

# General Applications of NiTi Shape Memory Alloys (SMAs)

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# Organization

- I) Introduction to shape memory alloys
  
- II) Properties of NiTi Shape Memory Alloys
  - (a) Shape memory effect of NiTi
  - (b) Superelasticity
  
- III) Applications of NiTi Shape Memory Alloys
  - (a) Industrial applications
  - (b) Medical and biomedical applications

## Introduction to shape memory alloys

Shape-memory effect was first discovered in a Au- 47.5% at.Cd alloy in 1951

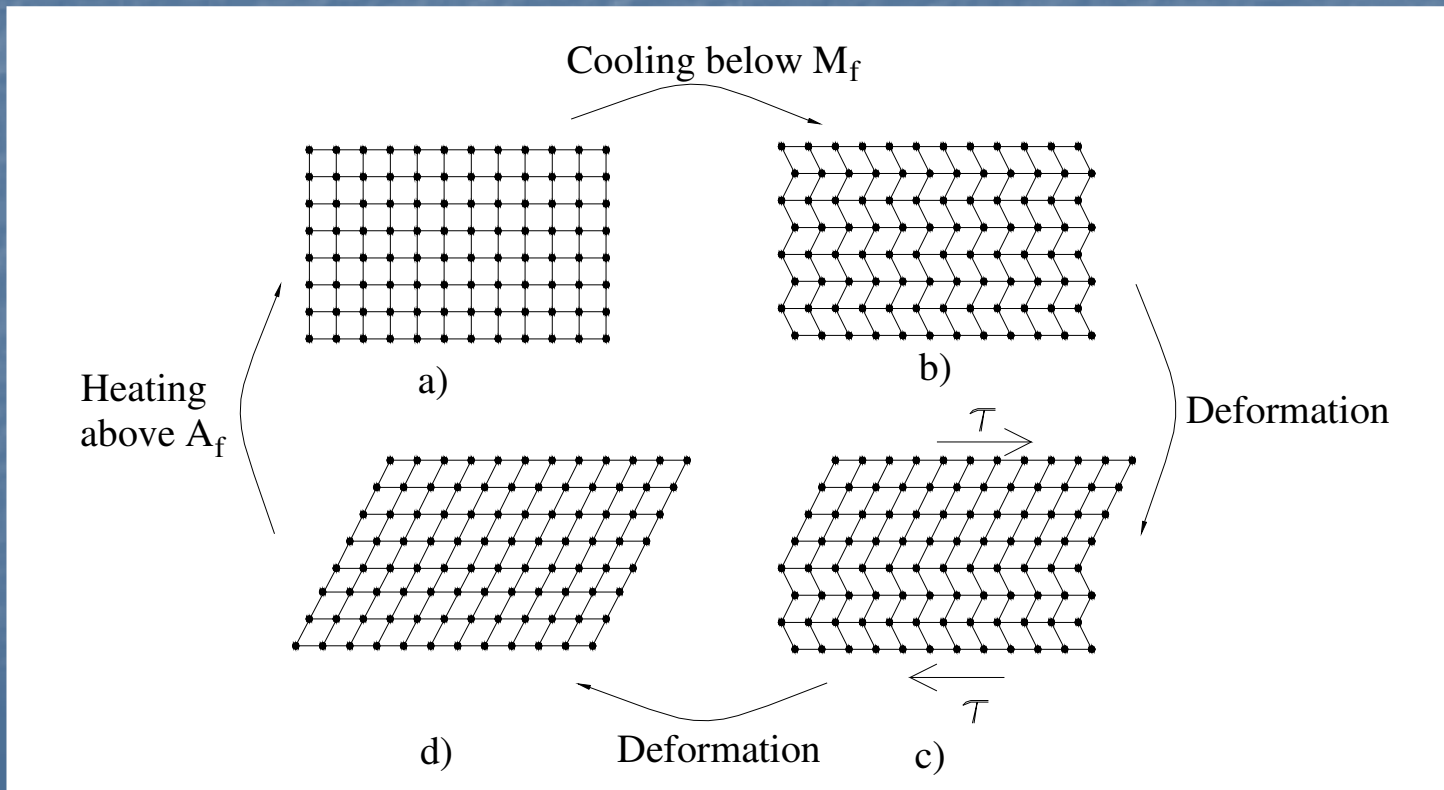
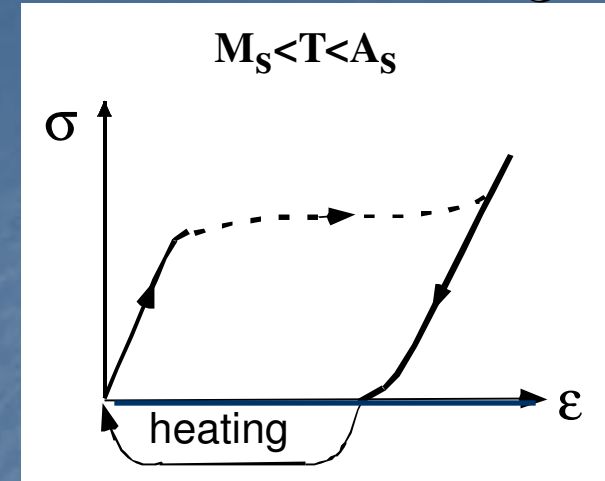
CuAlNi (% 14 Al , % 3.5 Ni wt.), CuZn (% 38.5 / 41.5 Zn wt.)  
NiAl (% 36-38 Al wt.) etc.

### NiTi (near equiatomic) Shape Memory Alloys;

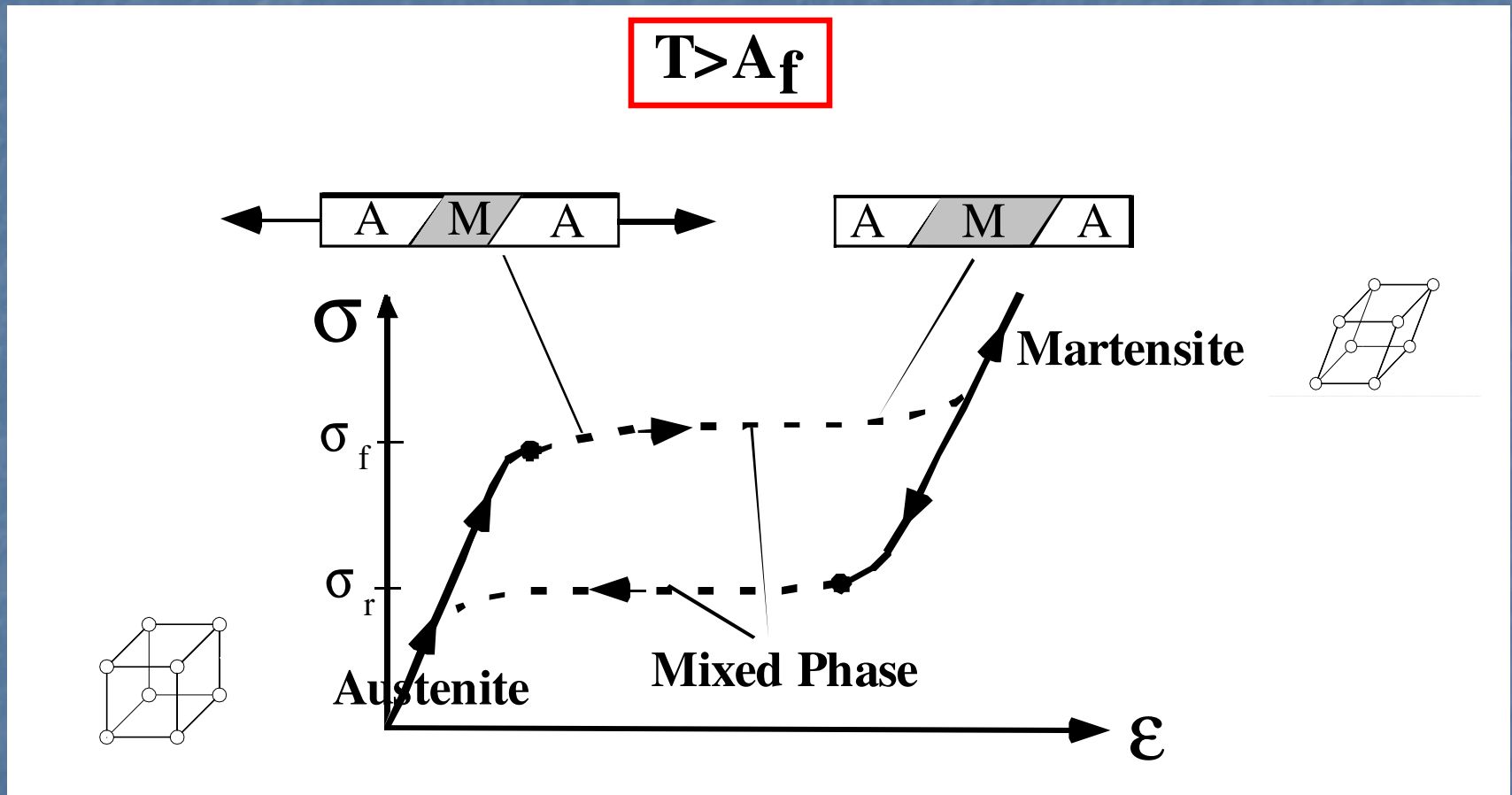
- discovered in 1962 by W.J. Buehler at the US Naval Ordnance Laboratory
- Commercially known as nitinol (Ni Ti Naval Ordnance Laboratory)

# Shape Memory Effect

High temperature phase: Austenite cubic  
Low temperature phase: Martensite monoclinic

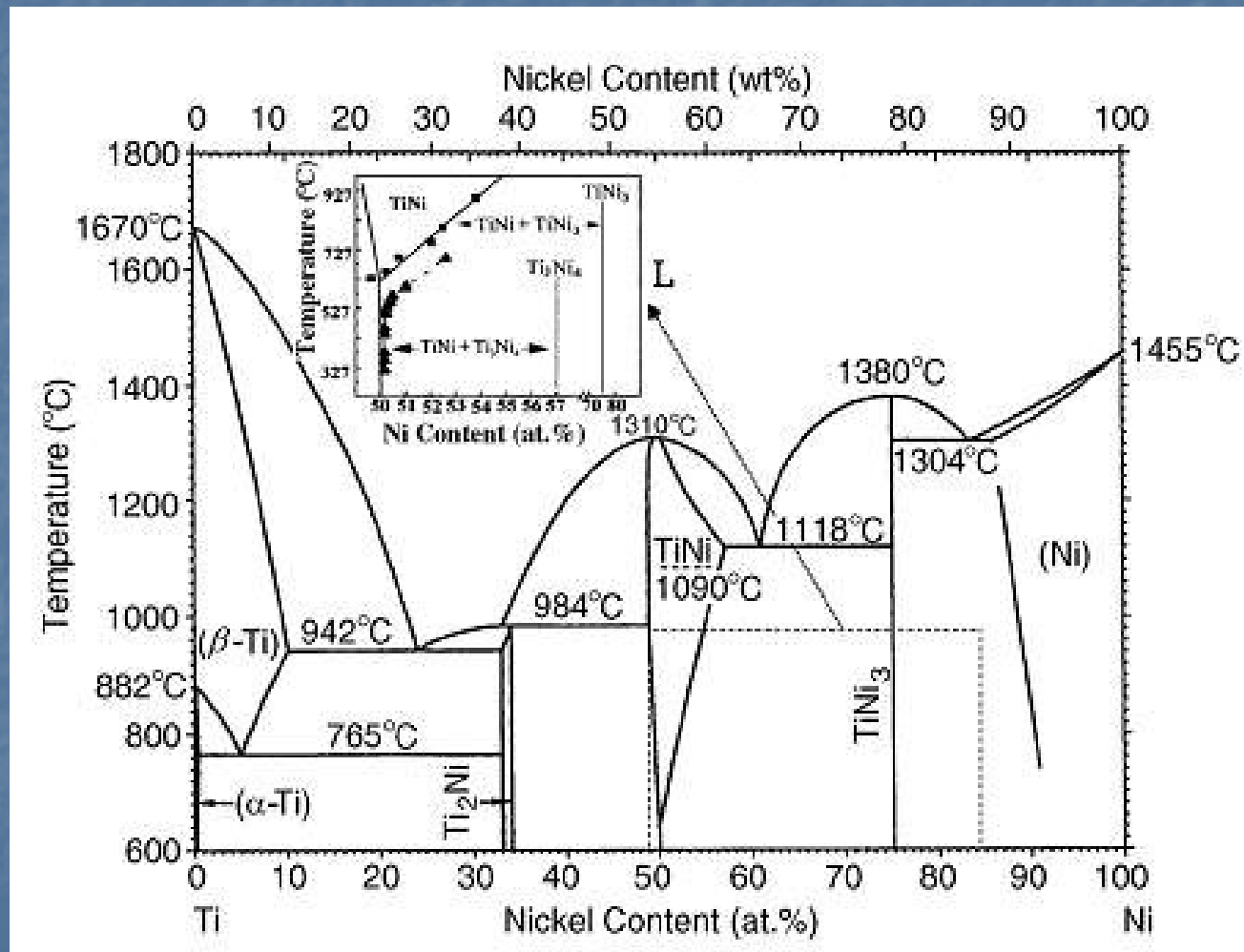


# Superelasticity:



In SE,  $T > A_f$  and the material is subjected to a quasistatic stretch after unloading, it recovers the first shape.

Phase diagram of a Ni-Ti alloy, intermetallic NiTi



Phase diagram of a Ni-Ti alloy by Massalski et al.

## Applications of NiTi Shape Memory Alloys

### Advantages of using NiTi SMAs in the engineering area ;

- \* Simple training mechanism
- \* High power/weight ratio
- \* Noiseless and silent training
- \* High corrosion resistance
- \* Can be controlled with electrical current

## Applications of NiTi Shape Memory Alloys



F-14

Aeronautics



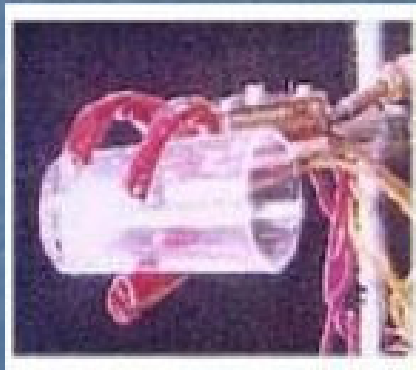
Orthodontics



Endodontic



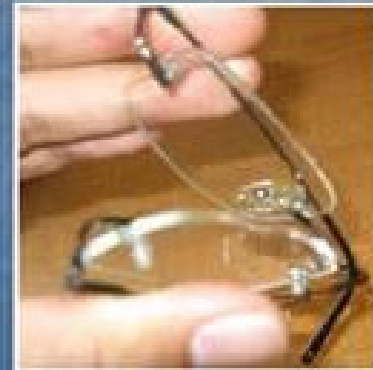
Angiography



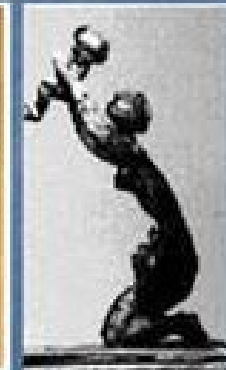
Robotics



Art

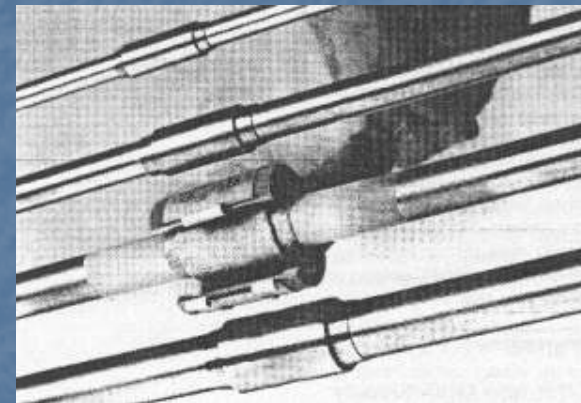
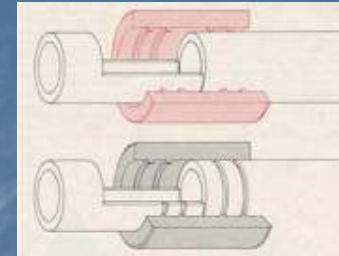


Eyeglass frames



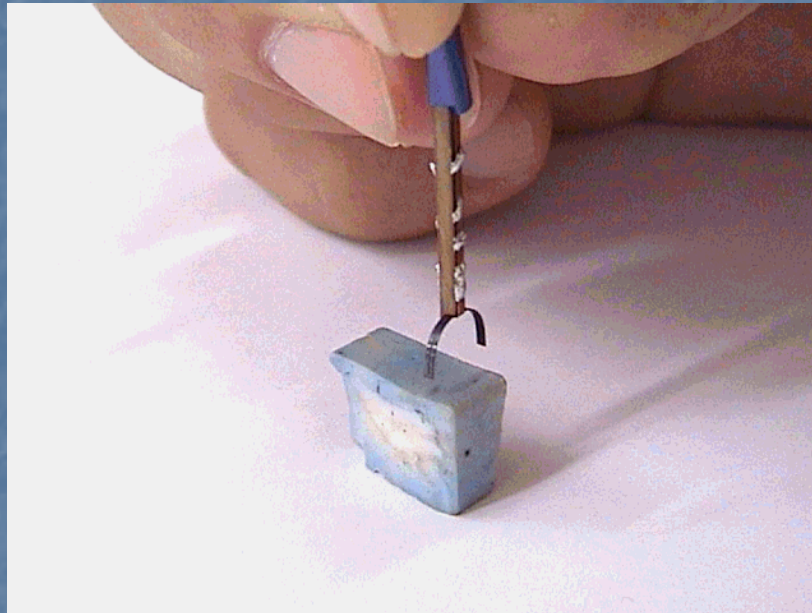
Arts

## Nickel-titanium Shape Memory Alloy Industrial application



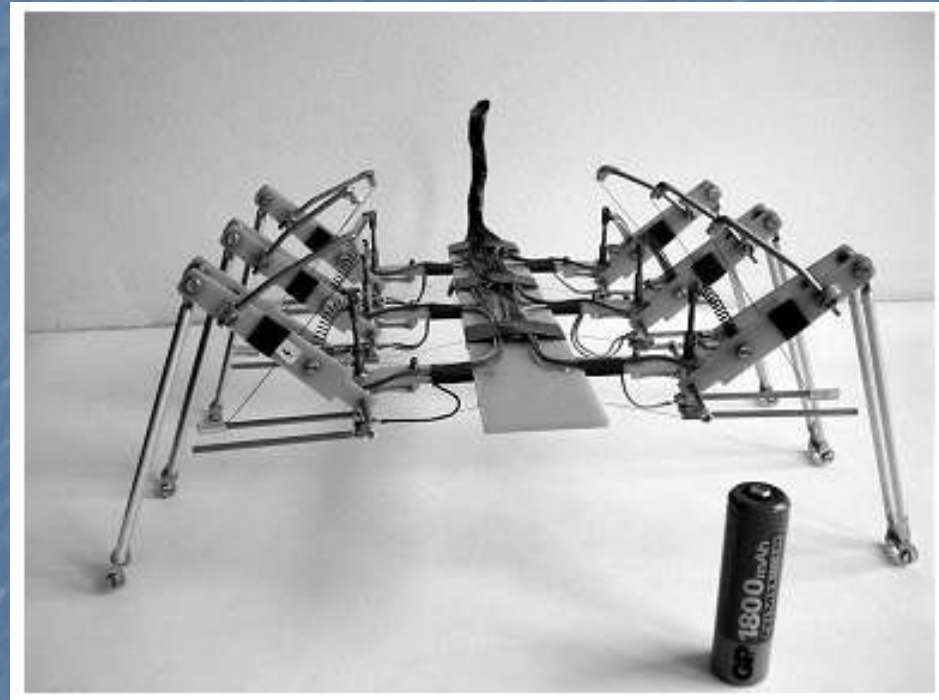
The first industrial application area was in F-14 warplanes in 1969, coupling instead of welding at the closest area of fuel storage units

## Nickel-titanium Shape Memory Alloy Industrial application



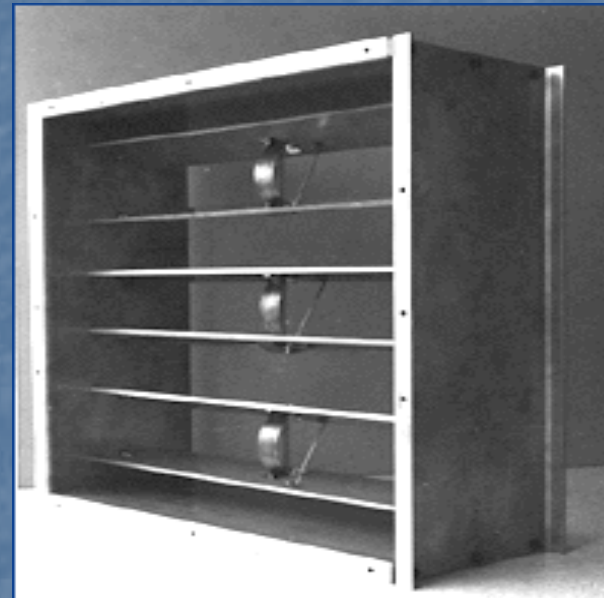
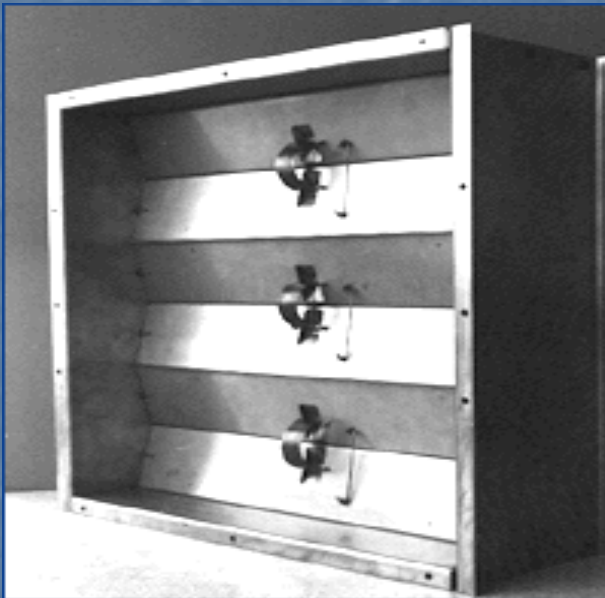
Micro gripper actuated using NiTi SMAs

## Nickel-titanium Shape Memory Alloy Industrial application



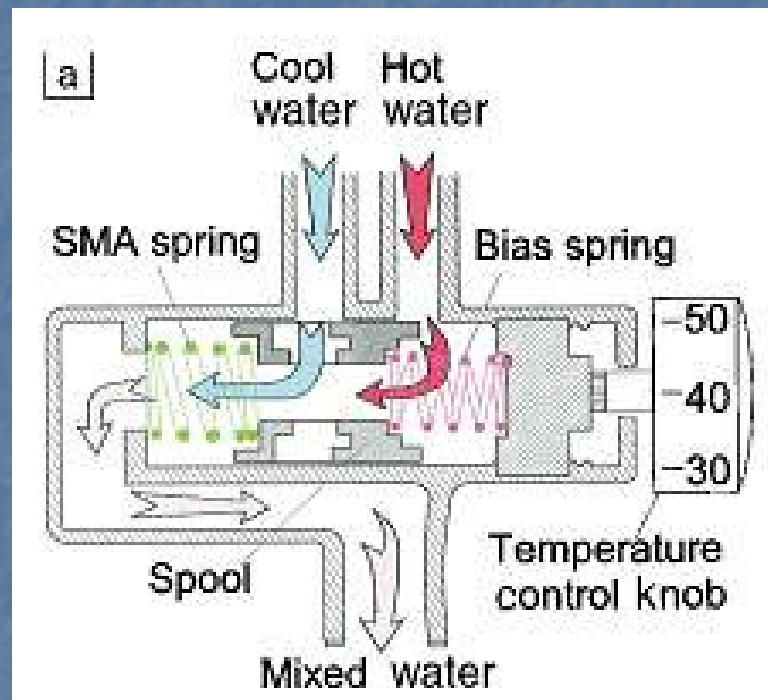
A six-legged stepping robot with two degrees of freedom in each SMA actuated leg

## Nickel-titanium Shape Memory Alloy Industrial application



Greenhouse window systems which close/open depending on the room temperature

# Nickel-titanium Shape Memory Alloy Industrial application

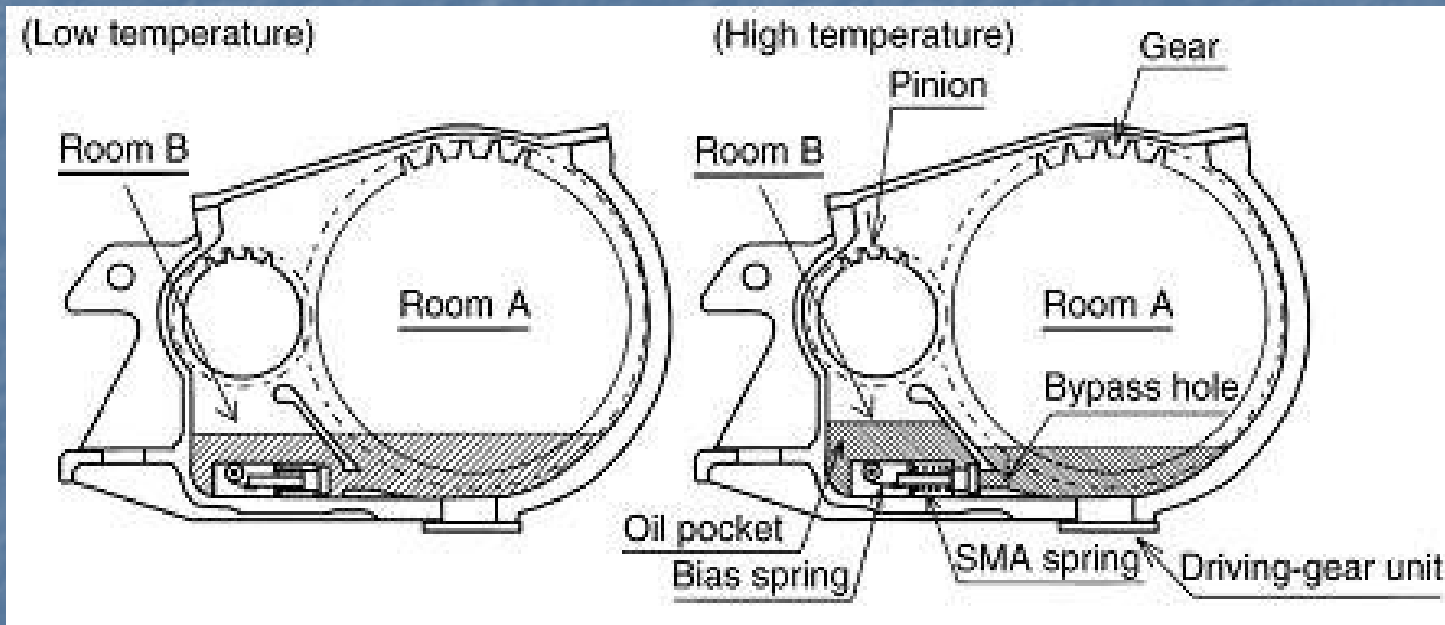


(a) structure

(b) example of a commercially available faucet  
(Otsuka et al.,1998)

thermostatic mixing valve controlled by SMA spring

# Nickel-titanium Shape Memory Alloy Industrial application



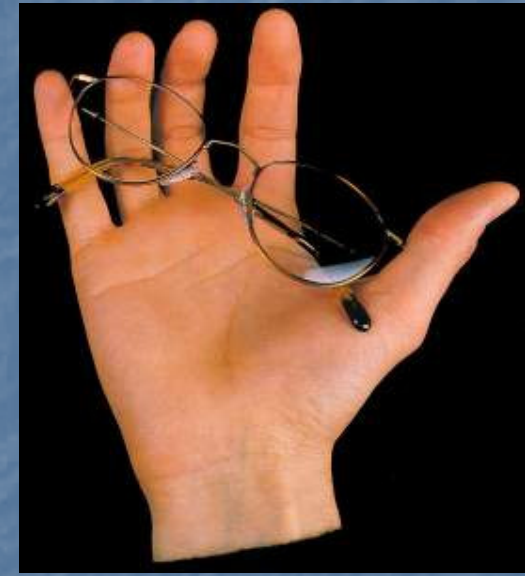
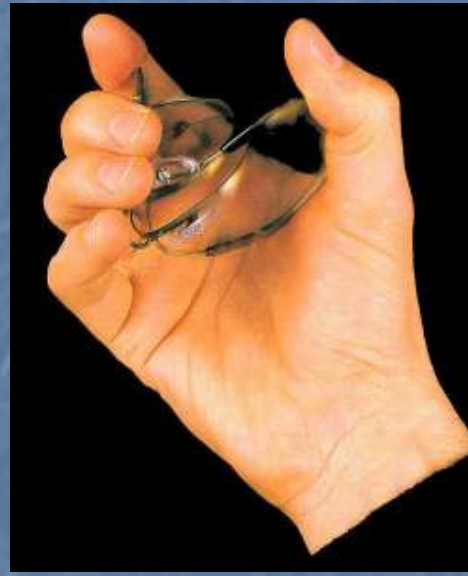
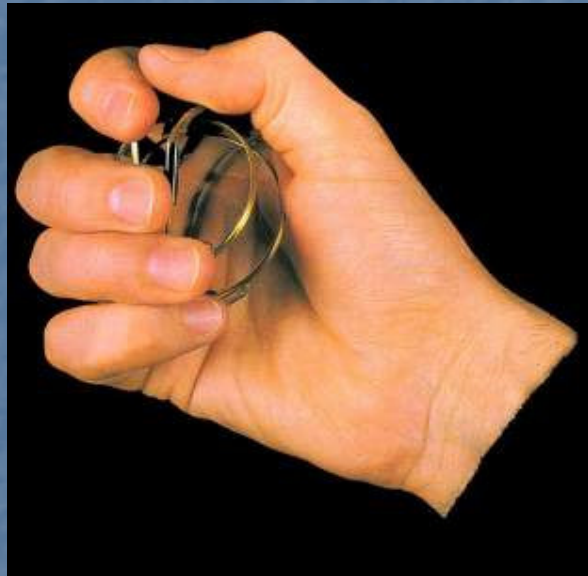
Application of SMAs to an automatic oil-level-adjustment device in high speed train in Japan

## Nickel-titanium Shape Memory Alloy Industrial application



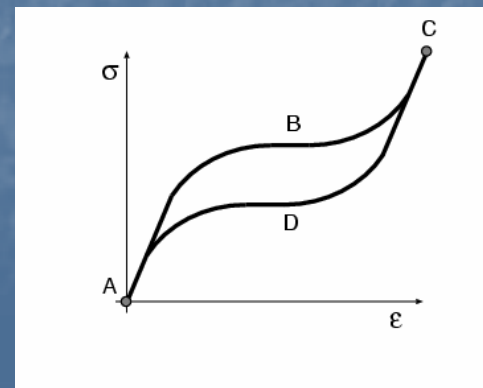
A simple nickel-titanium door locking system

# Nickel-titanium Shape Memory Alloy Industrial application

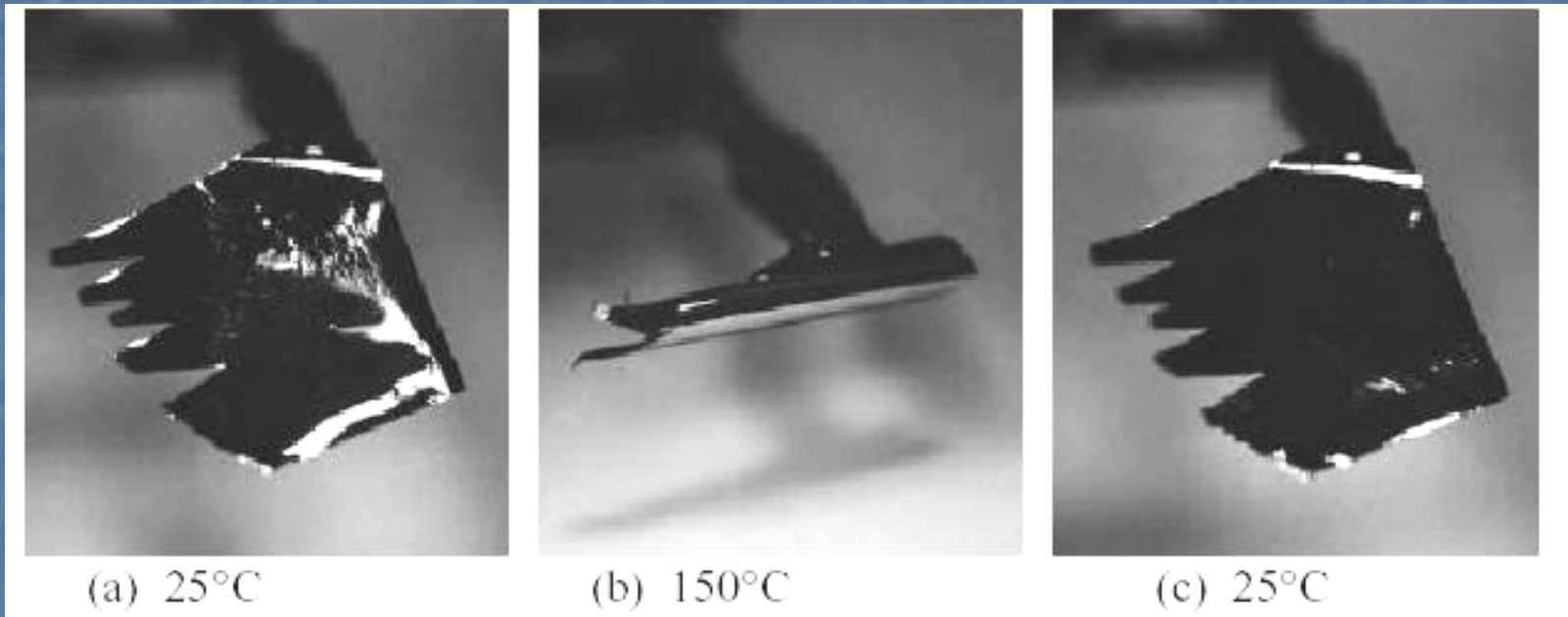


NiTi eyeglasses frame

Superelastic effect (SE)

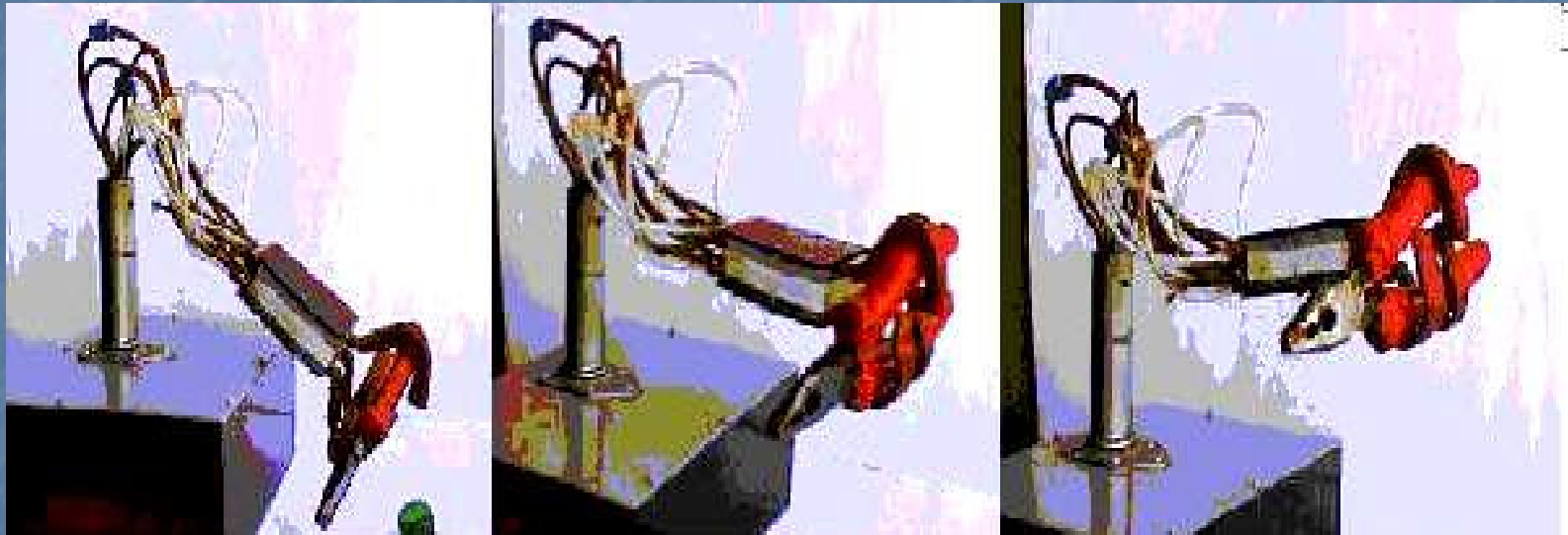


## Nickel-titanium Shape Memory Alloy Thin Film application



Thin film application using sputtering method (Ho vd., 1999)

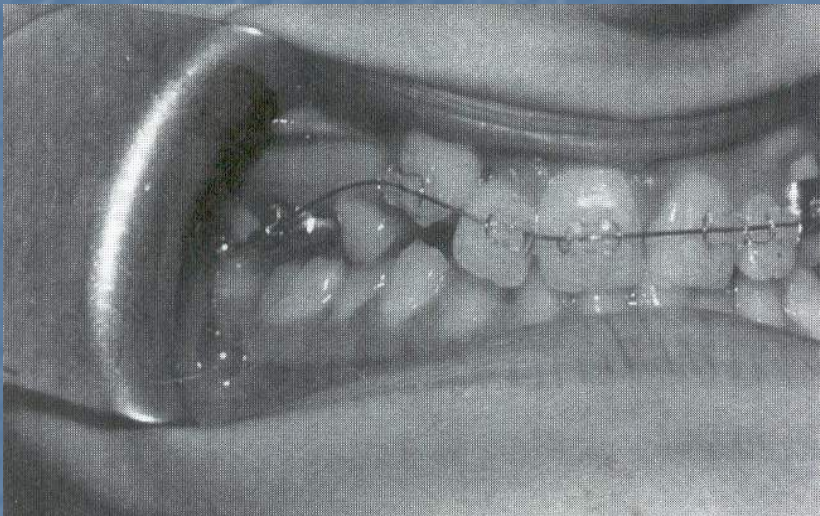
## Nickel-titanium Shape Memory Alloy Application on robotics



Grasping the pliers with ITU Robot Hand

Simplify your system using SMAs

## Nickel-titanium Shape Memory Alloy Medical applications



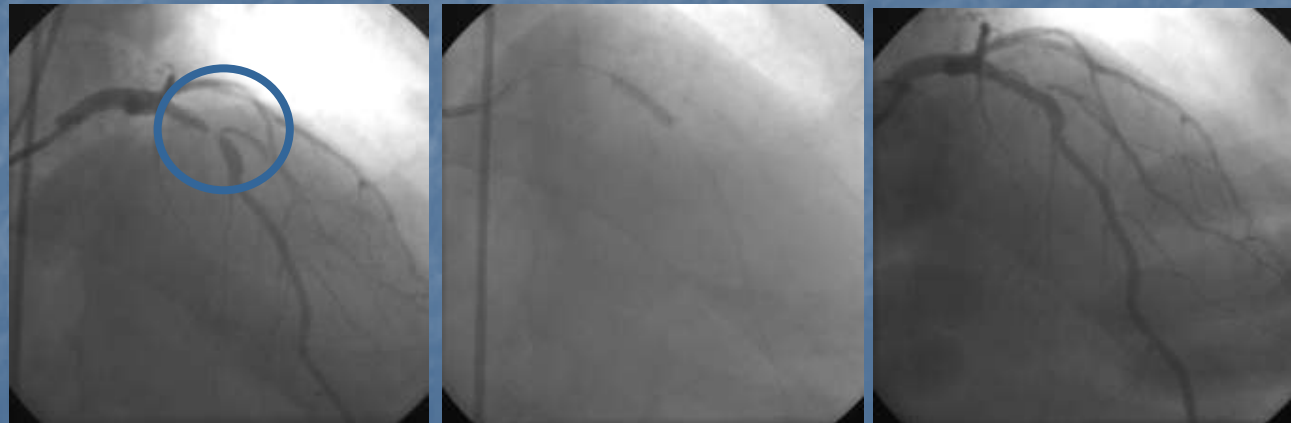
NiTi SMA Orthodontic wire applications

# Nickel-titanium Shape Memory Alloy Medical applications

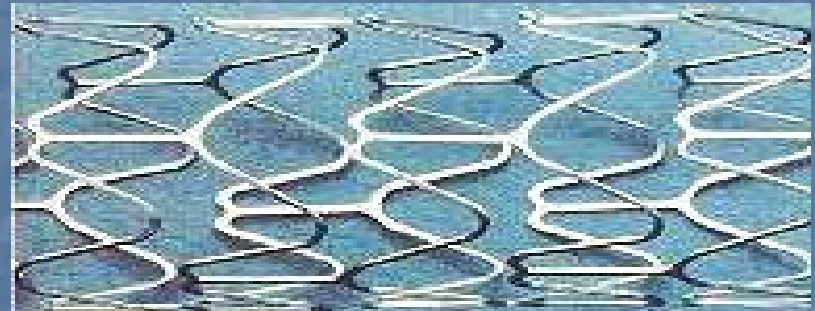
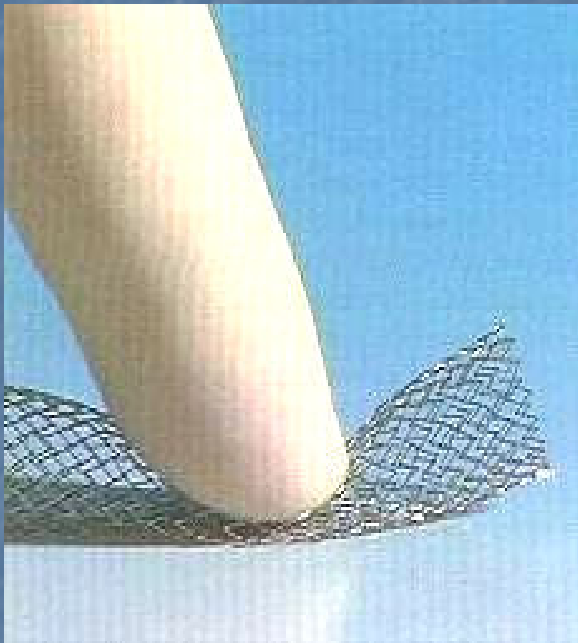


Nickel-titanium  
SMA stent

Coroner  
angiography



## Nickel-titanium Shape Memory Alloy Medical applications



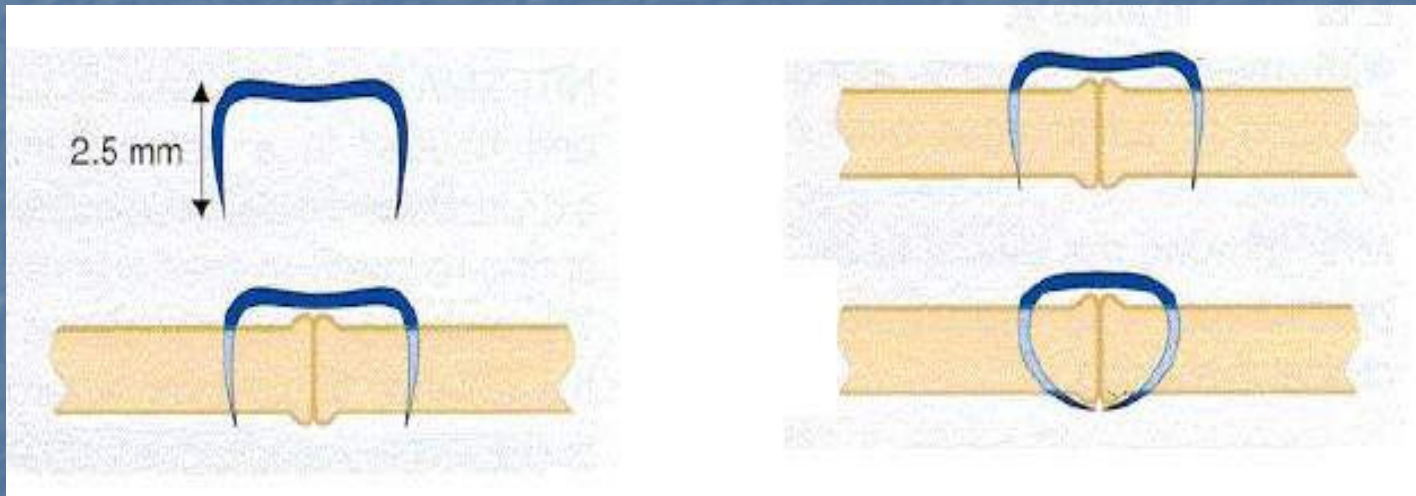
Nickel-titanium stent samples

## Nickel-titanium Shape Memory Alloy Medical applications



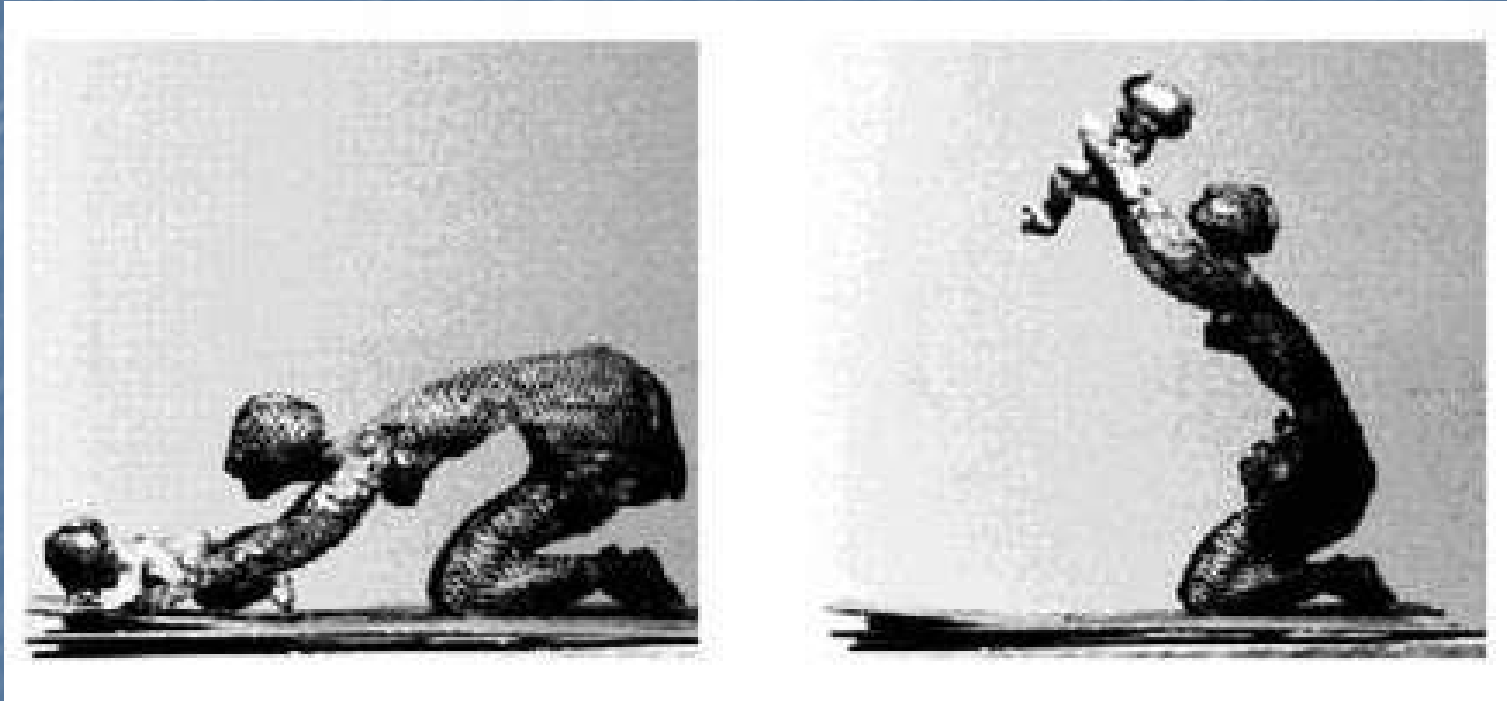
Endodontic application as a NiTi root canal instrument

# Nickel-titanium Shape Memory Alloy Medical applications



Superelastic NiTi wire used for connecting bones

## Nickel-titanium Shape Memory Alloy Art applications



Woman and baby figure  
created by Sculptor Olivier Deschamps

Manufacturing of Nickel-titanium shape memory alloy  
in zirconia crucible                      in vacuum arc/induction furnaces  
using remelting casting method.

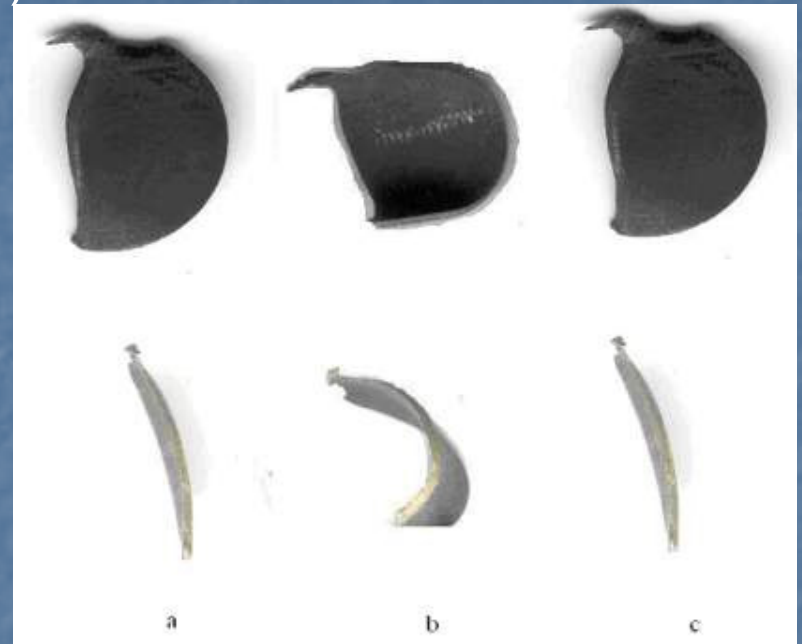


## Shape setting of NiTi Shape Memory Alloys



Shape setting of NiTi in a mold using a set of heat treatment  
0 - 500 deg.C

# Shape memory effect on produced NiTi Shape memory samples (after wire erosion machining process)



# QUESTIONS ?