Exploring Shape
Memory Alloys
Smart Materials
Shape Memory Alloys

Shape Memory Alloys (SMA) are novel and special materials

- They can “remember” their shape when heated above a certain transition temperature

Also called muscle wires
Shape Memory Alloys
History

First discovered by Arne Olande in 1938
- He observed the shape and recovery ability of a gold-cadmium alloy (Au-Cd)

W.J. Buehler and Wang at the US Naval Ordinance Laboratory 1963
- observed the shape memory effect in a nickel and titanium alloy, today known as nitinol (“Night in All”; Nickel Titanium Naval Ordinance Lab).
Shape Memory Alloys
How do they work?

- SMAs change shape based on a solid state phase transformation
- Atomic level changes
  - Rearrangement of atoms
- Change in shape occurs at a specific temperature
  - Shape Memory Effect
Shape Memory Alloys
How do they work?

We all know the most common phase changes:

- Solid
- Liquid
- Gas
Shape Memory Alloys

Nitinol has two phases:

- High temperature form austenite
  - Very hard and rigid; tight cubic symmetry (how the atoms are packed)
- Low temperature form martensite
  - Less symmetric, more flexible
  - With pressure, atoms change position. This crystal phase allows the material to be deformed.
How do they Work?

http://dopamine.chem.umn.edu/chempedia/index.php/Memory_Metals

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Muscles are the "engine" that your body uses to propel itself. Although they work differently than a car engine or an electric motor, muscles do the same thing -- they turn energy into motion.

The solid-state phase change and bounce back effect (pseudo-elasticity) are used to make devices from muscle wires.
SMA – Medical Applications

Stent – a reinforced graft for vascular application to replace or repair damaged arteries (25mm diameter)

Nitinol stents are used to open arteries that are clogged with plaque.
SMA – Medical Applications

- **Bone Plates** – Surgical tools to assist healing of broken bones
- **Problem** – tension reduces & break not under compression
- **Bone plates of SMA** cooled, inserted, and body temp causes contraction and plate maintains pressure for proper healing

Conventional bone plate used to repair jaw fracture

A badly fractured face can be reconstructed using SMA bone plates

SMA – Applications

- Aircraft maneuvers – flap movement very important
- Extensive hydraulic systems – flap actuators
- SMA – manipulate wing surface

SMA – Applications

- Mars Pathfinder Sojourner Rover -1997
- SMA used to help measure the amount of Martian dust on the rover’s upper surface
- The SMA and a solar cell worked together to pull a glass plate on top of the rover for the experiment
Other applications

- Cellular phone antennae
- Eyeglasses
- Coffee pots
- Space shuttle
- Bra underwires

Can you think of other applications?
Explore the Internet for a variety of information and uses for shape memory alloys

- Not all of them are metals
- Some are plastics!