



Exploring Shape Memory Alloys

Smart Materials

Shape Memory Alloys

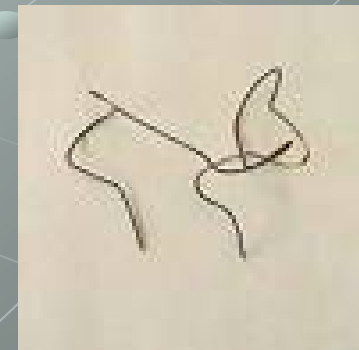
- Shape Memory Alloys (SMA) are novel and special materials
 - They can “remember” their shape when heated above a certain transition temperature
- Also called muscle wires



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 Ordnance Laboratory 1963
 - observed the shape memory effect in a nickel and titanium alloy, today known as nitinol (“Night in All”; **N**ickel **T**itanium **N**aval **O**rdinance **L**ab).



Shape Memory Alloys

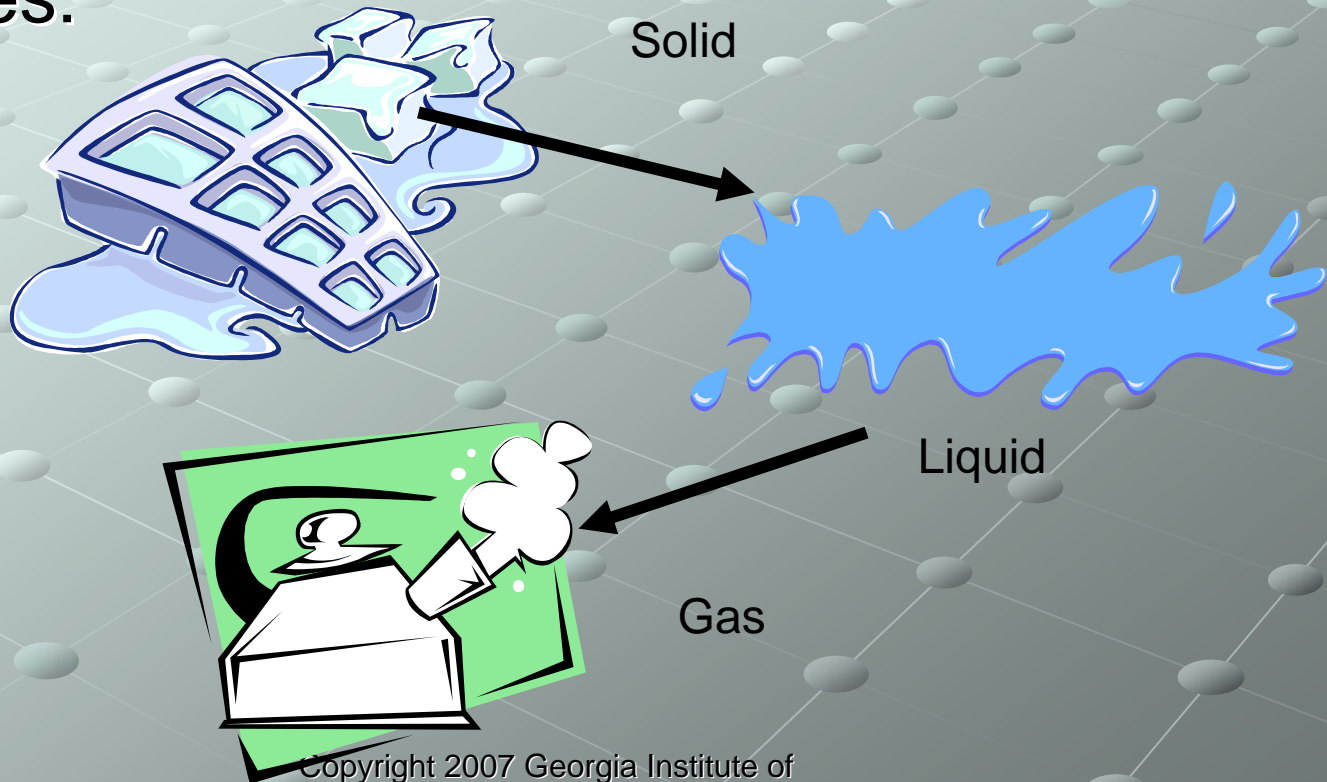
How do they work?

- 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

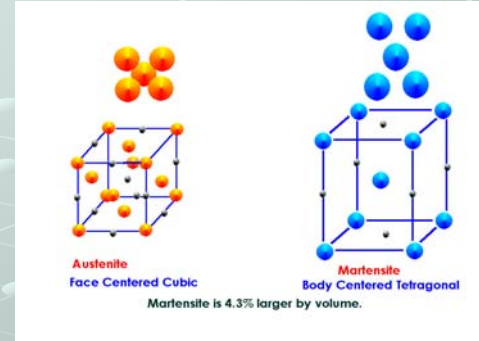
How do they work?

- We all know the most common phase changes:

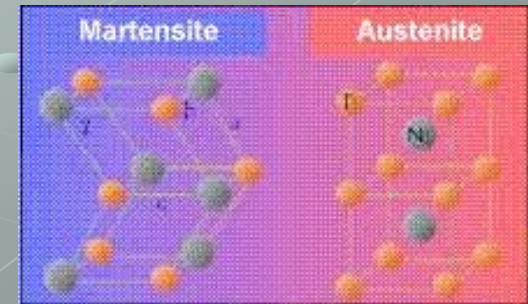


Shape Memory Alloys

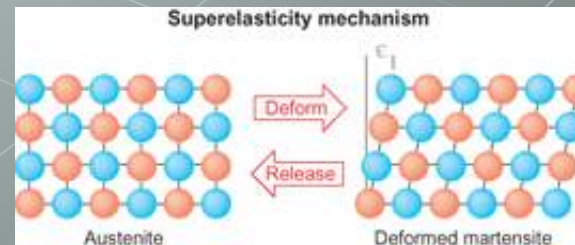
- Nitinol has two phases:
 - High temperature form austenite
 - Very hard and rigid; tight cubic symmetry (how the atoms are packed)
 - Low temperature form martensite
 - Less symmetric, more flexible
 - With pressure, atoms change position. This crystal phase allows the material to be deformed.



www.metal-wear.com/images/ausmart.gif

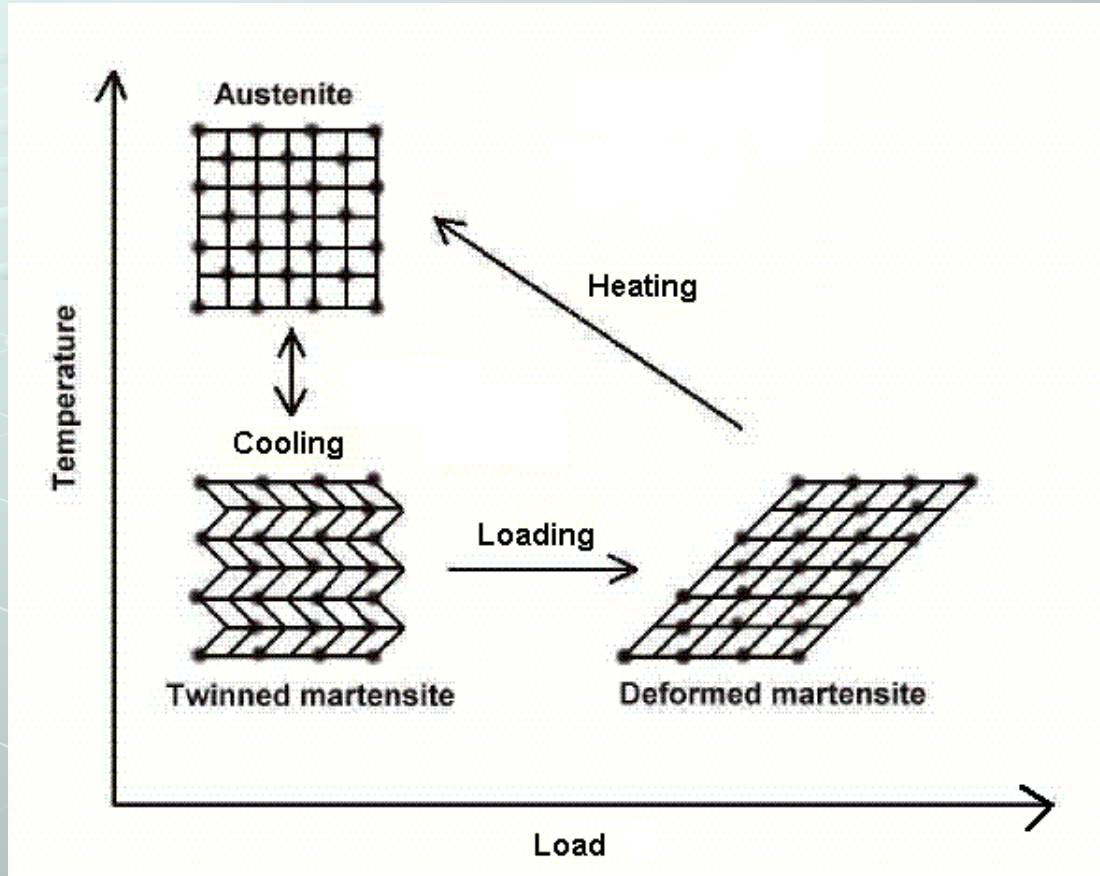


<http://smart.tamu.edu/>



www.c2i2.org/autumn2004/images/Lombardi.gif

How do they Work?



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

Shape Memory Alloys

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**.

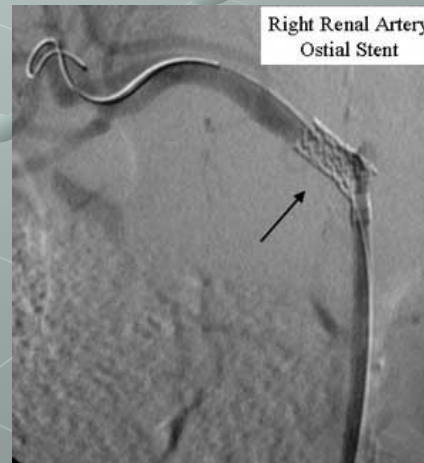
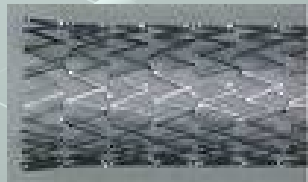


- The solid-state phase change and bounce back effect (pseudo-elasticity) are used to make devices from muscle wires.



SMA – Medical Applications

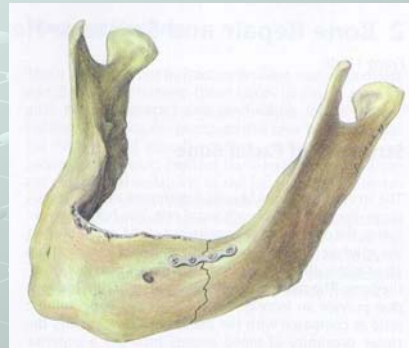
- Stent – a reinforced graft for vascular application to replace or repair damaged arteries (25mm diameter)
- Nitinol stents are used to open arteries that are clogged with plaque.



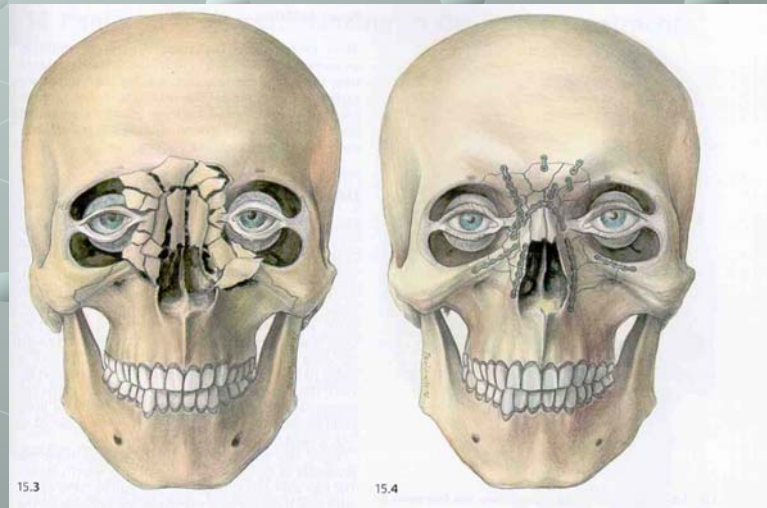
SMA – Medical Applications

- 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

http://www.cs.ualberta.ca/~database/MEMS/sma_mems/bone.html



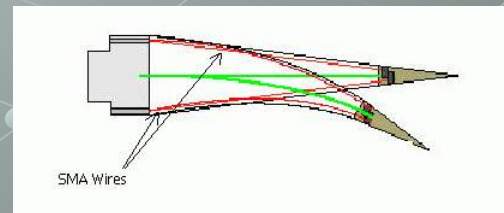
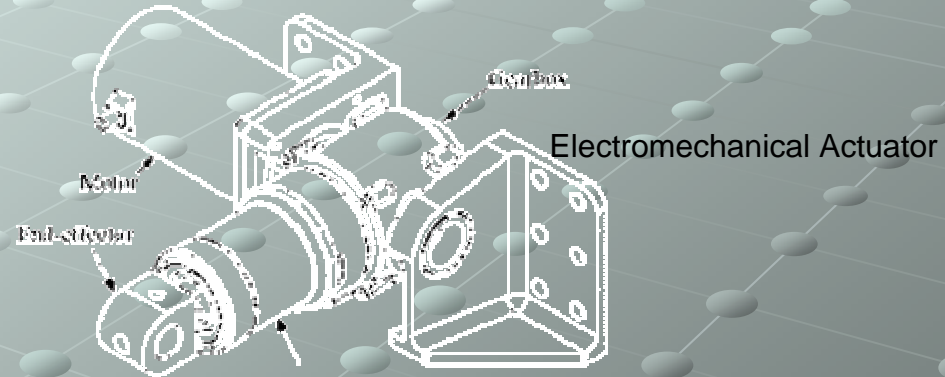
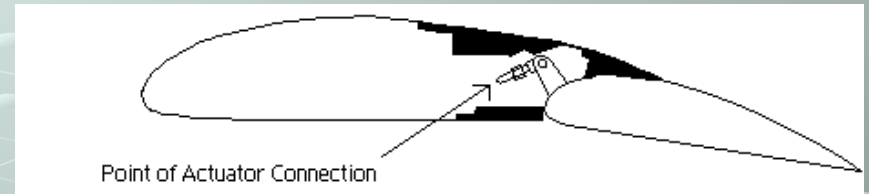
Conventional bone plate used to repair jaw fracture



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



http://www.cs.ualberta.ca/~database/MEMS/sma_mems/bone.html

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?

Resources

- Explore the Internet for a variety of information and uses for shape memory alloys
 - Not all of them are metals
 - Some are plastics!