Memory Metal

memory metal -

examples: NiTi, Cu-Zn-Al, Fe-Mn-Si, Au-Ca, Cu-Al-Ni, Cu-Al, etc.

smart material-

Characteristics of NiTi

1.

-"atomic ballet"

-some limits

2.

3. NiTi consists of 2 structures interconverted by changes in temp. or pressure
   -between 0-100°C there are 2 phases
      1.

      2.

+ energy ===
(more dense) (less dense)

Martensite can have _____ varients
-flexibility of martensite due to varients in structure & ability to re-orient these varients = mecahnical flexibility

Nickel-Titanium = Nitinol = _____
-nitinol discovered in 1965

-contains nearly equal amounts of _____ & _____ atoms

NiTi common composition but relative amounts of Ni & Ti varied to control temp. of the phase change responsible for its smart behavior

Ni_xTi_{1-x}

ex. $Ni_{0.5}Ti$ ___ Ni___$Ti_{0.7}$

BB board analogy

-case = _____, BB's = _____

-groups of atoms = small groups with regular internal pattern separated from each other by gaps

-gaps = _____

Nitinol composed of 3-D crystalline regions = _____

- grains have random shapes, sizes, orientations

heat to 500-550°C to fix shape, linear defects are minimized, not eliminated

-defects minimized by atoms moving & reshaping grains

-allows atoms to fit closer together

_____-study of the structure of crystals, including ways of describing the crystal structure, the principles that govern the various structures, & methods of determining a crystal's structure

<u>3 parts to crystallography</u>

1.

2.

3.

_____-an imaginary box that can be constructed from arrays of atoms, ions, or molecules-basic unit of a crystal structure

valid unit cells-used to represent the array

Note: Each unit cell contains 1 complete circle, & only the shaded portion of the circle lies in the unit cell.
If any of the unit cells is moved along its edges the entire pattern is produced.

Simple Cubic Face-centered cubic Body-centered cubic

valid unit cell vs. invalid unit cell

coordination number - _____

Thermochemical equation to represent transition between phases

martensite + energy === austenite

-energy of a few kJ/mol to change from martensite to austenite

Ni & Ti atoms within the grain(crystalline region) in a sample of memory metal in austenite phase are almost perfectly arranged with few imperfections

-memory from defects in _____ phase & grain boundaries

-to give metal a new shape, new defects must be created - goes to new set of defects, rather than old

-new defects obtained by heating metal 500°C while securing shape

-thermal energy allows atoms to relax into lower energy positions = _____ formed

-if heated too long, memory metal feature of wire destroyed because if atoms around defects have enough energy they relax & a defect free structure results

-defects created in _____ phase (altered by candle flame) create new memory by forcing groups of atoms to have particular positions relative to one another

<u>Uses and Capabilities</u>

-sense changes in environment & respond to disturbances in a pre-programmed way so used for...

_____	_____
1. high temp. phase	1. low temp. phase
2. rigid/hard	2. flexible
3. symmetrical	3. less symmetrical
4. ring	4. thud
5. uniform structure allows sound waves to travel through it easily	5. boundaries between regions with different orientations reduce vibrations & muffle the sound
6. less dense	6. more dense

_____ Effect - the phase changes in the 2 directions do not have the same temperature dependence-phase change from austenite to martensite occurs over a lower temp. range than that from martensite to austenite

Graph of figure 9.9 from Companion

Explanation: one solid phase needs to grow within the region of the other-elastic strain in region around new crystal growth

Overall effect: displacement of heating curve to higher temps.
therefore, whether it was heated or cooled makes a difference

_____ - system in which the rates of forward & reverse processes are equal
-processes can be chemical or physical

-system must be closed

closed vs. steady state

_____ - when a system at equilibrium is subjected to a stress (change in temperature, pressure, concentration), the equilibrium will shift in the direction that tends to counteract or relieve the stress

Straining material causes NiTi to change from one phase to another

-as rod is bent some atoms compressed & some pulled apart

Figure 9.7 from Companion

-therefore, pressure exerted on atoms
    -material favors matensite (more dense phase) formation under high pressure

Transistion temperature (TTR) -