# *SAES Getters S.p.A.*

## The Shape Memory Alloy Business Area for Industrial Applicatons

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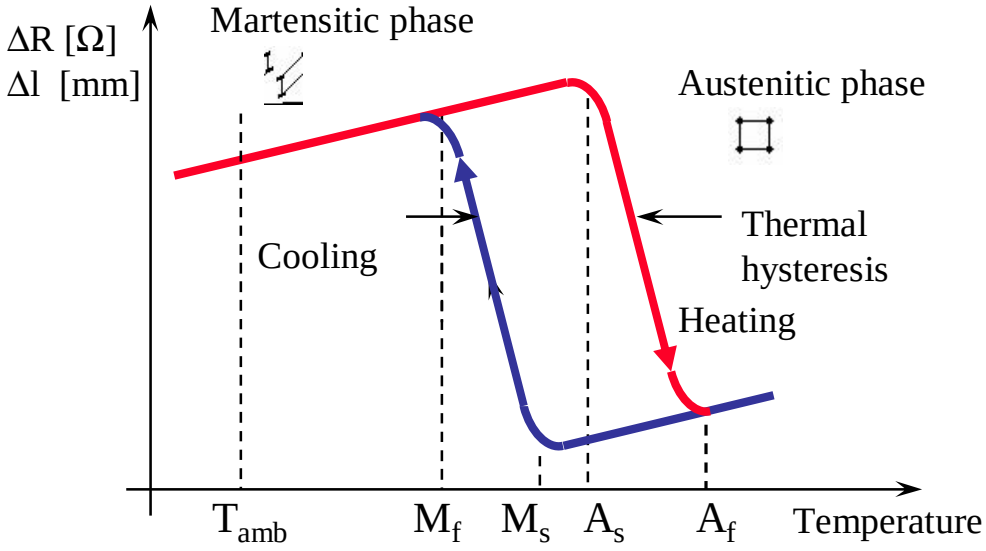
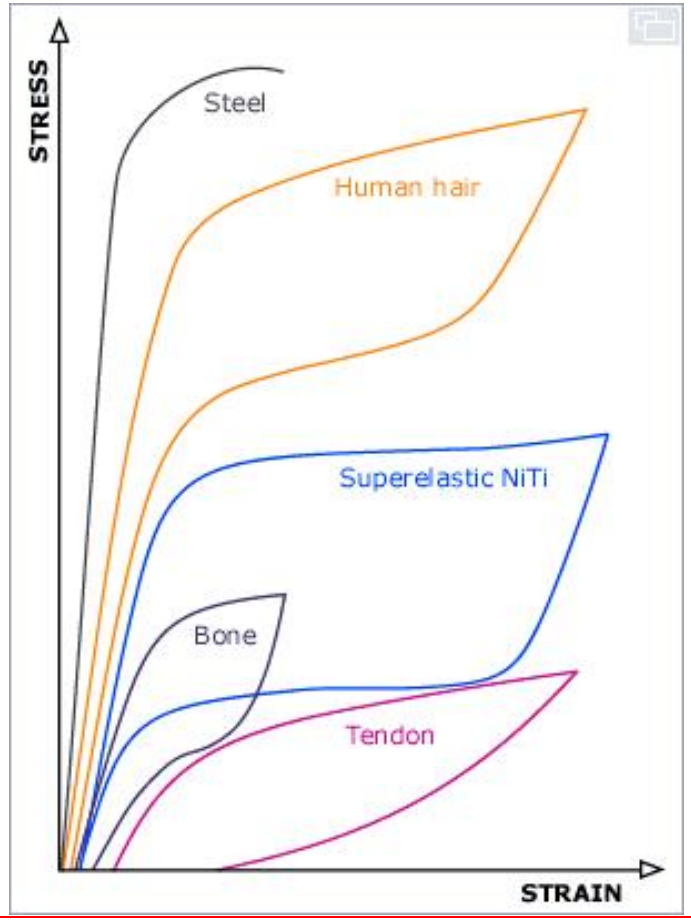
# SMA Shape Memory Alloys


Click in to play the movie !!!

Shape memory alloys (SMA), if thermally stimulated by external heat or internal electrical current flow (Joule effect), exhibit a reversible thermoelastic martensite transformation with a macroscopic shape change

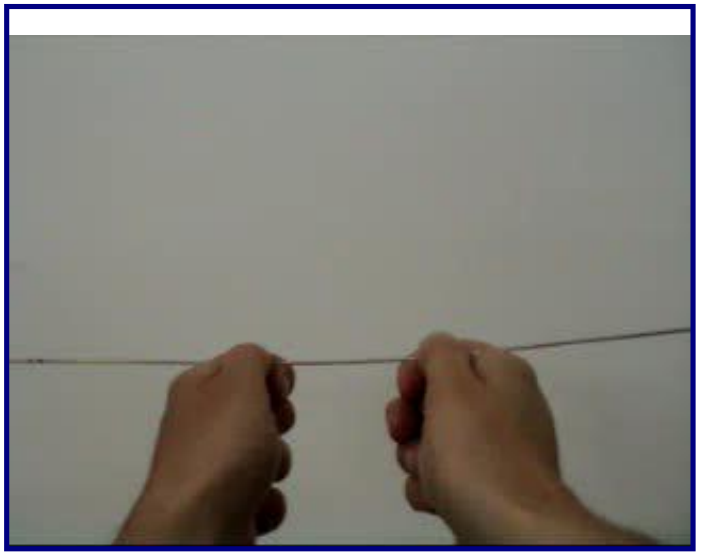


# SMA Superelastic alloys



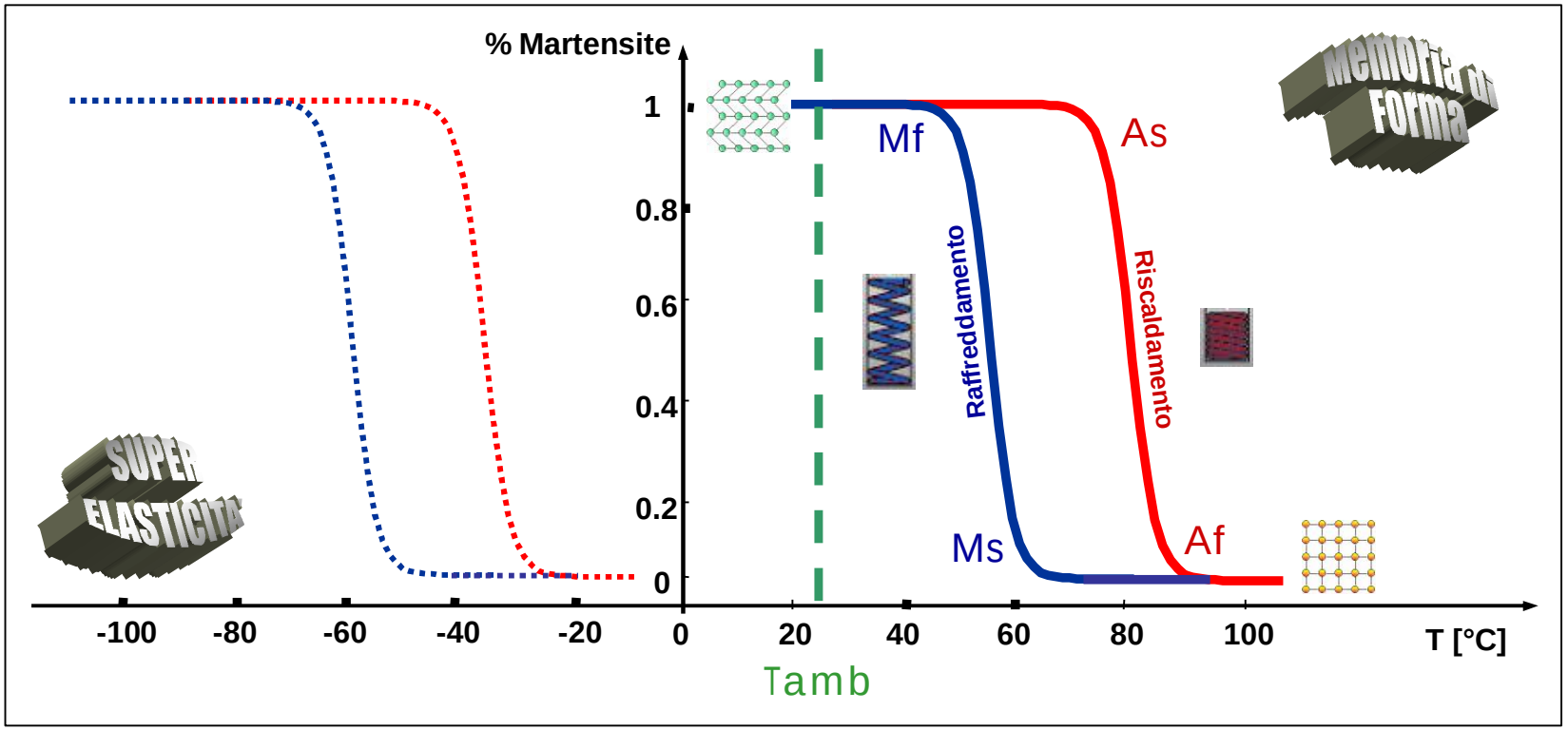

## Caratteristica di Superelasticità

**Abilità nel “recupero” elastico di grandi deformazioni**

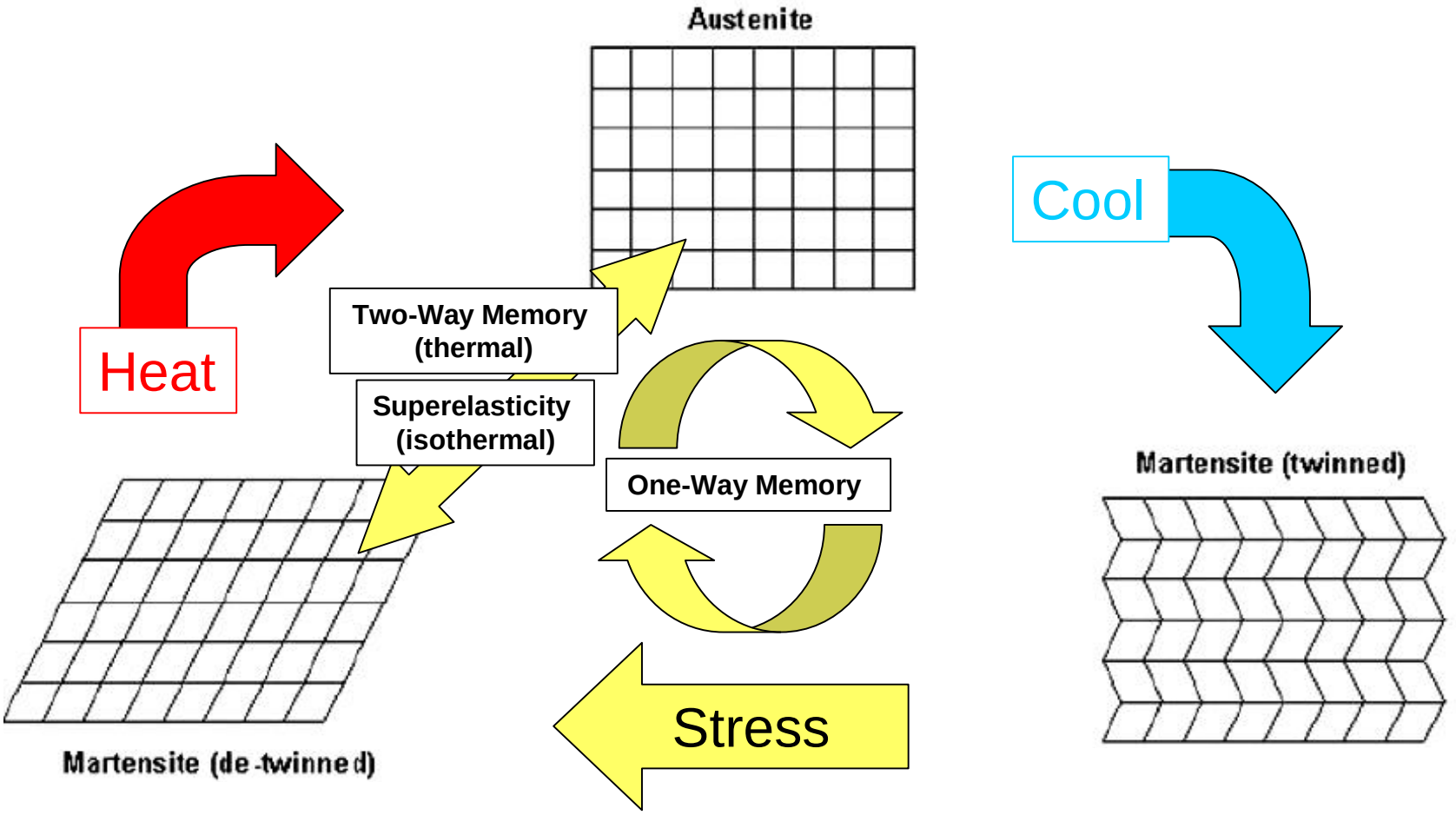


# Shape Memory & Superelastic effect

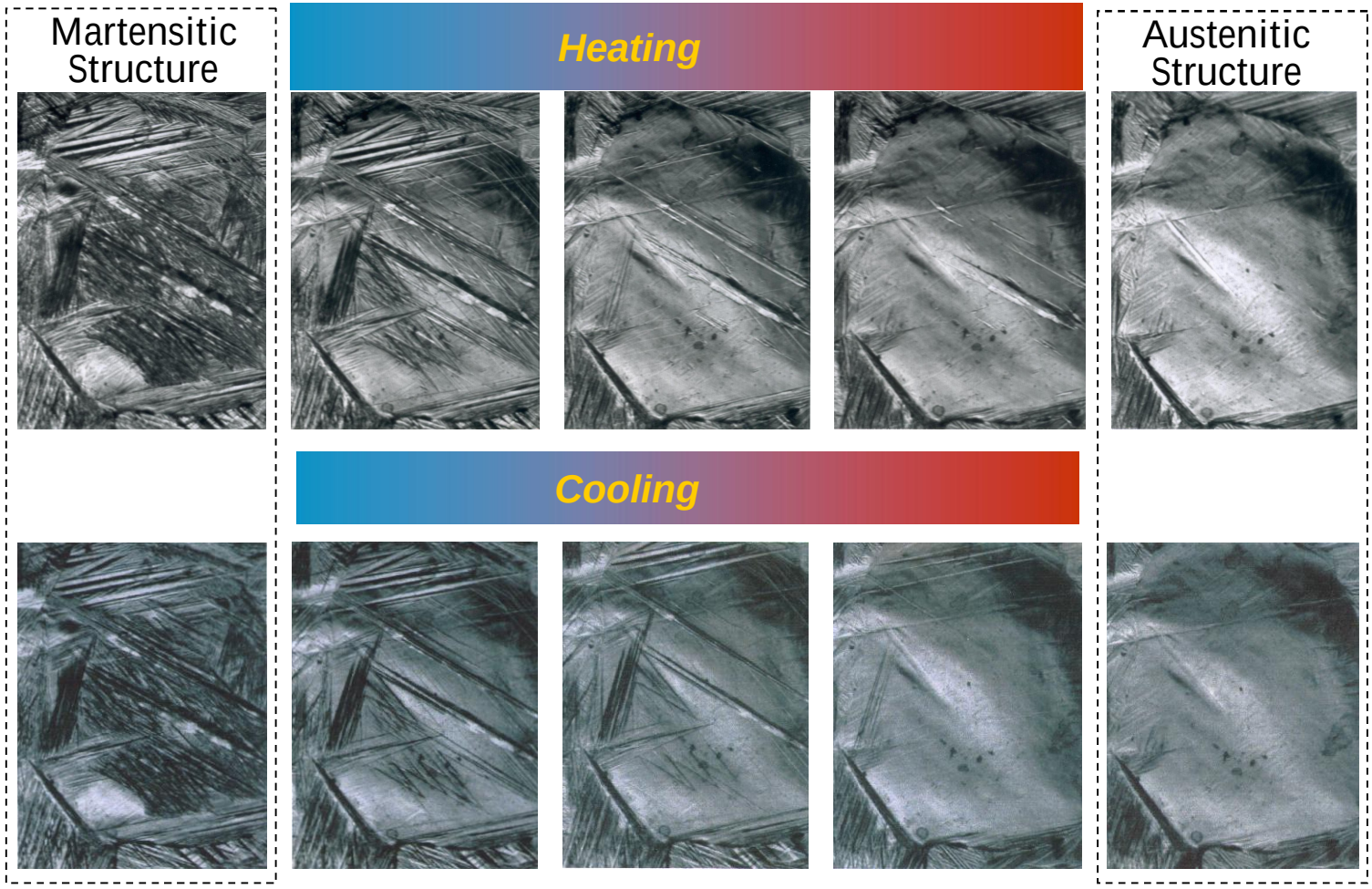
CICLO ISTERESI



# Shape Memory Effects



# Micropictures of martensitic transformation



# SMA Industrial Business Area
# The mission

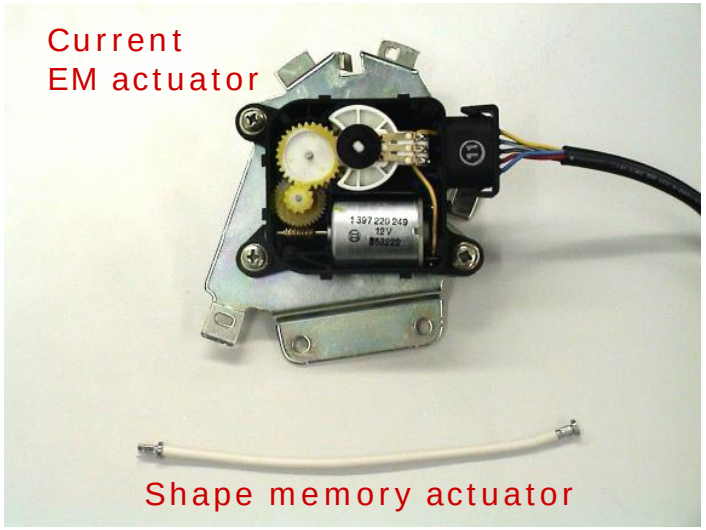
Since Jan 08 Saes has been the worldwide leader in supplying SMA alloys for medical applications

The Shape Memory Alloy (SMA) Industrial BA mission is to develop, manufacture and market TiNi components (e.g. wires, springs,…) "trained" for industrial applications with 100% quality controlled

The BA targets to become market leader in the supply of SMA components for large volume industrial applications in 2008

# Shape Memory Alloys for innovative micro-actuators

## Few centimeter of shape memory wire can replace bulky electromagnetic actuators

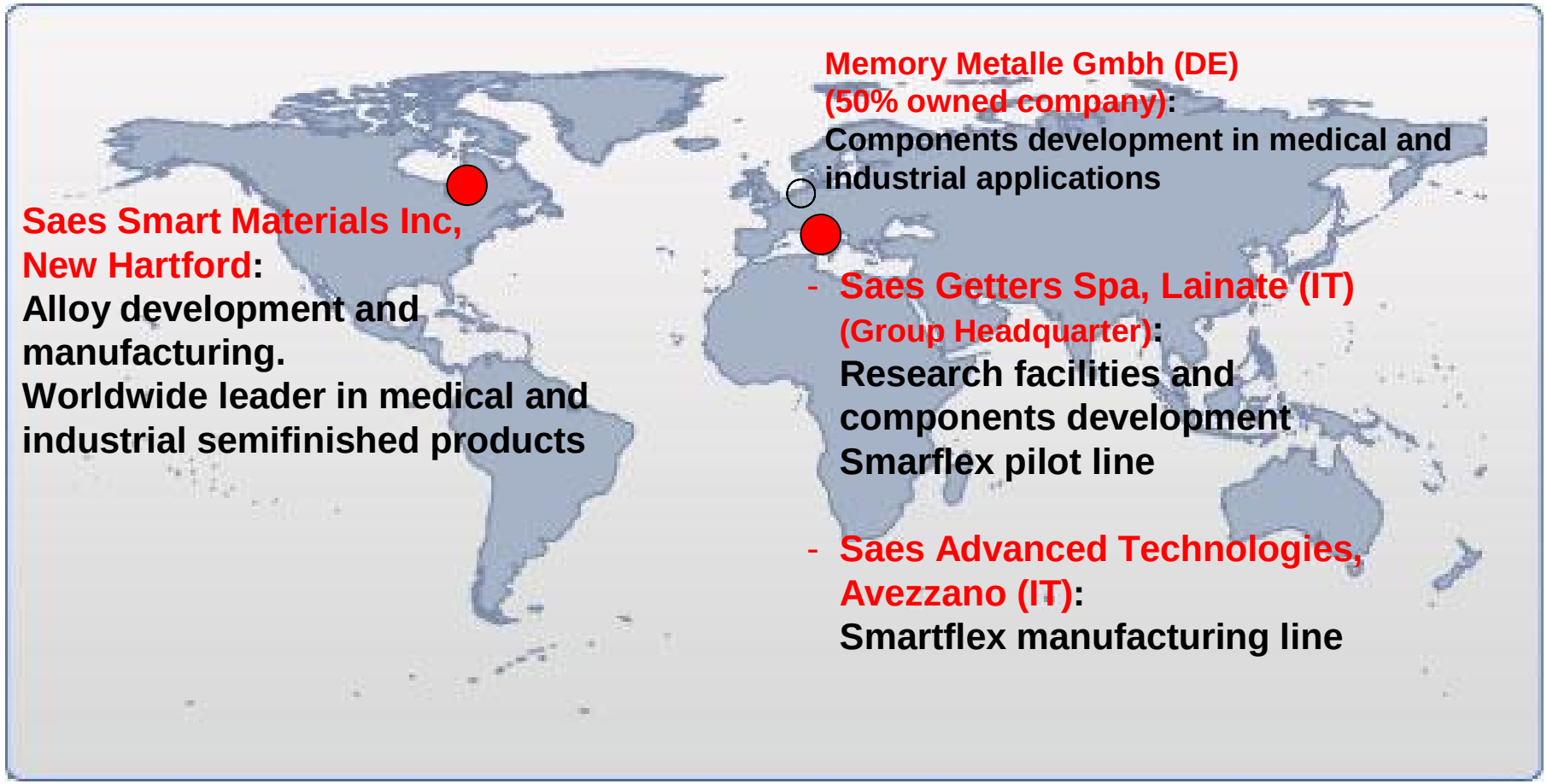



**Main advantages:**

- Compactness and flexibility
- Reduced costs
- Direct linear or angular movement
- High reliability
- Noiseless operation
- Work in “harsh environment”
- No EMI

| | Linear actuator (typ. performances) | |
|---|---|---|
| | Shape memory | Electromagnetic |
| Actuation stroke | 4 - 6 mm | 6 - 8 mm |
| Actuation Force | 60 N | 35 N |
| Actuation time | < 0,2 s | < 0,5 s |
| Operating temperature | -30 °C ÷ + 80°C | -30 °C ÷ + 80°C |
| Life cycles | > 200.000 | > 50.000 |
| Actuator volume | 1 cm3 | 60 $cm^3$ |
| Actuator weight | 1 g | 75 g |
| Operating voltage | 12 V DC | 12 V DC |

# Saes Group SMA industrial sites



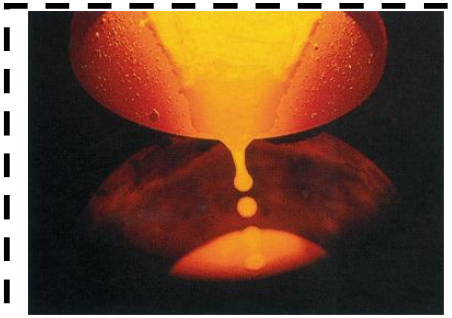
**Saes Smart Materials Inc, New Hartford:**
**Alloy development and manufacturing.**
**Worldwide leader in medical and industrial semifinished products**

**Memory Metalle Gmbh (DE) (50% owned company):**
**Components development in medical and industrial applications**

- **Saes Getters Spa, Lainate (IT) (Group Headquarter):**
  **Research facilities and components development**
  **Smarflex pilot line**

- **Saes Advanced Technologies, Avezzano (IT):**
  **Smartflex manufacturing line**

# Vertical integrated manufacturing process

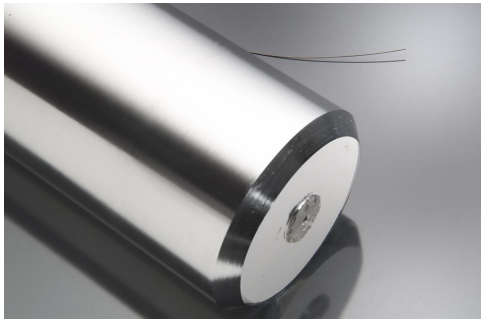


**Melting**

SSM

- Hot extrusion (900°C)
- Hot rolling (900°C)
- Cold rolling
- Drawing to wire

**Intermediate process steps**



**Fine wire drawing**
**Final annealing**

**Training process**

**Optional process**
- **Crimping**
- **Co-extrusion**
- **shaping**

**Final testing**

# Shape Memory Alloys @ SAES

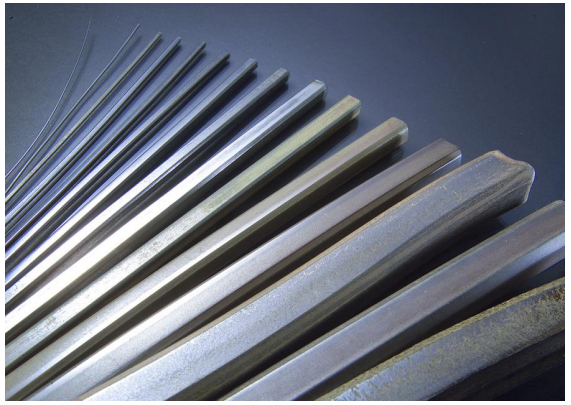
**A unique product offer:**

- vertically integrated production (from ingot to wire) offering better quality control and product mix flexibility

- research and development orientation implying deep and better understanding of material and provide engineering support

- quality system and global presence being a better assurance for industrial applications

The SMA production line in 2008 will be ISO TS qualified



# *SmartFlex® wire*

# *A new smart solution for your actuators*

# SmartFlex® Wires

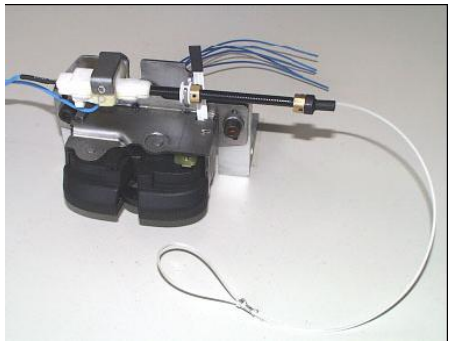
## SMARTFLEX
## is a 100% quality controlled
## SM wire for actuators

Main characteristics:

- Diameter: from 20 to 500 μm
- Transformation temperatures: 10 – 100 °C
- Maximum stroke: 5.0 %
- Force@150MPa: from 5 g to 3 Kg
- Lifetime: > 1.000.000 cycles (under controlled conditions)
- Shaping: Coil springs, torsion wires

# SmartFlex® - Some Applications






## *Automotive*

- *Latches and closures*
- *Mirrors*
- *Dashboard actuators*
- *Seats actuators*
- *HVAC actuators*

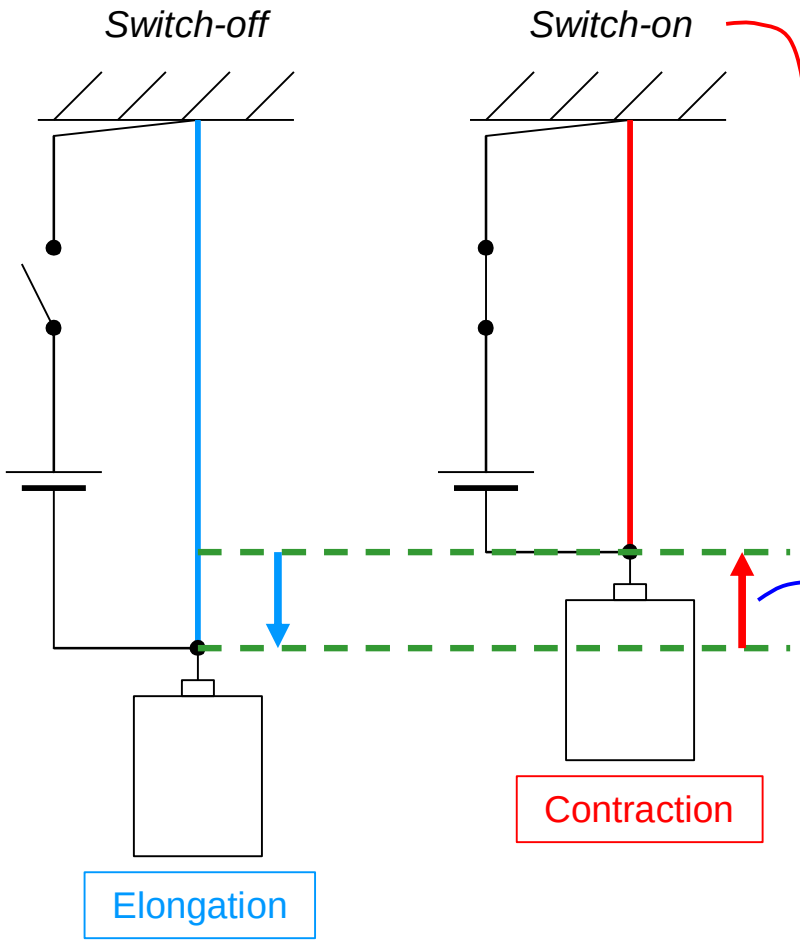
## *Consumer electronics*

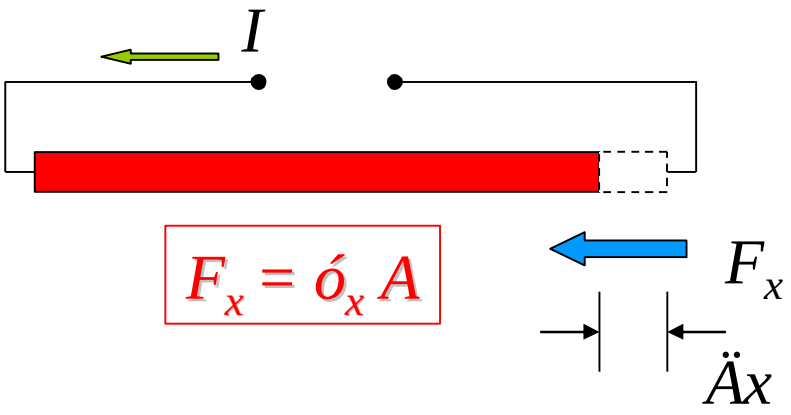
- *Latch mechanisms*
- *Flip mechanisms*
- *Autofocus*
- *Lens cover*
- *Shutters*

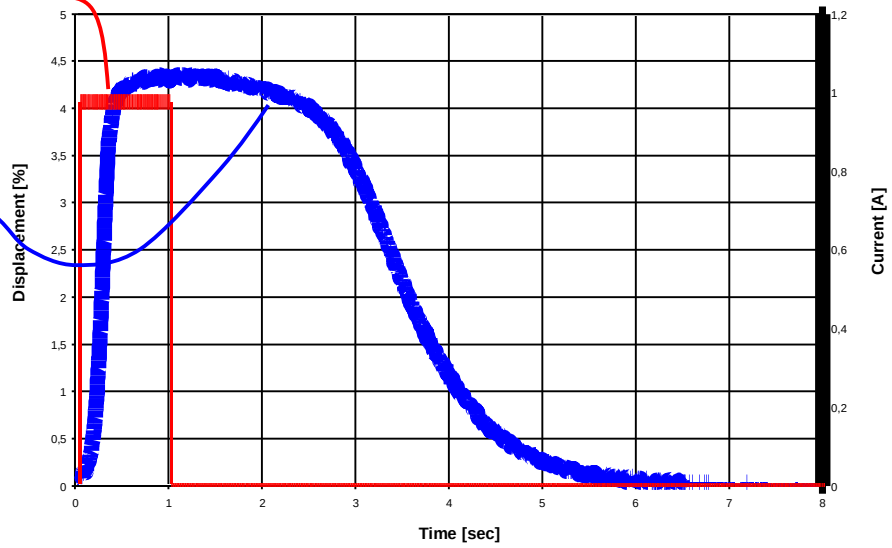
## *Appliances*

- *Latches and closures*
- *Valves*
- *Thermo-actuators*
- *Water mixing*
- *Dampers*

# Shape Memory Effect for Actuation

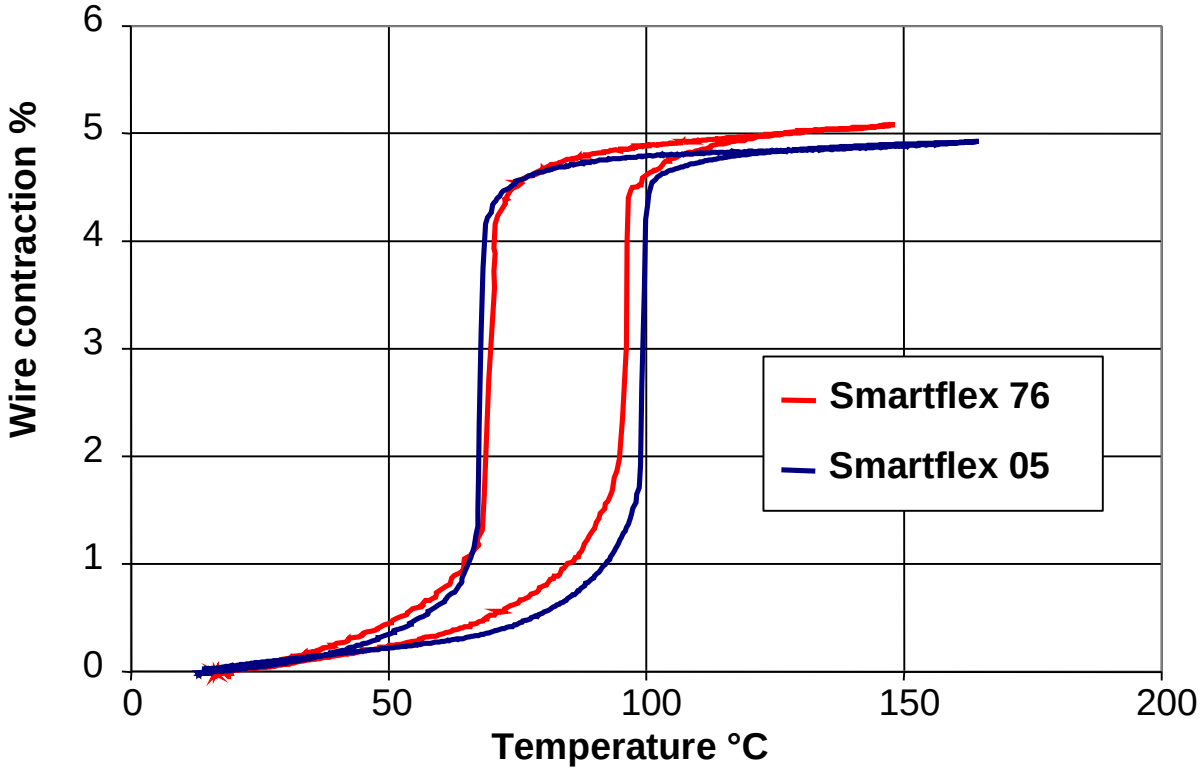


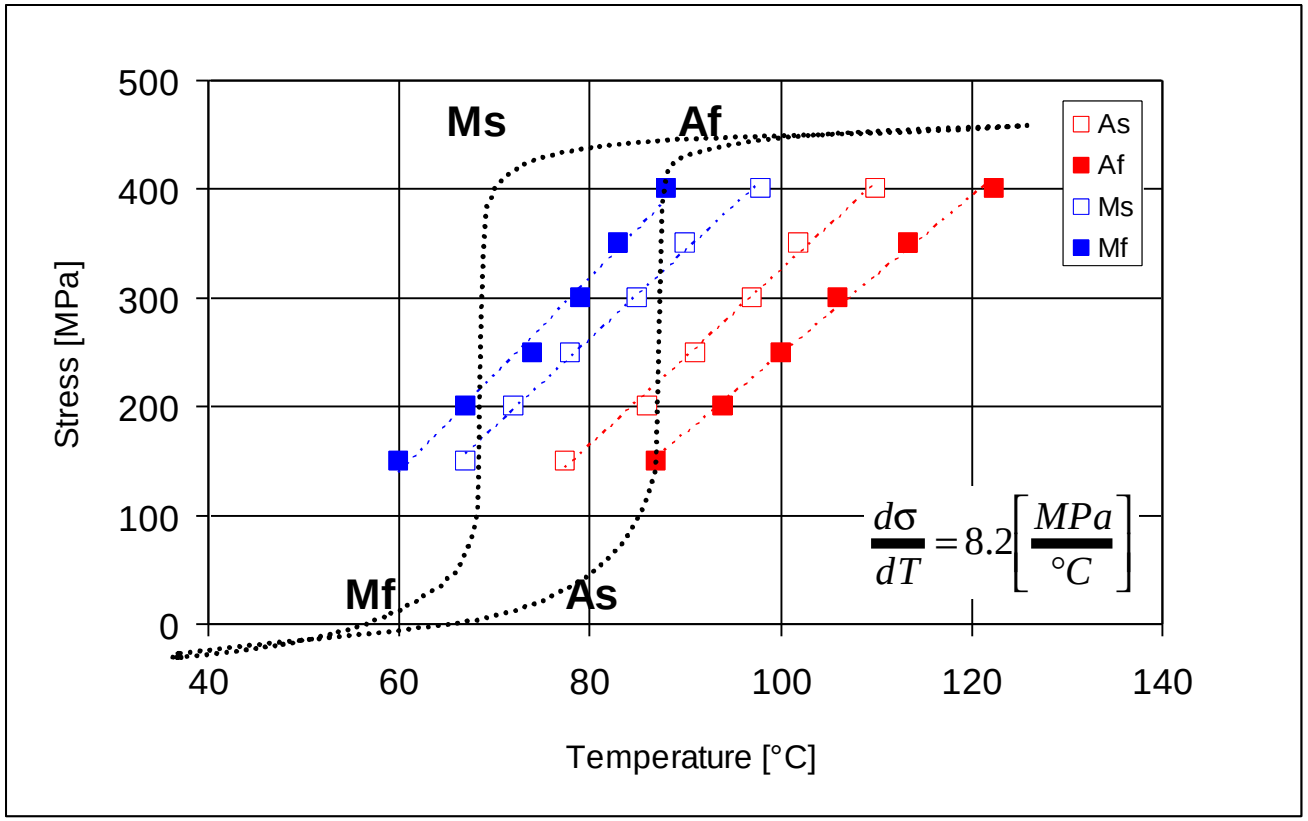
# Smartflex® NiTi wire – hysteresys curve

The curve shows a typical hysteresys cicle of 0,5 mm and 76 μm Smartflex wires
In the Smartflex wire the diameter does not affect the thermo-mechanical characteristics



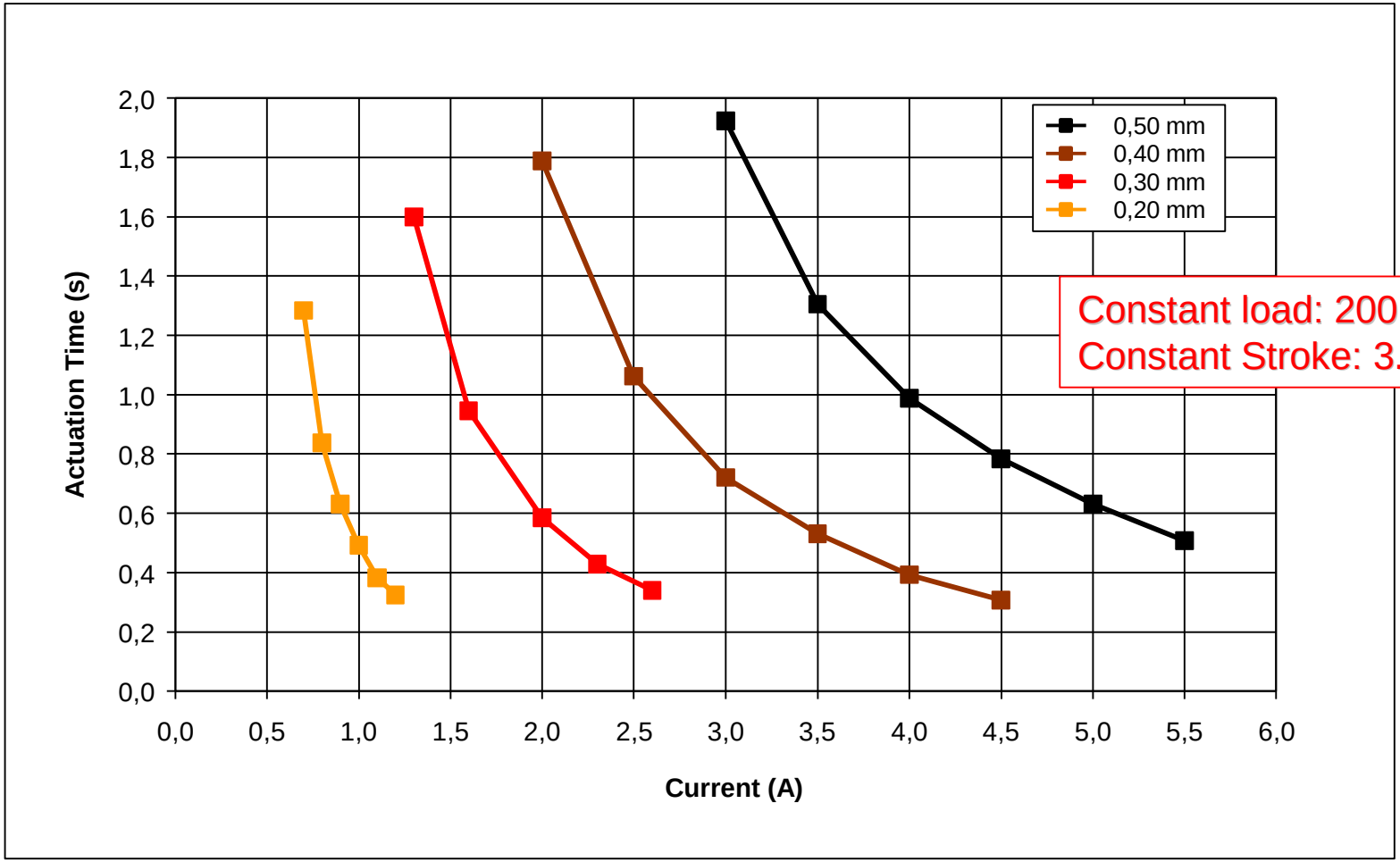
# Smartflex® NiTi wire – transformation temperatures

Hysteresys curve moves towards higher temperatures
by increasing the applied stress in the wire

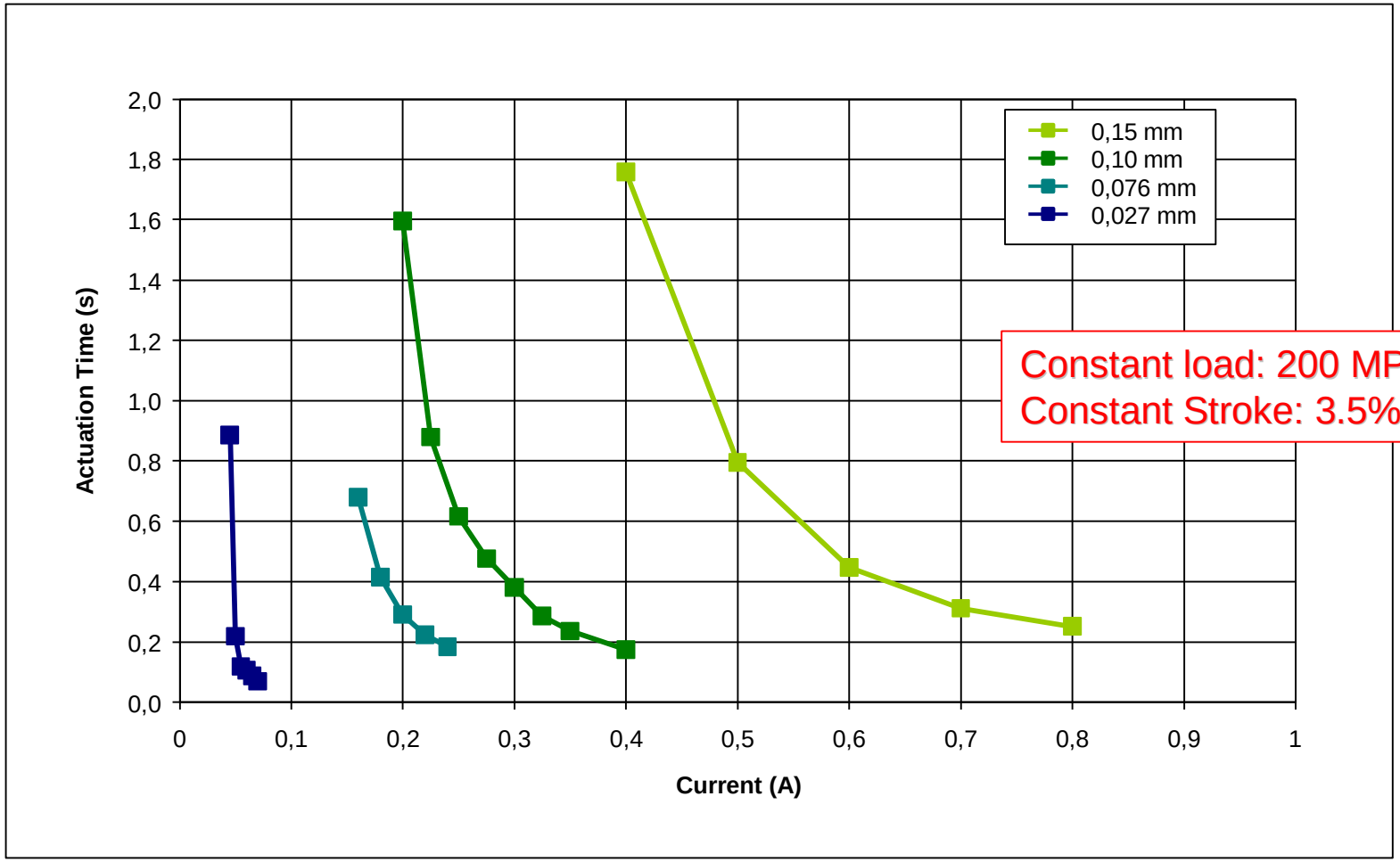



**Transformation temperature of a SmartFlex High temperature wire**

# SmartFlex® - Actuation Time

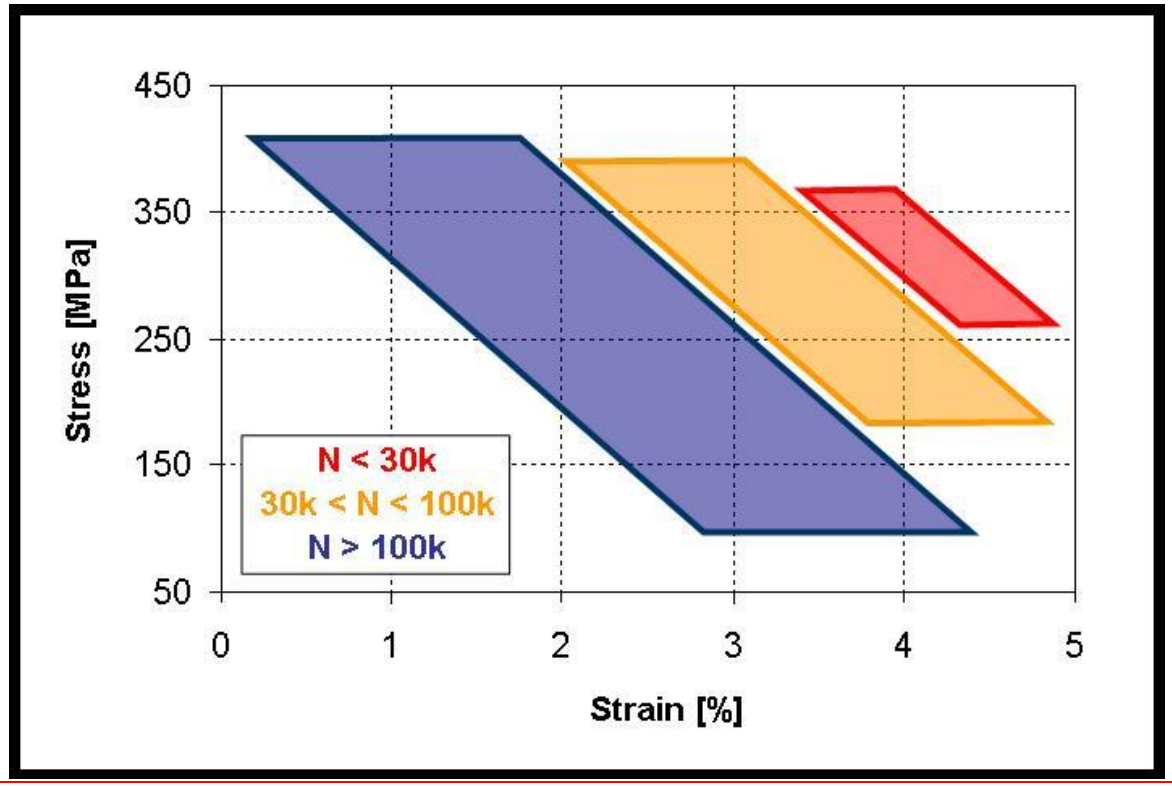


# SmartFlex® - Actuation Time



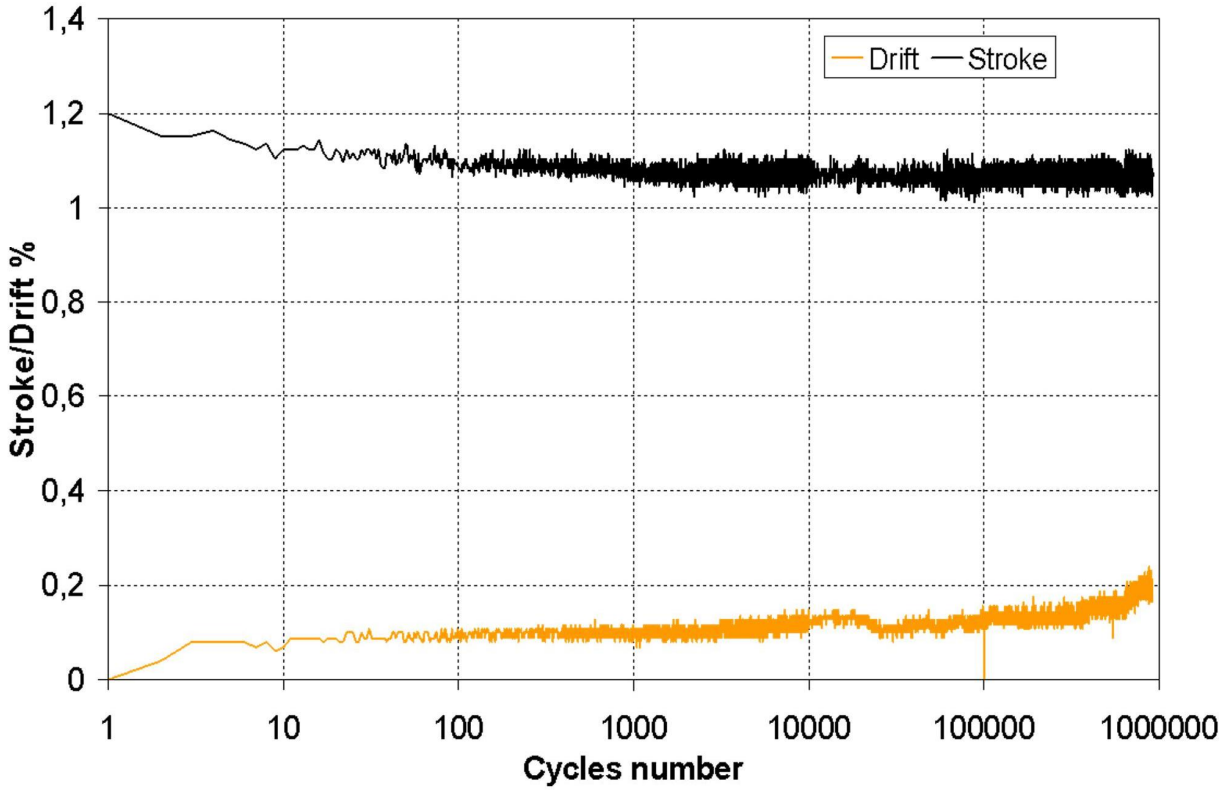
# Smartflex® NiTi wire – fatigue behaviour

Life cycles depend on a stress-strain trade-off
To increase the strain in the wire means to decrease the stress
to acheive the same fatigue life

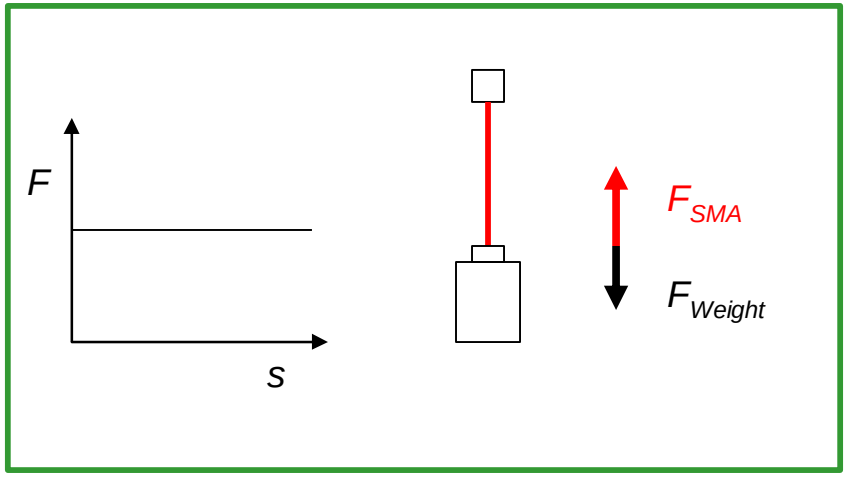


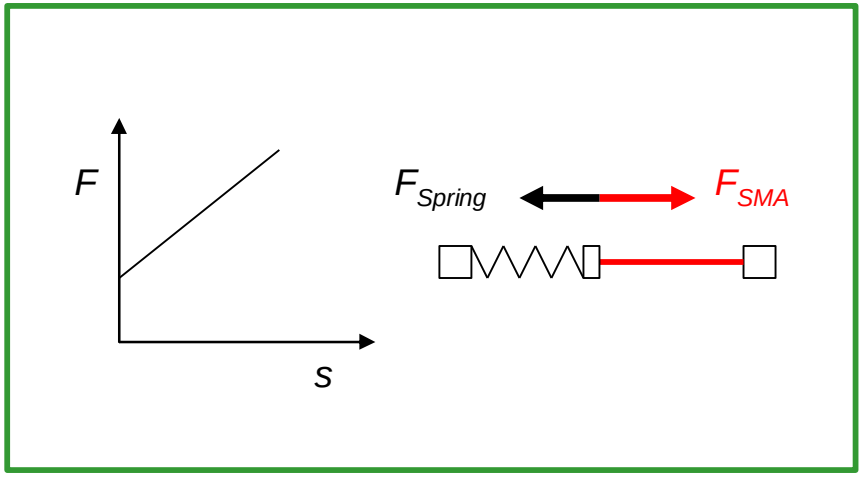
# SmartFlex® 76 µm - Fatigue test

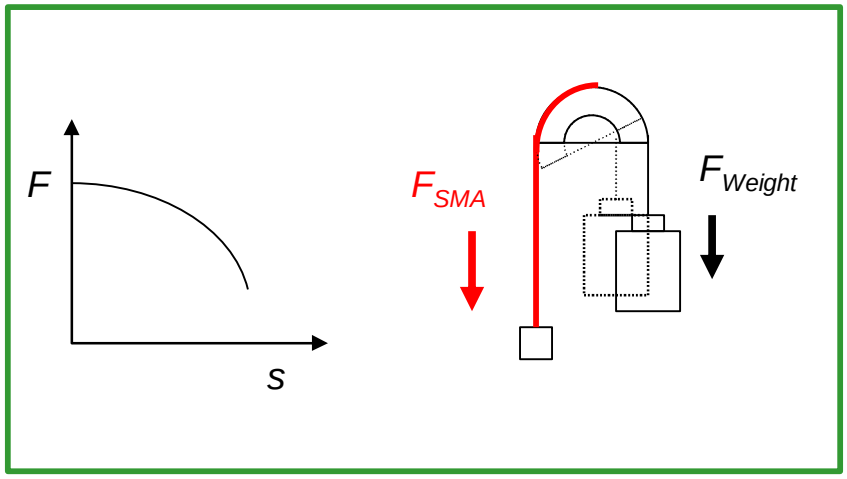
**SMARTFLEX wire performs more than 1 million of cycles at 1% of stroke and 350 MPa of stress**

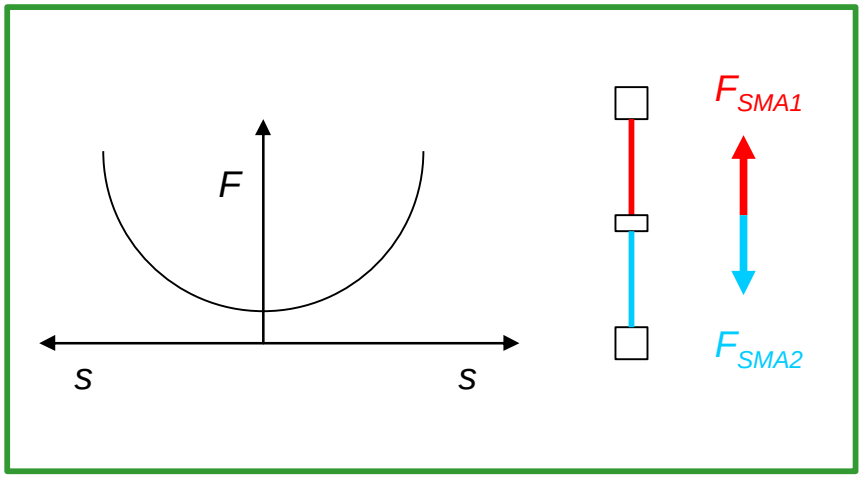


# Some Possible Actuation Mechanisms of a SMA Tension Wire

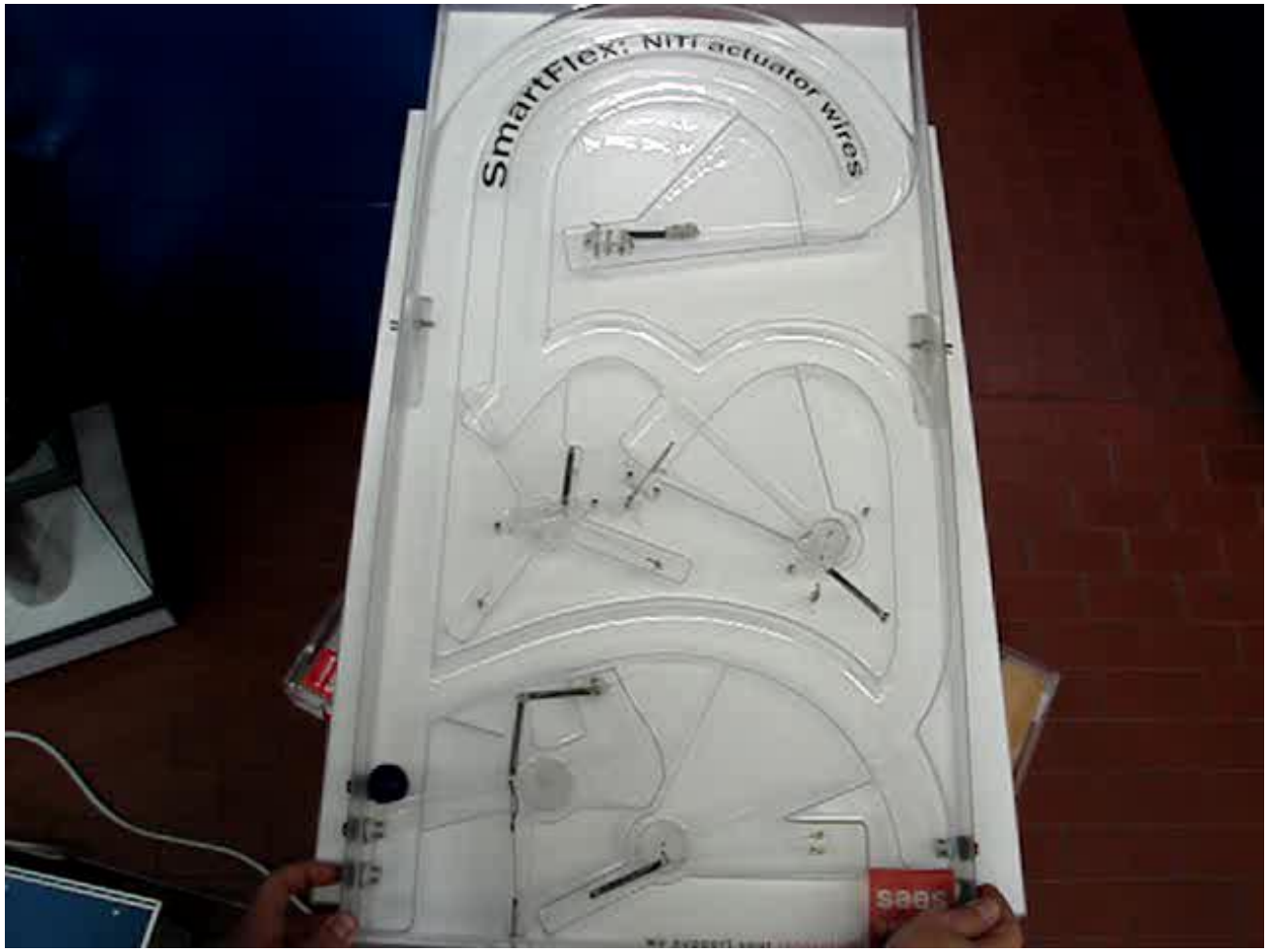


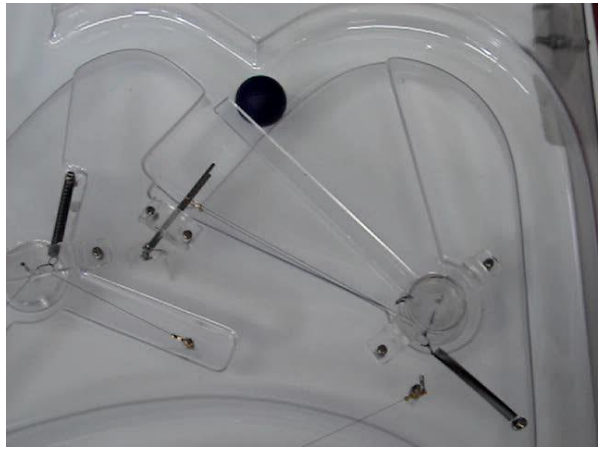



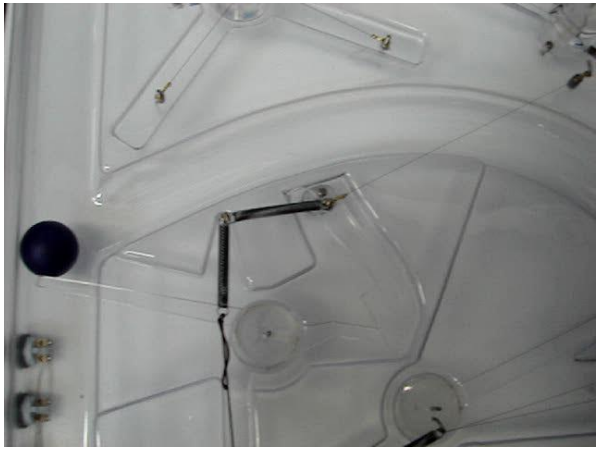



# SMA Pinball



# SMA Pinball – actuators details





# NiTi physical properties at a glance

| | |
|---|---|
| Transition T | -200 ÷ 100°C |
| Transformation strain | 8% (1 cycle), 6% ($10^2$ cycles), 4% ($10^5$ cycles) |
| Thermal hysteresis | 15 - 30°C |
| Bulk density | 6,45 g/cm$^3$ |
| Electrical resistivity | 80 μΩcm (M) ; 100 μΩcm (A) |
| Corrosion resistance | Excellent |
| Melting point | 1310°C |
| Elastic modulus | 28 ÷ 41 GPa (Martensite), 83 GPa (Austenite) |
| Breaking load | 1500 (cold worked) MPa |