




## WP4 - Manufacturing of MEMS built on LTCC :

**MS configuration:** the MEMS shown in the picture represented a bridge standing over a MS line in shunt configuration. CPW/MS transitions have been introduced in order to allow for on-wafer probe measurement.

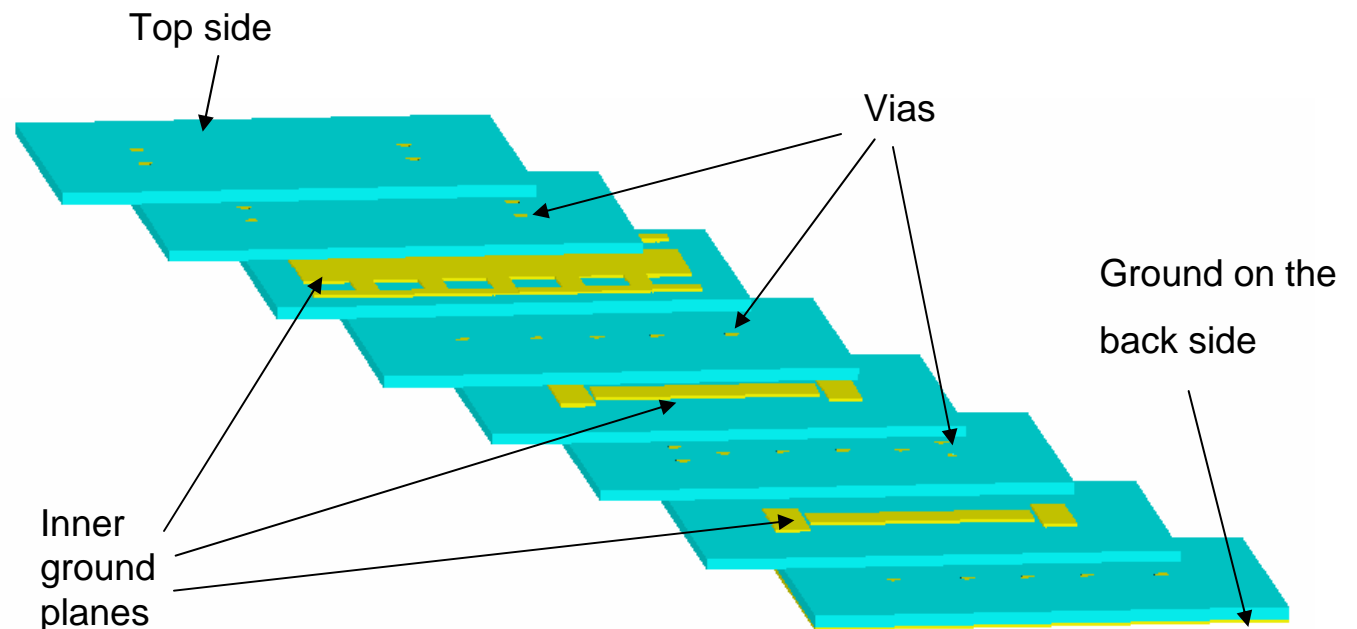
### RF simulation of MS-CPW transition:



## WP4 - Manufacturing of MEMS built on LTCC - LAYOUT:

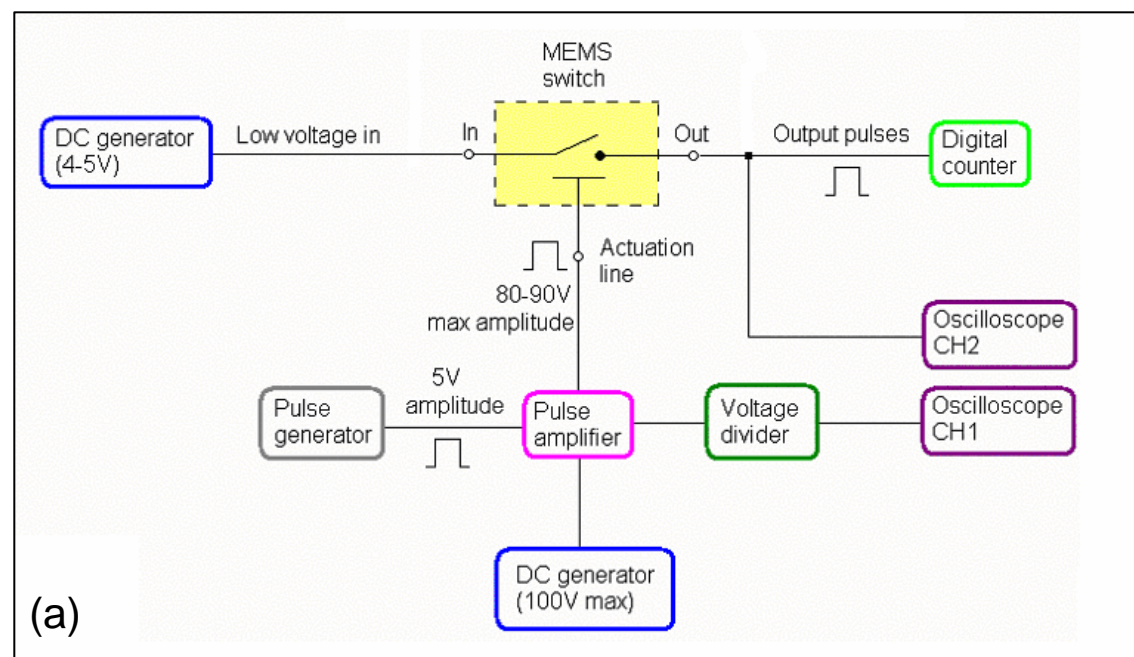
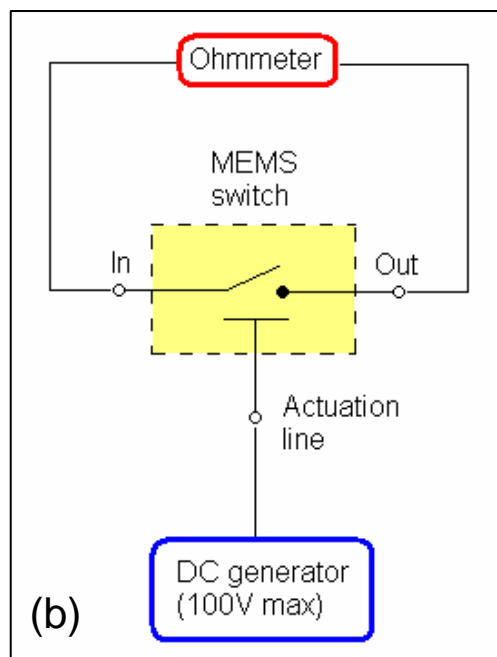
The MS configuration has been developed on eight layers :

For the microstrip design it has been necessary to place a ground plane at the dept of 274  $\mu\text{m}$  (between the second and third LTCC layer) and the patterned via holes are used to connect the metal on the surface with the buried ground plane.

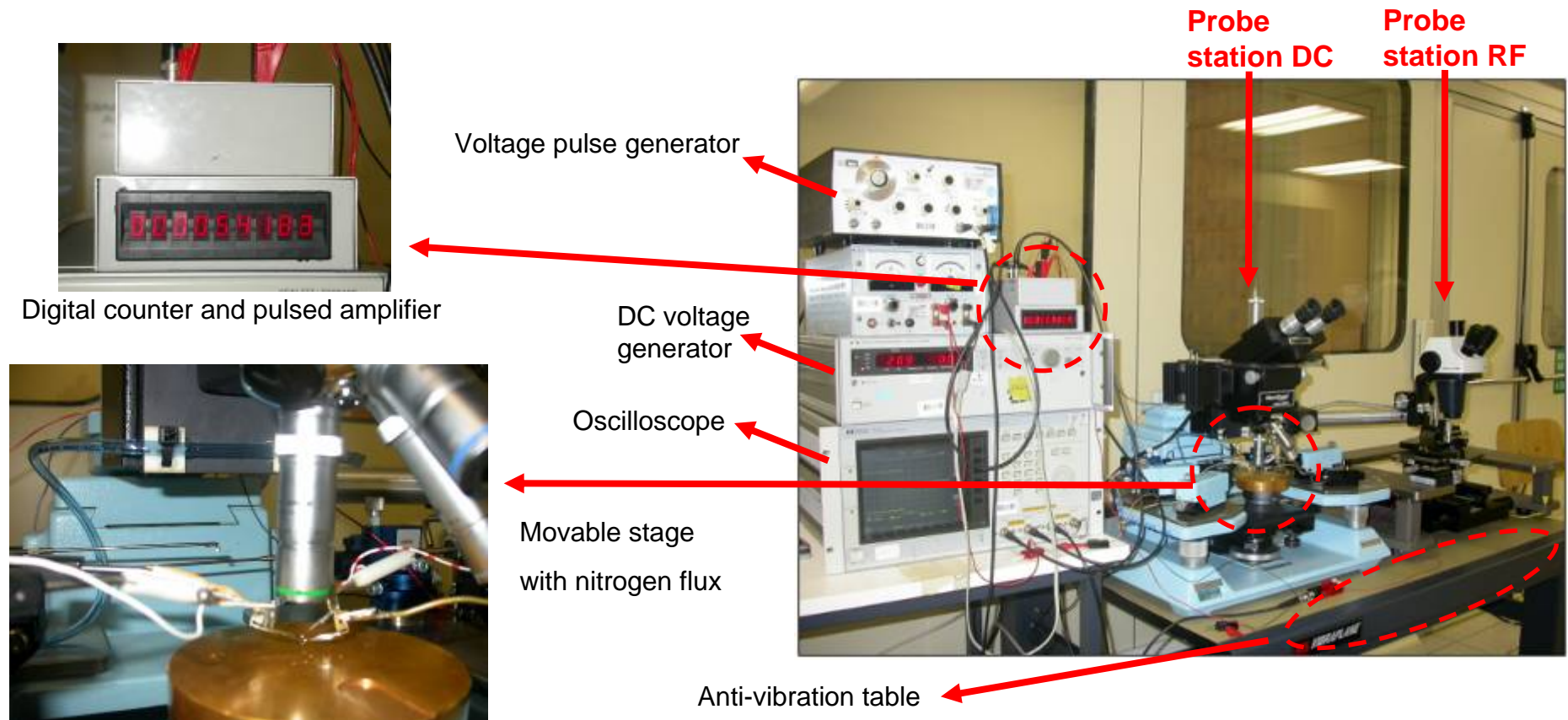


## WP3 – Design of a dedicated test equipment (DC measurements)

Set-up of static (b) and dynamic (a) tests:



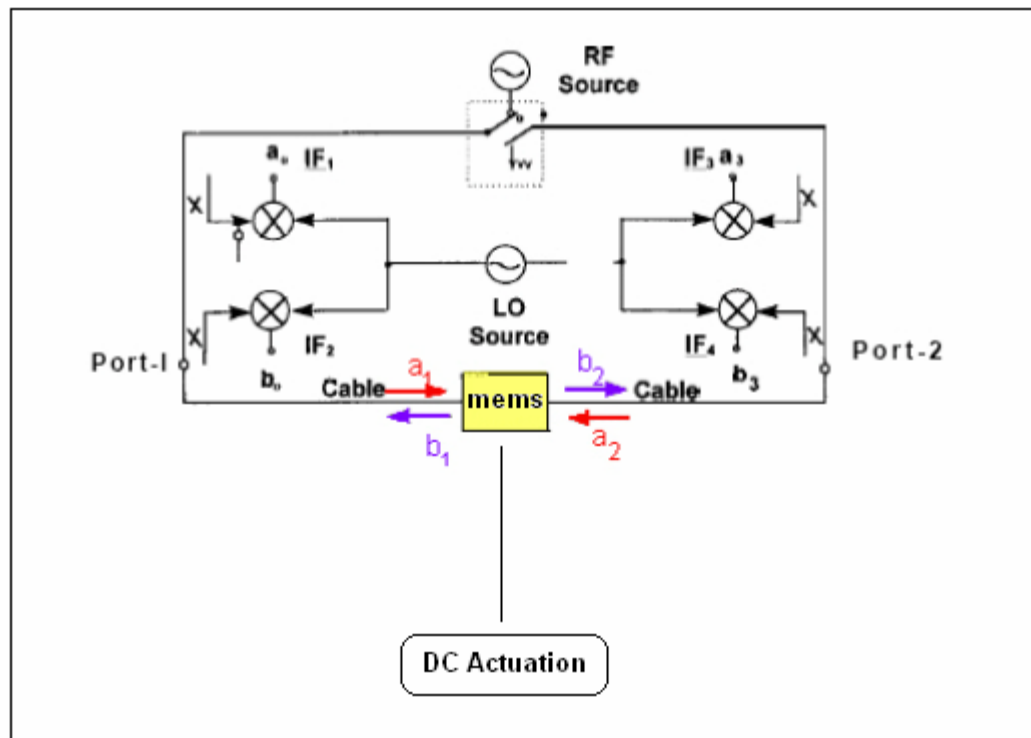
## WP5 – Set-up of the test equipment – DC Electromechanical test



### WP3 – Design of a dedicated test equipment (RF measurements)

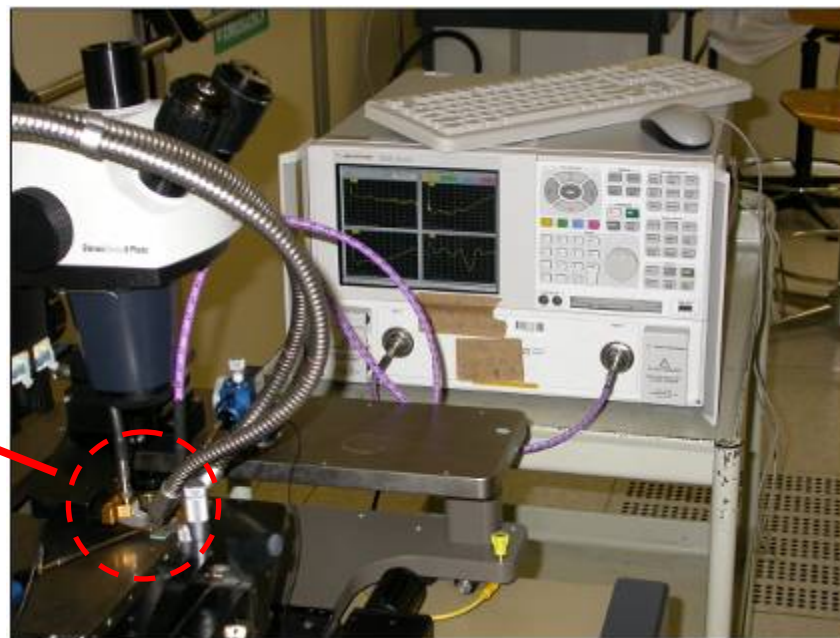
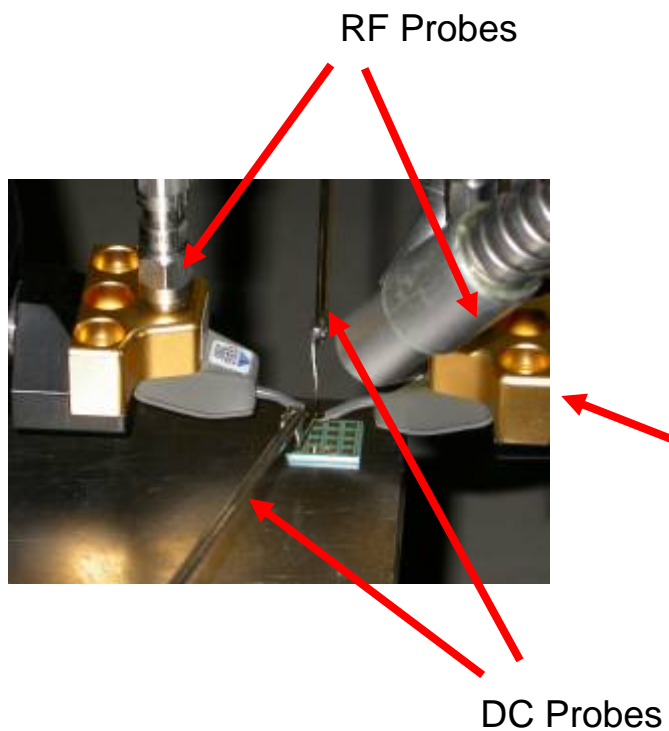
Frequency range of the spectrum analyzer: up to 50GHz

Measurements performed up to 30GHz.



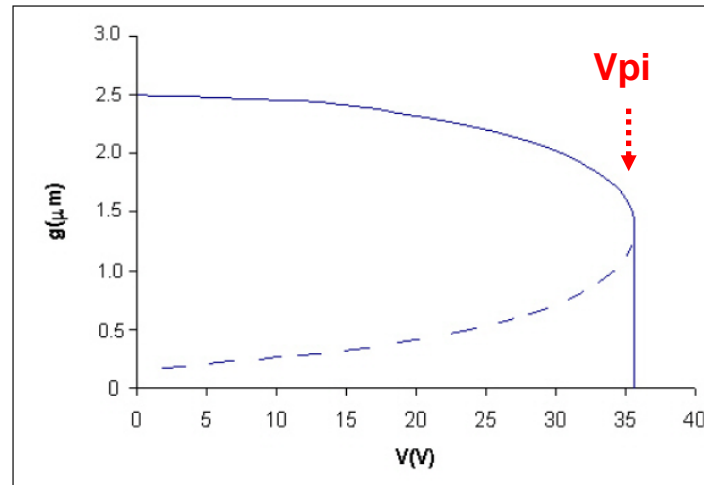
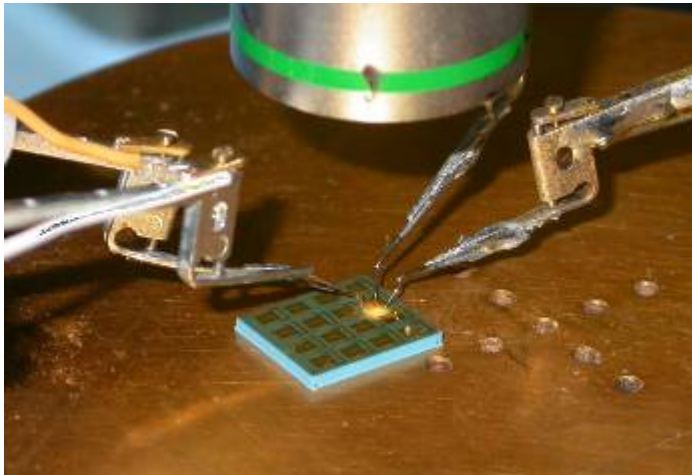


## WP5 – Set-up of the test equipment – RF Electromagnetic test



## WP6 – Electromechanical test

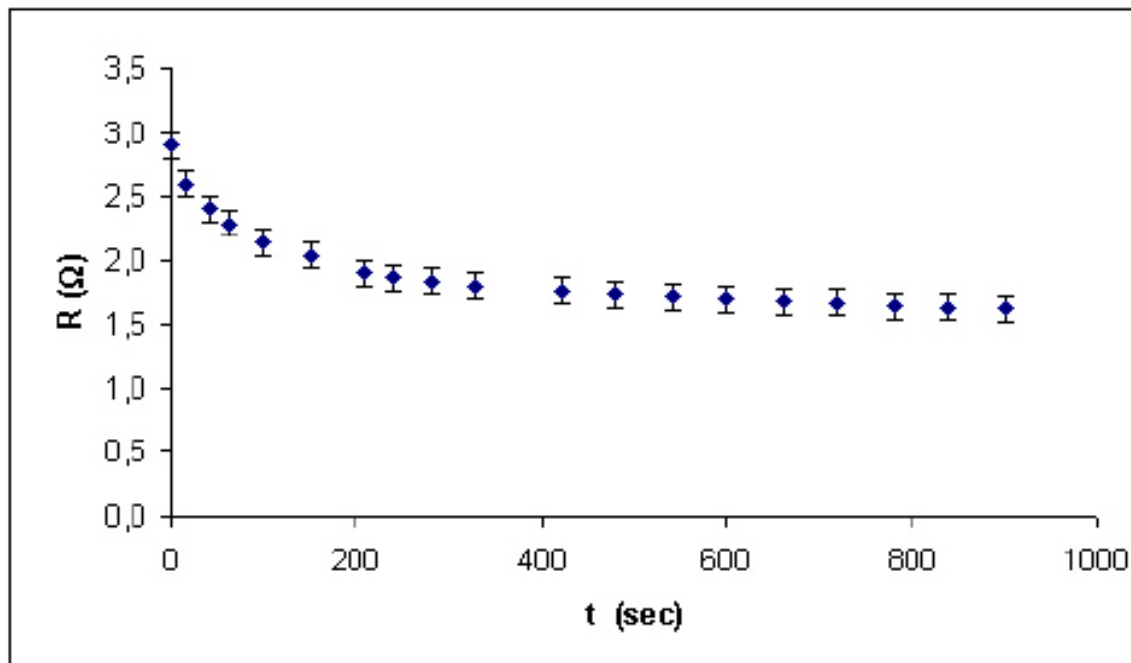
**Pull-in voltage definition  
and measurement:**



- Pull-in voltage in the range 20V – 50V (depending of geometry).
- Contact resistance (gold-gold): 0.2-50hm (TBV)
- No variation of contact resistance have been detected over  $10^5$  actuation cycles

## WP6 – Electromechanical test

Static characterization: results after prolonged actuation time:



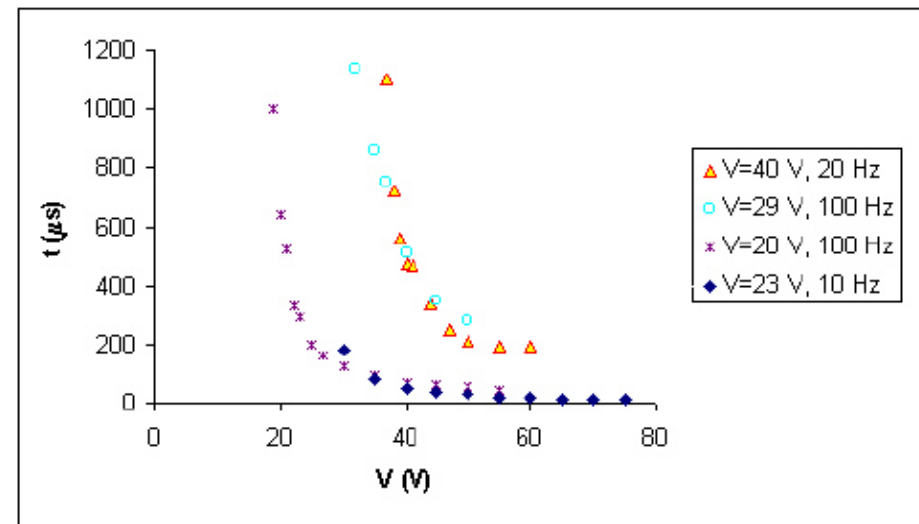
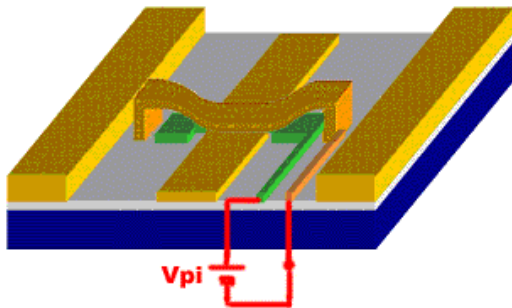
The reduction of the resistance can be explained by an ageing effect



## WP6 – Electromechanical test - Dynamic characterization.

The switches have been actuated and de-actuated in a dynamic manner: different behaviors have been detected:

1) The switch follows the pulsed waveform with good behavior: actuation time vs applied voltage are reported below for different devices:

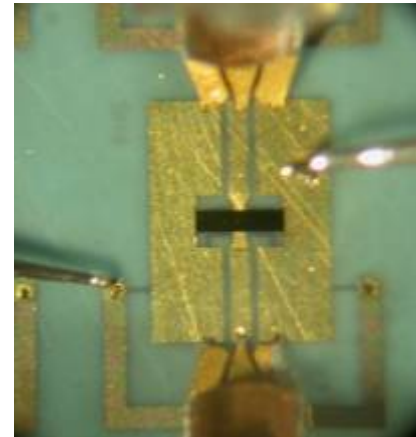


2) The switch doesn't follow the pulsed waveform. Cause under investigation.

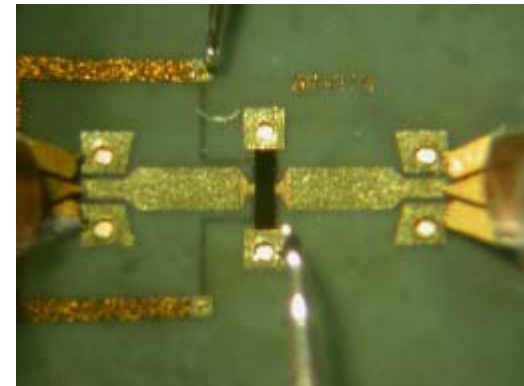
## **WP6** – Electromagnetic test

**Different configurations are under test:**

- 1. Shunt switches on CPW**
- 2. Shunt switches on MS**
- 3. Series switches on CPW**



Shunt on CPW



Shunt on MS

## Conclusions

- A manufacturing process for MEMS switches on LTCC has been set-up.
- Preliminary electromechanical and electromagnetic tests have shown a fairly good behavior and encouraging results for future developments.
- Pull-in voltage of the manufactured devices are in the range 20-50V.
- Electro mechanical test have to be concluded (milestone 02/10/07)