Memory Metals

Background Information Slides

Overview

The following slides present background information on crystal structure, metals, and the phenomenon of the shape memory effect. They may be presented as part of a lecture introducing the Memory Metals activity.

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Crystals

Crystals are regular arrangements of atoms, bonded together to make a crystalline solid.

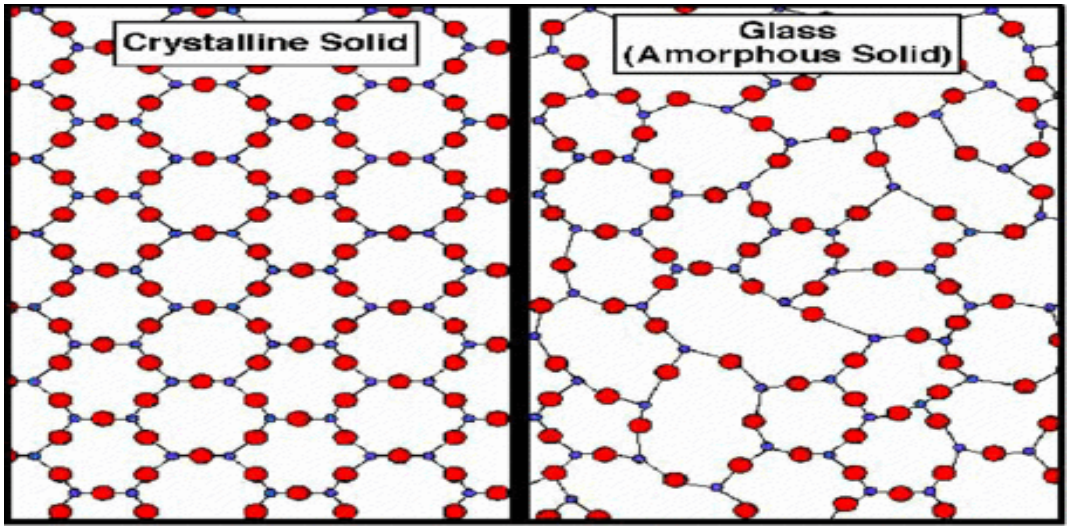

Image: apchemcyhs.wikispaces.com

Crystalline solids are distinct from *amorphous* solids, known generally as *glasses.* In a glass, the atoms show a more random arrangement, similar to a liquid.

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Atomic Bonding

Crystals form due to atomic bonding between like or unlike atoms. There are three main types of bonds between atoms in a solid:

- **Covalent bonding**: neighboring atoms share one electron between them. Leads to very strong bonds and tough solids.
- **Ionic bonding** occurs between ions of opposite sign. These are strong bonds, but they can be broken by a polar liquid like water. An example is rock salt, which is hard and rigid, but readily dissolves in water.
- **Metallic bonding:** made of those elements in the Periodic Table that have one or two outer electrons. When these atoms bond, the nuclei bond strongly, but the outer electrons are free to move through the solid. This gives metals their good electrical and thermal conductivity, as well as making them malleable.

Each of these bonding types produces crystalline solids with different properties

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Examples of Crystals

Ionic crystals make up all salts, like sodium chloride (halite, table salt) and calcium chloride

Image: saltworks.us

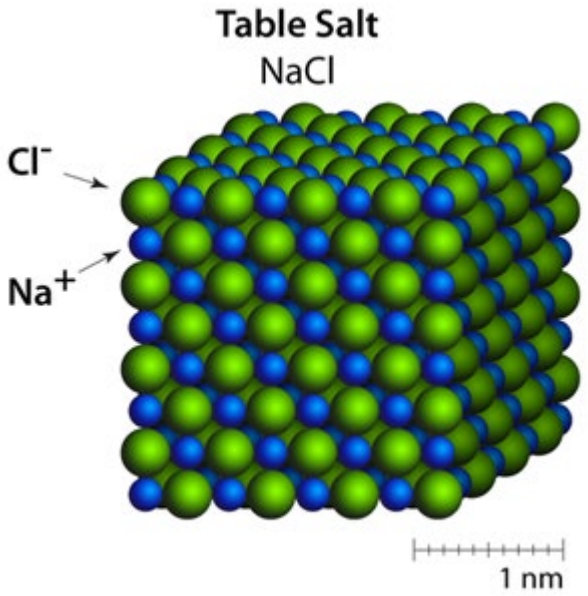

Image: atominmotion.com

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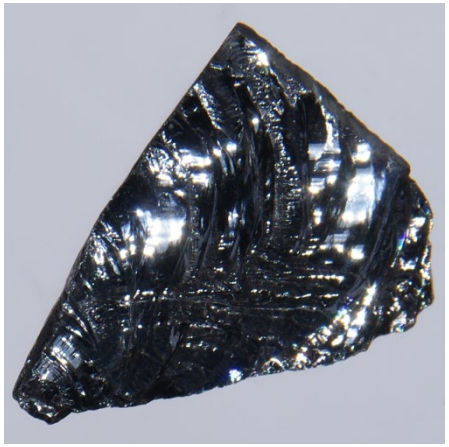
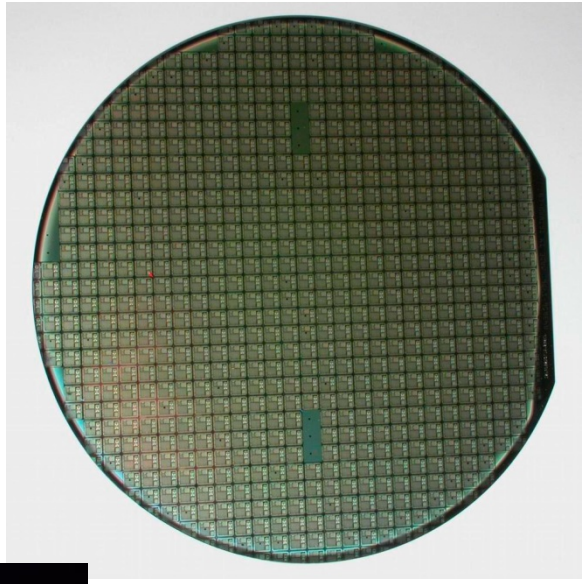
Examples of Crystals

Covalent crystals make up many common minerals, such as silicon,



which may be refined to make a silicon wafer;



and silicon dioxide, found in pure form as the mineral quartz

Image credits: pictures-of-elements.com; www.worktopfactory.co.uk; periodictable.com

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Examples of Crystals

Covalently bonded crystals also make up many precious gems, like rubies (made of aluminum oxide), sapphires (aluminum oxide), and diamonds (carbon).

Ruby (from keywordpicture.com)

Sapphire (from www.gemselect.com)

Diamonds (from www.mining.com)

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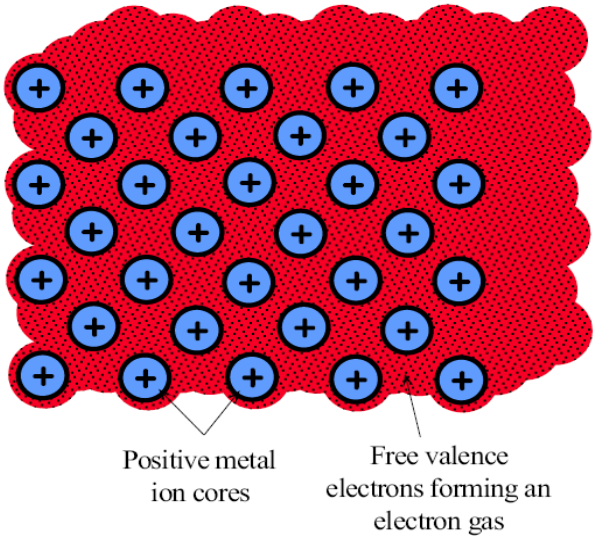
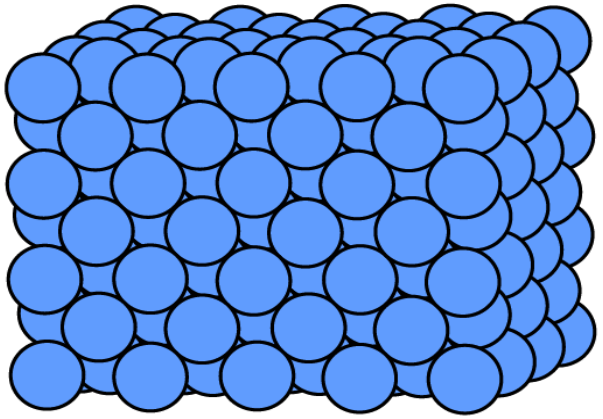
Examples of Crystals

Metals: iron, gold, silver, aluminum…virtually all metals are crystalline in form.

In metallic bonding the outer electrons of the metal atoms are loosely bound to their nuclei. They form a cloud that fills the spaces between the metal nuclei. These mobile electrons give metals their good electrical con-ductivity. The tightly packed nuclei are rigid but can deform under impact, making metals malleable (workable).





From *Principles of Electronic Materials and Devices, Third Edition*, S.O. Kasap (© McGraw-Hill, 2005)

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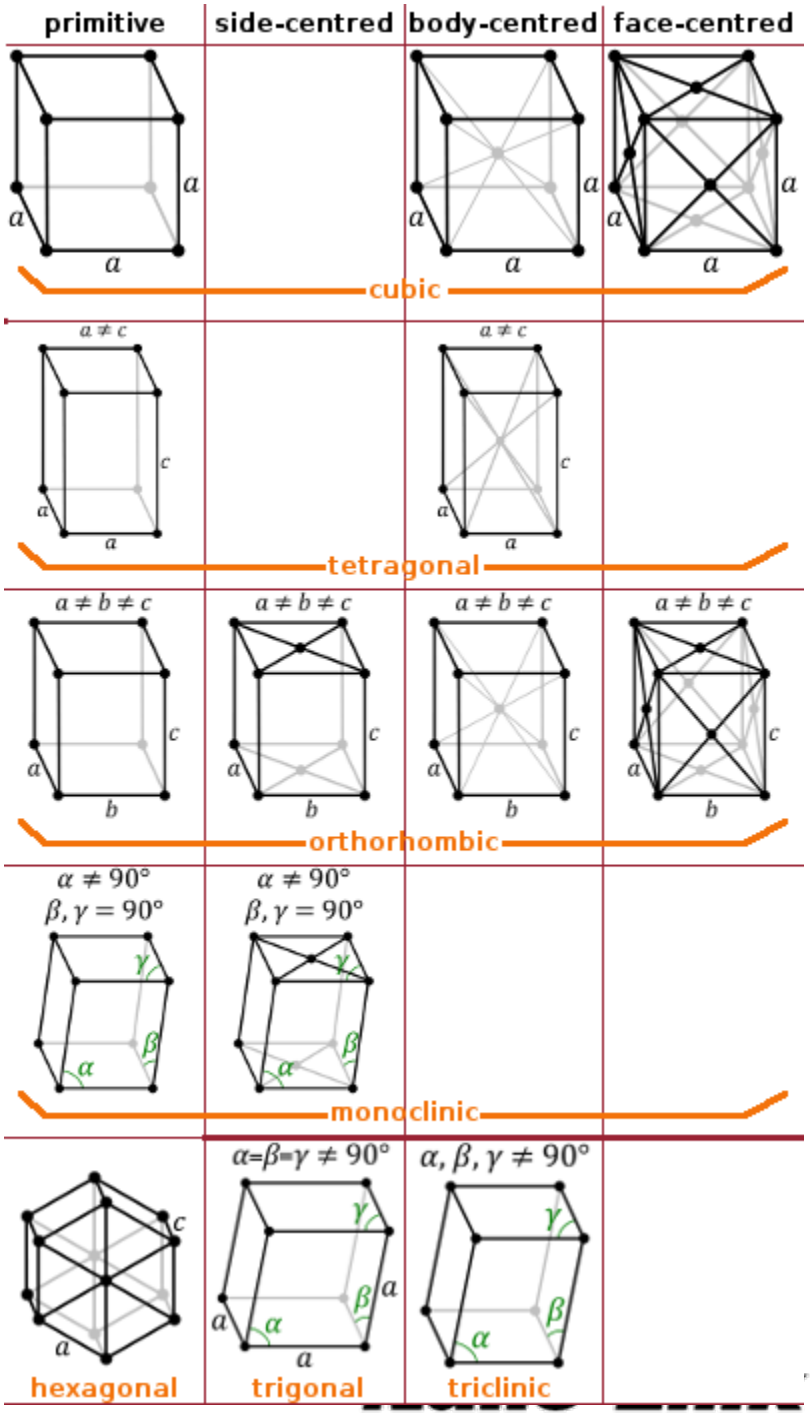
Classifying Crystals

Crystals arrangements are classified in a system of ideal shapes call *Bravais lattices.*

Of these lattice types, the body-centered cubic (BCC) and face centered cubic (FCC) forms are often seen in common materials.

Image:
http://users.aber.ac.uk



Crystals in Nitinol

Nitinol is an alloy—atoms of nickel and titanium are arranged in an orderly crystalline form. Unlike most metals, however, nitinol can exist in more than one crystal form, or *phase*. The two phases are called Martensite and Austenite.

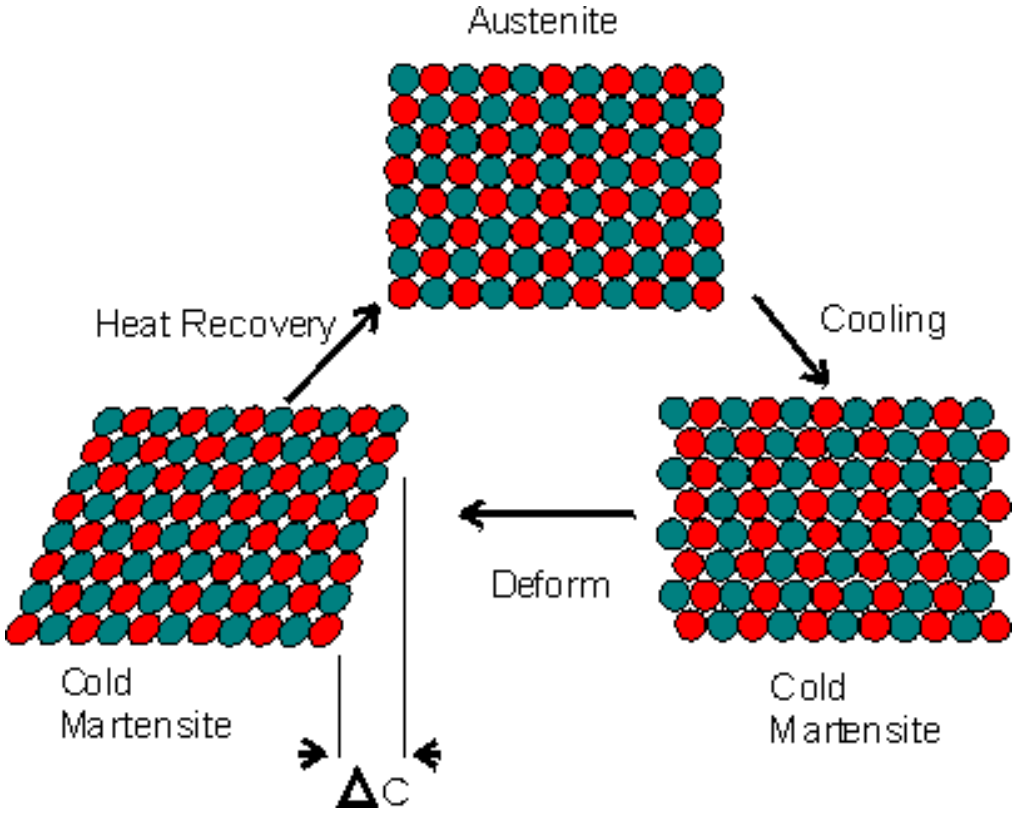


Image: imagesco.com.com

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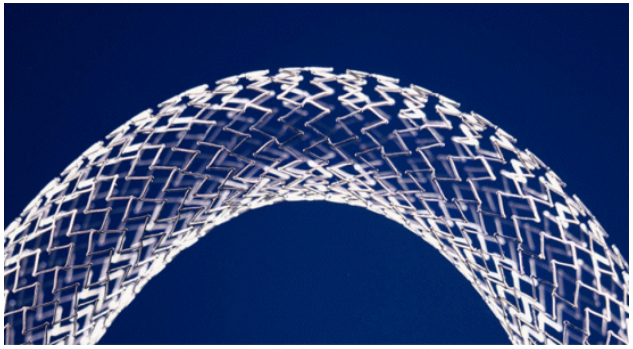
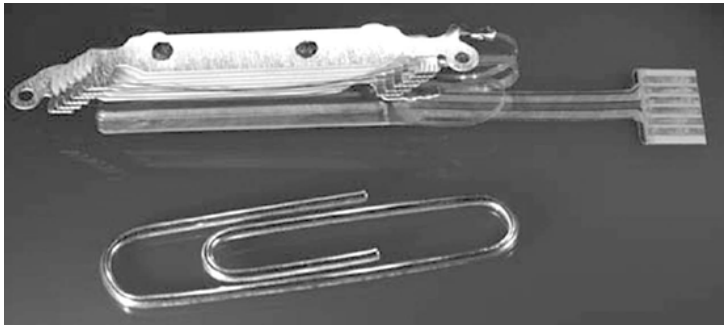
Applications of Nitinol

Parts for medical devices (from: todaysmachiningworld.com)



Stents for arteries (from: smartstructures.wikispaces.com

Braces wire (from: www.nnoble.com



Mechanical actuators (from: imagesco.com.com)