An All-Metal Large Contact Force RF-MEMS Relay for Space Applications

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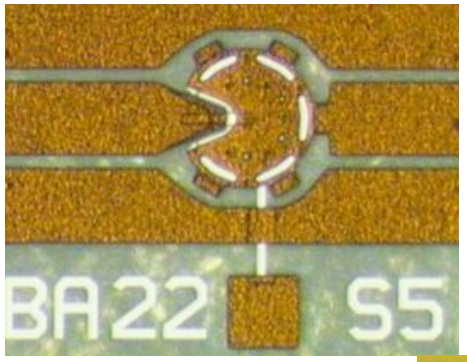
RF - MEMS

- Consumer Electronics (Cell Phones) applications are here
- High power (~few Watts), High Q (>200 @ 2GHz) digital-like variable capacitors are currently integrated into cell phones
- « All-in one chip » approach has been successful
- Reliability is still critical, but a few commercial products are getting to very good levels
- Key reliability issues like dielectric charging, contact ageing are beginning to be better understood.
- Available components are ohmic switches and switched capacitor banks

XLIM Developments

- Ohmic Switch



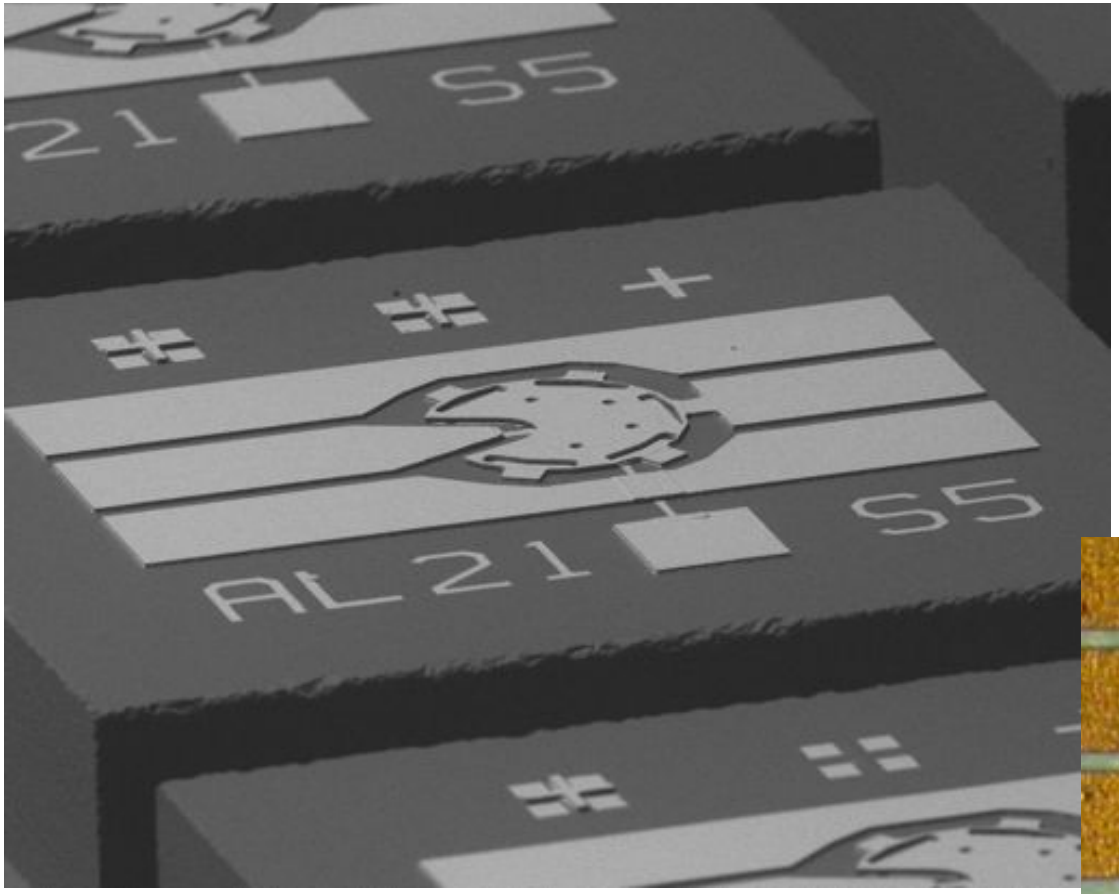
- Switched Capacitor
  - On/off is 5-8

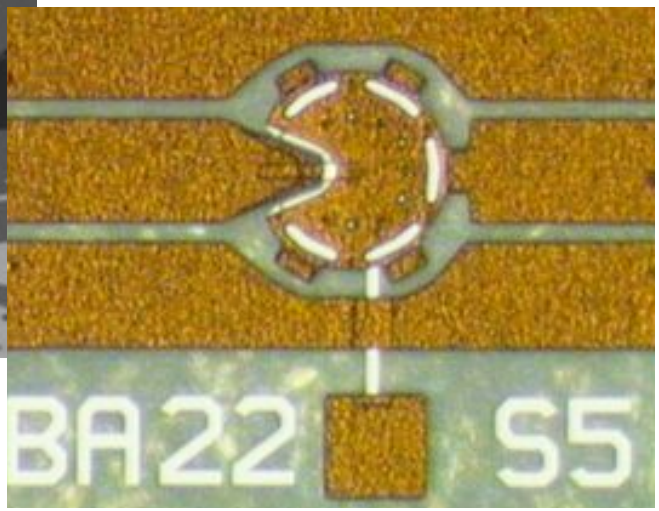
- Long time cooperation with Thales Alenia Space in Toulouse
- >> 200 parts delivered to TAS in 2012

Reliability - Physics of Failure

- Dielectric Charging: Charge retention inside the dielectric layers of the actuator
- Actuator design: crucial in Ohmic RF-MEMS switches
- Contact metallurgy
- Creep: Thin film metals suffer from mechanical creep. This is causing actuation voltage shifting.

SEM View of XLIM Relay





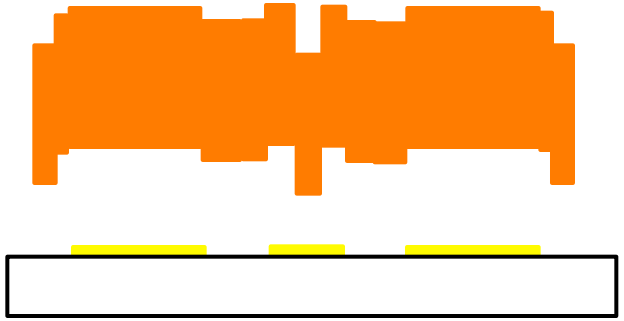
Process Switch Ohmique 2012

1 - Métal 1

2 – Sacri 1 (dimple)

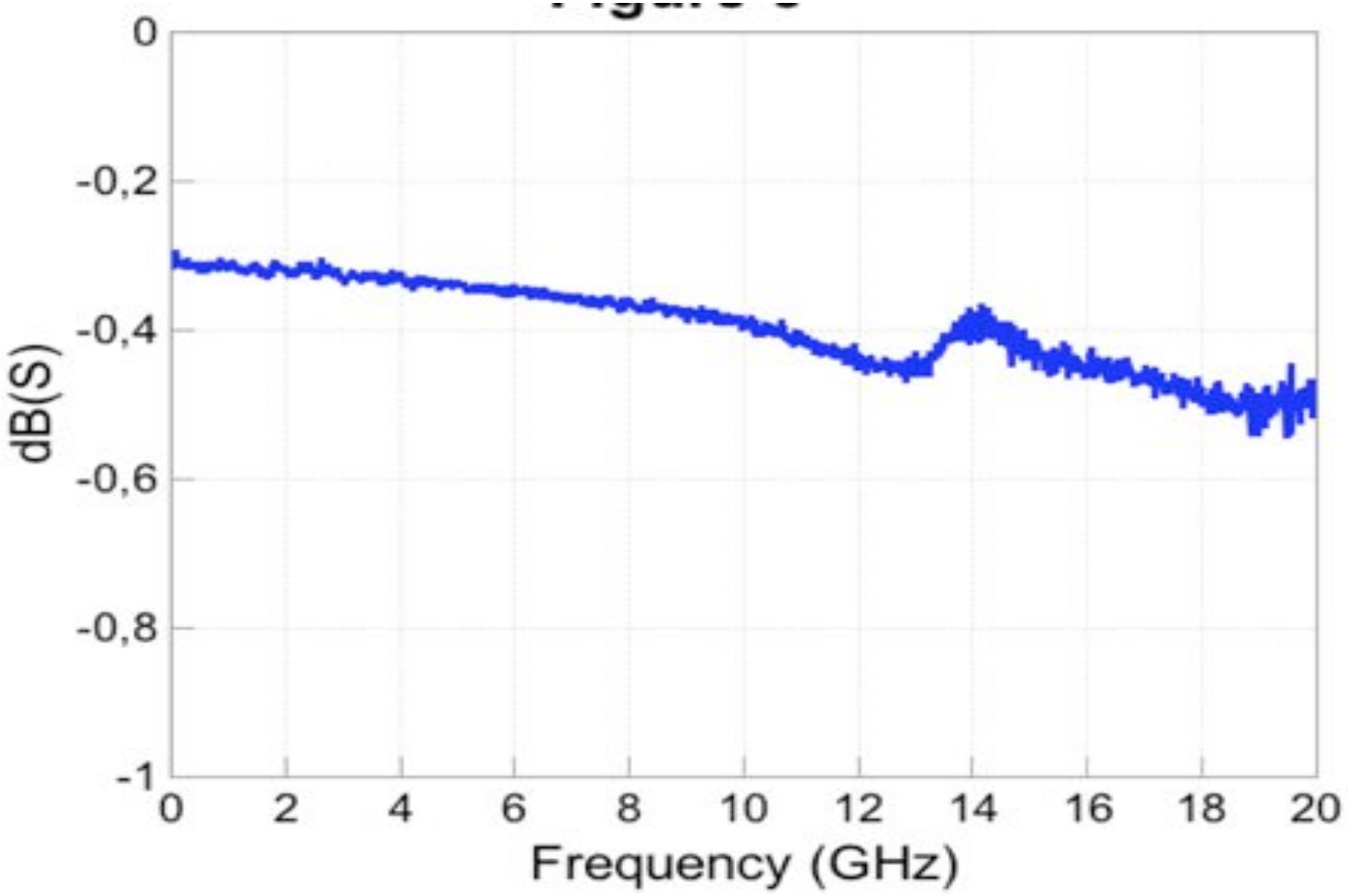
3 – Sacri 2

4 – Metal2 – Ti/Au/Au/Ti



5 – Release

S Parameters



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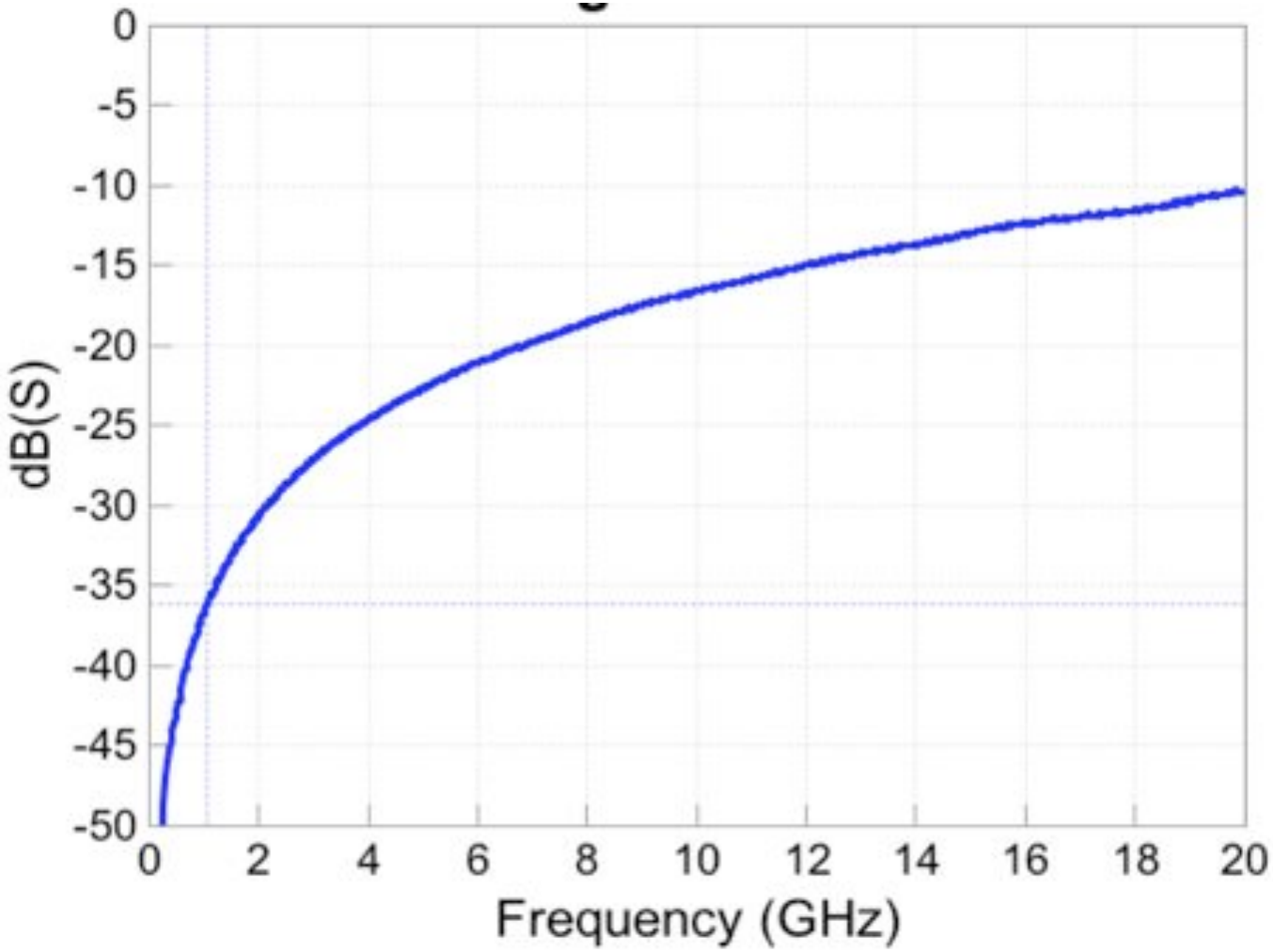
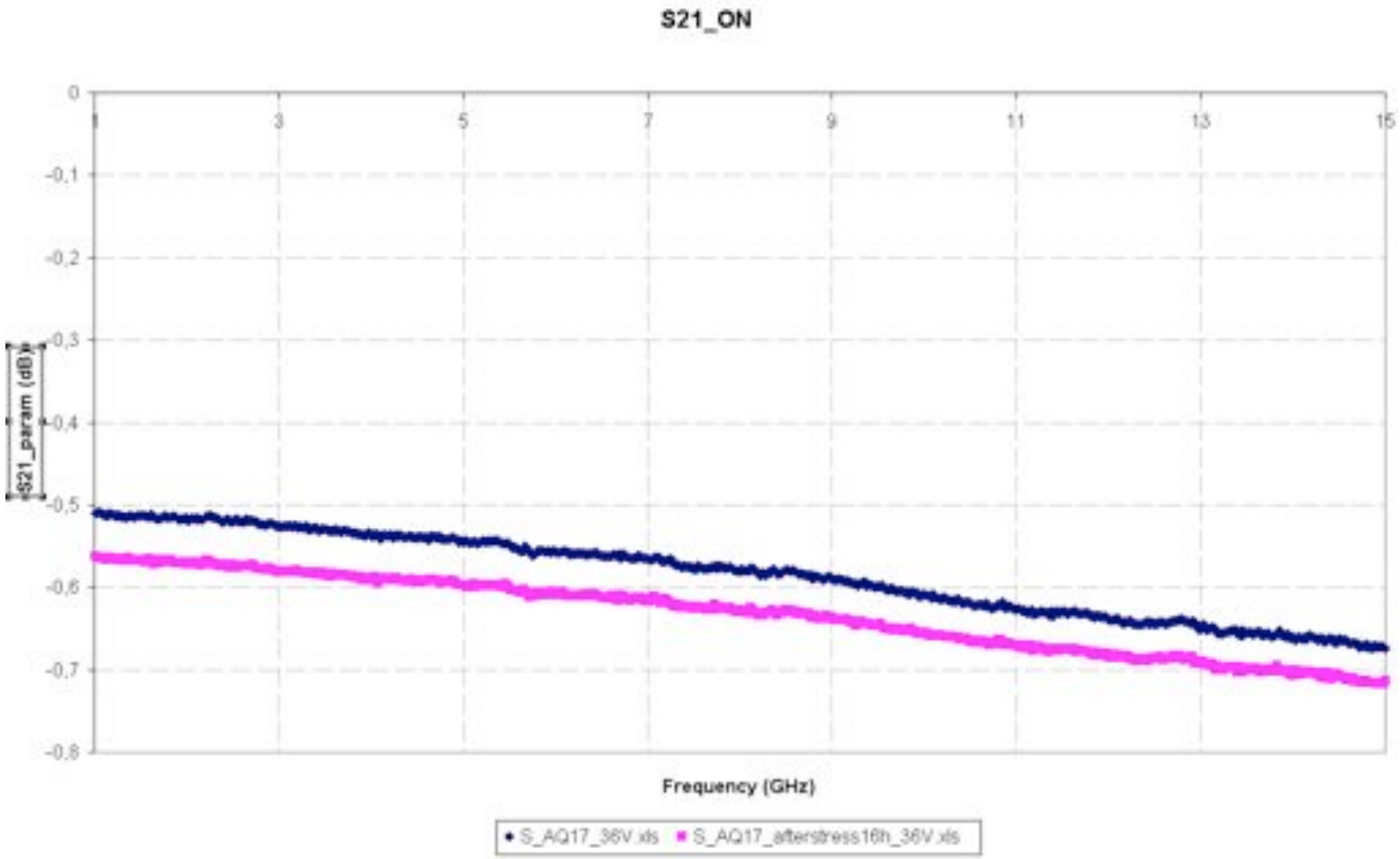


Testings done at Thales Alenia Space Toulouse



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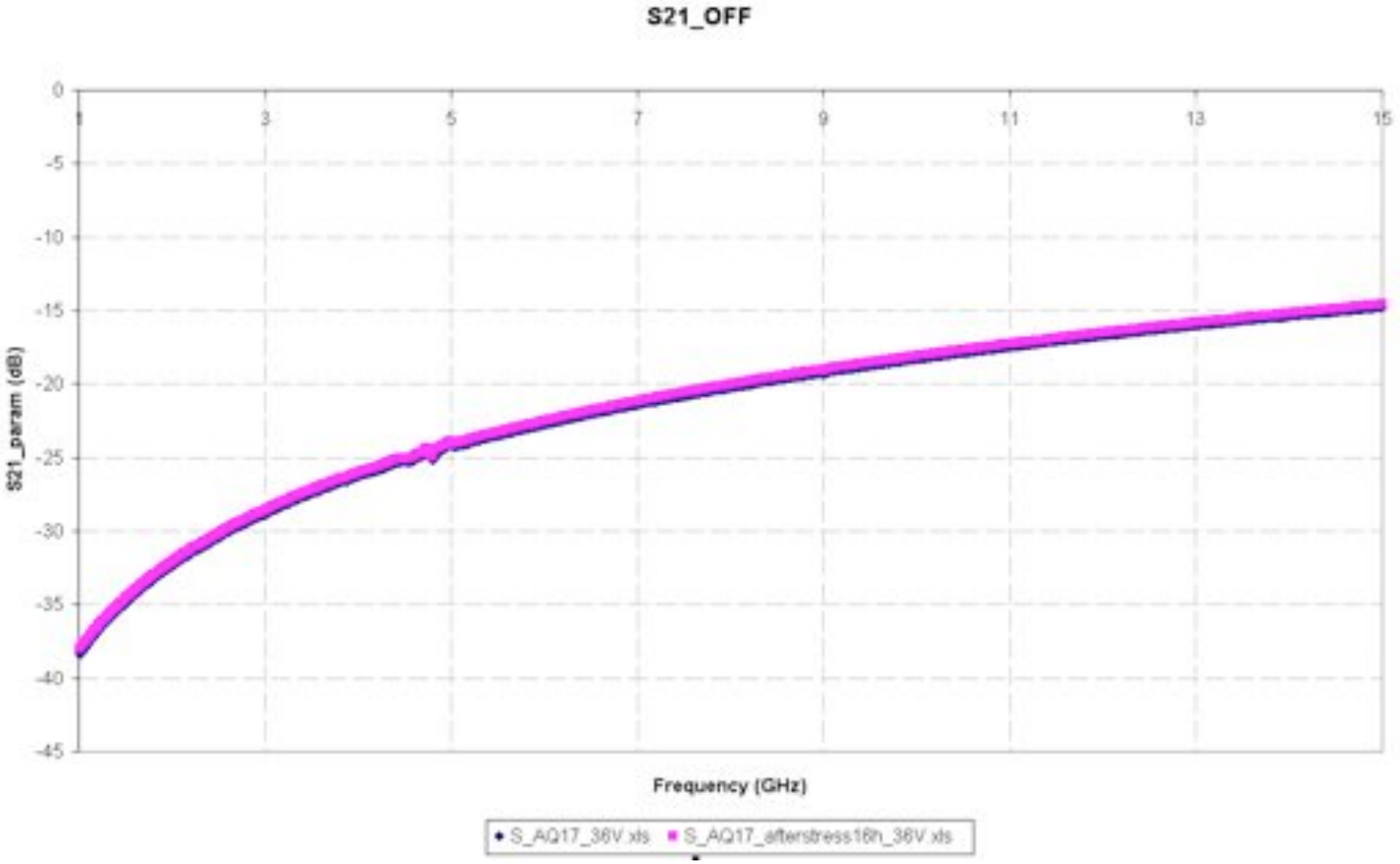

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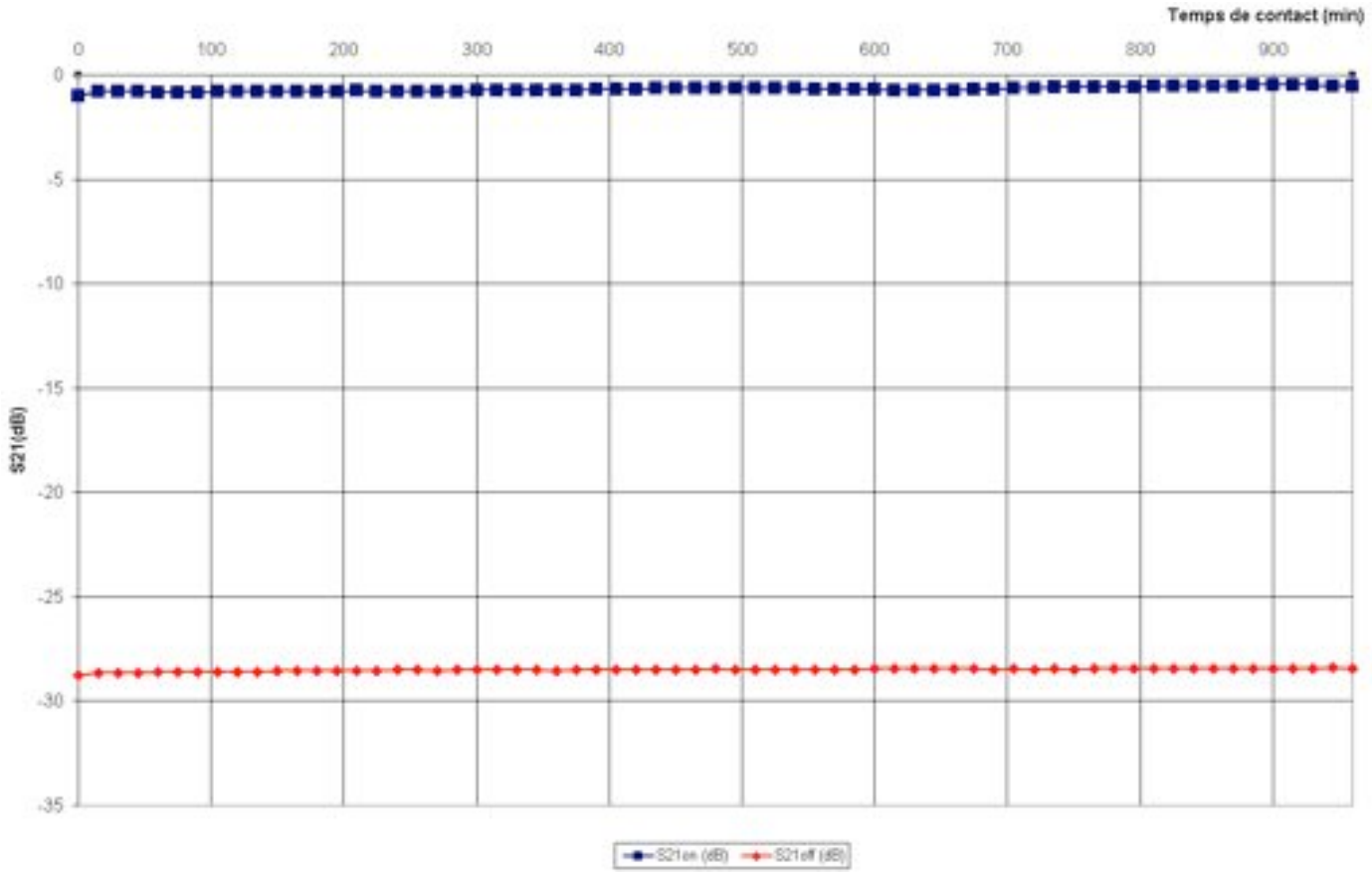
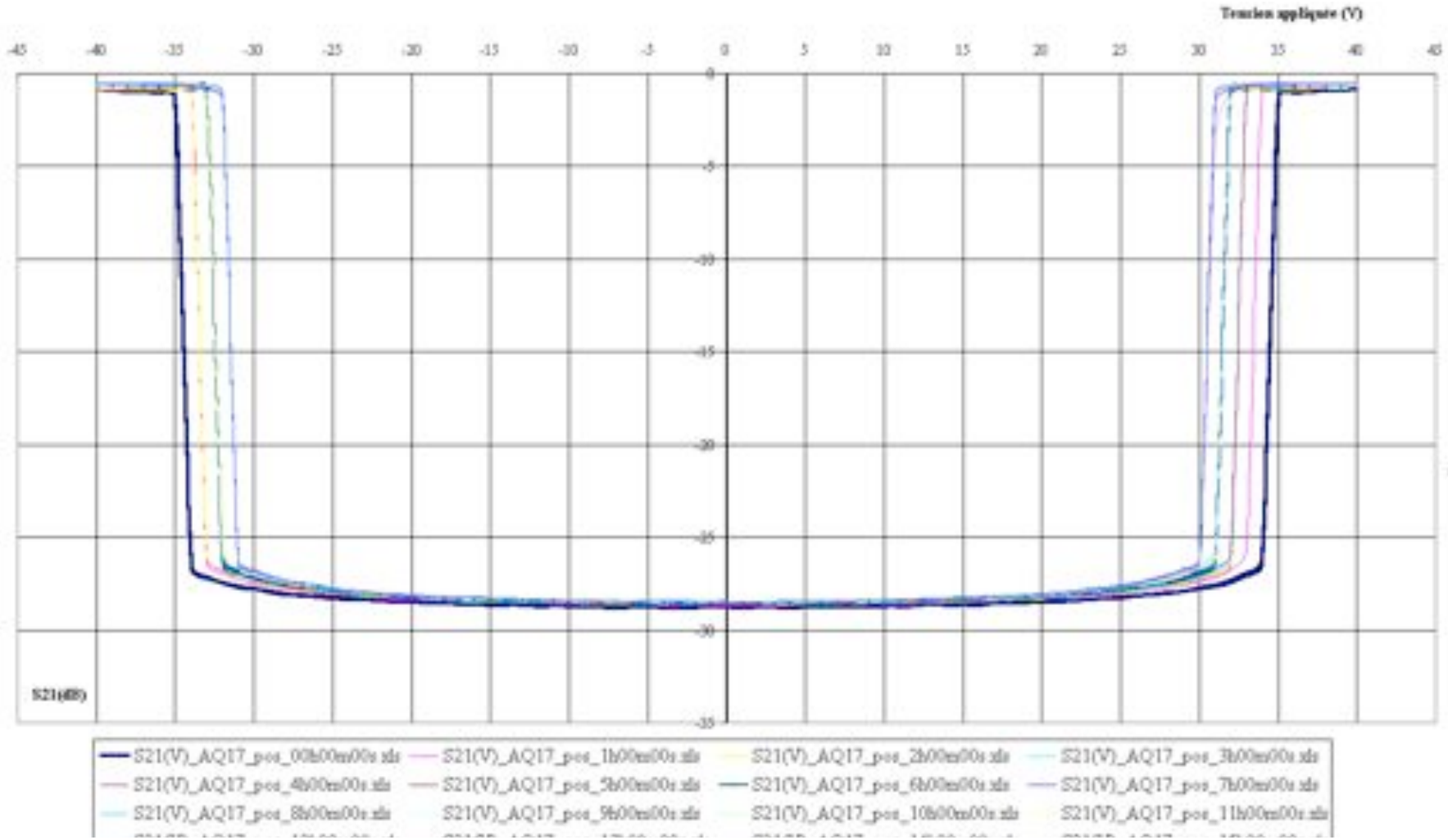


Hold-down Testings
Thales Alenia Space



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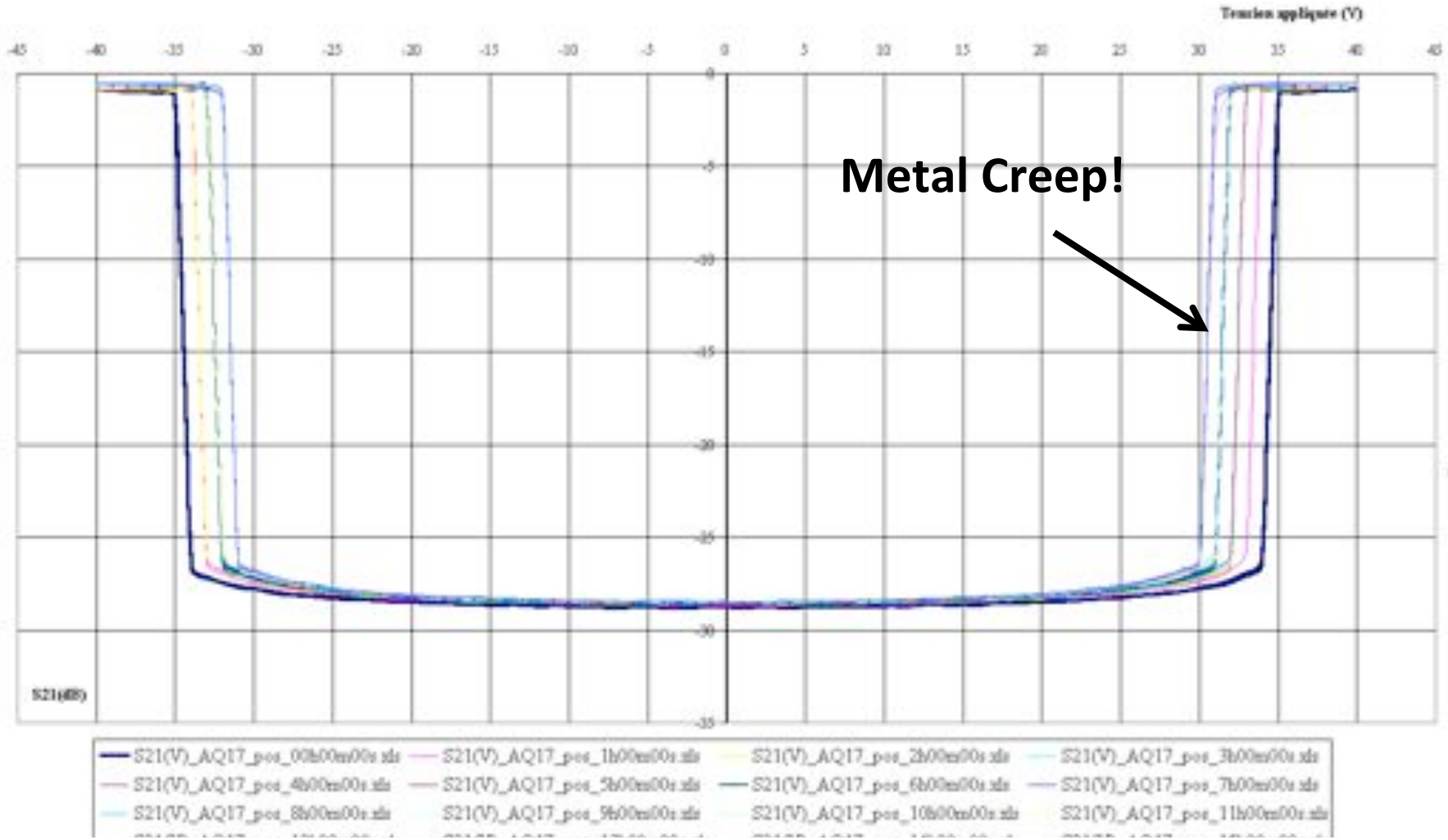
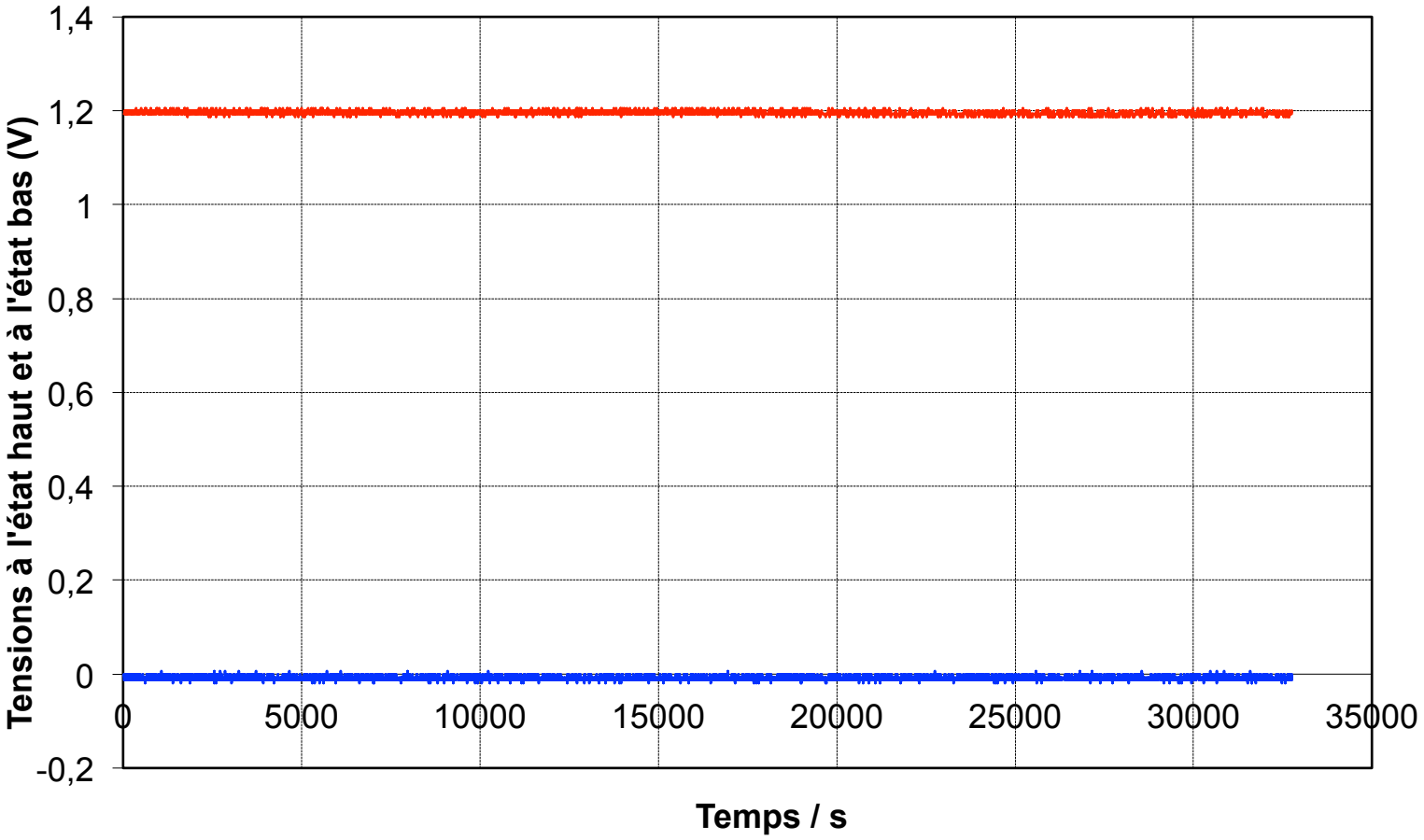


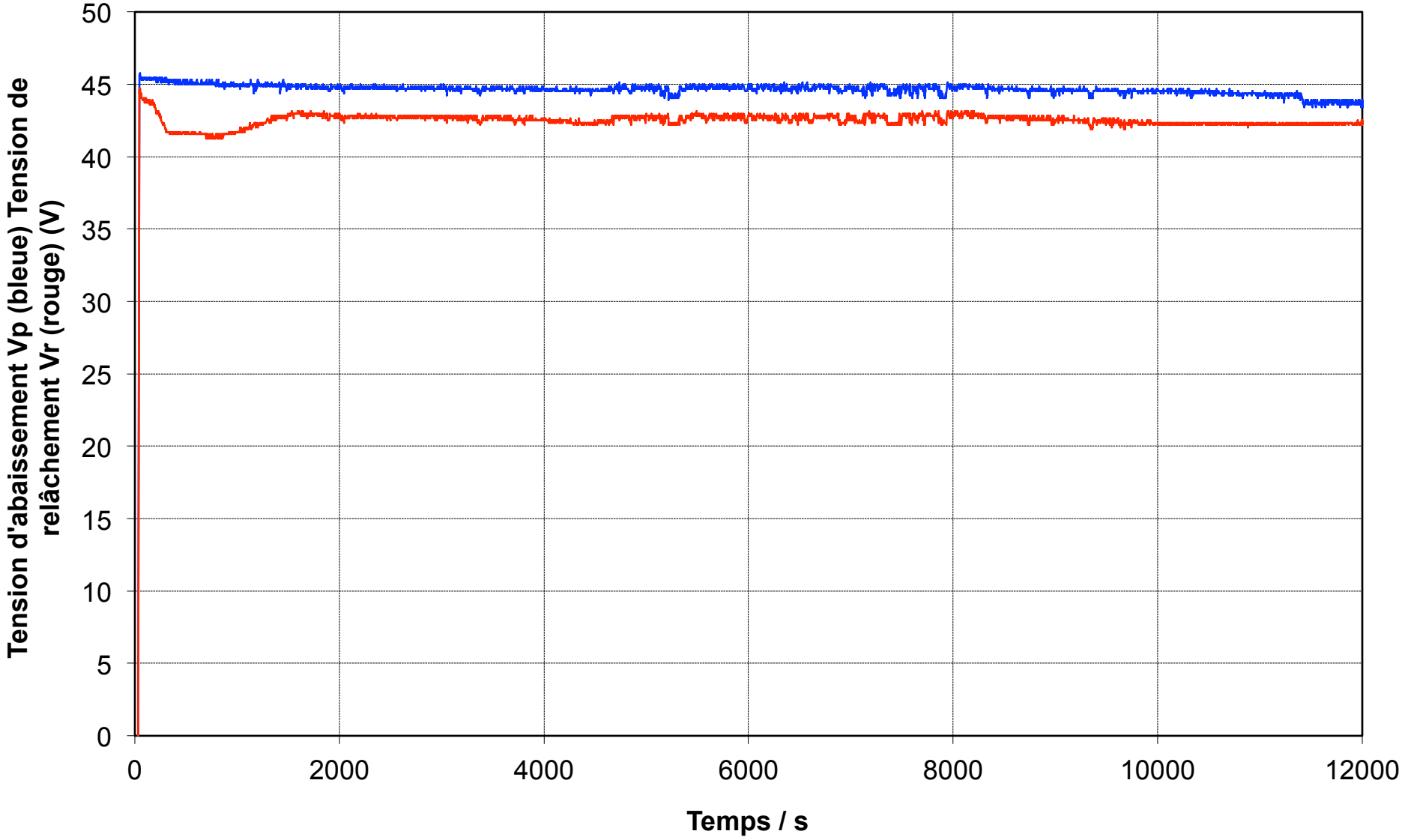
Cold Switching 26dBm @ 1GHz

AT29P9



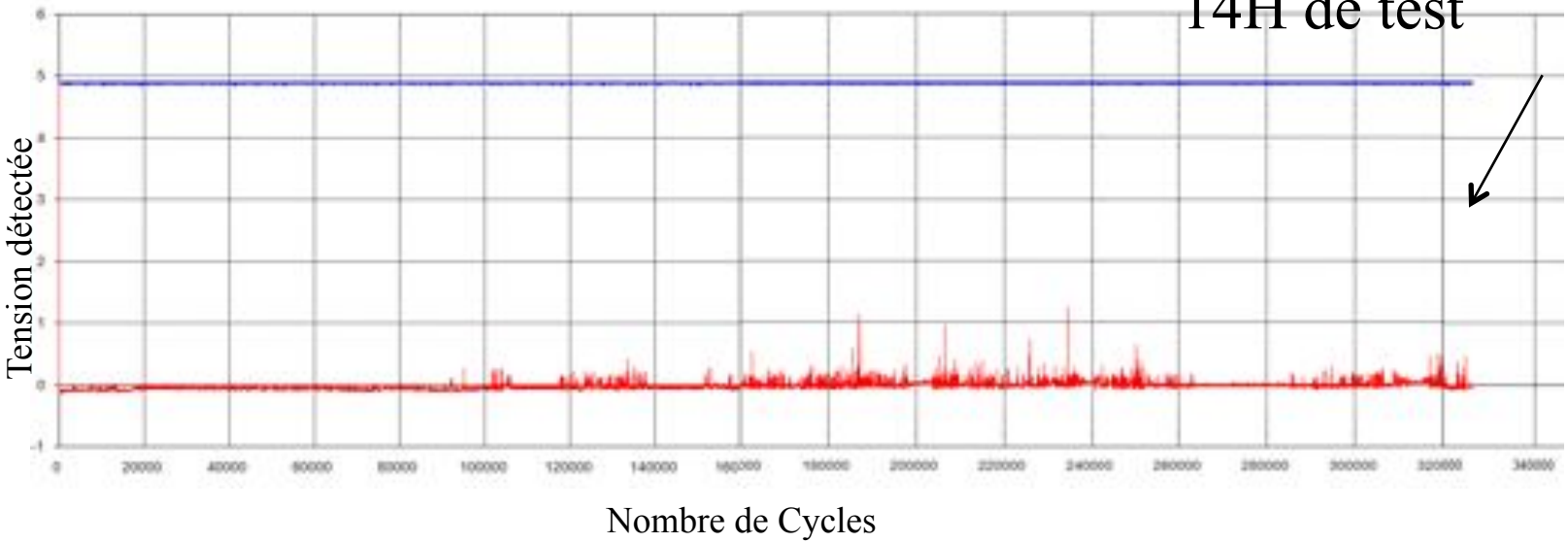
Fréquence de cyclage 2,5 kHz, tension de polarisation 50V, test stoppé à 82 millions de cycles

3 hours hold-down



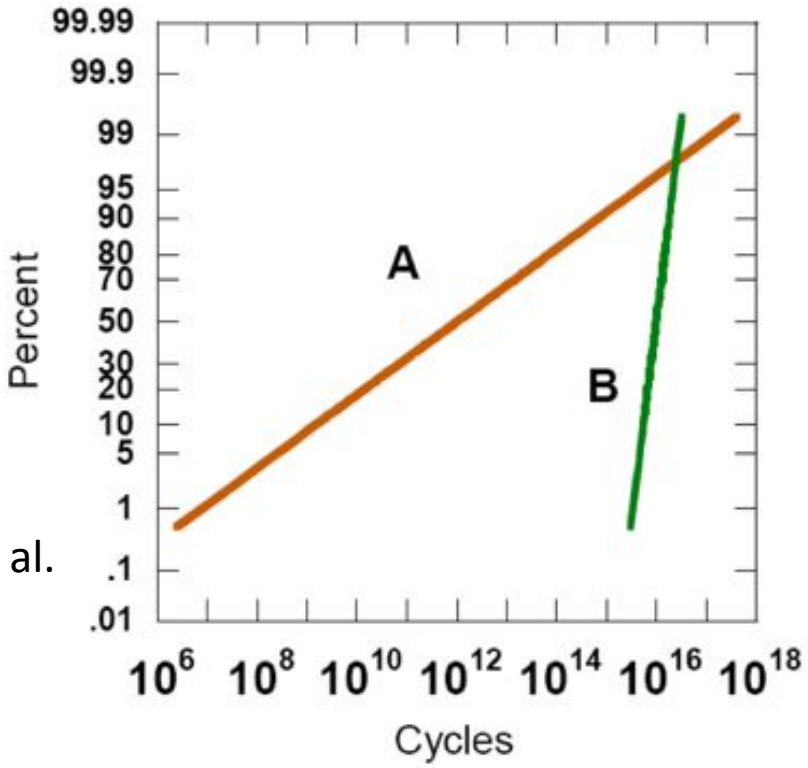
Cold switching with High Input-Output Voltage DC (5V)

136 Millions de Cycles
14H de test



Quality

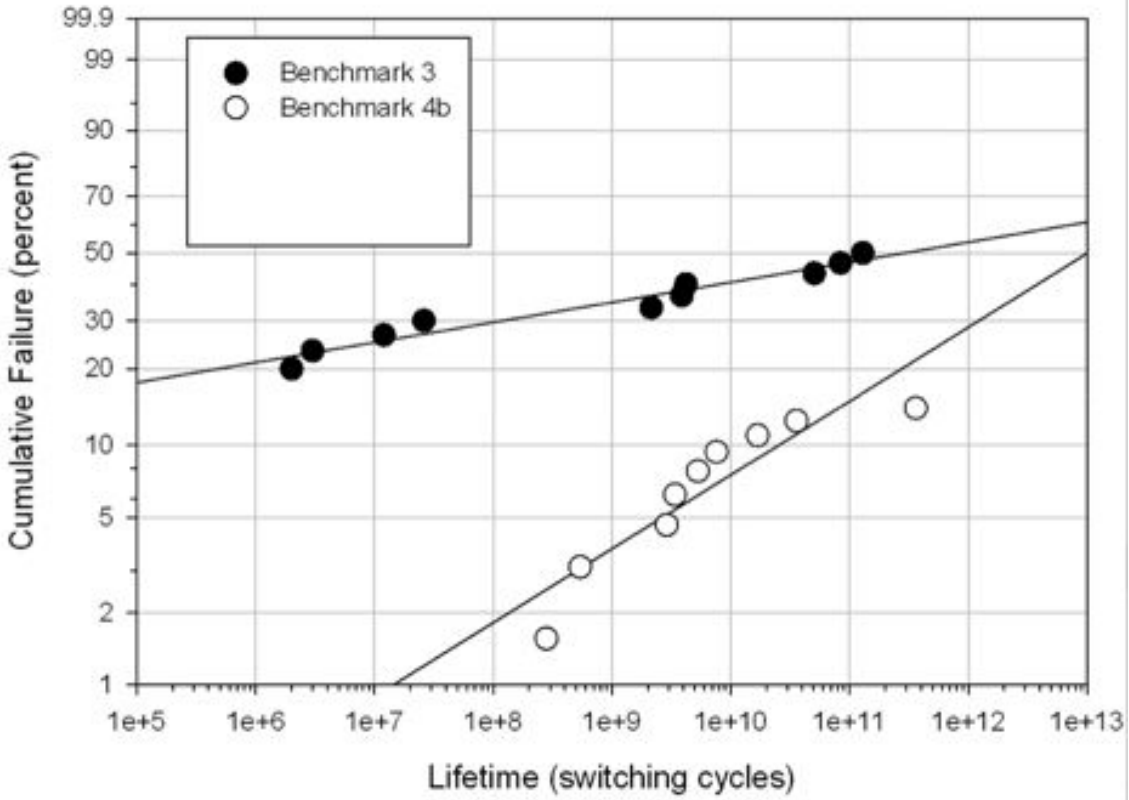
- How good is my process?
- How can I guarantee that my switch(es) will actually work for X cycles?
- MEMS switches are slow
- Reaching failure may take up to several months



After D. Peroulis et al.

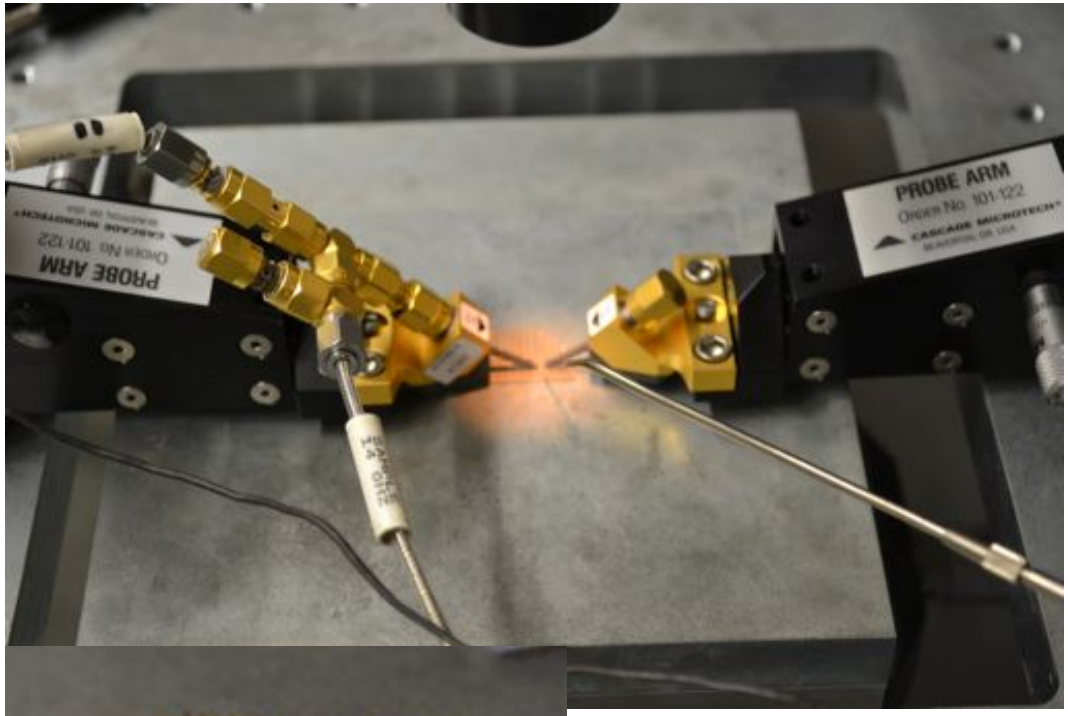
Quality

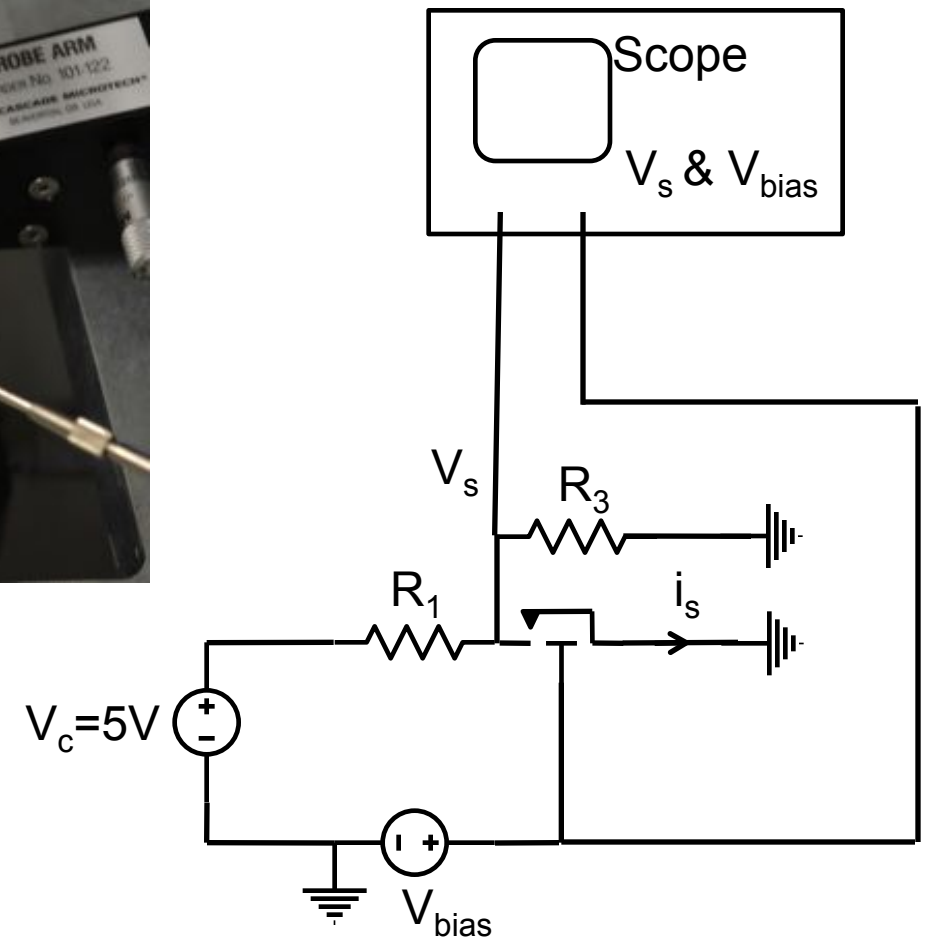
- Typical Weibul plot in the open litterature on RF-MEMS switches
- More consistency is needed



"Rugged and Reliable Ohmic MEMS Switches "
John Maciel, Sumit Majumder, James Lampen and Charles Guthy
Radant MEMS, Inc., Stow, MA 01775
IMS 2012 Montreal

DC Testing

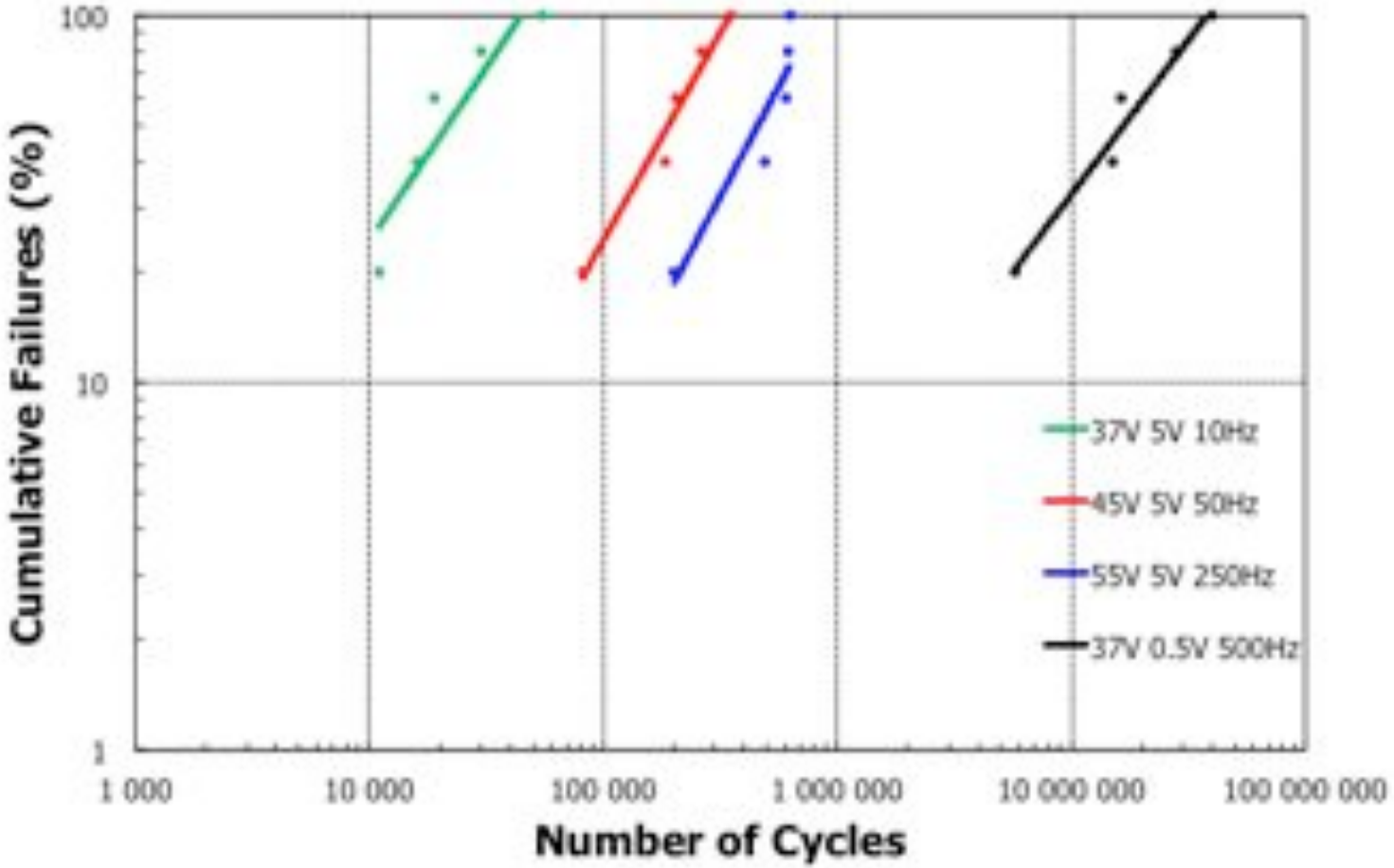




Testings

Quality Testings

- Hot switching with DC input-output voltage



Quality Testings

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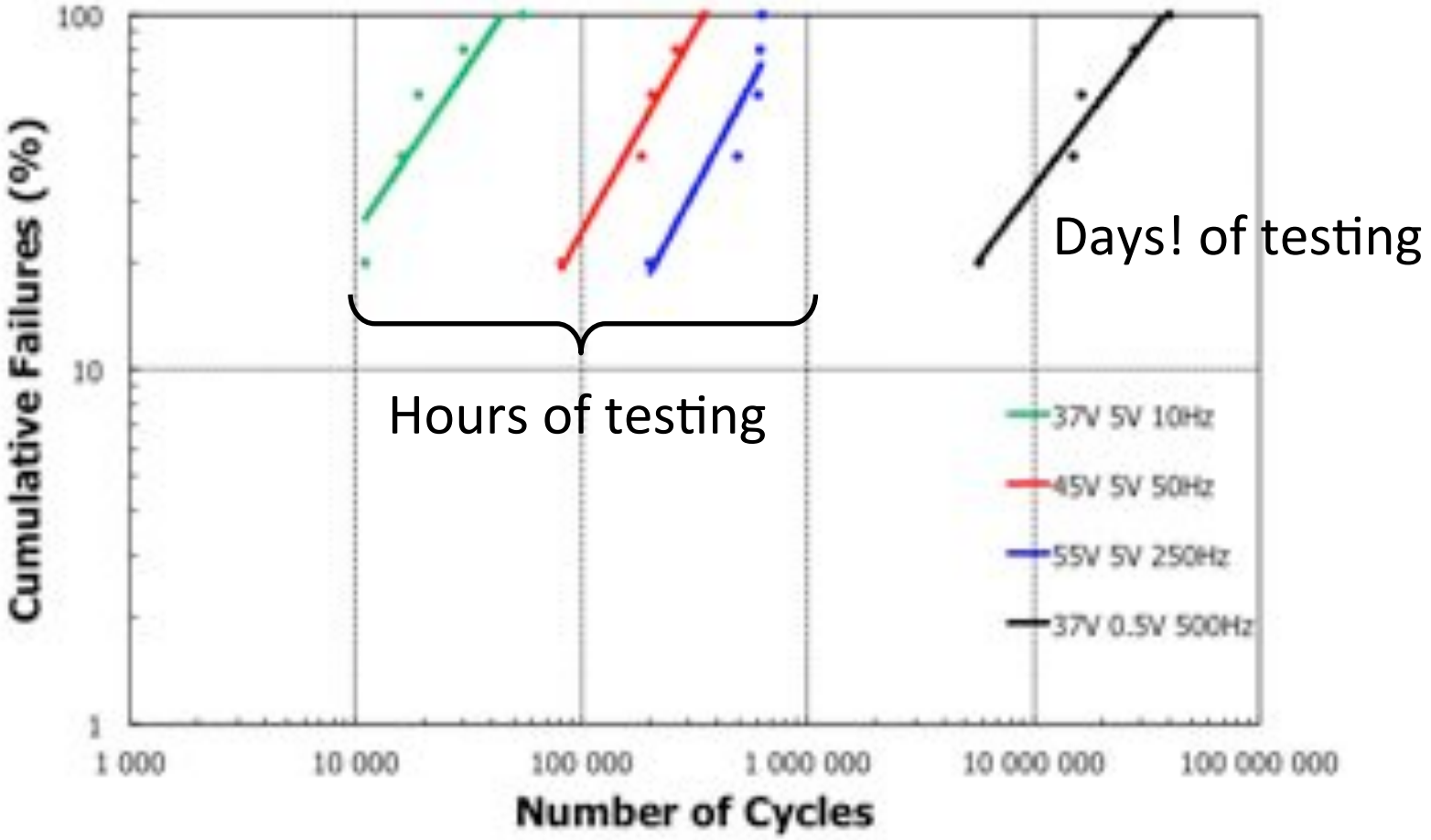

Quality Testings

- Charging is marginal: reliability increases when actuation voltage increases
- Cold switched RF-MEMS ohmic switches easily achieve days of lifetime: Acceleration testing is needed
- Firsts testings indicates that the slope of the Weibul plot remain the same under various bias conditions. Hot switching under high input to output voltage accelerates failure.

Current developments

- « Zero-level » packaging (DGA support)

Cross section

Challenges:

Sealing method and material

Conclusions

- Dramatic improvement in reliability
- Temp. Accerelation is under way
- Statistical testings under way -> Screening is critical
- Hybrid assembly in a space qualified hybrid package has been done
- Other demonstrators are under way:
  - Integration into ESA Mercury Reflectarray elements
  - Workhorse for E. Lemoine NPI
- AirMems spin-off company to commercialize this product (will be at the EuMw exhibition)

Acknowledgments

- CNES support under the « MEMO » project
- ESA support « Avoidance of Dielectric Charging » - « Mercury »