

2016 fall

<Freshman Seminar>

"New materials to open the future"

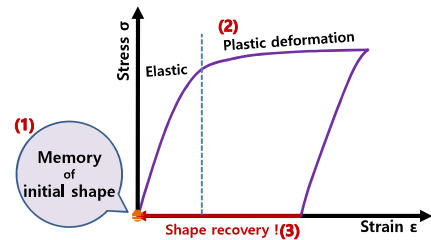
10.10.2016

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Introduction - Shape Memory Effect



Introduction

What is Shape memory alloy??

	Elastic Deformation	Plastic Deformation	Transformation Deformation
Ceramics	○	×	×
Conventional Metals, Alloys & Plastics	○	○	×
Shape Memory Alloys	○	○	○
	<u>Recoverable Small Deformation</u> ↓ Elasticity	<u>Permanent Large Deformation</u> ↓ Plasticity	<u>Recoverable Large Deformation</u> ↓ Shape Memory Effect Superelasticity (Pseudoelasticity)

- Shape memory effect

Introduction

What is Shape memory alloy??

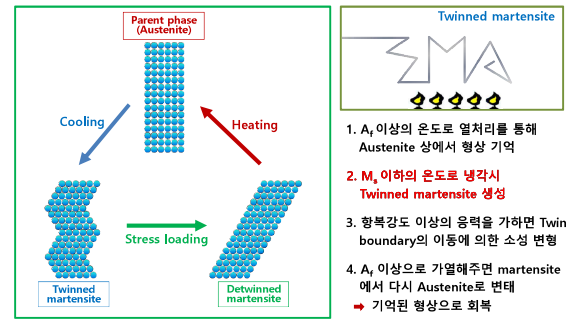
Principles

How can shape memory effect occur?

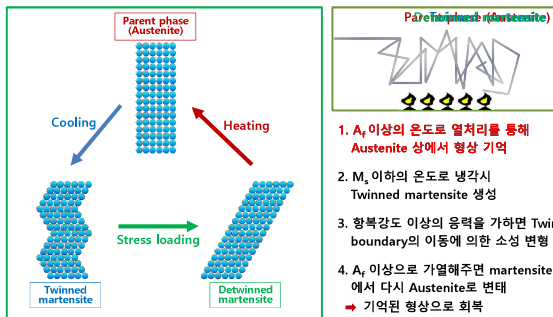
Principles

How can shape memory effect occur?

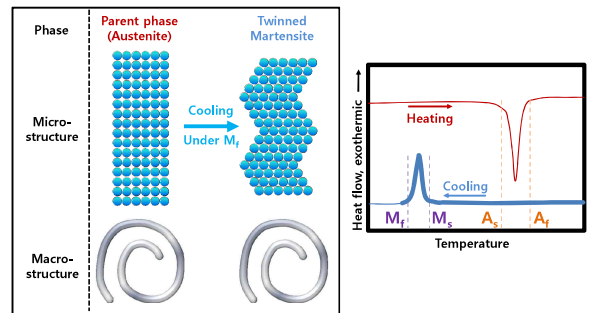
Principles - Shape memory process



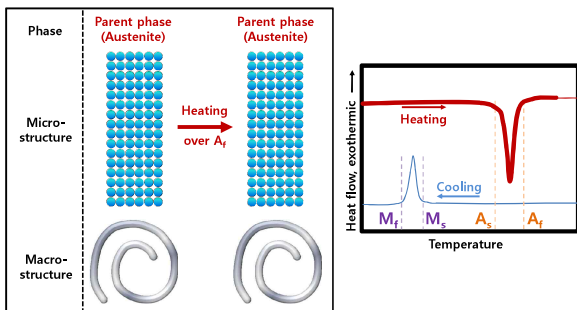
Principles - Shape memory process



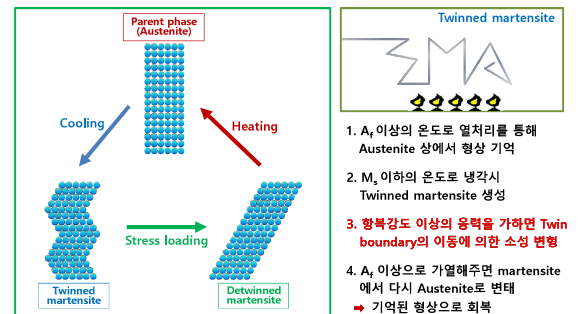
2. Transformation into a low-temp. stable phase



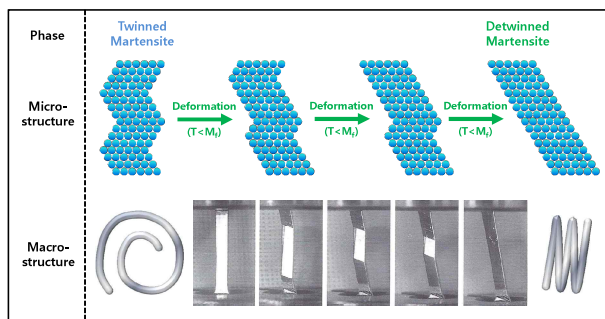
1. Shape memory processing



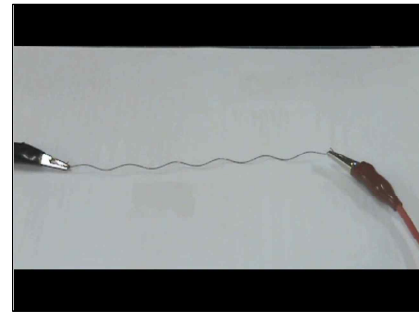
Principles - Shape memory process



3. Low-temperature shape deformation

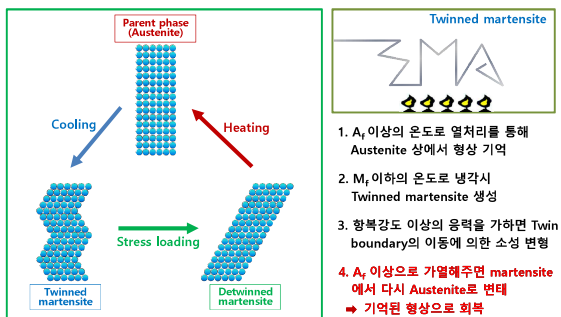


One-way shape memory alloy

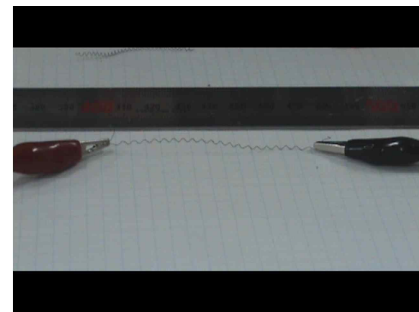


- Remember only the shape memorized at high temperature
- After heating at room temperature, it is restored to its original shape

Principles - Shape memory process

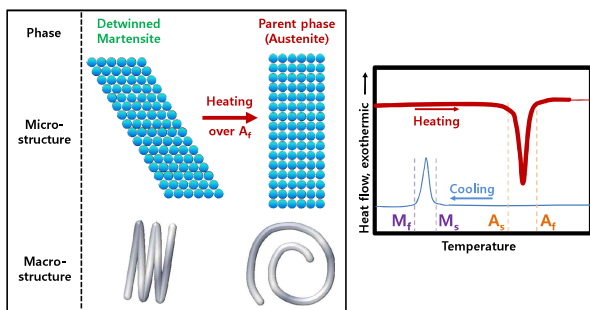


Two-way shape memory alloy

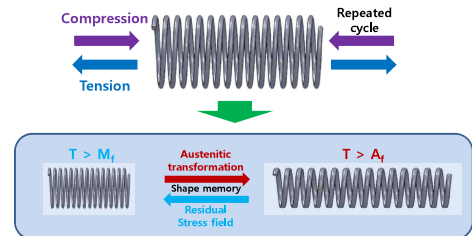


- Remember both the shape of the high temperature and the room temperature.
- When the heating and cooling are repeated, the two memorized shapes repeatedly appear

4. Heating - shape recovery



Two-way shape memory alloy



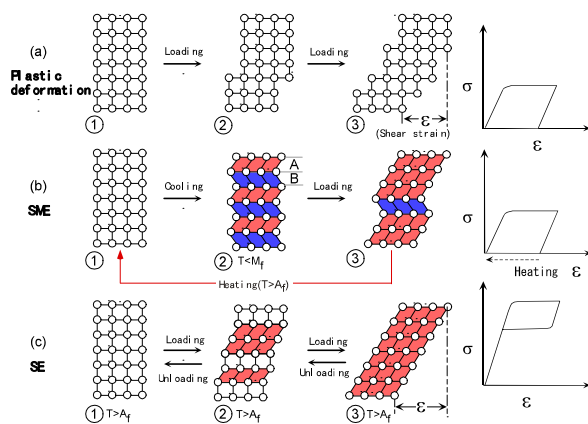
- Increase of dislocation density in shape memory alloy due to iterative deformation, formation of residual stress field
- Stress occurs in the direction of returning to the form on Martensite

Multi-stage shape memory alloy

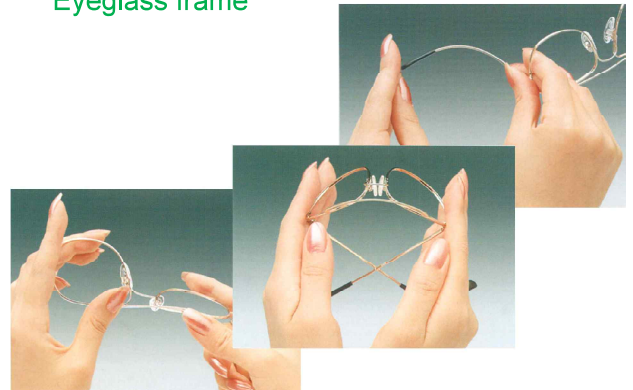


Applications

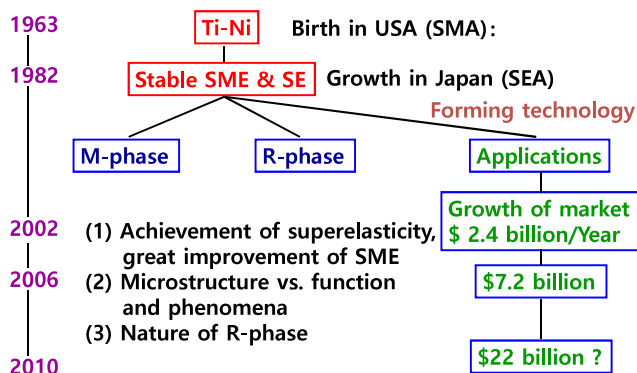
Shape memory alloys around us



Eyeglass frame



History of Ti-Ni

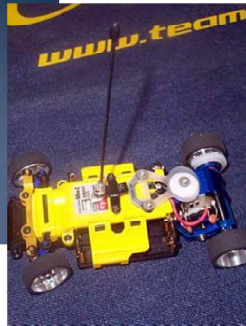


Headphone





Antenna wire

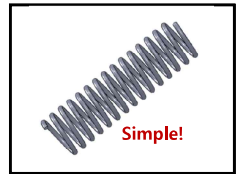


Applications - Micro-actuator

▶ Actuator : A driving device for converting an energy source such as electric energy or thermal energy into kinetic energy to move the mechanical device

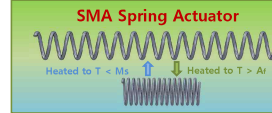


▲ Conventional macro scale actuator (Motor-Gear type)



Simple!

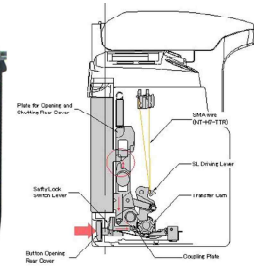
▲ SMA Spring Actuator



Enables mechanical action through contraction and elongation.

1. High output per unit volume
2. Very simple structure compared to motor
3. Easy to control by temperature
4. Easy to miniaturize.

Actuator Wire activated by Flowing Current



Applications - Micro-actuator



Fishing Lines



Applications - Micro-actuator



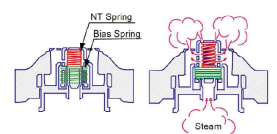
Applications - Micro actuator



Applications - Micro actuator



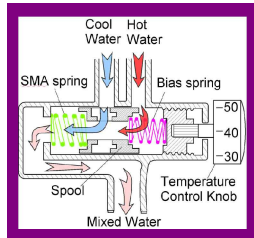
Rice cooker



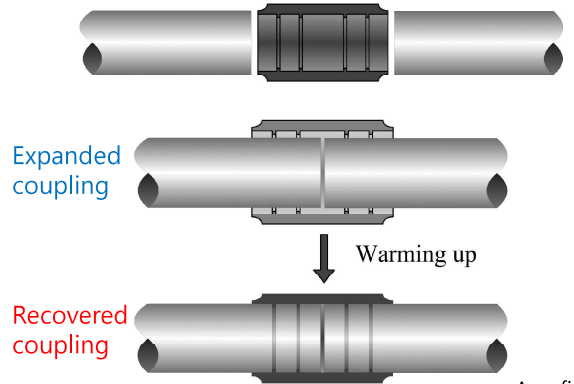
Water faucet / mixing valve for a shower



- Quick Reaction Speed
- Minimal size
- Reduced Number of Assembly Parts



Shape Memory Pipe Coupling → Applications for Oil Industry



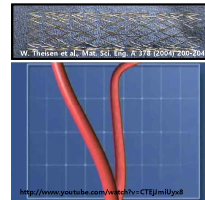
Aerofit Inc.

Automatic oil volume adjusting equipment

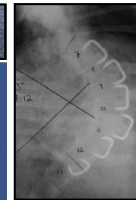


Applications - Medical device

- Shape Memory Alloy controlled by transformation temperature so that shape recovery is caused by body temperature (Austenite finish temp. A_f < body temp.)
- Widely used medical application



▲ SMA stents



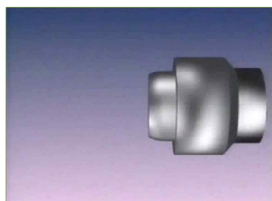
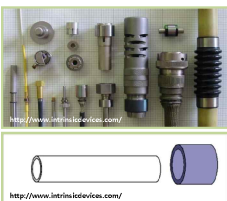
▲ Staples of SMA



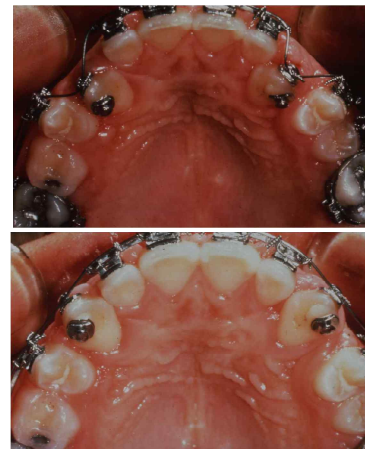
▲ SMA teeth brace

Applications - Pipe joint

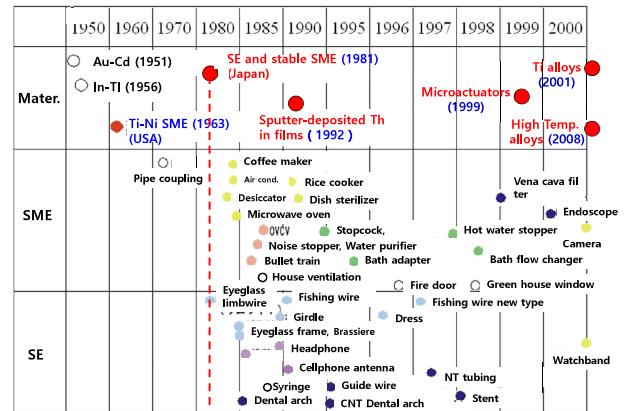
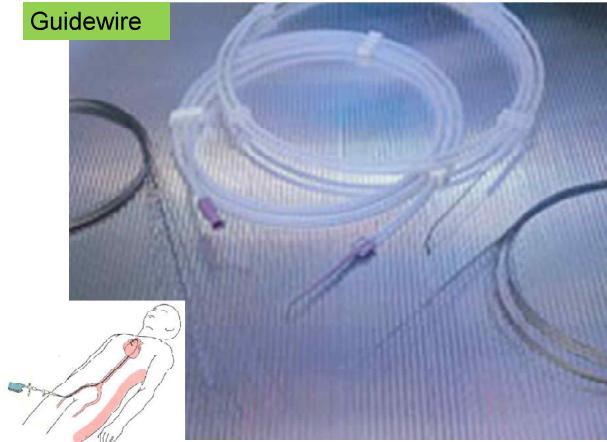
- Application of a SMA as a pipe-joint by utilizing the force of shrinkage during shape recovery
- After a shape having a pore diameter smaller than the pipe thickness is stored at room temperature, it is transformed into martensite under a liquid nitrogen environment
- After inserting the pipe in a cryogenic environment, heat it by body temp.
- Fast and easy installation that does not require welding equipment



Dental Archwire

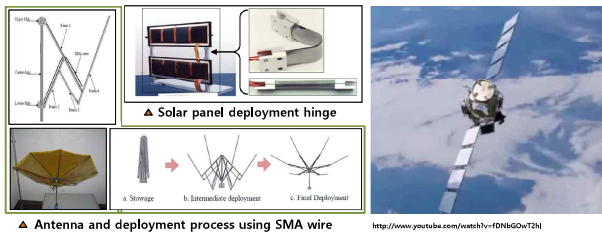


Guidewire

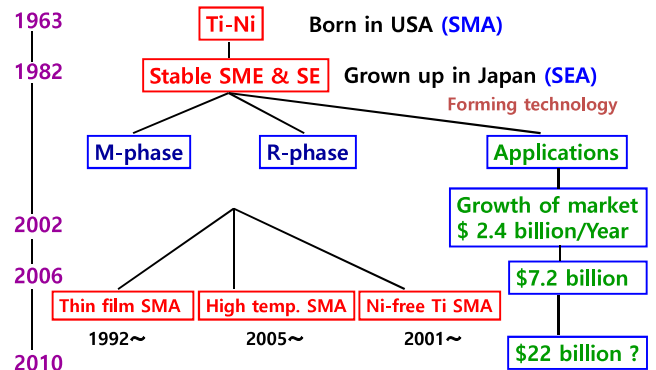


Applications - Aerospace

- ▶ Shape memory alloy is used to fabricate an antenna and solar collector that develop automatically by detecting temperature change by solar heat in cryogenic environment where it is difficult to drive by motor-gear like outer space.

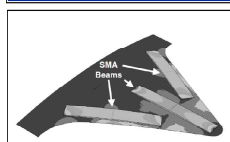
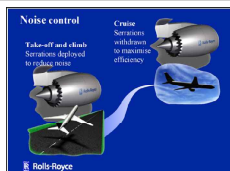
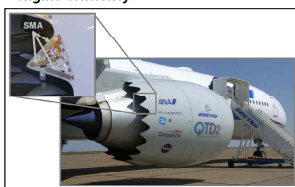


Summary



Applications - Aerospace

- ▶ During take-off and landing where high exhaust pipe temperature is formed, the fan nozzle is opened so that the outlet has the maximum cross-sectional area.
- ▶ During high altitude cruising, the low ambient air temperature closes the nozzle to reduce noise and improve engine efficiency.



▲ Structure of Serrated Nozzle tip

Unique Idea

Shape memory alloy for presbyopia

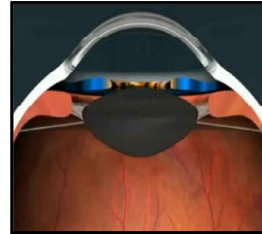
- Artificial muscle

Unique Idea

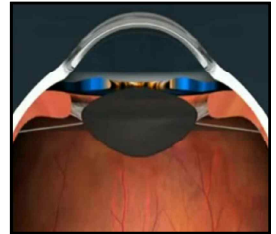
Shape memory alloy for presbyopia

Unique Idea- Occurrence of presbyopia

▶ 정합안



▲ When you look far



▲ When you look close

Unique Idea - Artificial muscle

Shape memory alloy

Recover the shape under a specific stimulus

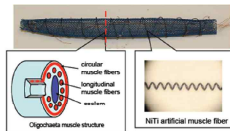
Repetitive strain-recovery

Human muscle

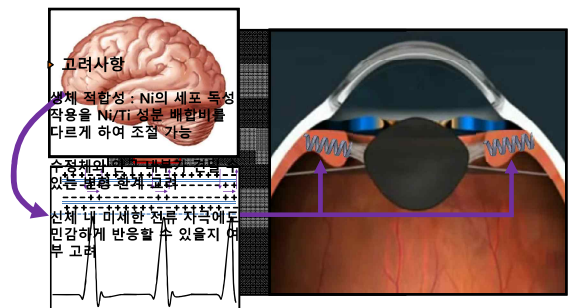
Acting in response to an electrical signal

Unidirectional contraction - Relaxation

Artificial muscle using SMA



Unique Idea - Artificial muscle



Unique Idea- Occurrence of presbyopia

