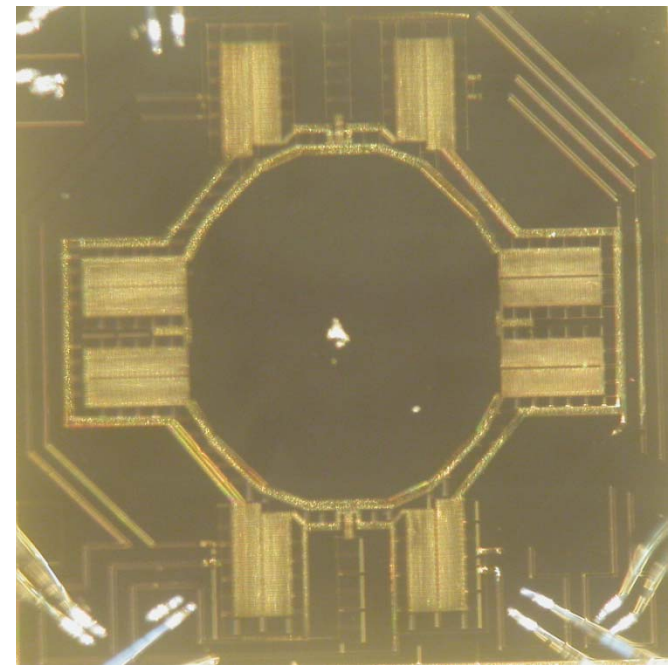
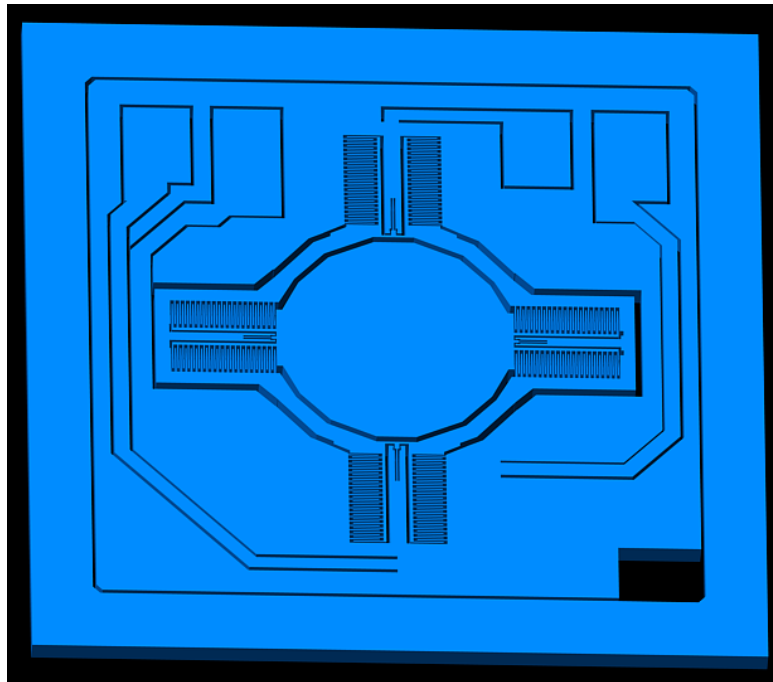


# Applications of Optical MEMS for Space Missions

*Mathilde Gobet, Peter Herbst, Paolo Baroni, Cornel Marxer*



**Sercalo Microtechnology Ltd.**  
Rue des Draizes 5  
CH-2000 Neuchâtel, Switzerland

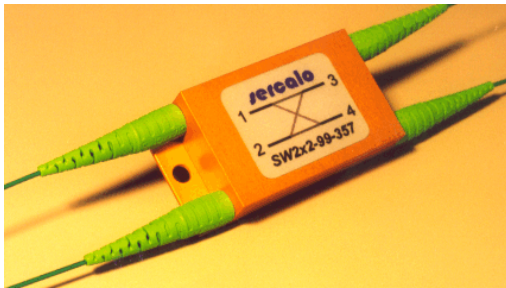
**sercalo**

# Outline

- Application overview
- Low port count switch
- 50x50 optical MEMS switch matrix
- 3D MEMS mirror
- Conclusions

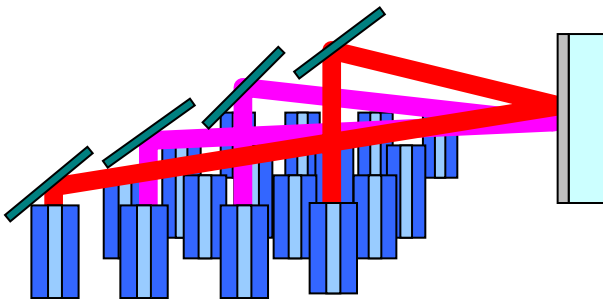
# Application overview (1)

## 1) Low port count fiber optical switches



- Reconfiguration in experimental satellites
- Redundancy switching in telecommunication satellites
- Optical sensors in satellites
- Delta Space Qualification

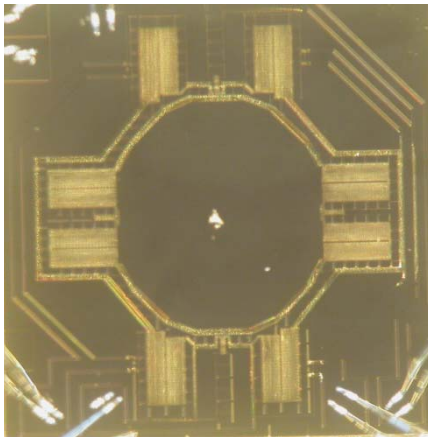
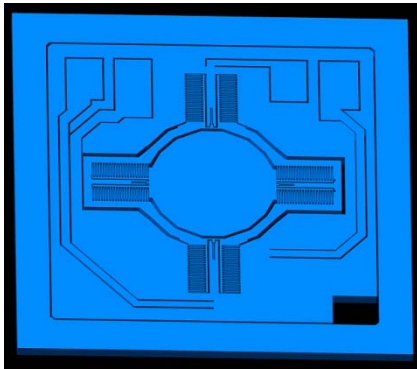
## 2) Large port count (50x50) optical switch matrix



- Large scale optical cross connects
- Switching in telecommunication satellites
- On board signal routing and reconfiguration in telecommunication satellites

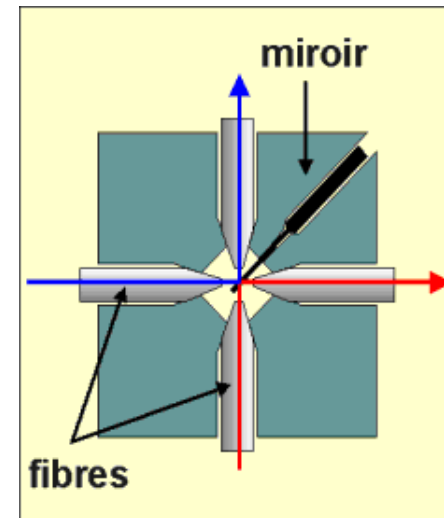
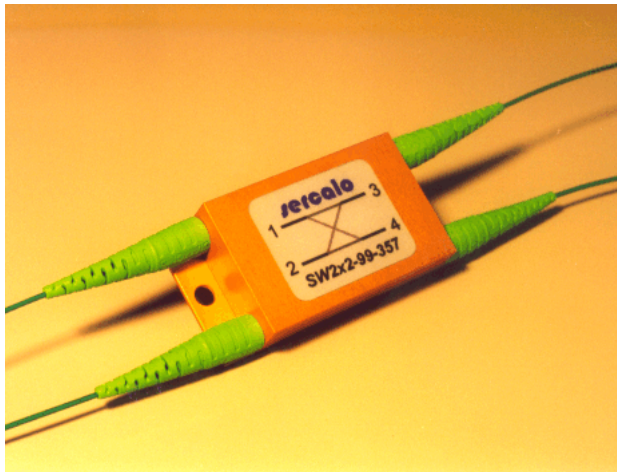
# Application overview (2)

## 3) MEMS mirror



- Pointing and tracking applications:
  - fixed position
  - telecommunications
- Scanning applications:
  - LIDAR
  - 3D vision system with time of flight measurement
  - In satellite structural measurement
  - Mars rover

# Low port count fiber optical switches

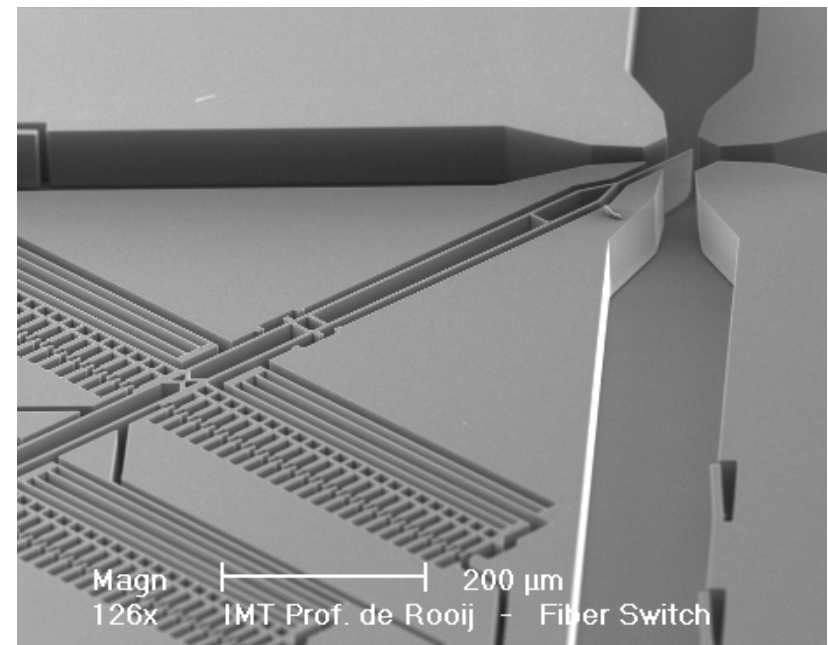
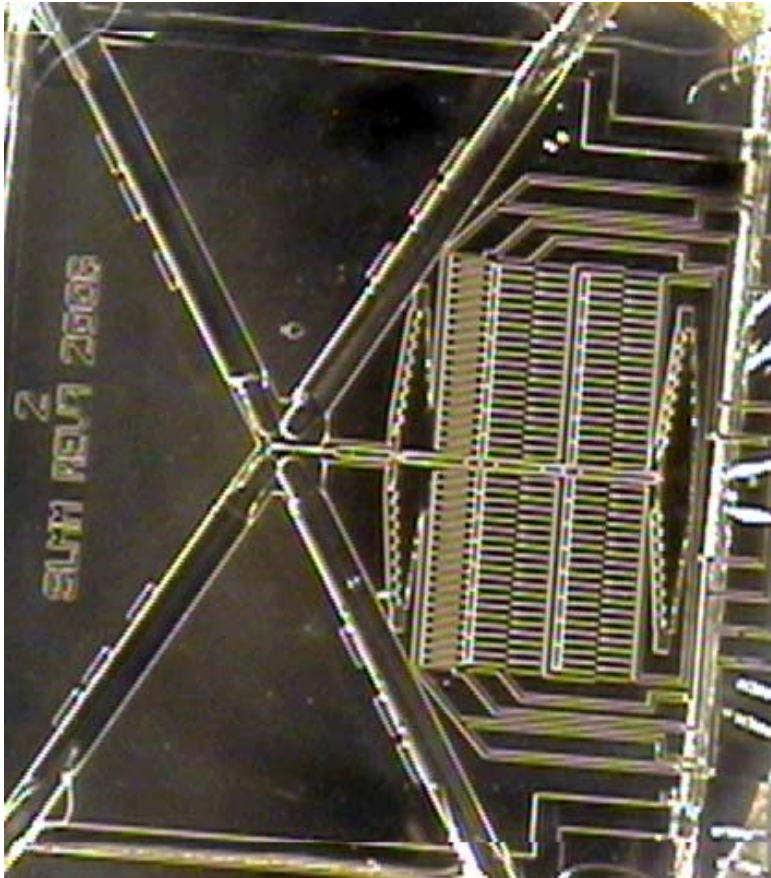


# Low port count fiber optical switches

2x2 optical switch

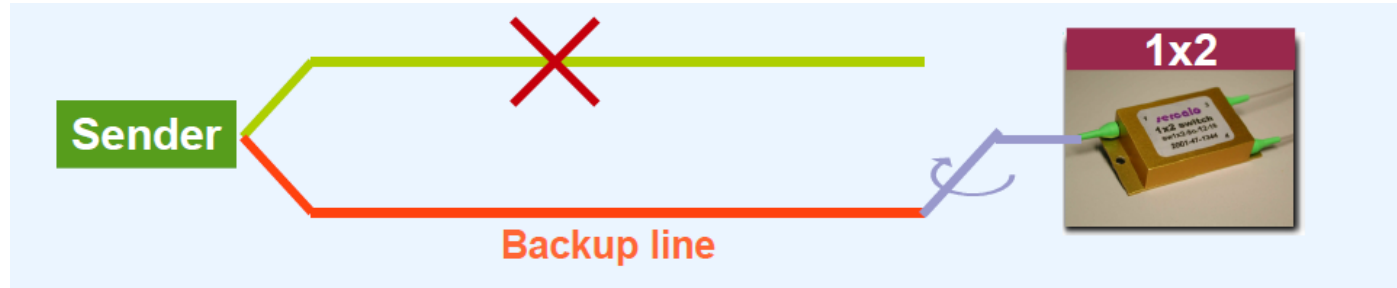
ON/OFF switch

→ inherently no feedback required

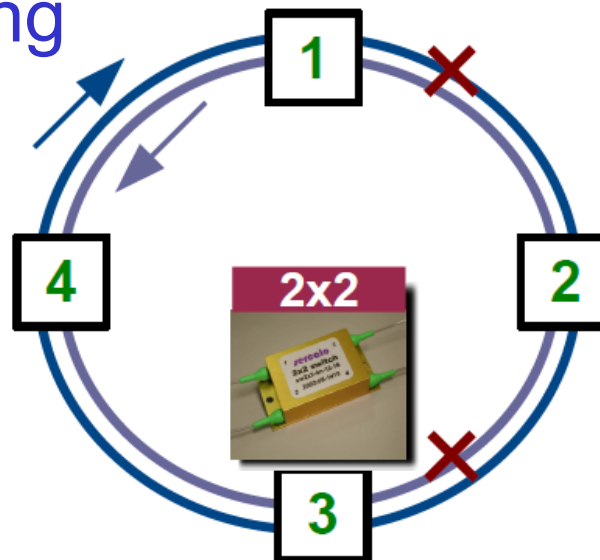


# Applications: Redundancy switching

- Line protection

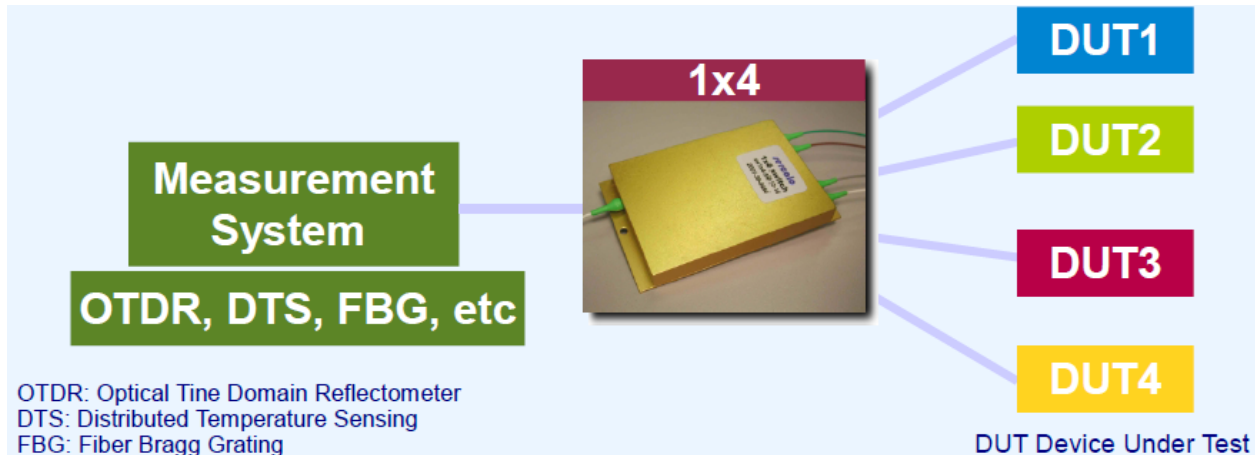


- By-pass switching

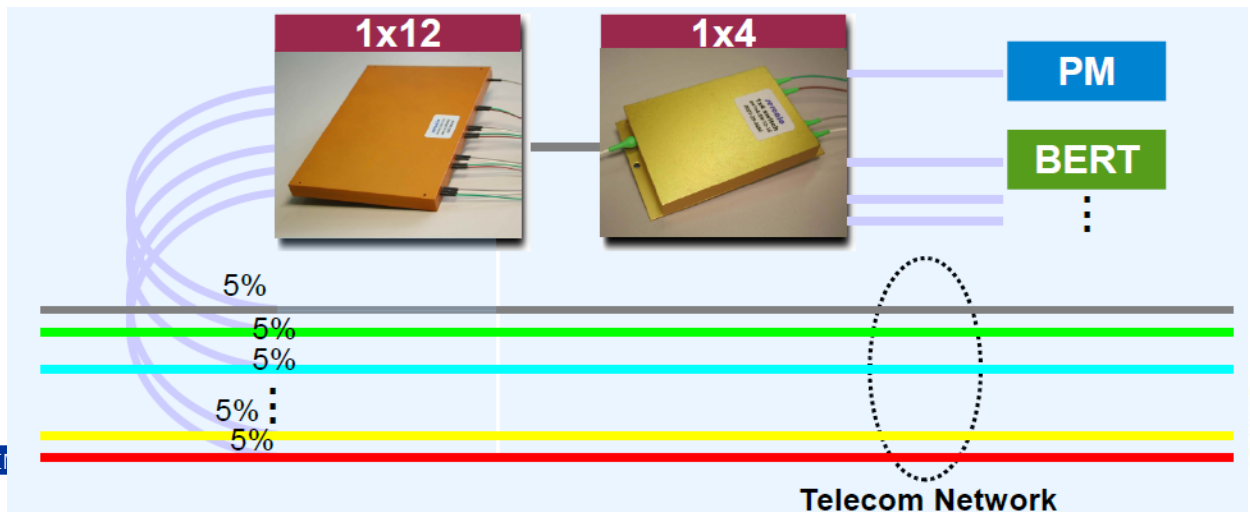


# Applications: Optical sensors

- Measurement ressource sharing

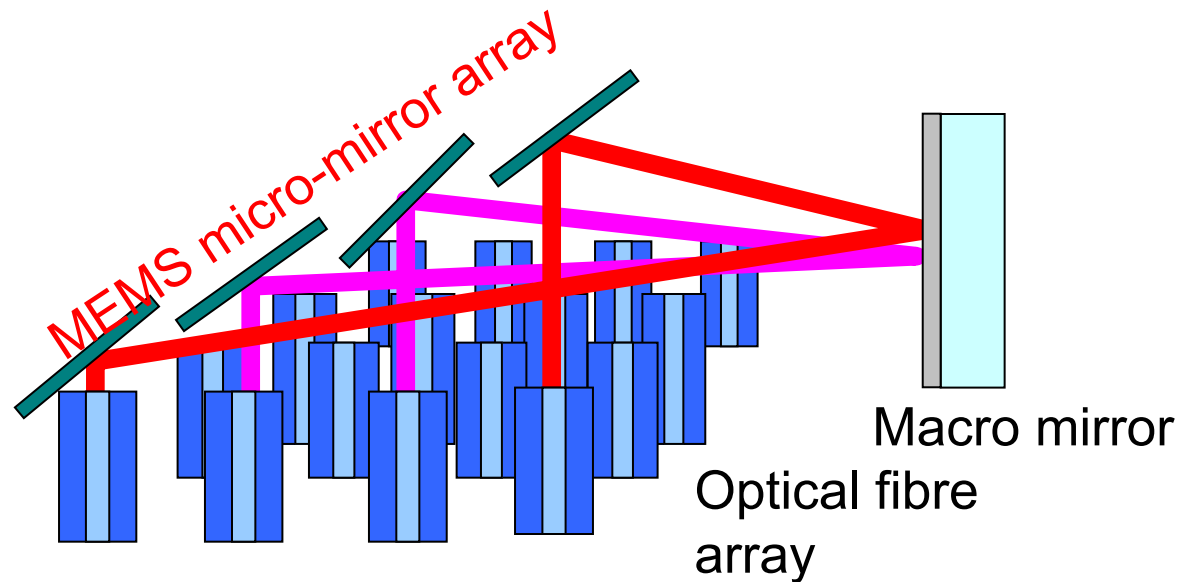


- Remote Network Monitoring





# Large port count (50x50) MEMS switch matrix

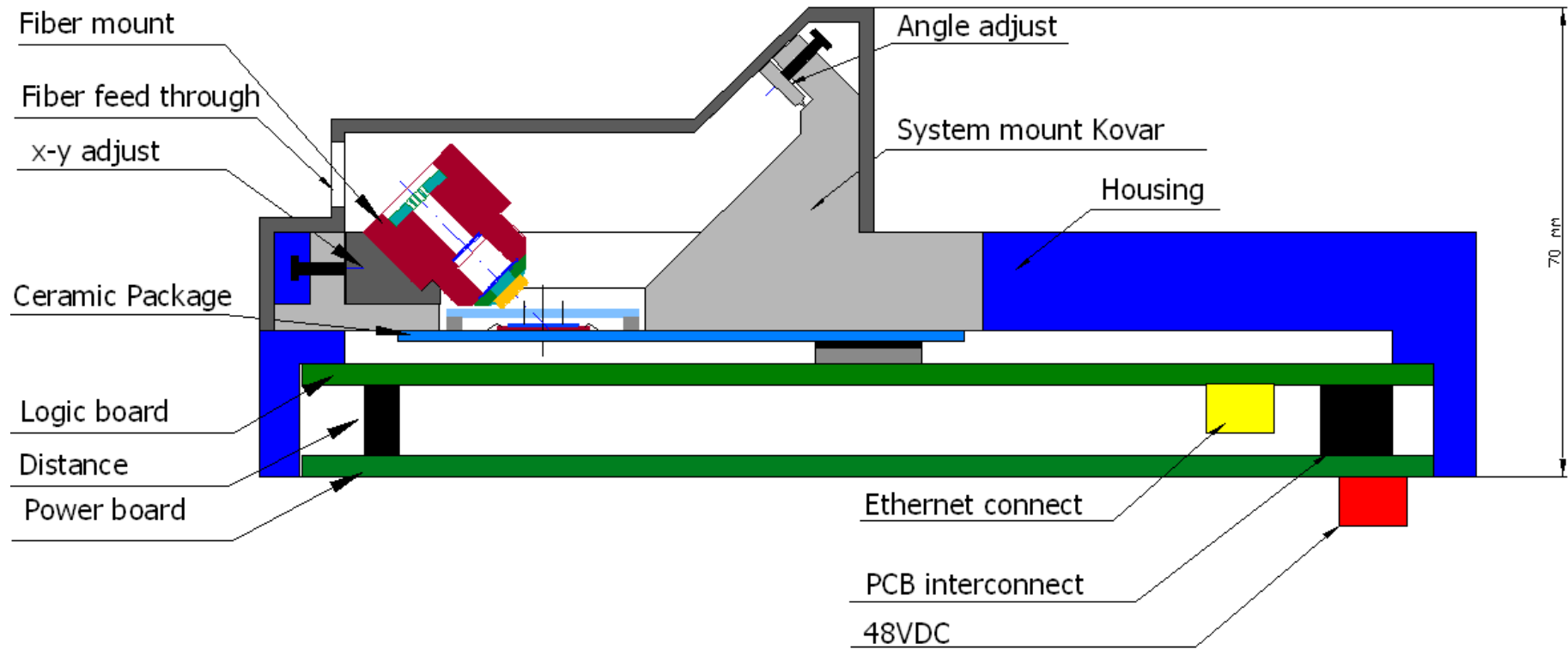


ESA project ITT AO/1-4783/05/NL/PM



# 50x50 Optical MEMS Switch Matrices

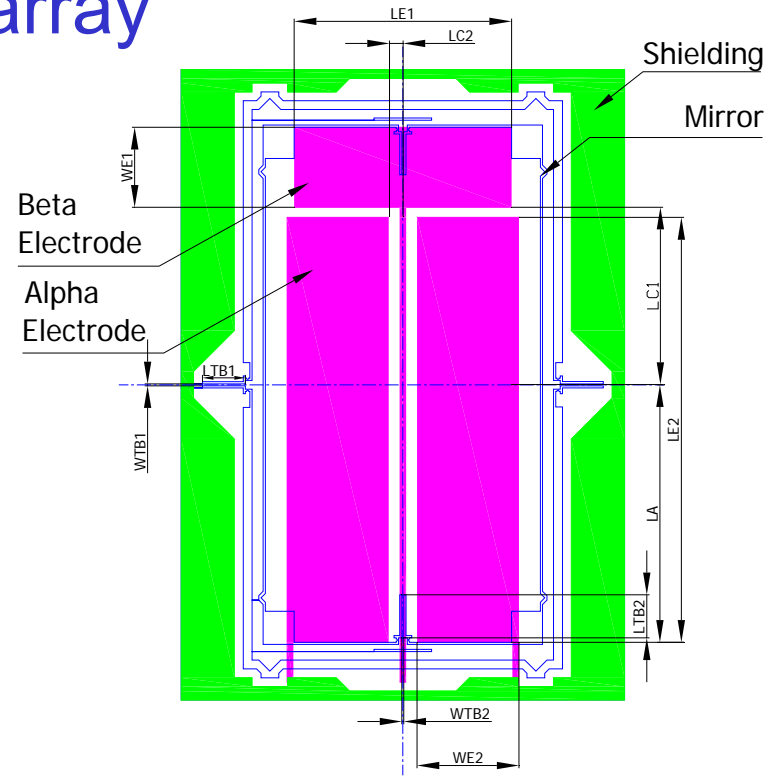
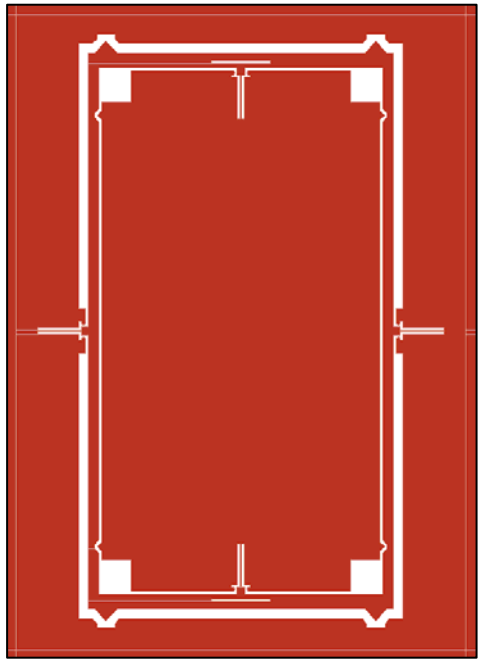
ESA project ITT AO/1-4783/05/NL/PM



# 50x50 Optical MEMS Switch Matrices

## Micro-mirror array

- No feedback
- “easy” calibration
- “simple” look-up table
- **No feedback required**

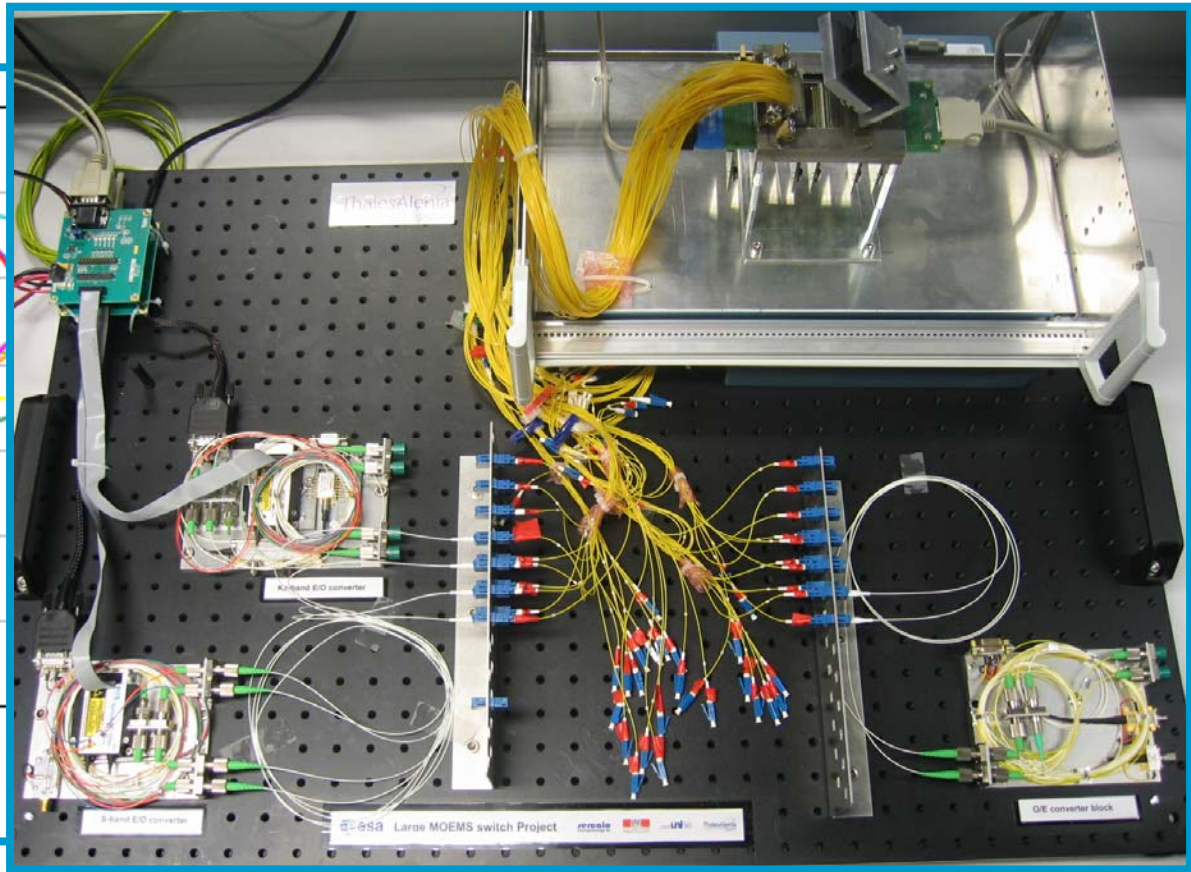
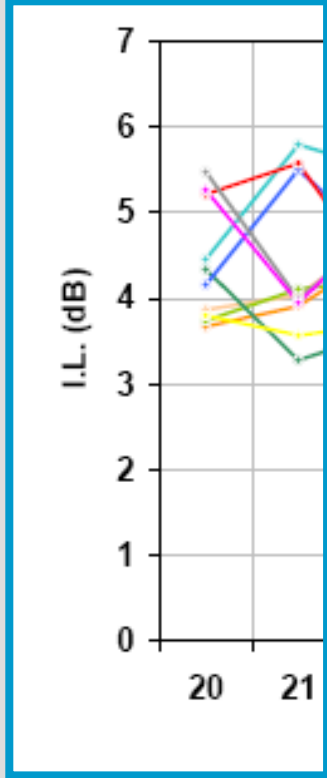


Max. tilt angle $\alpha$ / actuation voltage	$\pm 3.1^\circ$ / 130V
Max. tilt angle $+\beta$ / actuation voltage (Beta Electrode)	$+2.0^\circ$ / 88V
Max. tilt angle $-\beta$ / actuation voltage (Two Alpha Electrodes)	$-2.0^\circ$ / 69V
Resonance frequency	$> 490$ Hz (13 $\mu$ m)



# 50x50 Optical MEMS Switch Matrices

ESA project ITT AO/1-4783/05/NL/PM



in losses  
 average IL : ~ 5 dB  
 maximum IL : 6 dB  
 position dependent  
 in losses  
 $\Delta$ IL : 0.17 dB

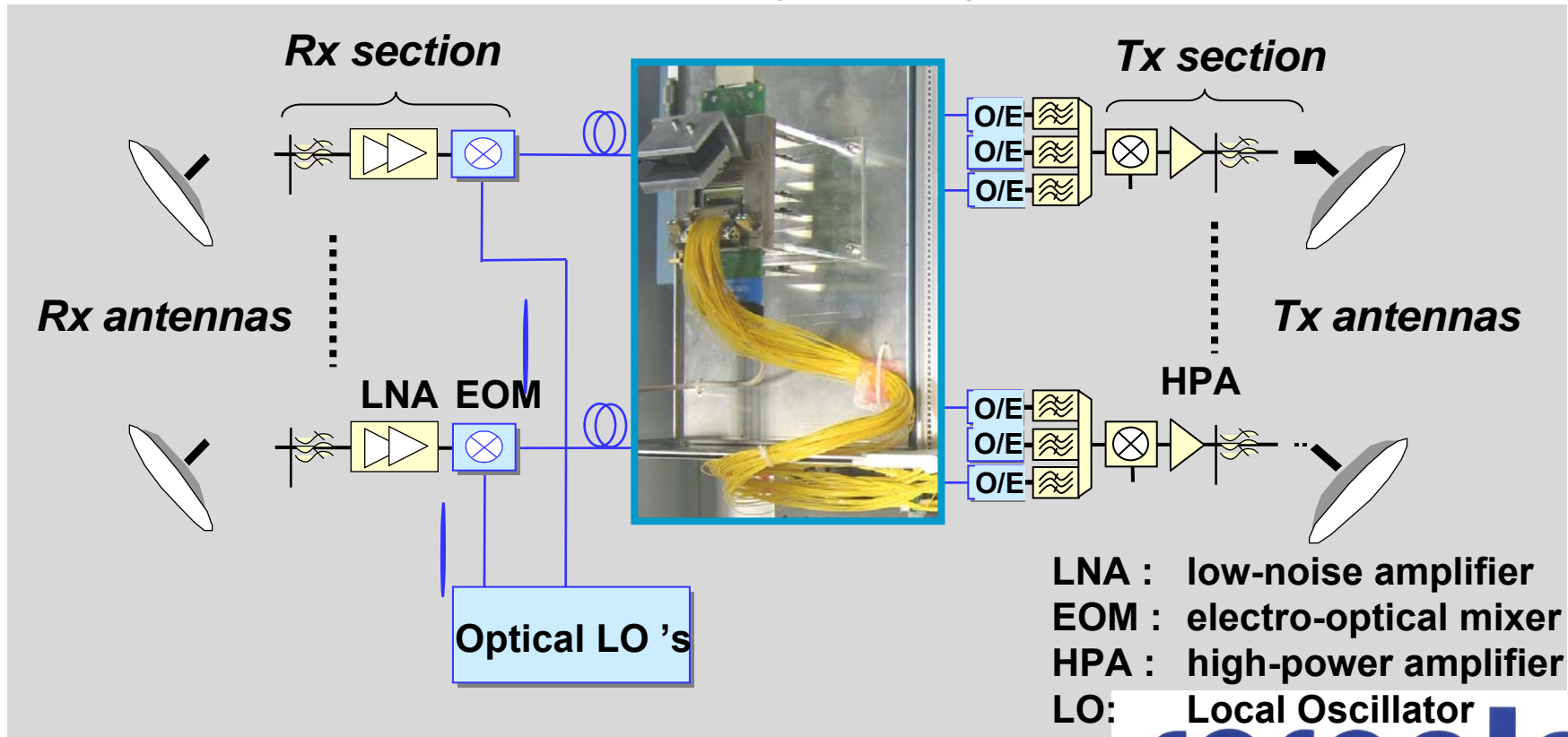


Courtesy of A. Le Kerneç and M. Sotom, Thales Alenia Space

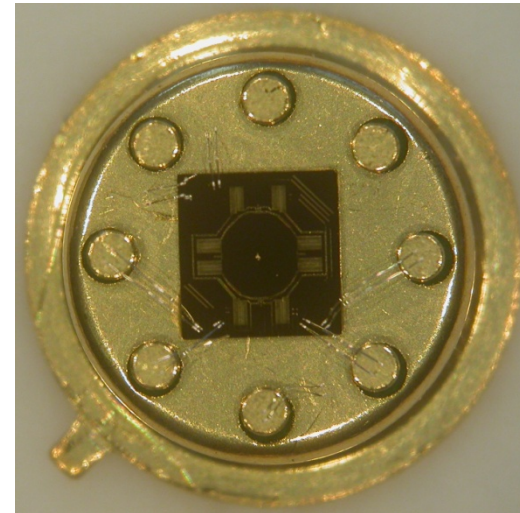
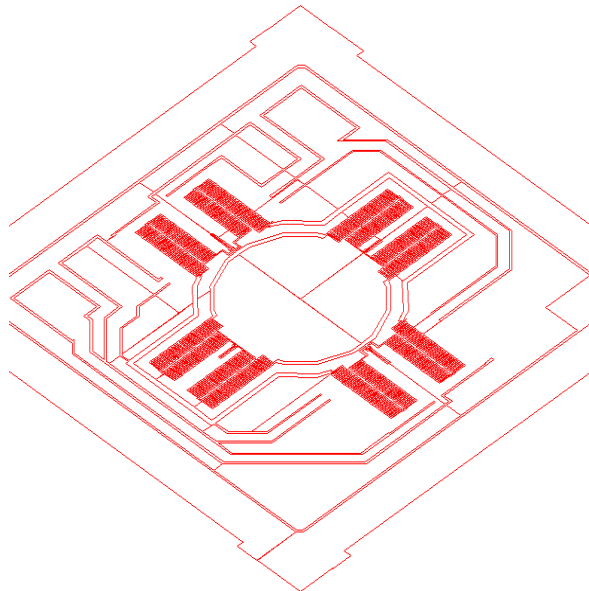


# Application: Large-Scale Optical Cross Connect

- **Satellite telecom payload with flexible beam-to-beam connectivity**
  - optical generation & distribution of high-frequency LO's (> 10 GHz)
  - optical frequency mixing and down-conversion, e.g. from Ka (30GHz) to C (4GHz)
  - optical cross-connection of  $\mu$ -wave signals through MOEMS switches

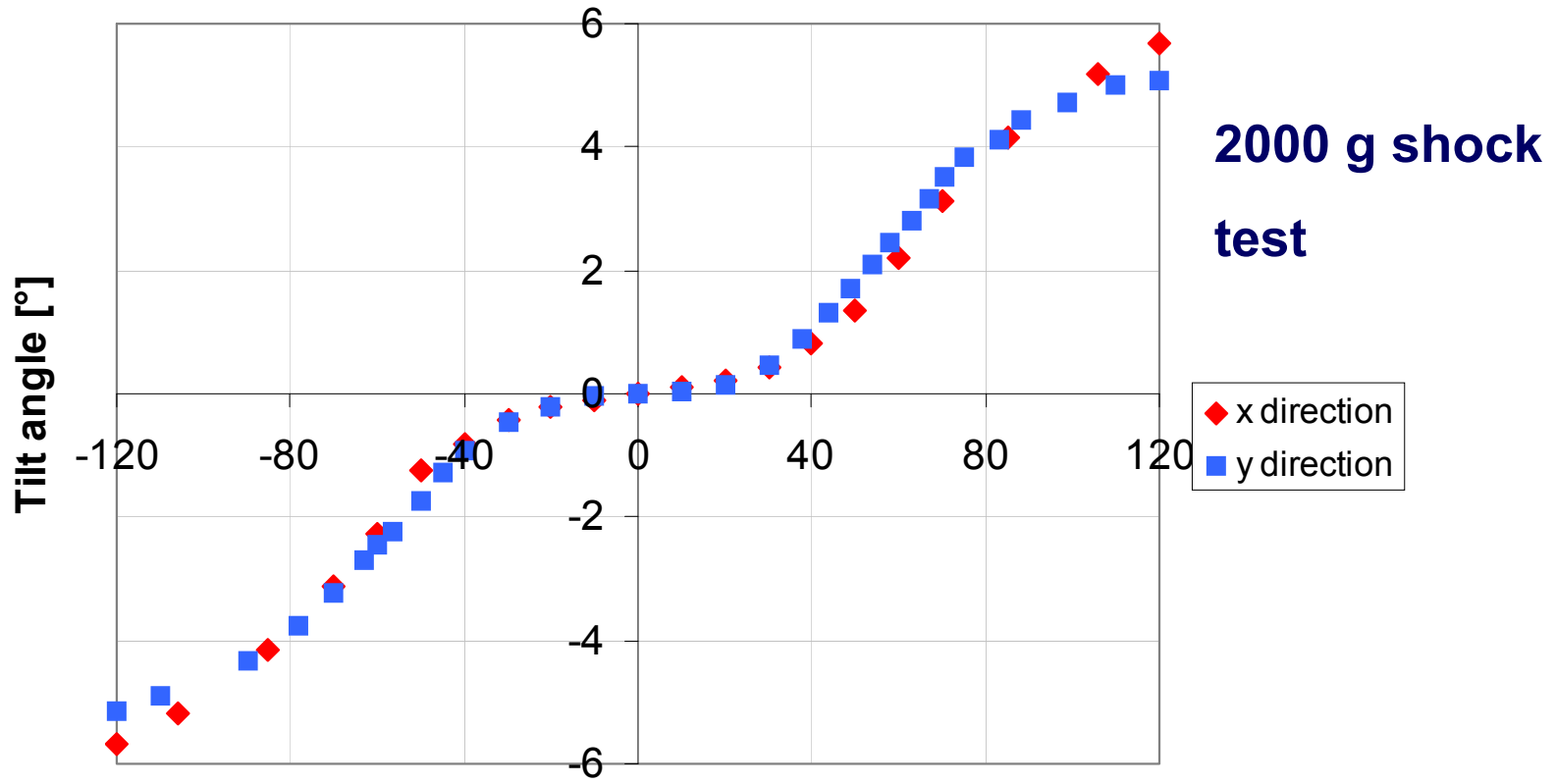


# Vertical comb drive MEMS mirror



# 3D MEMS mirror

1 mm x 1 mm



$f_{resX} = 320 \text{ Hz}$

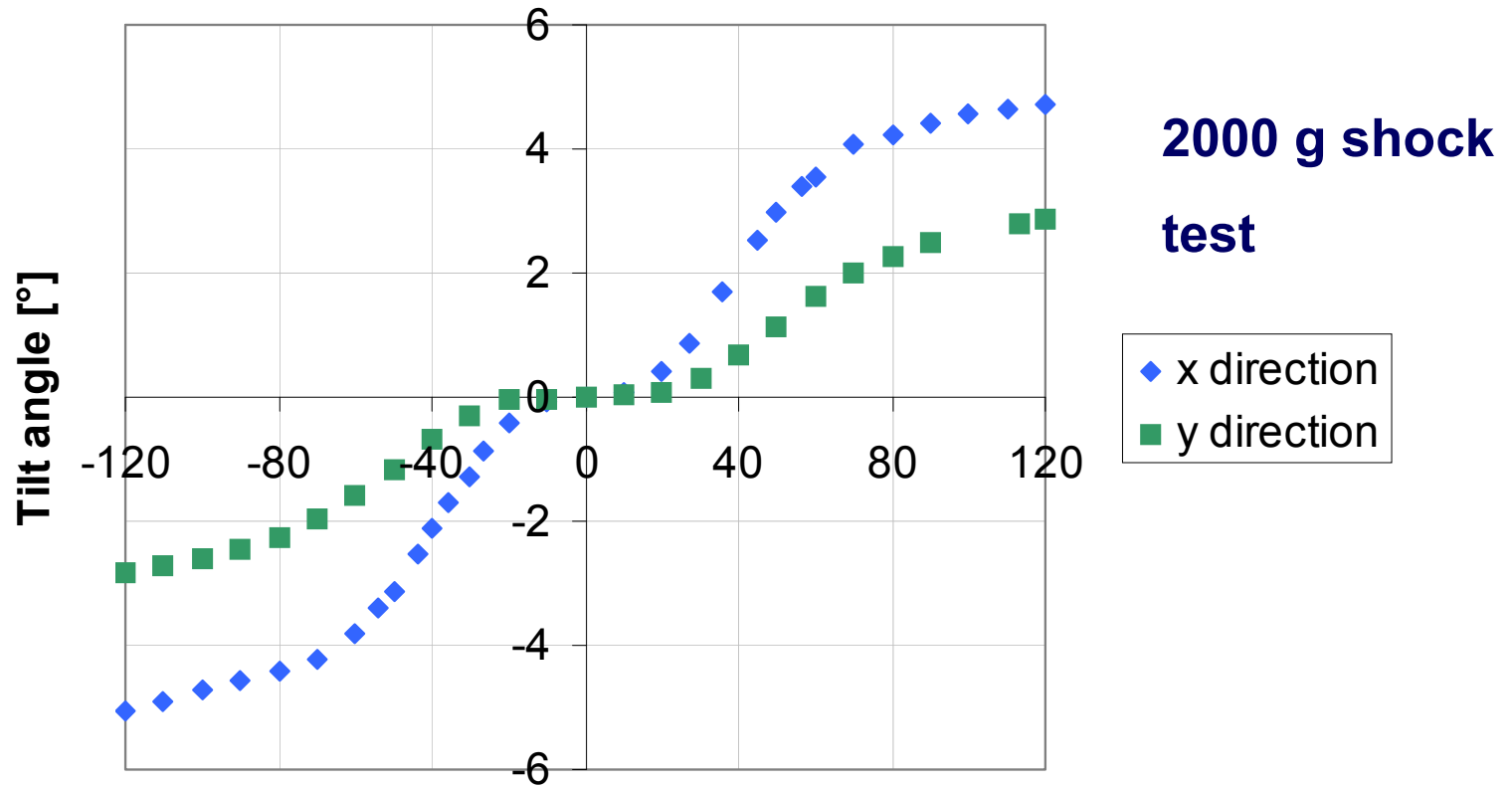
Applied voltage [V]

$f_{resY} = 380 \text{ Hz}$



# 3D MEMS mirror

1.4 mm x 1.6 mm



$f_{resX} = 400 \text{ Hz}$

Applied voltage [V]

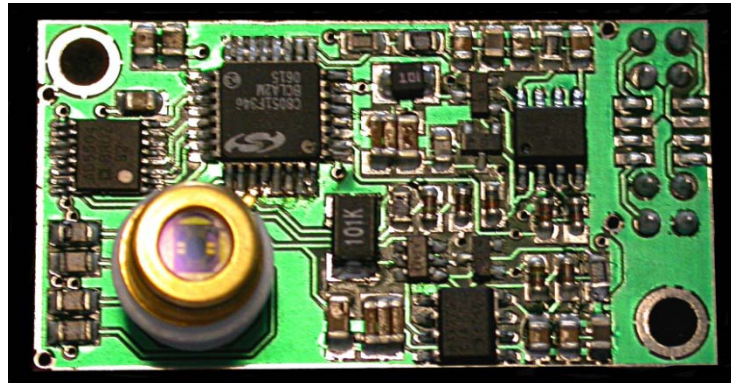
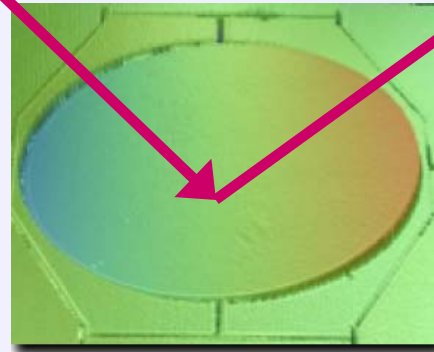
$f_{resY} = 500 \text{ Hz}$





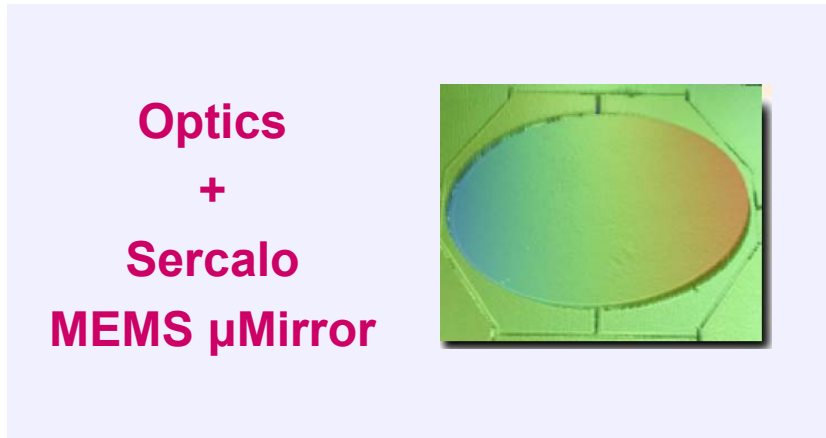
# Applications: Scanning, tracking and pointing

**Sercalo  
MEMS  $\mu$ Mirror**



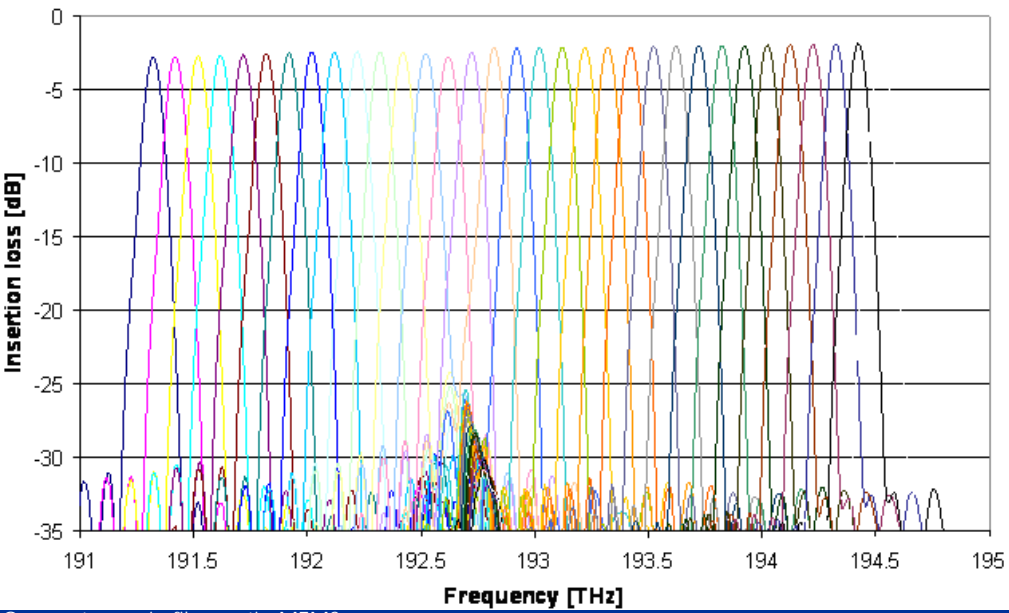
- No feedback loop
- 2 independent axis
- Continuous tilting
- Single mirror or array

# Applications: Tunable filter, miniature spectrometer



$\lambda_i$  selection with software

- Switching time < 50 ms
- Durability: no wear



## Conclusions

- Large number of spatial applications for commercialized low port count switch, large optical switch matrix and tilt mirror
- Less weight and size -> important for satellite integration
- No light through the switch necessary for maintaining the mirror position
- Mirror tilt angle and resonant frequency can be adapted to customer's needs