

Introduction to Engineering Materials

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Why Study materials Science & Engineering

- Understand the prosperities of Materials
- Selection of Right Materials in Terms of-
 - Material Properties, characteristics
 - Materials Abundance, Availability
 - Materials Processing
 - Materials Durability
 - Materials Cost

Classification of Materials

Metal

- Ferrous-
 - Iron, Commonly known as 'Fe' came from 'Ferrous', This is called Ferrous material.
 - Cast Iron
 - Carbon Steel (Alloy of Iron)
 - 1018
 - 1065
 - 1080
 - Stainless Steel (Alloy of Iron)
 - SAE 304, SAE 310, SAE 316, SAE 410
- Non-Ferrous
 - Aluminum
 - Al 6061
 - Cu
 - Brass (An Alloy of Cu and Ni)

Plastic

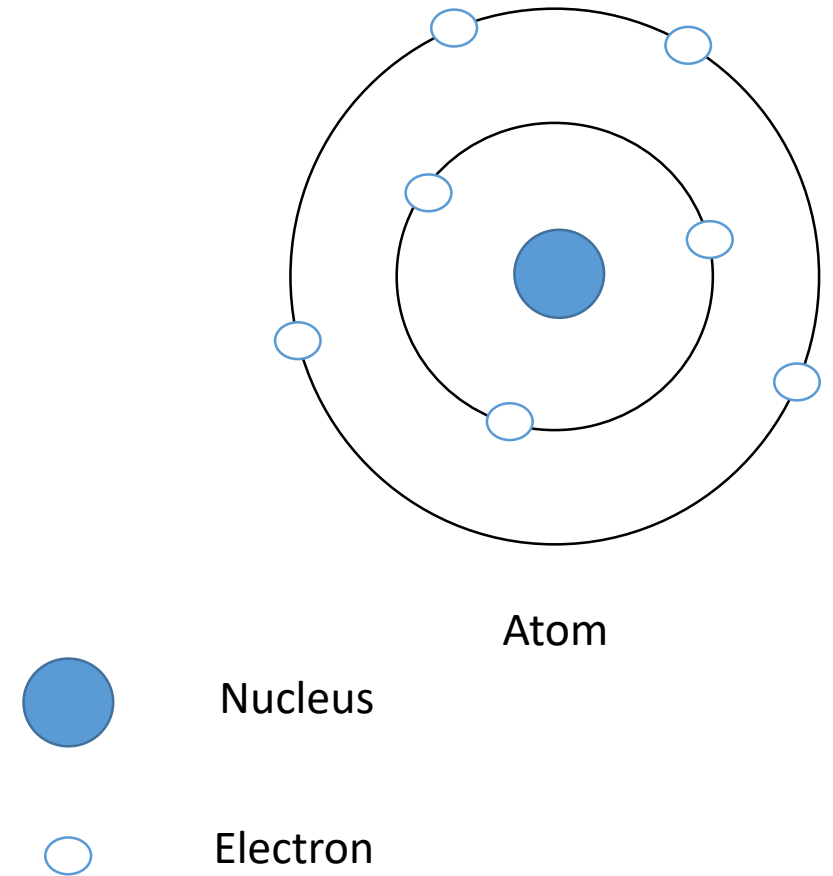
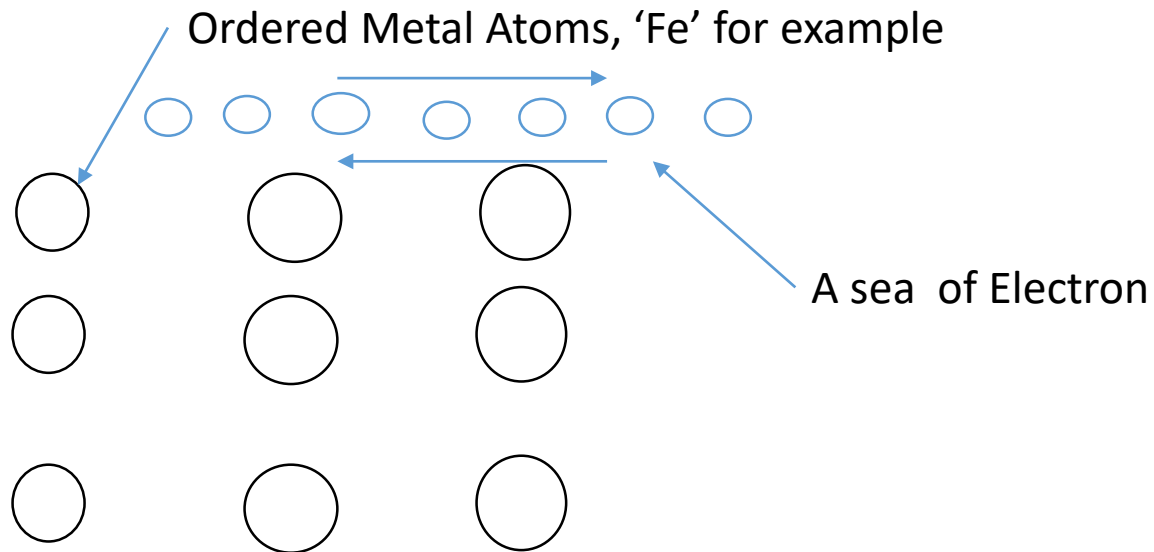
- Thermoplastics- Poly Ethylene (PE), Poly-Propylene (PP), Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Acrylic, ABS, Nylon, PLA, Poly-Carbonate.
- Thermosets- Poly-Urethanes, Polyester, Epoxy Resin, Vulcanized Rubber.

Ceramics

- Sintered (A Process where high pressure and Temperature are simultaneously applied)
 - Aluminum Nitrides, Aluminum Oxides, Crucibles
- Non-sintered
 - Bricks, Concretes, Tiles, Pottery


Metals

- Ordered group of atoms and molecules
- Relatively Denser than Metals and Polymers
- Large number of non-localized electrons
- Metals show electrical conductivity



Ceramics

- Mostly oxide, carbides and Nitrides, Example Aluminum Oxide, Iron Oxide, Silicon Di-Oxide (Silica)
- Typically Very Hard and Brittle
- Low Resistance to Fracture
- High Temperature Resistant
- Low Thermal Conductivity



Silicon-→Silica

Silicon is a Single Si Atom

$\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$

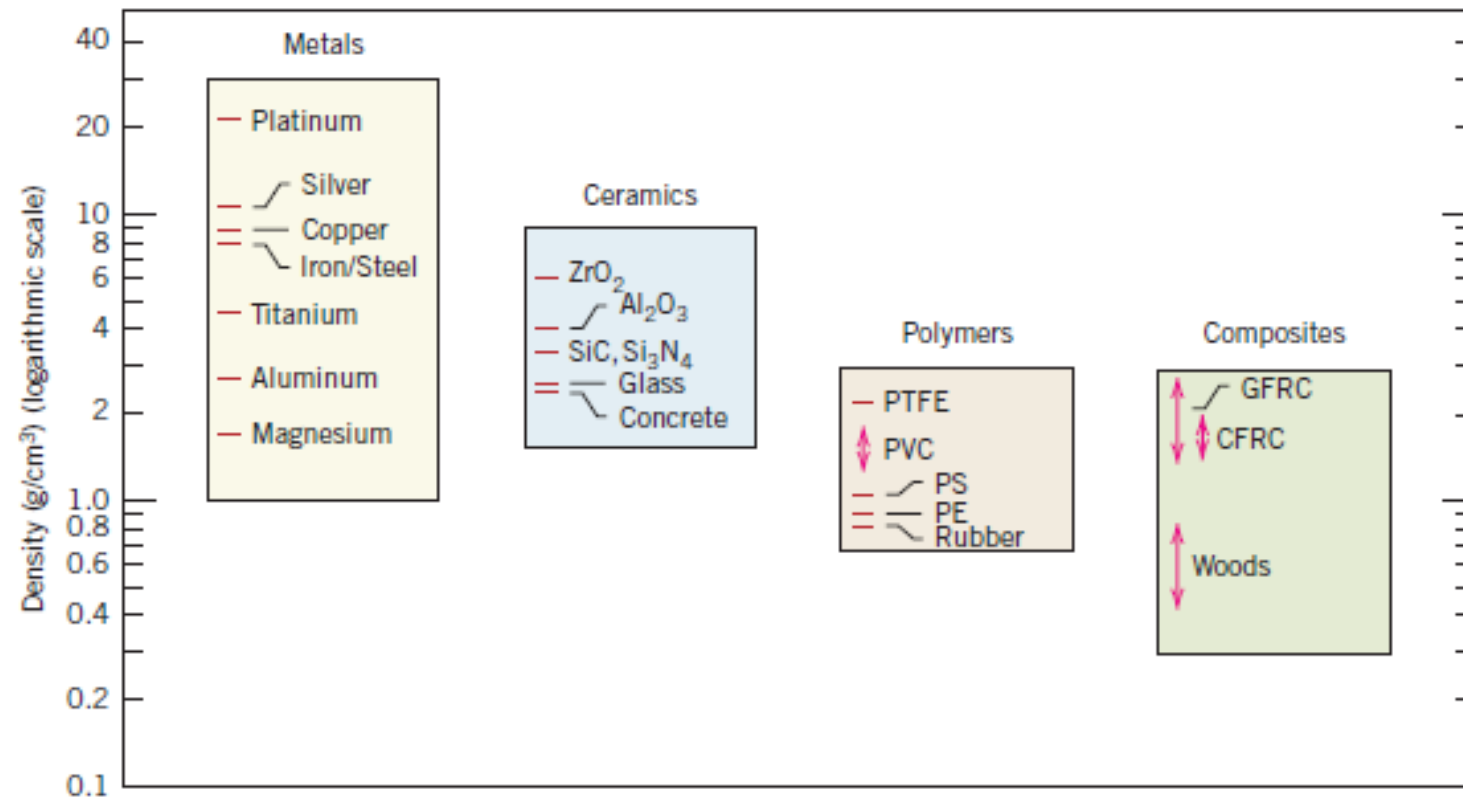
Silica is a Molecule, made of Si and O

Polymers

- Plastic and Rubber Materials
- Mostly Organic Compounds (Compound that contains Carbon)
- Molecular Structure is very Large
- Start from a *Monomer* and create a large chain after reaction

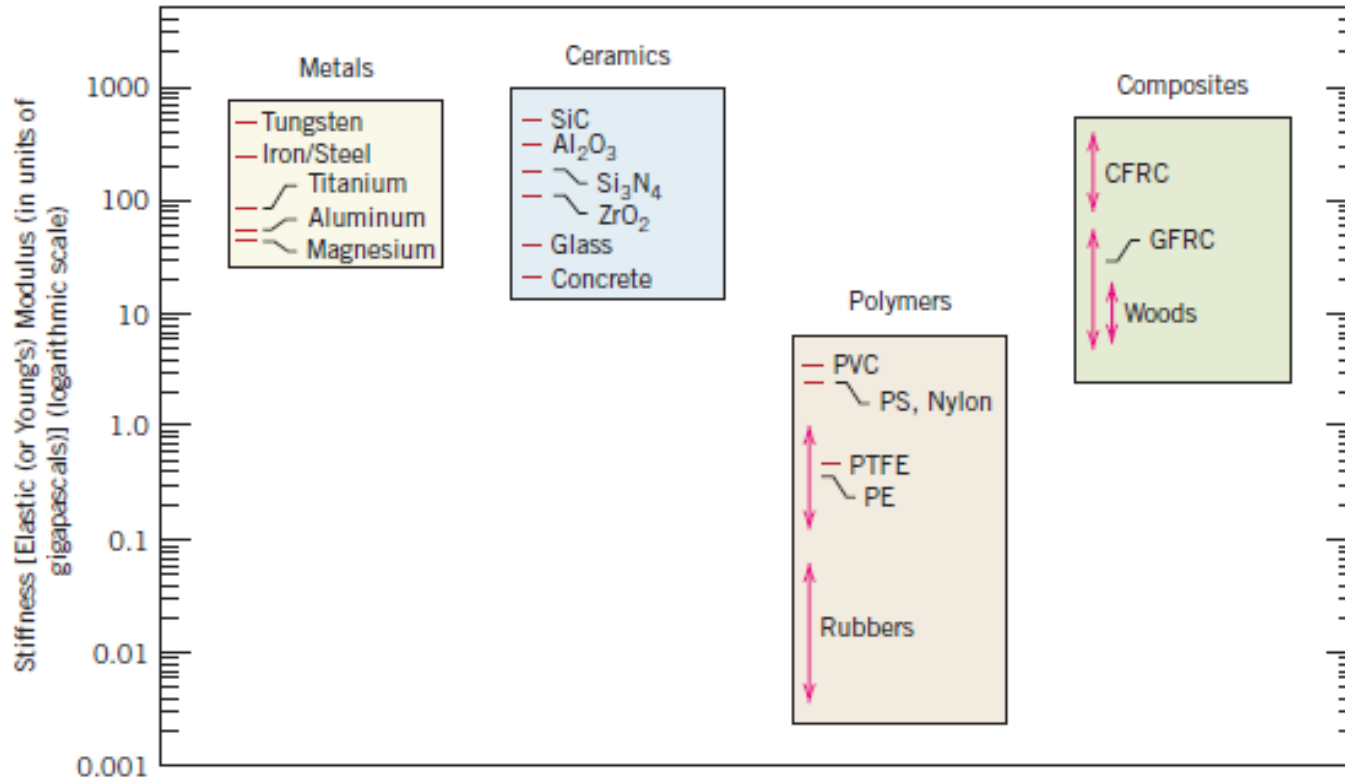
Mostly Abundant elements are- Carbon, Si, O, N

Density Comparison of Materials



- What is density?
- $\text{Density} = \text{Mass} / \text{Volume}$
- Why Density matters?
 - Higher the density, heavier
 - Lighter material saves weight

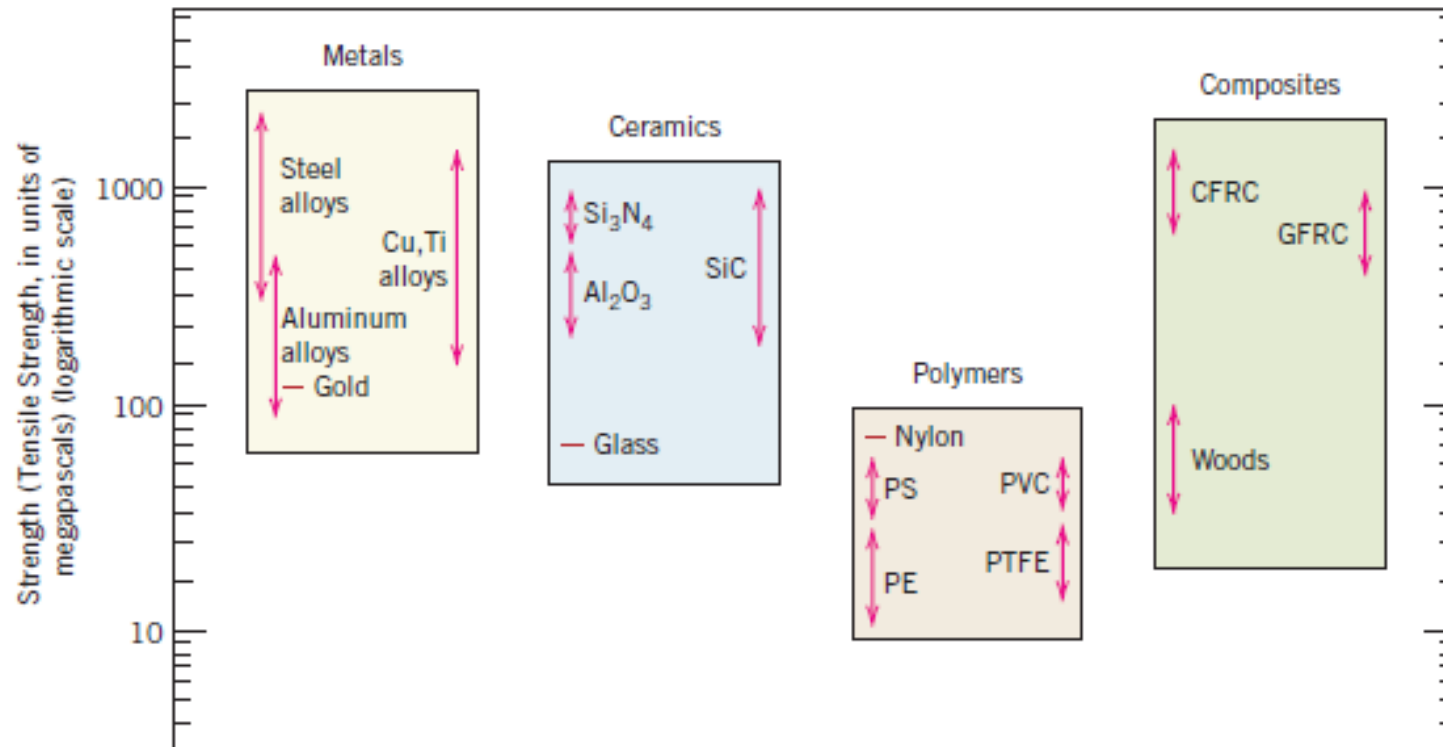
Stiffness Comparison



What is stiffness?

- Modulus of rigidity
- Tells you how rigid the material is.

Tensile Strength Comparison

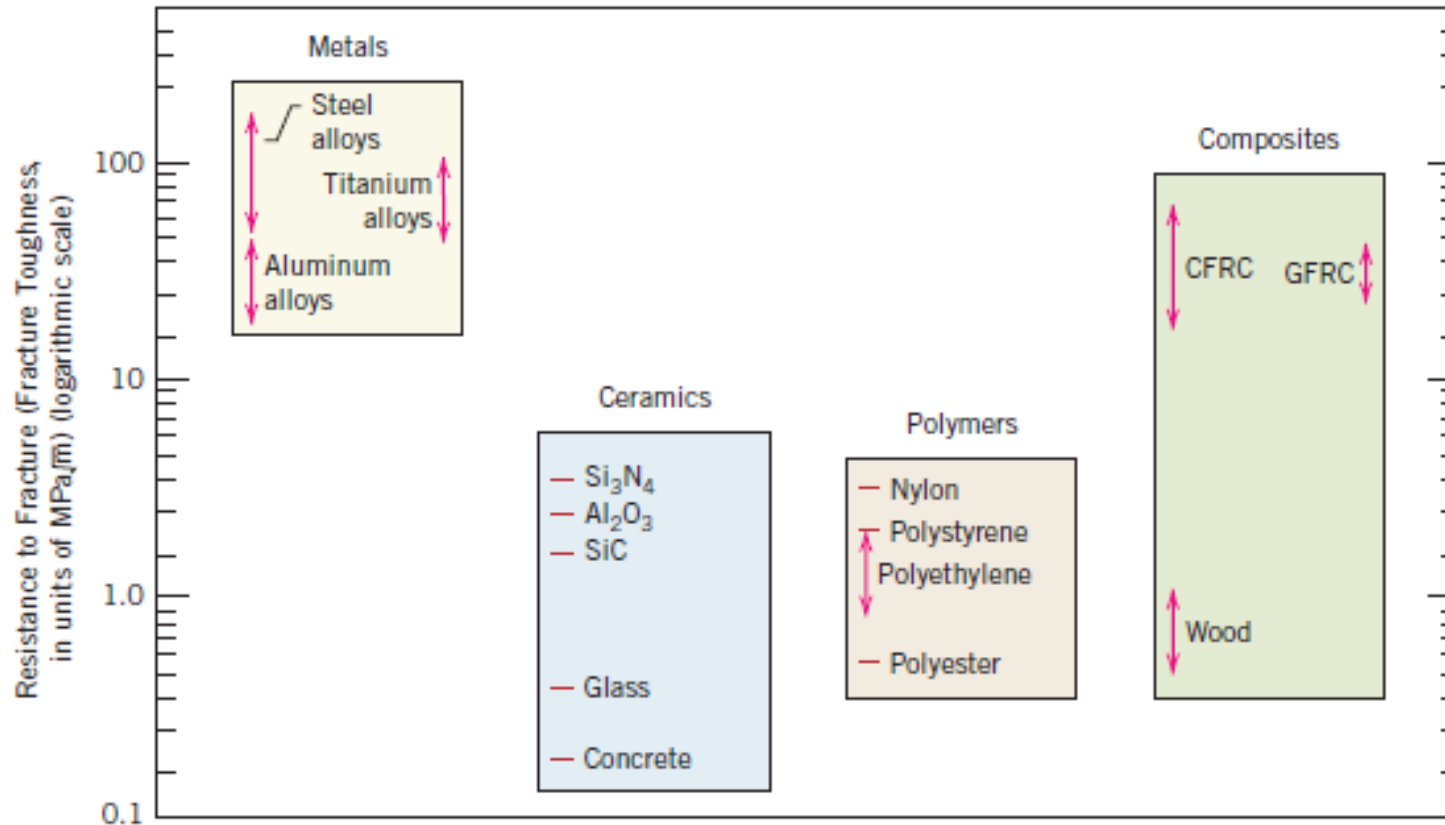


- What is strength?
 - Stress that can be applied without failure

What is Stress?

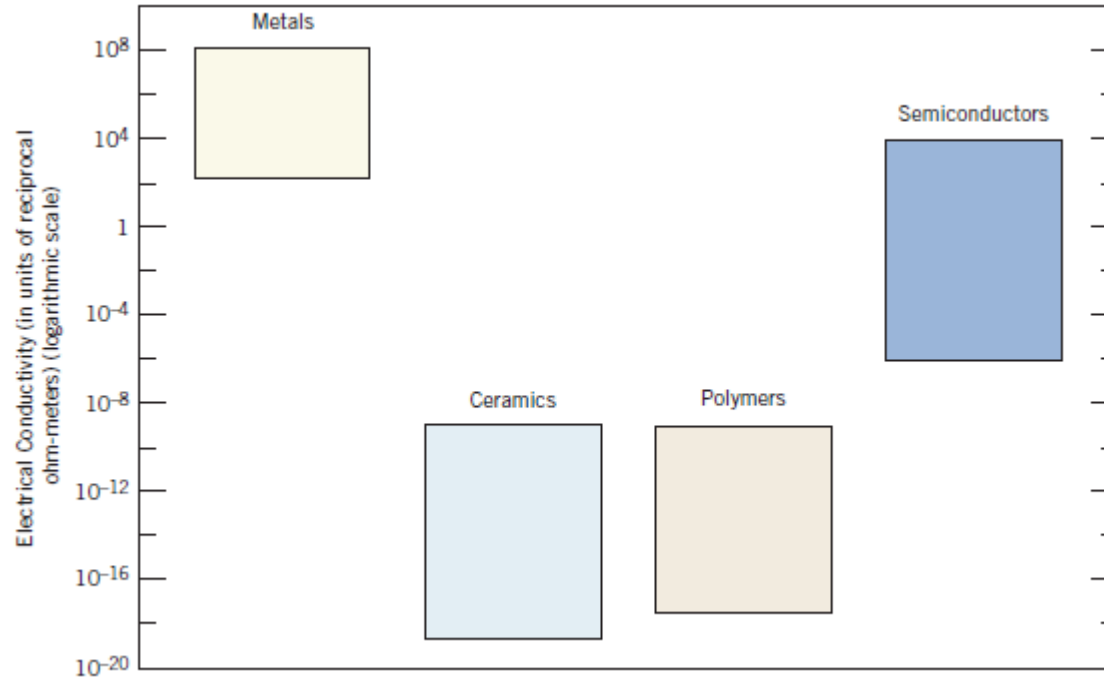
- Force applied to unit sectional area.

Fracture Resistance



- This is not Tensile Resistance
- Fracture Resistance
 - With Crack
 - Metal is good
 - Polymer is not good
 - Ceramic is not good
 - Without Crack
 - Metal is good
 - Polymer is okay
 - Ceramic is not good

Electrical Conductivity



- What is this?
 - Ability to conduct electrons.
- Conductors
 - Cu, Aluminum
- Insulators
 - Ceramics and Polymers

Common Materials Applications



- What Materials are They?
- Kitchen ware
- Coins
- Nuts and Bolts
- Scissors
- Ring
- All metals



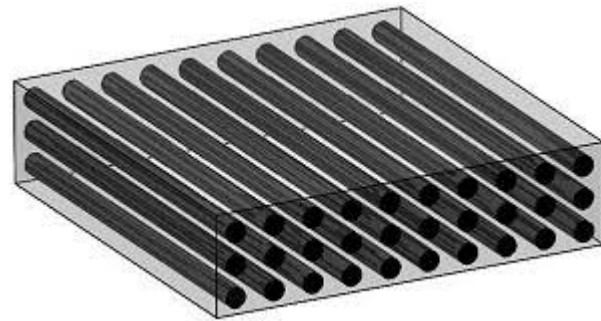
- What Materials Are They?
 - Brick
 - Pottery
 - Tile
 - Glass
 - Scissor
- Glass and Scissor are not ceramic
- Everything else Ceramic



- What Materials are They?
- Helmet-Plastic
- Hard Balls- Hard Plastic
- Bottles- Soft Plastic
- Tire- Rubber
- Dice- Hard Plastic
- Utensils-Plastic

Composites

- A Composition of two or More Materials
- Man Made-
 - CFRP- Carbon Fiber reinforced Polymers
 - GFRP-Glass fiber reinforced Polymers
- Natural-
 - Wood



CFRP



Some Properties of Common material

Materials	Ultimate Tensile Strength, MPa	Hardness	Density g/cc	% Elongation
Acrylic	62	94, Rockwell M	1.18	4-5%
HDPE	11-43	33-66, Rockwell R	0.92-2.55	
Epoxy	96.5	121, Rockwell M	1.5	0.7-400%
1018 Steel, cold drawn	440	71, Rockwell B	7.87	15%
6061 Al-T6	275	100, BHN	2.70	17-95%
Silicon Nitride	830 (Flexural Strength)	9, MOHS	3.44	0.5-1%

What Materials Properties are Concerned?

- Strength
- Hardness
- Density
- Ductility vs Rigidity
- Conductivity (Electrical and Thermal)
- Thermal Resistance

Assignment

- Explore a number of Engineering applications of Materials in your daily life.
- List at least 10 applications with materials. Try to include picture of each.
- Categorize them in terms of following-
 - Engineering/Technical Name of Material and its Application
 - Types (Metals, Ceramics, Polymers, Composites)
 - Strength
 - Ductility
- Include everything in a Table.
- Submit in D2L/Blackboard Assignment link.