

SMA's for Industrial
applications
From first NiTiNOL
to a big success

Francesco Butera



making **innovation happen**, together

70 years of World Wide leadership

For more than **70 years**, our **technology** has been supporting **innovation** in the:

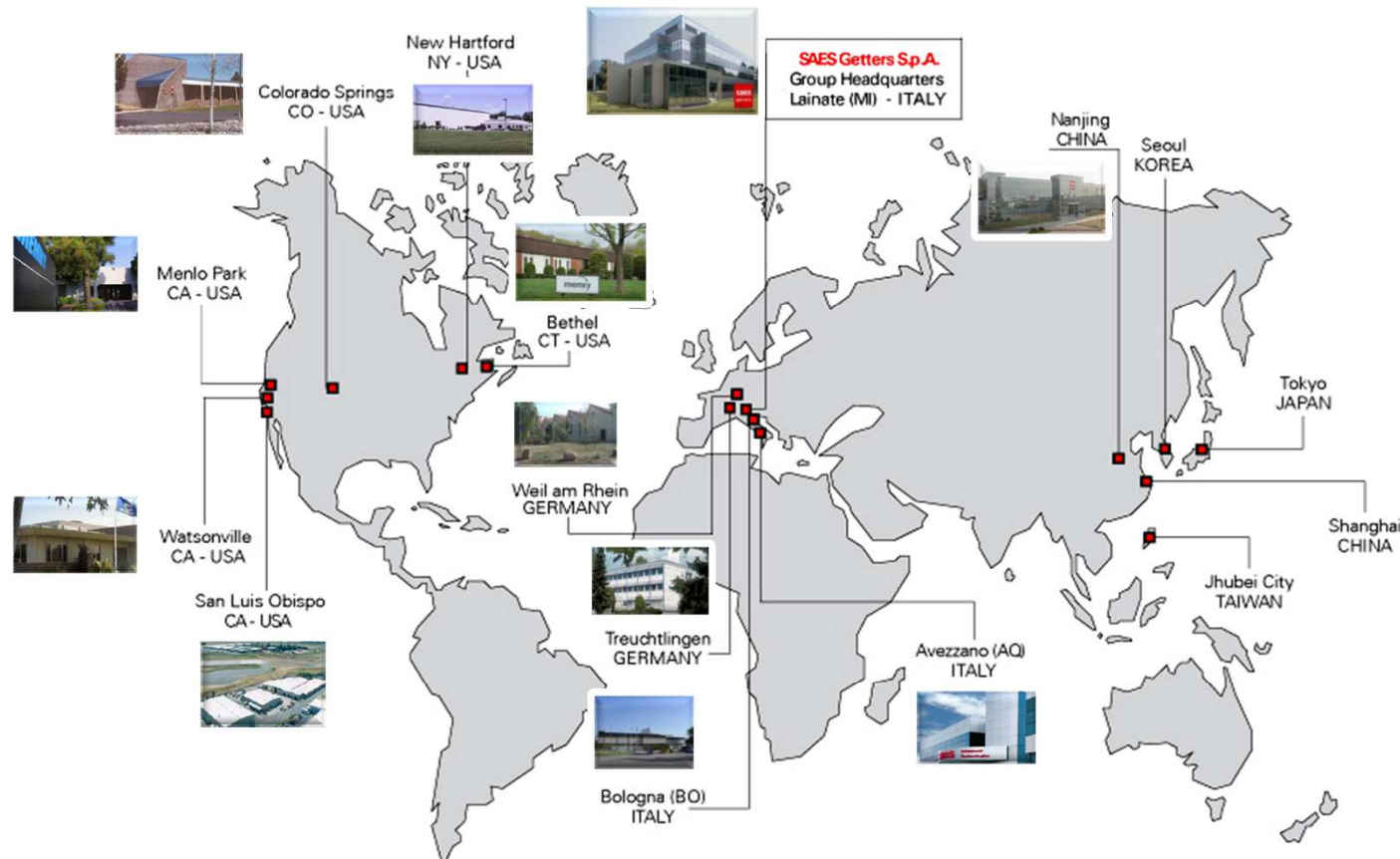
- Information and Displays industry,
- Lamp industry,
- Vacuum and Ultra-high Vacuum applications,
- Vacuum tubes and electronic devices industry,
- Ultra-high gas purification for Semiconductors,
- Renewable Energies area.

Since 2004 our **NiTi smart materials solutions** have been innovating:

- the Medical devices industry,
- the Consumer electronics industry,
- the Automotive industry,
- the White Goods and Domestic industries.



Global Presence



- Worldwide-based sales and service network through Subsidiaries located in Europe, Asia, USA
- Over 1000 employees
- 10 manufacturing facilities in 3 continents

Group Organization

SAES Group serves customers through four global **Business Units** that addresses different markets and applications



Industrial Applications BU

- LIGHT SOURCES
- ELECTRONIC DEVICES
- VACUUM SYSTEMS & THERMAL INSULATION
- RENEWABLE ENERGIES
- SEMICONDUCTORS



Shape Memory Alloys BU

- MEDICAL DEVICES
- INDUSTRIAL APPLICATIONS for Consumer Electronics, Domestic, Automotive



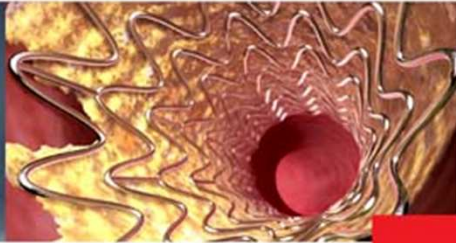
Information Displays BU

- ORGANIC LIGHT EMITTING DIODES DISPLAYS (OLEDs)
- LIQUID CRYSTAL DISPLAYS (LCDs)
- COLOR CATHODE RAY TUBES (CCRTs)



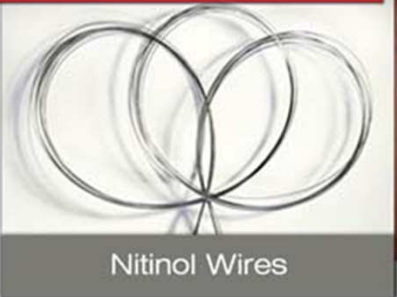
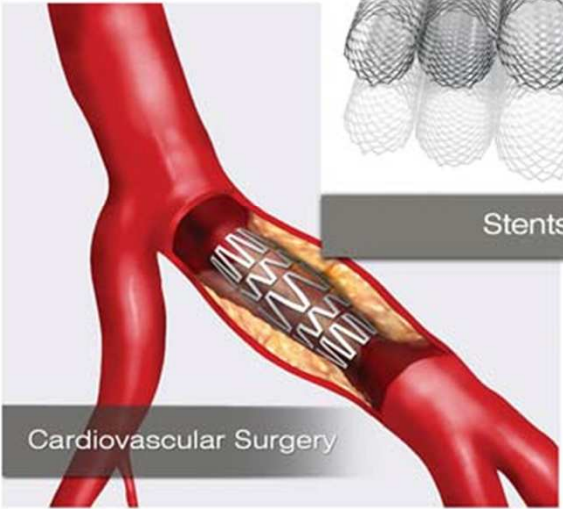
Business Development BU

SMA for medical



Medical
Devices

State of the art
mini invasive
technology



SMA for industrial

White goods



SMA Products

Domotics



Air Management

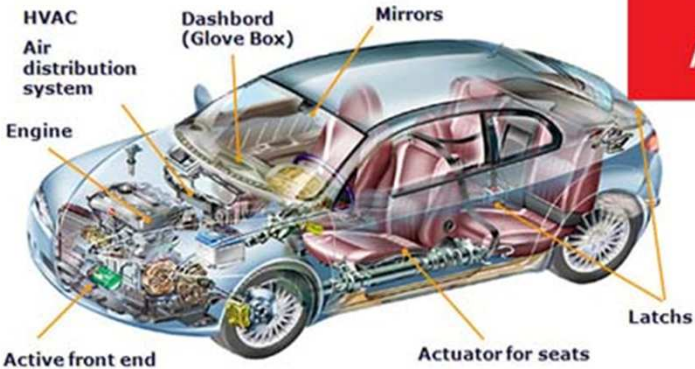
Lighting Control & Retrofit

Smoke Control



Shape Memory Alloys
Industrial Applications

Automotive



HVAC
Air distribution system

Dashboard (Glove Box)

Mirrors

Engine

Active front end

Actuator for seats

Latches



SMA Springs

Consumer Electronics



Our SMA Device company



Domotics



Air Mixing Device

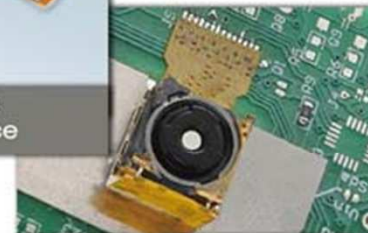
Consumer Electronics



Actuator Solutions
Joint Venture
a SMA devices
Company



Optical Image Stabilizer Device



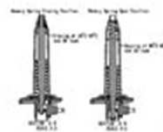
Camera Tilt Optical Image Stabilizer



Automotive



Actuator



White goods

SMA Actuators

silent, powerfull, controllable, simple and ready for your business

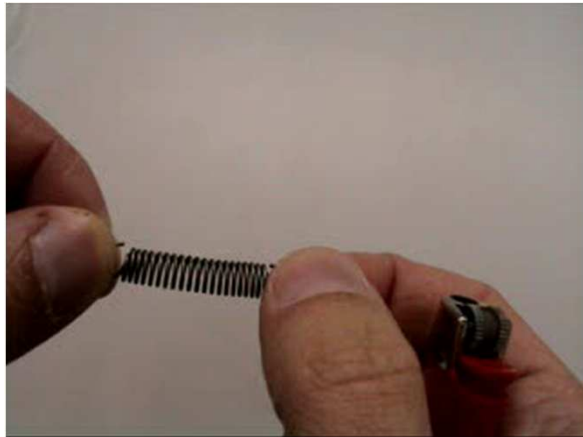
Have fun !!!



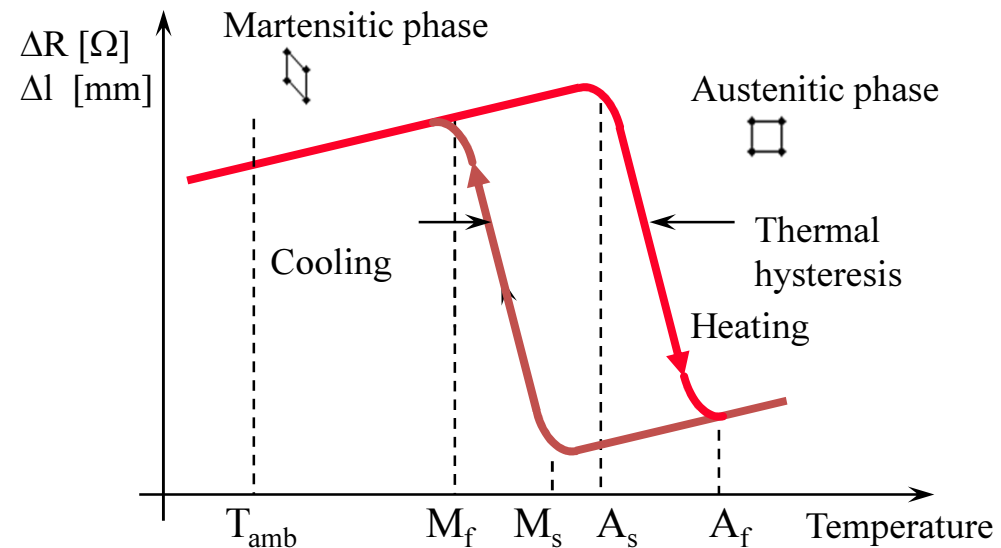
making innovation happen, together



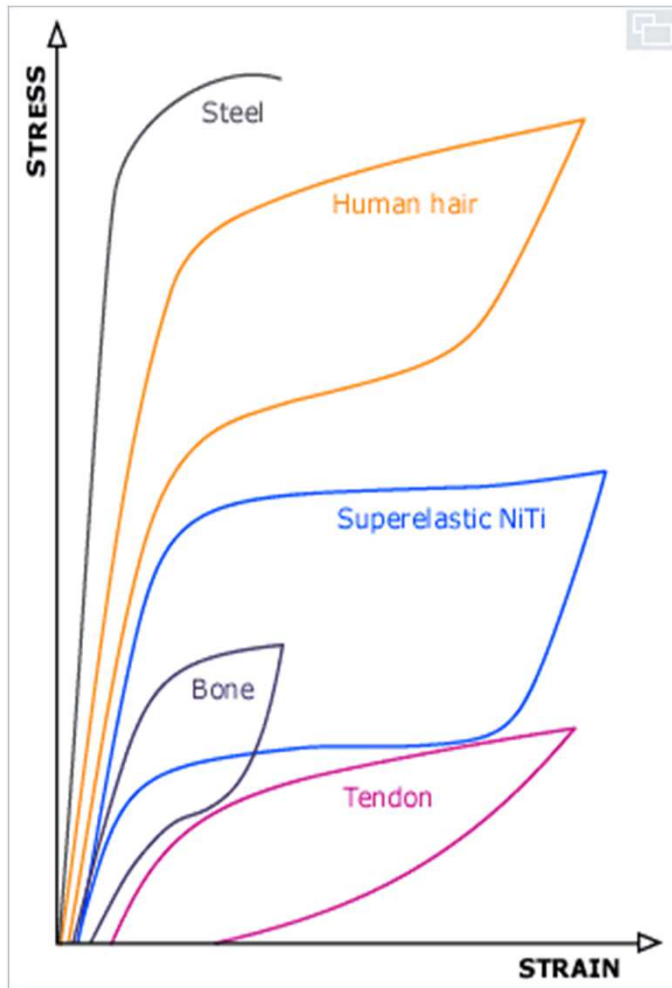
Shape Memory Effect



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

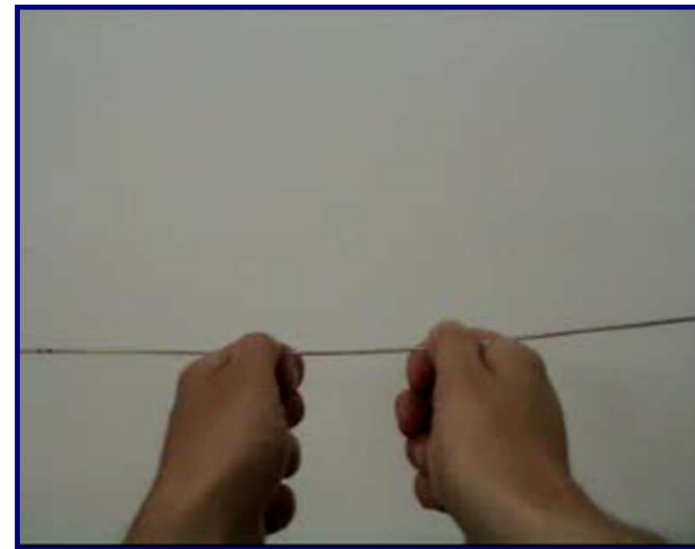


SMA Superelastic alloys



Superelastic behaviour

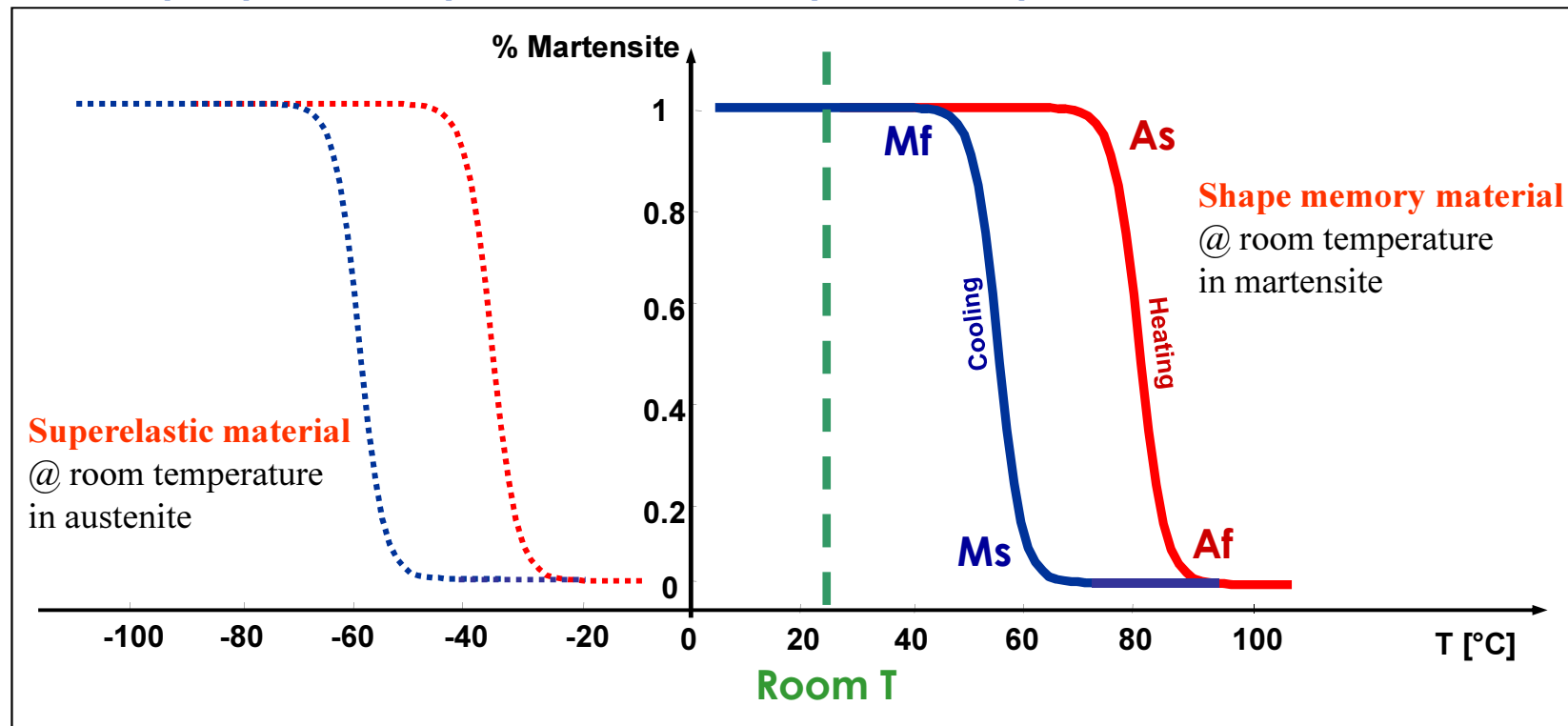
Elastic recovery of a very large deformation (10 – 12 %)



Shape Memory & Superelastic effect

Making small changes in the composition can change the transition temperature of the alloy significantly. For this reason, SMA may be in austenite or in martensite at room temperature, showing a superelastic or a shape memory properties.

Histeresys cycle for Superelastic and shape memory material



Full portfolio of Nitinol products



Ingots
Bars
Coils and Redraw



Tubes
Wires
Sheets
Ribbon



Trained wires
Coil Springs
Shaped components



Tubular Laser Cut Stents
Wire Stents and Wire Forms
Micro-coils and Shapes
Specialty Guidewire
Clean room assembly



**From raw material to advanced components –
an unique and integrated offer**

Some pictures





VIM Furnace



NiTi Ingot



NiTi coils

making innovation happen, together

Wire drawing line



SmartFlex[®] Wires

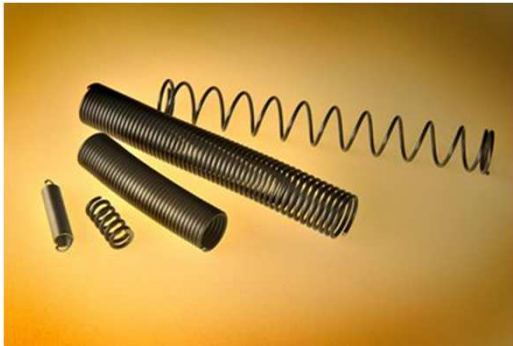


SMARTFLEX
is a 100% quality controlled
SM wire for actuators

Main characteristics:

- Diameter: from 20 to 500 μm
- Transformation temperatures: 10 – 100 $^{\circ}\text{C}$
- 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

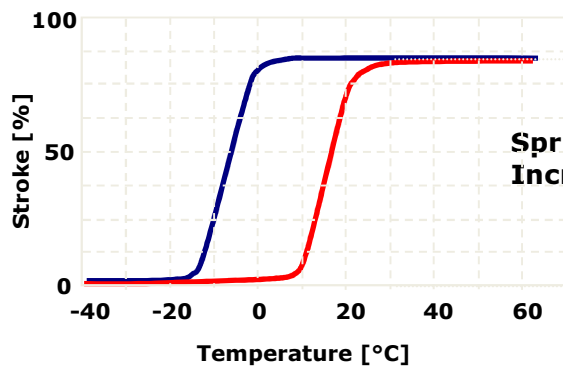
SmartFlex springs



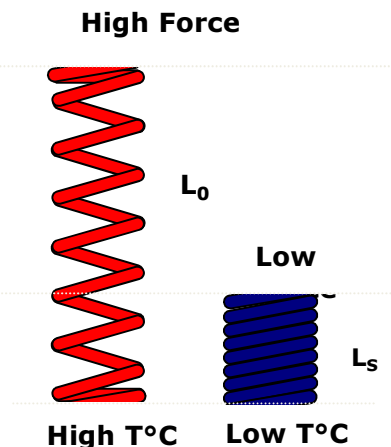
As thermal-actuators SMA' springs are very specific products. The combination of composition, heat treatment and operating conditions permits to cover a wide range of activation temperatures. Customized solutions may be developed to fulfill several applications.

Springs vs. Wire

- Higher Stroke
- Lower Force
- Indirect Heating
- Sensor - Actuator
- Customization



Typical Hysteresis curve of a Compression Spring



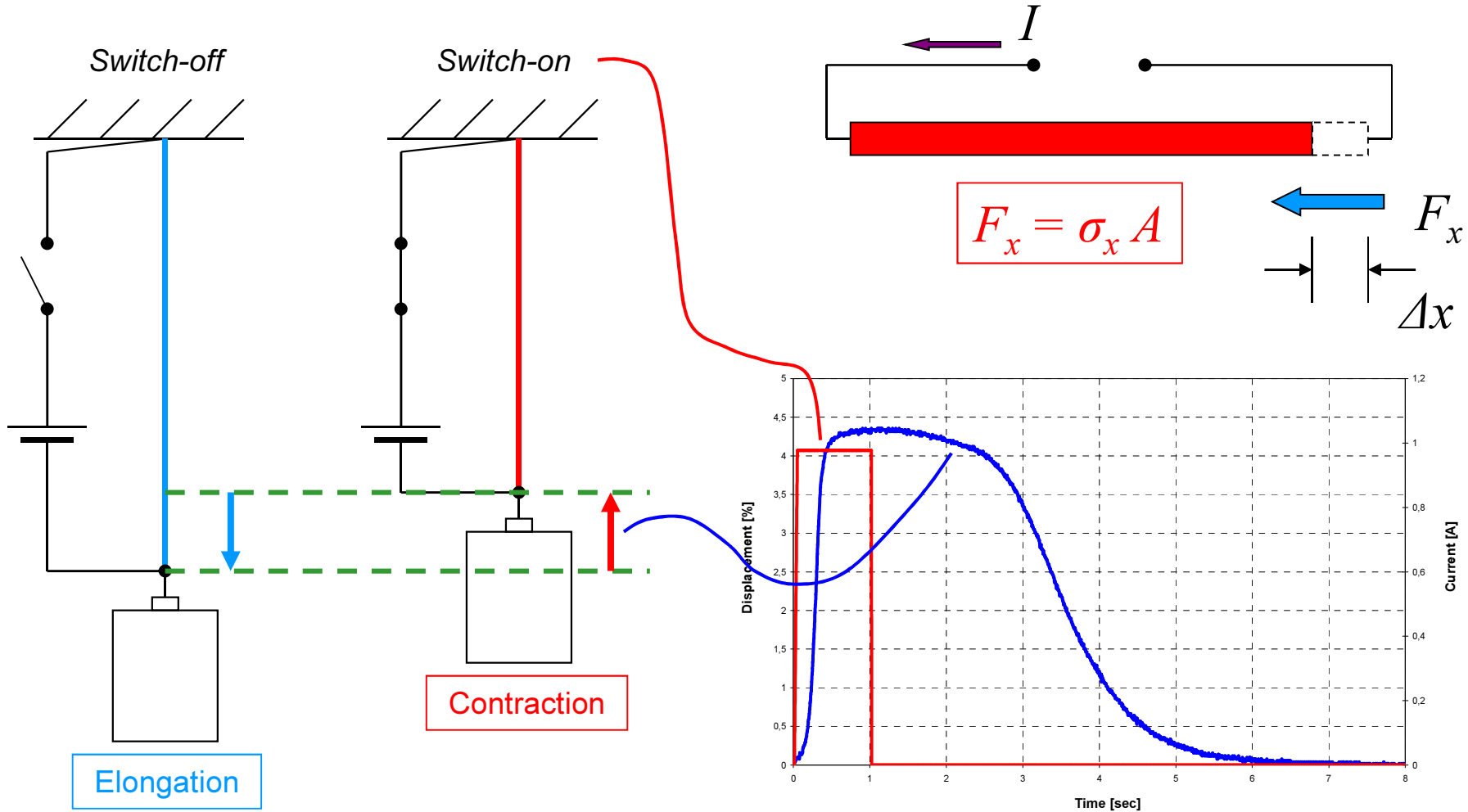
At low temperature the Martensite phase presents low force.

At high temperature the Austenite phase presents high force.

The spring moves continuously between such extreme positions in noiseless operation.

Activation temperature can be set between -50 and +100°C

Shape Memory Effect for Actuation

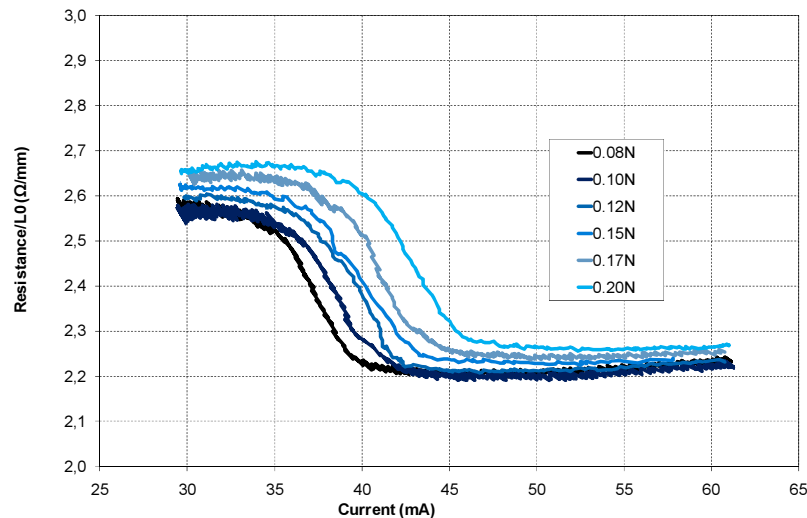


SMA works as an on-off operation, I need to control it ...

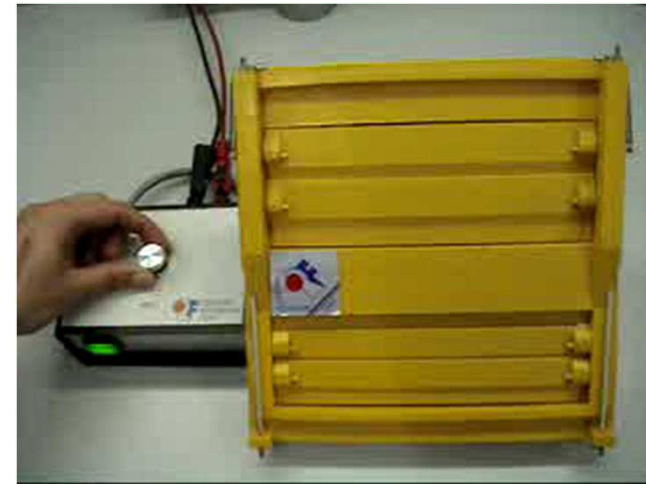
... SMA wires offer an intrinsic position sensor

since their electrical resistance change accordingly to the displacement during the transition from martensite to austenite (from about 100 to 80 $\mu\Omega$ cm).

It is possible to control the displacement using the linear part of the curve as a feedback.



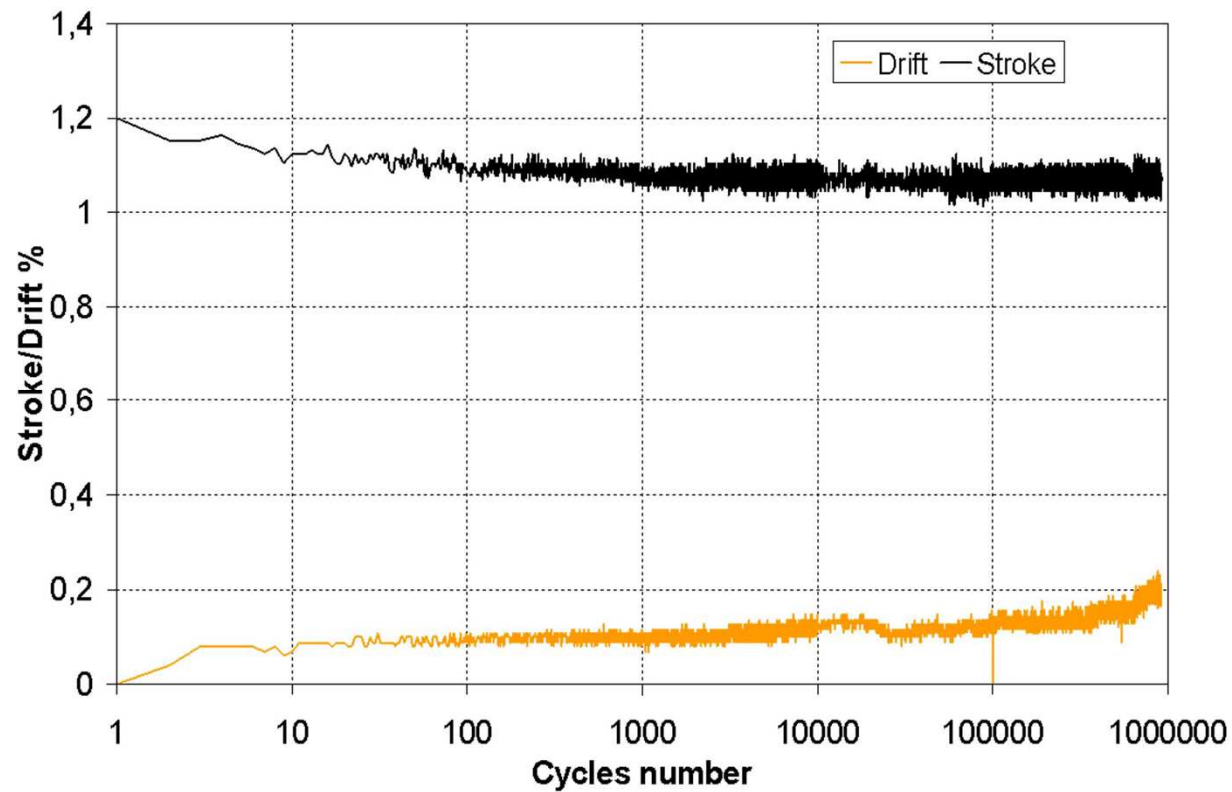
Electrical resistance vs current during the transformation cycle



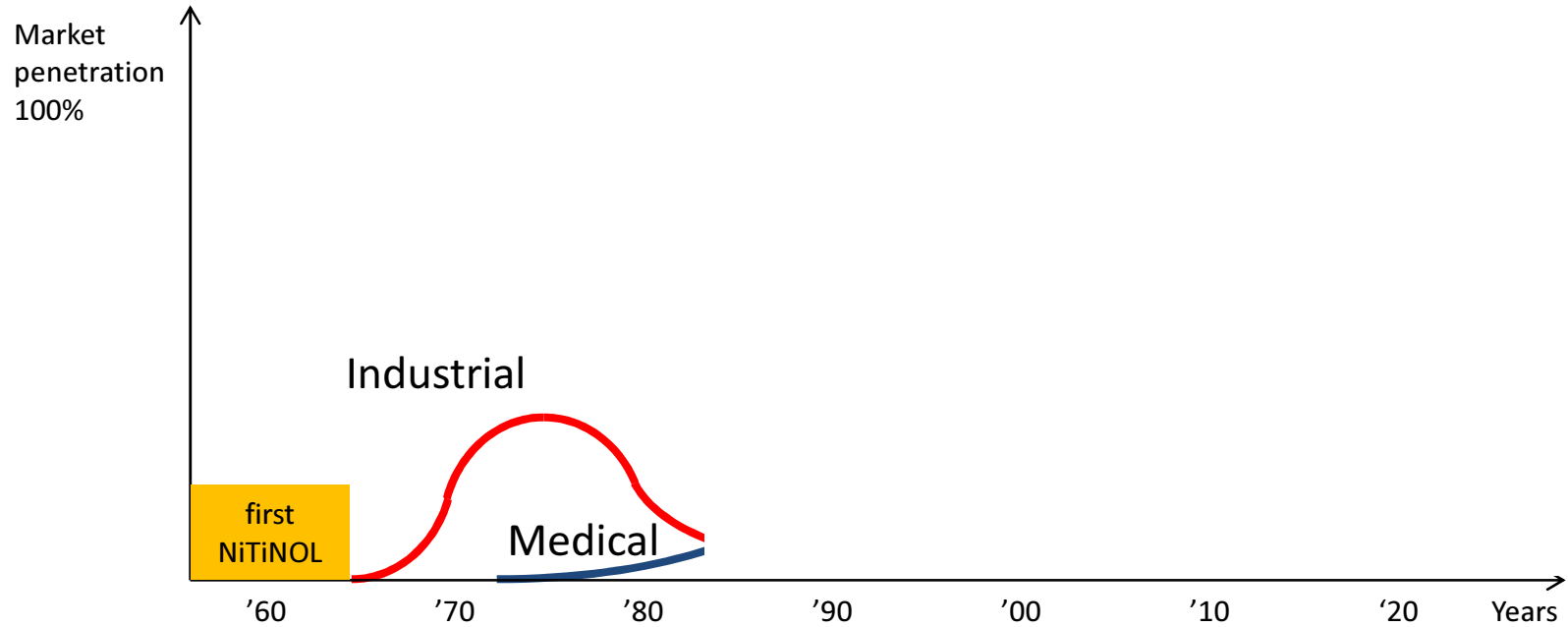
Example of controllable actuator from Fiat Research Centre

SmartFlex[®] 76 μm - Fatigue test

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



NiTiNOL on the market: From discovery to full success



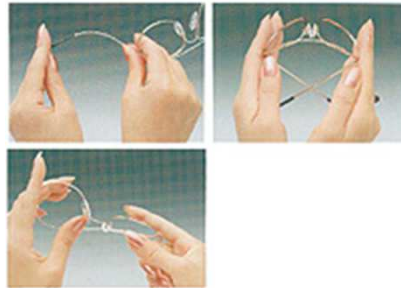
Technology	SE effect SE design	
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Applications	Antennas Dental wires Lock rings	
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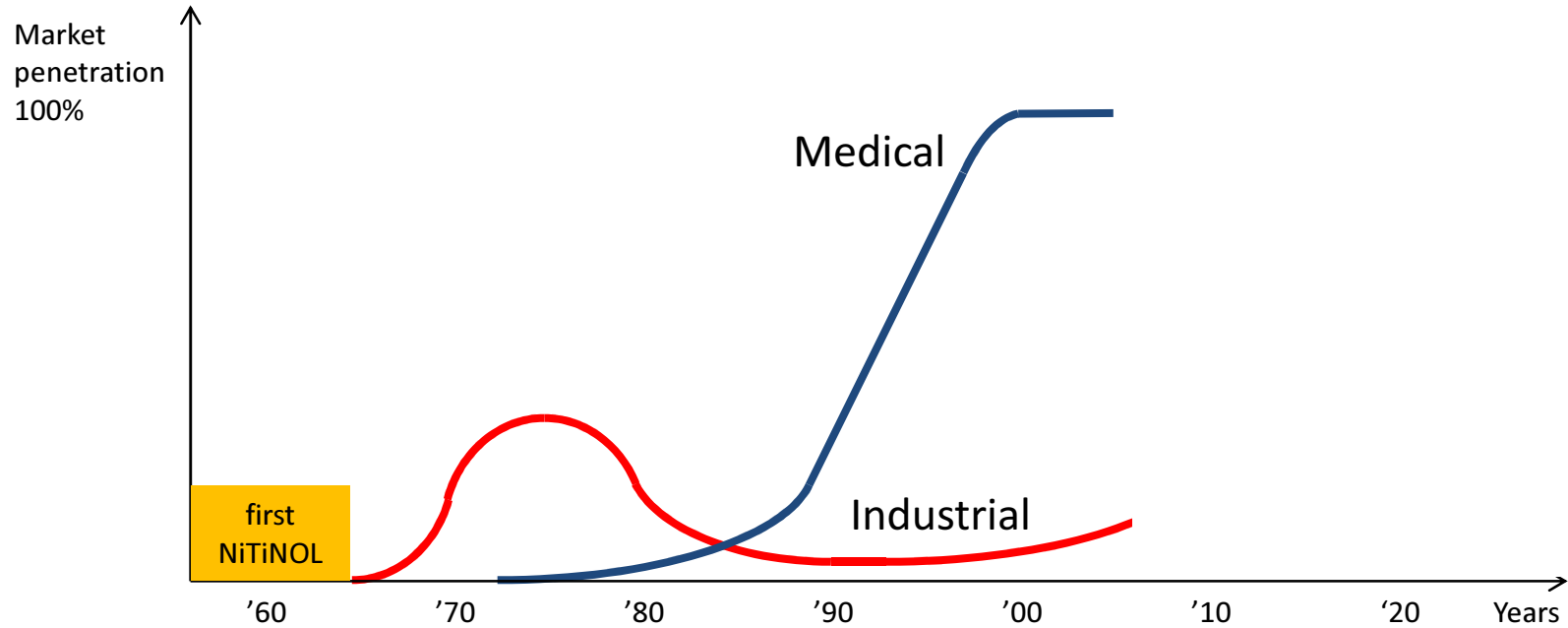
'80s: First Industrial applications

First applications exploited the superelastic effect for simple devices...

The first Shape Memory application was on “one shot” shrinkage to tighten connectors. This solution is still in production in the aerospace field



NiTiNOL on the market: From discovery to full success



Technology	SE effect SE design	High quality SE SMA Large scale melting	SE modelling Laser cutting	
		Tubing	Coil springs	

Applications	Antennas Dental wires Lock rings	First actuators	Guidewires Stents Bone staples Implantable dev.	
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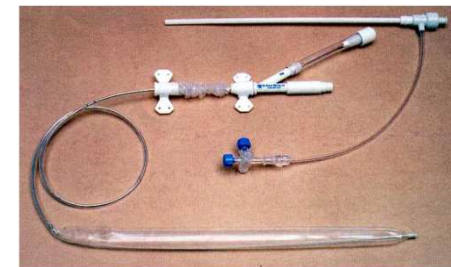
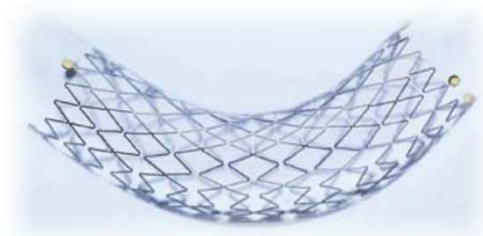
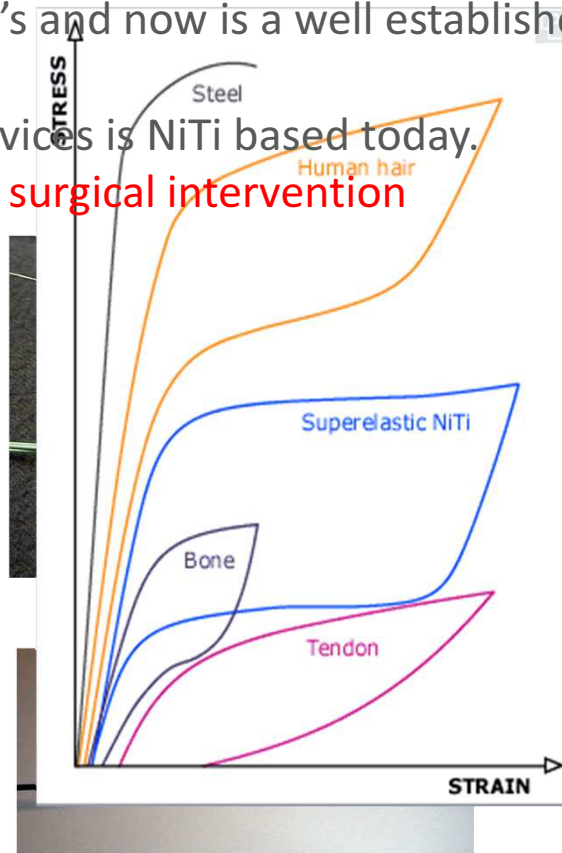
'90s – '00s: Medical applications and market

Due to the perfect match between superelasticity in SMAs and human tissues properties, NiTi has been introduced and successfully used in several medical application.

This market started in the 90's and now is a well established business.

Almost every implantable device is NiTi based today.

This was a real revolution on surgical intervention



'90s – '00s: JP pioneering the industrial application

...At the same time, only in JP, University and Companies started first real applications using shape memory elements as thermal or electrical actuators

Some of them are still successfully in production



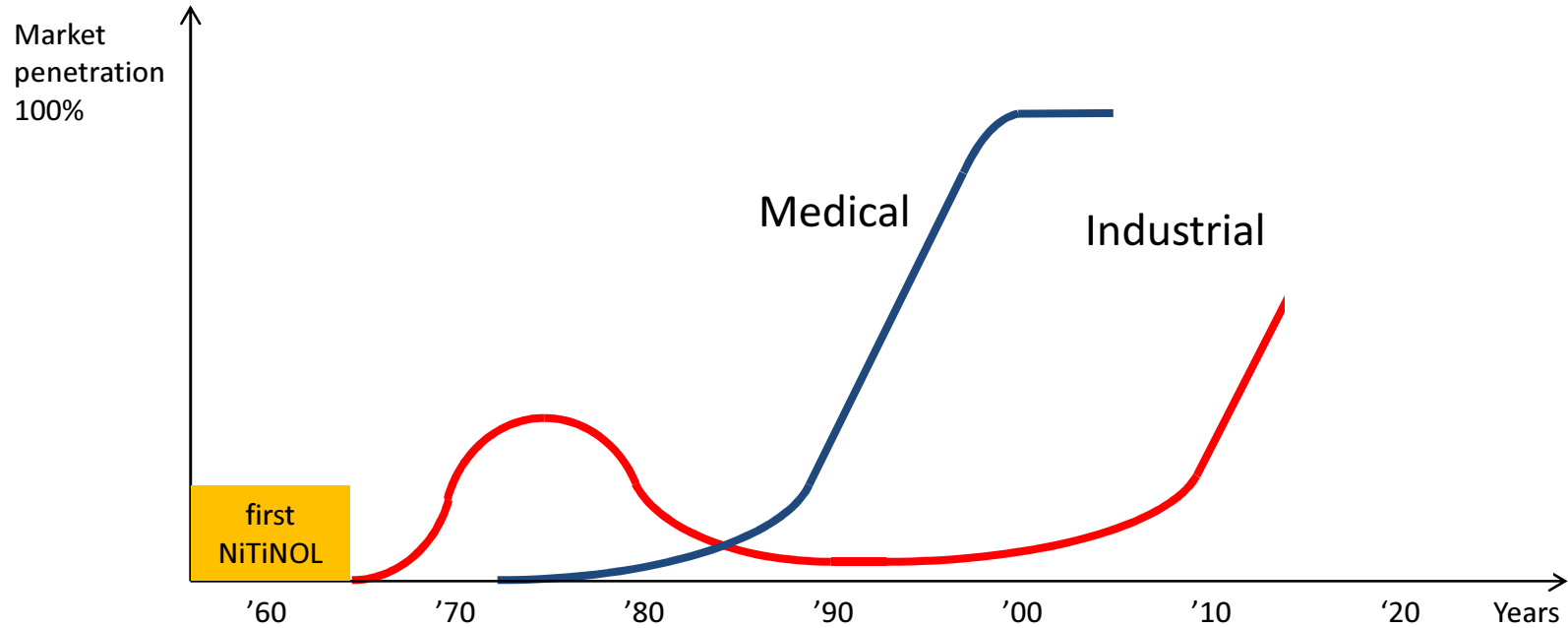
←Hot

Cold→



...In EU and USA automotive companies like FIAT and GM started interesting research on new devices generating new interest on this technology for industrial application

NiTiNOL on the market: From discovery to full success



Technology	SE effect SE design	High quality SE SMA Large scale melting	SE modelling Laser cutting	High quality SMA SMA control SMA design SMA modelling
		Tubing	Coil springs	

Applications	Antennas Dental wires Lock rings	First actuators	Guidewires Stents Bone staples Implantable dev.	Thermostatic actuators Electrically Controlled actuators
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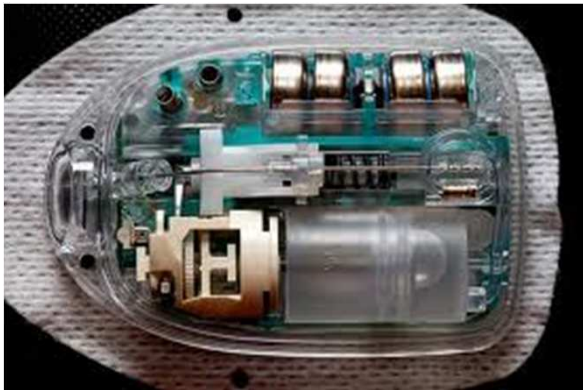
Today: Omnipod – the SMA insuline pump



The Omnipod Insulin Pump portable delivery system provides a “freedom of lifestyle” change for diabetics requiring Insulin use.

The unique product was made possible with the use of a Shape Memory Alloy wire actuator jointly developed with Insulet and manufactured by Autosplice

Standard motors are too costly, too heavy, generate too much heat, and require far too much power to provide a portable solution.



The SMA actuator makes this assembly possible from both a technical and cost effective standpoint.

Today: First high volumes automotive application

SMA pneumatic valves for lumbar support in Car's seats from ALFMEIER

Actual production in

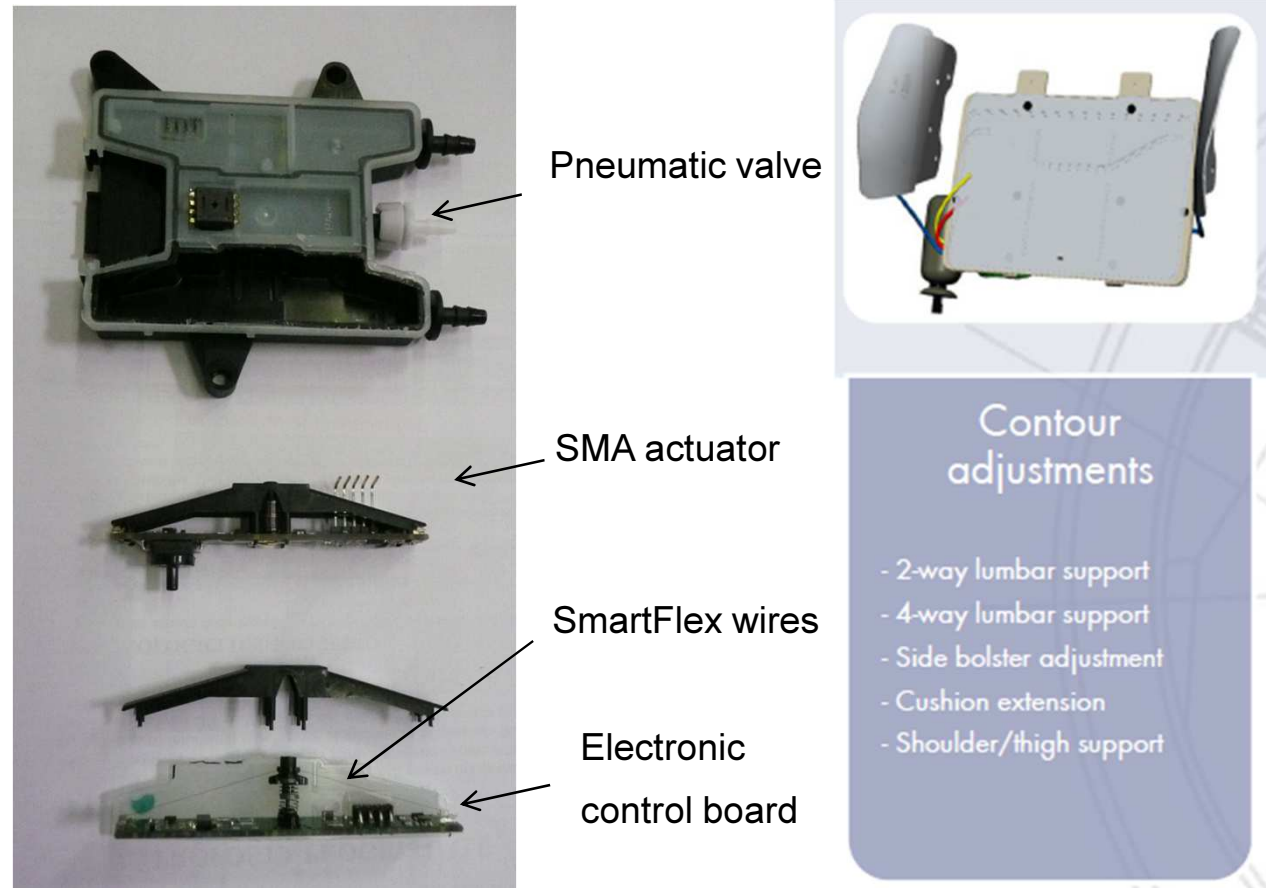
ACTUATOR SOLUTIONS GMBH:

10 million actuators/year

Pneumatic valve to inflate and deflate cushions in car's seats.

Installed in all main vehicle's platform of:

- Daimler
- BMW
- GM
- Hyundai
- Ford
- Porsche/VW



Today: A very large mass production is coming

SMA Optical Image Stabilizer + AF for mobile phones from ACTUATOR SOLUTIONS GmbH

SMA OIS is placed underneath the SMA AF module.

ASG already has a fully working module integrated with a sensor under evaluation by major camera modules makers



With OIS enabled, the lens and sensor tilt inside the camera but remain **still** to the image subject – giving a sharp image

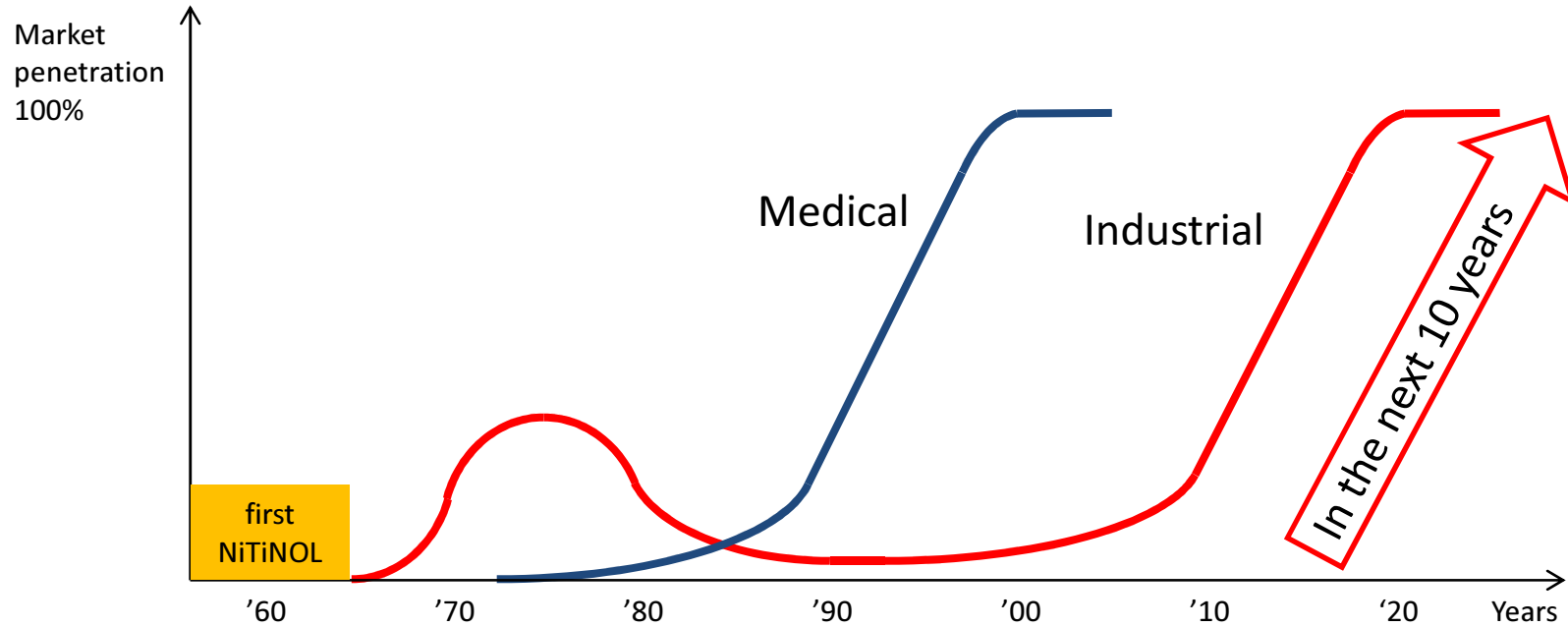


The lens and sensor are tilted **together** with SMA wire on all 4 sides of the camera

Both pitch & yaw tilt are measured by a gyroscope moving mechanically attached to the camera and compensated to a **ZERO output** by the OIS actuator



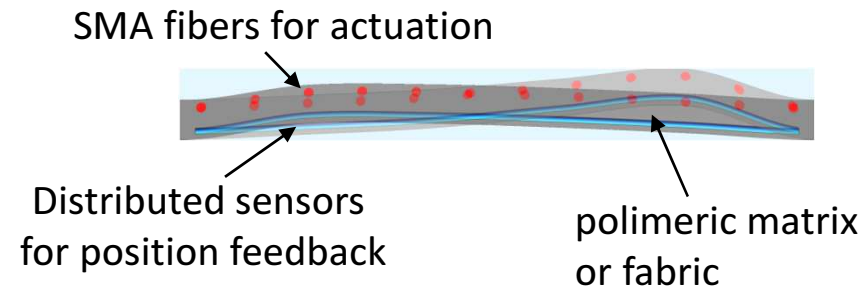
NiTiNOL on the market: From discovery to full success



Technology	SE effect SE design	High quality SE SMA Large scale melting	SE modelling Laser cutting	High quality SMA SMA control SMA design SMA modelling	Thin films
		Tubing	Coil springs		

Applications	Antennas Dental wires Lock rings	First actuators	Guidewires Stents Bone staples Implantable dev.	Thermostatic Actuators Electrical Actuators	MEMS Textiles
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The future... Smart composites

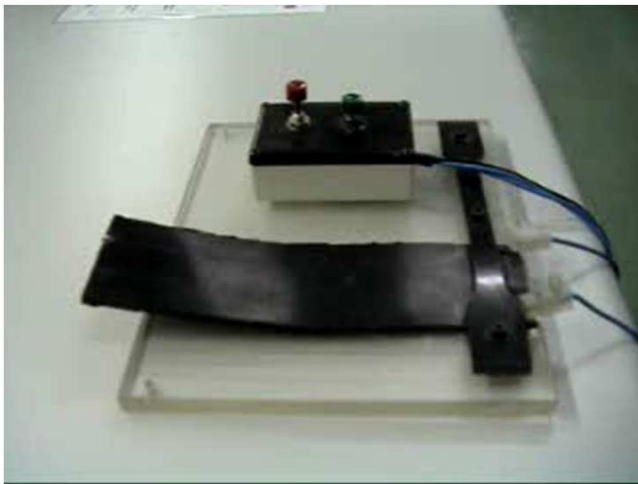


Multifunctional composite structure

Active material with integrated fibers
 Distributed deformable sensor layer
 Smart composite structure

→
 →
 →

Surface morphing and stiffness adaptation
 Detection of deformation feedback
 Adaptive noise reduction

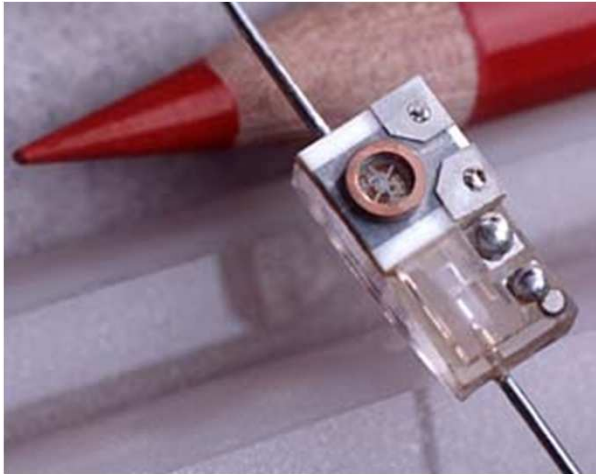


Active flaps based on SMA composite (CRF)

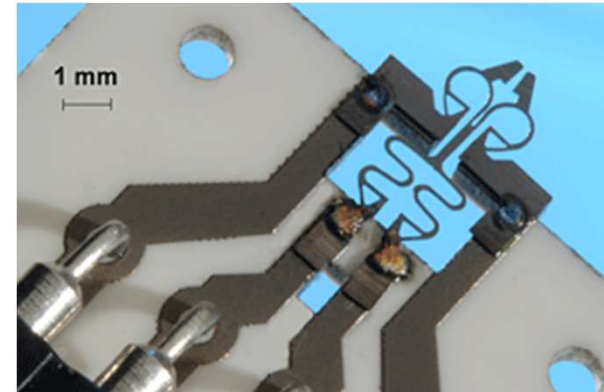


SMA active textile

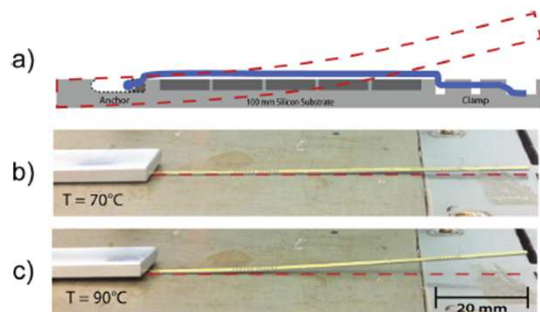
The future... SMA MEMS



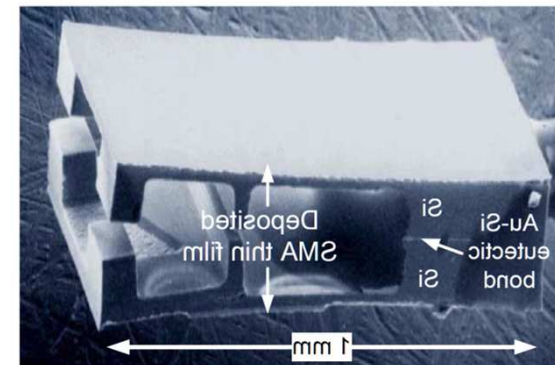
Dosing of a shape memory and a micro-valve flow sensor
Functional Films: PD Dr. Manfred Kohl
KIT - University of the State of Baden



Microgripper of NiTi

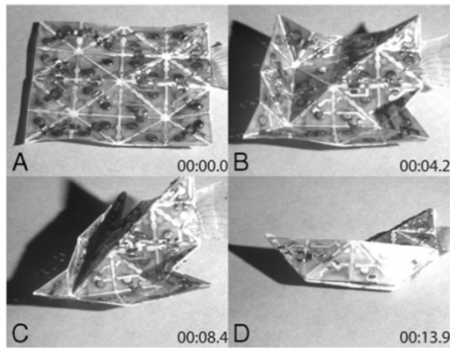


Wafer-level integration of niti shape
memory alloy wires
KTH – Royal Institute of Technology, Stockholm,
Sweden



Heterogeneous Integration of Shape Memory
Alloys for High-Performance Microvalves (2012)
Henrik Gradin, KTH Electrical Engineering

The future... Thin Films and programmable matter



Programmable matter by folding (2010)
Harvard University
Massachusetts Institute of Technology

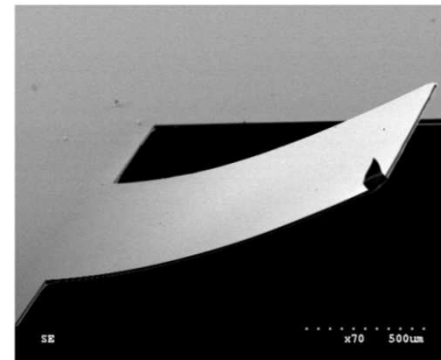


Fig. 10. TiNi deposited micro-cantilever when heated showing shape memory effect

TiNi shape memory alloy thin films for
microactuator application
Nanyang Technological University, Singapore-MIT Alliance

Let's start projects together

Thank for your attention

making innovation happen, together

saes
group

www.saesgetters.com