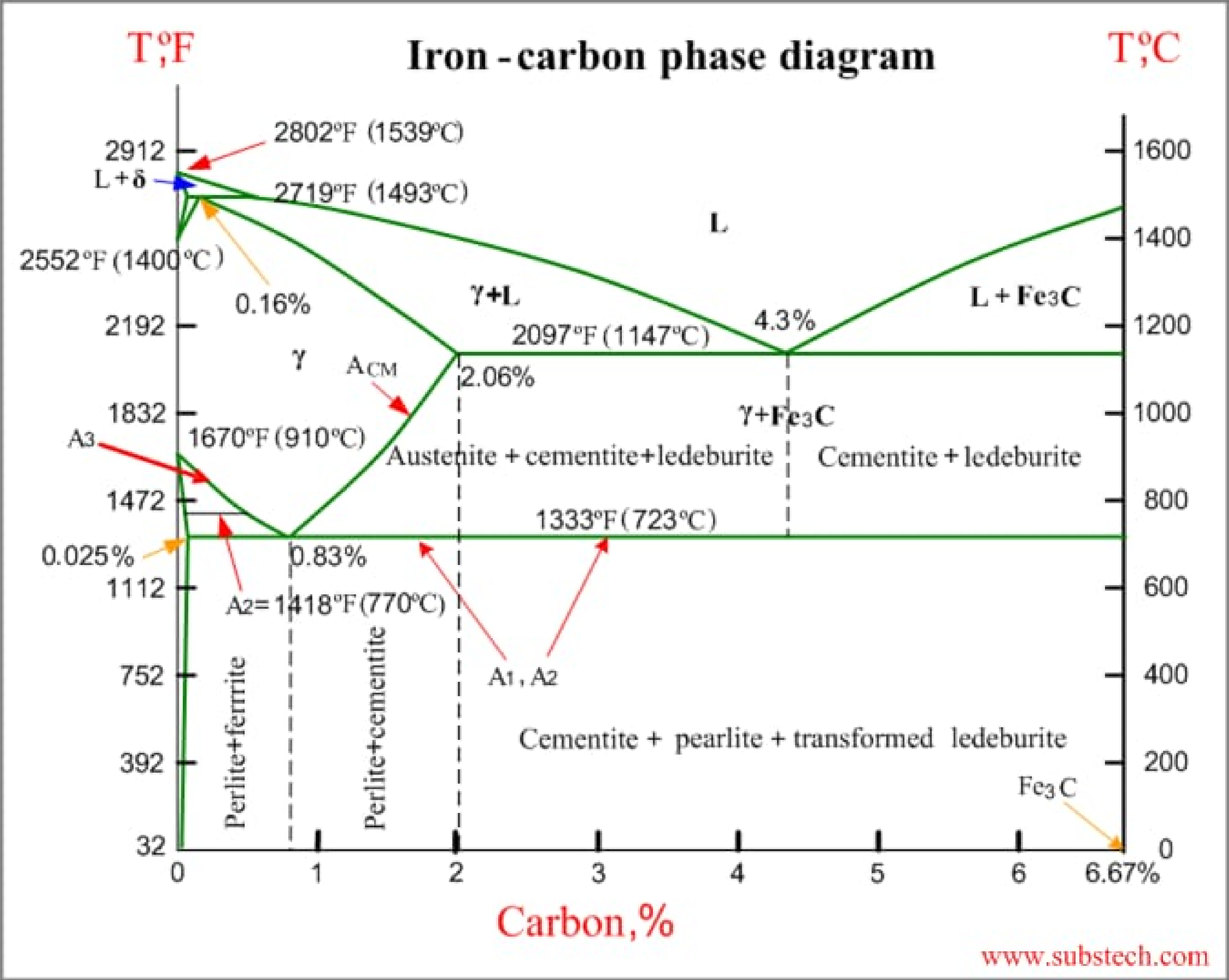


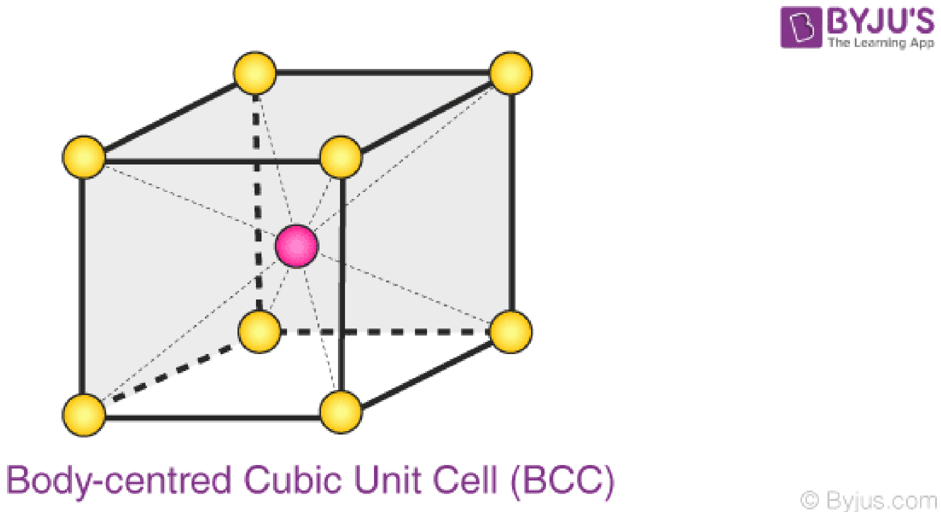
T,°F
Iron - carbon phase diagram
T,°C
2802°F (1539°C)
2912
L + δ
2719°F (1493°C)
L
2552°F (1400°C)
0.16%
γ+L
L + Fe3C
2192
4.3%
2097°F (1147°C)
γ
ACM
2.06%
1832
γ+Fe3C
A3
1670°F (910°C)
Austenite + cementite+ledeburite
Cementite + ledeburite
1472
1333°F (723°C)
0.025%
0.83%
1112
A2=1418°F (770°C)
Perlite+ferrite
Perlite+cementite
752
A1, A2
Cementite + pearlite + transformed ledeburite
392
Fe3C
32
0
1
2
3
4
5
6
6.67%
1600
1400
1200
1000
800
600
400
200
0
Carbon,%
www.substech.com

8 × 1/8 = **1 atom**.

2. Body-centred Cubic Unit Cell (BCC)

A BCC unit cell has atoms at each corner of the cube and an atom at the centre of the structure. The diagram shown below is an open structure. According to this structure, the atom at the body centre wholly belongs to the unit cell in which it is present.

1. In BCC unit cell every corner has atoms.
2. There is one atom present at the centre of the structure
3. Below diagram is an open structure
4. According to this structure atom at the body centres wholly belongs to the unit cell in which it is present.



Body centred Cubic (BCC) Unit Cell

Number of Atoms in BCC Cell:

Thus, in a BCC cell, we have:

- 8 corners × 1/8 per corner atom = 8 × 1/8 = 1 atom
- 1 body centre atom = 1 × 1 = 1 atom

Therefore, the total number of atoms present per unit cell = **2 atoms.**

Solved Example

Question:

Lithium metal crystallizes in a body centered cubic crystal. If the length of the side of the unit cell of lithium is 351pm, the atomic radius of the lithium will be

Solution:

In case of body centered cubic (BCC) crystal,

$a\sqrt{3} = 4r$

Hence, atomic radius of lithium

$r = \frac{a\sqrt{3}}{4}$

$= \frac{351 \times 1.732}{4}$

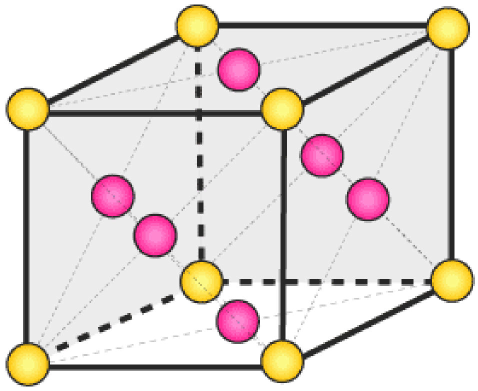
= 151.98

3. Face-centred Cubic Unit Cell (FCC)

An FCC unit cell contains atoms at all the corners of the crystal lattice and at the centre of all the faces of the cube. The atom present at the face-centered is shared between 2 adjacent unit cells and only 1/2 of each atom belongs to an individual cell.

1. In FCC unit cell atoms are present in all the corners of the crystal lattice
2. Also, there is an atom present at the centre of every face of the cube
3. This face-centre atom is shared between two adjacent unit cells
4. Only 12 of each atom belongs to a unit cell

The diagram shown below is an open structure.



Face-centred Cubic Unit Cell (FCC)

Number of Atoms in BCC Cell

a) 8 corners × 1/8 per corner atom = 8 × 1/8 = 1 atom
b) 6 face-centered atoms × 1/2 atom per unit cell = 3 atoms

Hence, the total number of atoms in a unit cell = 4 atoms

Thus, in a face-centred cubic unit cell, we have:

- 8 corners × 1/8 per corner atom = 8 × 1/8 = 1 atom
- 6 face-centred atoms × 1/2 atom per unit cell = 3 atoms

Therefore, the total number of atoms in a unit cell = **4 atoms**.

Volume of HCP Unit Cell

A unit cell is the smallest representation of an entire crystal. The hexagonal closest packed (HCP) has a coordination number of 12 and contains 6 atoms per unit cell. The face-centered cubic (FCC) has a coordination number of 12 and contains 4 atoms per unit cell.

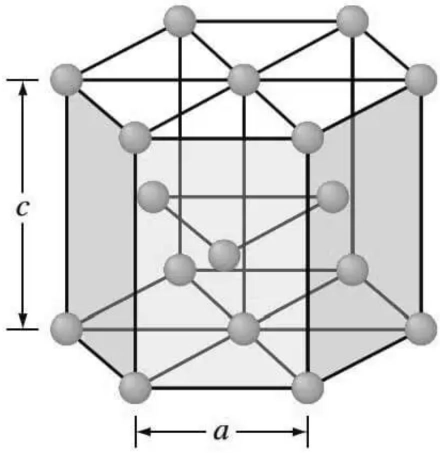
Volume = area of base × height

$$Height\ of\ unit\ cell = \sqrt{\frac{2}{3}}4r$$
$$Area\ of\ base = 6\sqrt{3} \times r^2$$
$$Volume = 6\sqrt{3} \times r^2 \times \sqrt{\frac{2}{3}}4r$$
$$Volume = 24\sqrt{2r^3}$$

Calculated from lattice constants by using the above equation, $R = \sqrt{2}a/4$.

3. Hexagonal Close-Packed (HCP) Crystal Structure

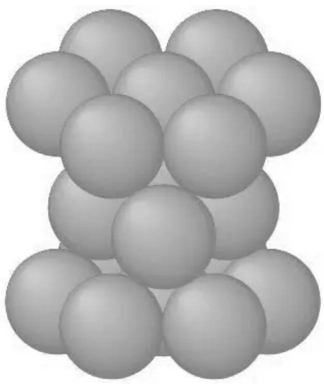
The third common metallic crystal structure is the hexagonal close-packed (HCP) structure shown below.



schematic of the HCP crystal structure

Metals do not crystallize into the simple hexagonal crystal structure because the APF is too low.

The atoms can attain lower energy and a more stable condition by forming the HCP structure as shown in the below figure.



HCP hard-sphere model

The APF of the HCP crystal structure is 0.74, the same as that for the FCC crystal structure since in both structures the atoms are packed as tightly as possible.

In both the HCP and FCC crystal structures, each atom is surrounded by 12 other atoms, and thus both structures have a coordination number of 12.

The isolated HCP unit cell, also called the primitive cell, is shown in the below figure.

Hume-Rothery rules, named after William Hume-Rothery, are a set of basic rules that describe the conditions under which an element could dissolve in a metal, forming a solid solution. There are two sets of rules; one refers to substitutional solid solutions, and the other refers to interstitial solid solutions.

Substitutional solid solution rules

For substitutional solid solutions, the Hume-Rothery rules are as follows:

1. The atomic radius of the solute and solvent atoms must differ by no more than 15%:[1]

$$\% \text{ difference} = \left(\frac{r_{\text{solute}} - r_{\text{solvent}}}{r_{\text{solvent}}} \right) \times 100\% \le 15\%.$$

2. The crystal structures of solute and solvent must be similar.
3. Complete solubility occurs when the solvent and solute have the same valency.[2] A metal is more likely to dissolve a metal of higher valency, than vice versa. [3] [4] [5]
4. The solute and solvent should have similar electronegativity. If the electronegativity difference is too great, the metals tend to form intermetallic compounds instead of solid solutions.

Nanomaterial

Nano material can be defined as material with an average grain size less than 100 nano meter.

Nano material have an extreamly small size which having atleast one dimension 100nm

One million nano meter equl to 1 meter

INTRODUCTION

1. a material having particles or constituents of nanoscale dimensions, or one that is produced by nanotechnology.

meant by nano materials

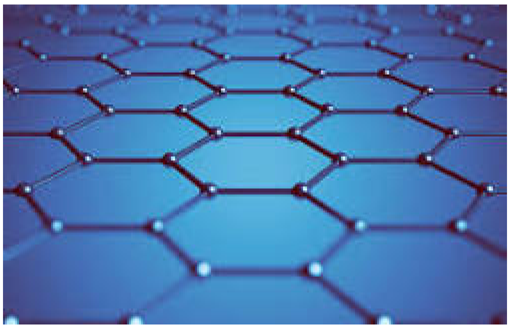
Nanomaterials are **chemical substances or materials that are manufactured and used at a very small scale**. ... ISO (2015) defines a nanomaterial as a: 'material with any external dimension in the nanoscale (size range from approximately 1 – 100 nm) or having internal structure or surface structure in the nanoscale'.

are examples of nano materials?

Nanomaterial examples

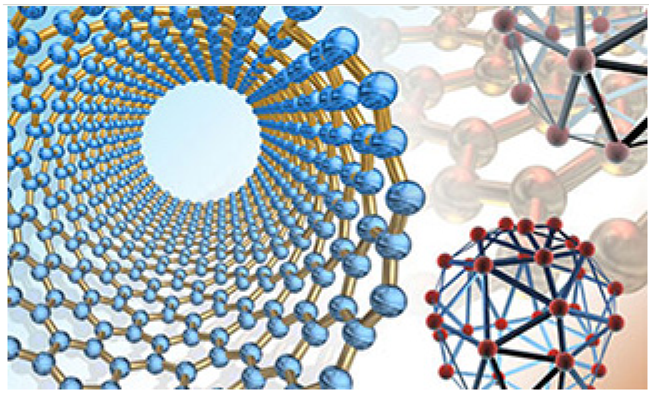
- Titanium dioxide.
- Silver.
- Synthetic amorphous silica.
- Iron oxide.
- Azo pigments.
- Phthalocyanine pigments.

What are the nano materials and how are they made



Nanomaterials can occur naturally, be **created as the by-products of combustion reactions**, or be produced purposefully through engineering to perform a specialised function. These materials can have different physical and chemical properties to their bulk-form counterparts.

Introduction



What are nanomaterials?

Scientists have not unanimously settled on a precise definition of nanomaterials, but agree that they are partially characterized by their tiny size, measured in nanometers. A nanometer is one millionth of a millimeter - approximately 100,000 times smaller than the diameter of a human hair.

Nano-sized particles exist in nature and can be created from a variety of products, such as carbon or minerals like silver, but nanomaterials by definition must have at least one dimension that is less than approximately 100 nanometers. Most nanoscale materials are too small to be seen with the naked eye and even with conventional lab microscopes.

Materials engineered to such a small scale are often referred to as engineered nanomaterials (ENMs), which can take on unique optical, magnetic, electrical, and other properties. These emergent properties have the potential for great impacts in electronics, medicine, and other fields. For example,

1. Nanotechnology can be used to design pharmaceuticals that can target specific organs or cells in the body such as cancer cells, and enhance the effectiveness of therapy.
2. Nanomaterials can also be added to cement, cloth and other materials to make them stronger and yet lighter.
3. Their size makes them extremely useful in electronics, and they can also be used in environmental remediation or clean-up to bind with and neutralize toxins.

However, while engineered nanomaterials provide great benefits, we know very little about the potential effects on human health and the environment. Even well-known materials, such as silver for example, may pose a hazard when engineered to nano size.

Nano-sized particles can enter the human body through inhalation and ingestion and through the skin. Fibrous nanomaterials made of carbon have been shown to induce inflammation in the lungs in ways that are similar to Asbestos .

Where are nanomaterials found?

Some nanomaterials can occur naturally, such as blood borne proteins essential for life and lipids found in the blood and body fat. Scientists, however, are particularly interested in engineered nanomaterials (ENMs), which are designed for use in many commercial materials, devices and structures. Already, thousands of common products-- including sunscreens, cosmetics, sporting goods, stain-resistant clothing, tires, and electronics—are manufactured using ENMs. They are also in medical diagnosis, imaging and drug delivery and in environmental remediation.

What are some of the main take-home points that NIEHS want people to know about nonmaterials? ((National Institute of Environmental Health Sciences)

There are three main take-home points:

- **There is no single type of nanomaterial.** Nanoscale materials can in theory be engineered from minerals and nearly any chemical substance, and they can differ with respect to composition, primary particle size, shape, surface coatings and strength of particle bonds. A few of the many examples include nanocrystals, which are composed of a quantum dot surrounded by semiconductor materials, nano-scale silver, dendrimers, which are repetitively branched molecules, and fullerenes, which are carbon molecules in the form of a hollow sphere, ellipsoid or tube.
- **The small size makes the material both promising and challenging.** To researchers, nanomaterials are often seen as a "two-edged sword." The properties that make nanomaterials potentially beneficial in product development and drug delivery, such as their size, shape, high reactivity and other unique characteristics, are the same properties that cause concern about the nature of their interaction with biological systems and potential effects in the environment. For example, nanotechnology can enable sensors to detect very small amounts of chemical vapors, yet often there are no means to detect levels of nanoparticles in the air—a particular concern in workplaces where nanomaterials are being used.
- **Research focused on the potential health effects of manufactured nano-scale materials is being developed, but much is not known yet.** NIEHS is committed to developing novel applications within the environmental health sciences, while also investigating the potential risks of these materials to human health.

Why is NIEHS involved in nanotechnology?

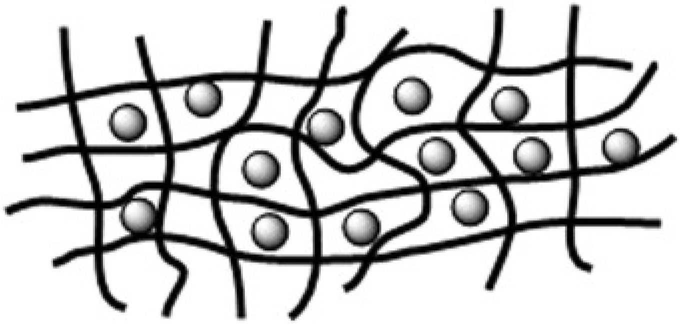
NIEHS has two primary interests in the field of nanotechnology: harnessing the power of engineered nanomaterials to improve public health, while at the same time understanding the potential risks associated with exposure to the materials.

Fibre-reinforced plastic (FRP)

is a composite material made of a polymer matrix ...

polymer matrix

Polymer matrix is **the continuous phase in the composites used to hold the reinforcing agent in its place**, and its properties determine most of the degradative processes (delamination, impact damage, chemical resistance, water absorption, and high-temperature creep).

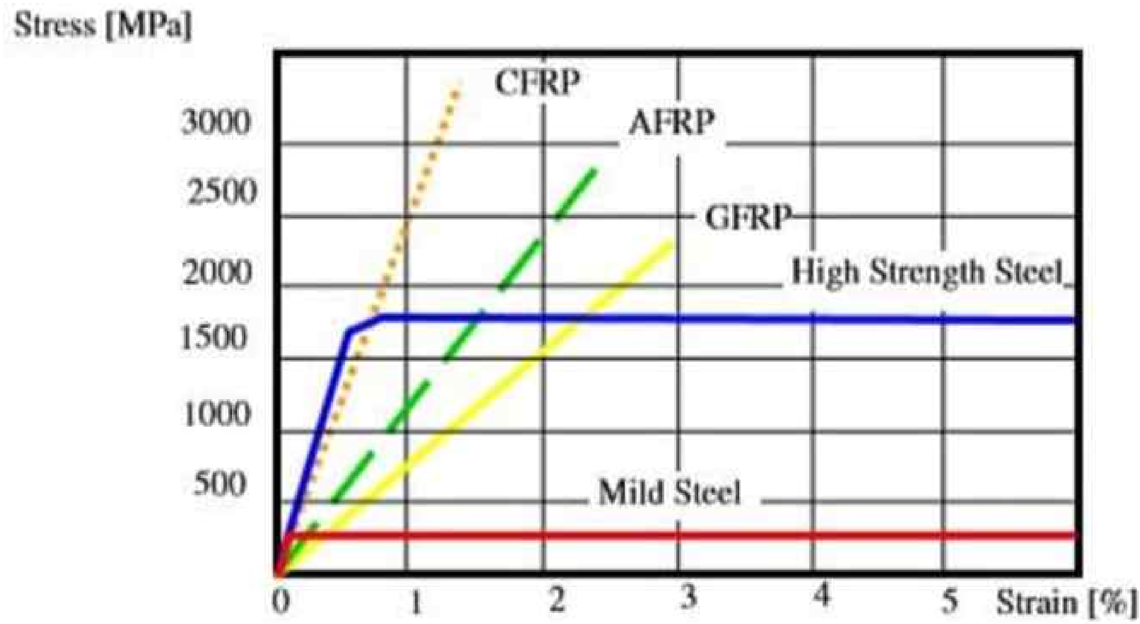


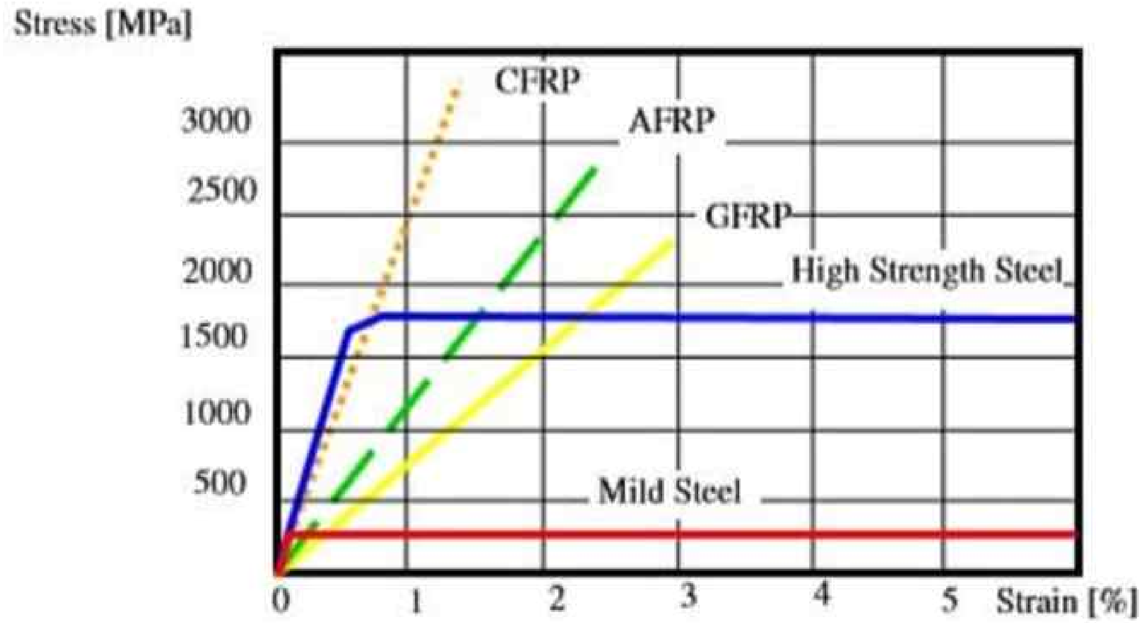
What is fiber reinforced plastic used for?

Fibre reinforced polymer (FRP) are composites used in almost every type of **advanced engineering structure**, with their usage ranging from aircraft, helicopters and spacecraft through to boats, ships and offshore platforms and to automobiles, sports goods, chemical processing equipment and civil infrastructure

Types of Fibre Reinforced Polymer (FRP)

- Glass Fibre Reinforced Polymer (GFRP) Ad. Glass fibres are basically made by mixing silica sand, limestone, folic acid and other minor ingredients. ...
- Carbon Fibre Reinforced Polymer (CFRP) Ad. ...
- Aramid Fibre Reinforced Polymer (AFRP) Aramid is the short form for aromatic polyamide.





Types of Cast Iron

The following are **types of cast iron used for engineering purposes:**

1. Grey cast iron
2. White cast iron
3. Chilled cast iron
4. Mottled cast iron
5. Malleable cast iron
6. Nodular cast iron
7. Alloy cast iron

#1 Grey Cast Iron

Grey cast iron is commercial iron has the following **compositions:**

It consists of Carbon – 3 to 3.5%, Silicon – 1 to 2.75%, Manganese – 0.40 to 1%, Phosphorus – 0.15 to 1%, Sulphur – 0.02 to 0.15% and the remaining is iron.

2 White Cast Iron

White cast iron shows a white fracture and have the following relative **compositions**:

It consists of Carbon – 1.75 to 2.3%, Silicon – 0.85 to 1.2%, Manganese – 0.10 to 0.40%, Phosphorus – 0.05 to 0.20%, Sulphur – 0.12 to 0.35%

#3 Chilled Cast Iron

It is white cast iron produced by quick cooling of molten iron. The quick cooling is generally called chilling and the iron so produced is known as chilled iron. All casting moulds have contact with molten iron with cool sand on their outer skin. But on most casting, this hardness penetrates to a very small depth (less than mm).

#5 Malleable Cast Iron

The malleable cast iron is obtained from white cast iron by a suitable heat treatment process (i.e., annealing). The annealing process separates the combined carbon of the white cast iron into nodules of free graphite.

7 Alloy Cast Iron

The cast iron discussed above is called plain cast irons. The alloy cast iron is produced by adding elements like nickel, chromium, molybdenum, copper, silicon, and manganese.

These alloys give greater strength and result in improved element properties.

The alloy cast iron has,

1. Carbon – 0.02%
2. Silicon – 0.15%
3. Manganese – 0.03%
4. Phosphorus – 0.12%
5. Sulphur – 0.02%
6. Slag – 3% (by weight) and the remaining is iron.