

An Introduction to COMPOSITES



Presentation will cover the topics.....

- ◉ History and Introduction of Composites
- ◉ Examples and composites in our daily life
- ◉ General Properties of Composites
- ◉ Manufacturing of Composites
- ◉ Advantages
- ◉ Disadvantages and Limitations
- ◉ Uses of Composites

What are Composites?

- ◎ Composite materials are formed by combining two or more materials that have quite different properties. The different materials work together to give the composite unique properties, but within the composite you can easily tell the different materials apart – they do not dissolve or blend into each other.

Composite materials are engineered materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure.



Existence in Nature

- Composites exist in nature. A piece of wood is a composite, with long fibers of cellulose (a very complex form of starch) held together by a much weaker substance called lignin. Cellulose is also found in cotton and linen, but it is the binding power of the lignin that makes a piece of timber much stronger than a bundle of cotton fibers.

History

- ◉ Wood is a natural composite of cellulose fibers
- ◉ The most primitive manmade composite materials were straw and mud combined to form bricks for building construction;
- ◉ Plywood is a commonly used composite material



For example

- ◎ Fiberglass , developed in the late 1940s, was the first modern composite and is still the most common.
- ◎ Another well-known composite is concrete.

Constituents

- ◉ Matrix
- ◉ Reinforcement
- ◉ Additional materials

- **Composites** are combinations of two materials in which one of the material is called the **reinforcing phase**, is in the form of fibers, sheets, or particles, and is embedded in the other material called the **matrix phase**.

- **Reinforcing materials are strong with low densities while the matrix is usually a ductile or tough material. If the composite is designed and fabricated correctly, it combines the strength of the reinforcement with the toughness of the matrix to achieve a combination of desirable properties not available in any single conventional material.**

Components of composite materials

Reinforcement: fibers

Glass
Carbon
Organic
Boron
Ceramic
Metallic

Matrix materials

Polymers
Metals
Ceramics

Interface

Bonding
surface

Matrix

- Matrix may also be called binder. . The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions

Reinforcement

- ◎ The reinforcements impart their special mechanical and physical properties to enhance the matrix properties.

The reinforcement materials are often fibers but also commonly ground minerals

Composites

Material	Characteristics
Fibers	
Glass	High strength, low stiffness, high density; lowest cost; E (calcium aluminoborosilicate) and S (magnesia-aluminosilicate) types commonly used.
Graphite	Available as high-modulus or high-strength; low cost; less dense than glass.
Boron	High strength and stiffness; highest density; highest cost; has tungsten filament at its center.
Aramids (Kevlar)	Highest strength-to-weight ratio of all fibers; high cost.
Other fibers	Nylon, silicon carbide, silicon nitride, aluminum oxide, boron carbide, boron nitride, tantalum carbide, steel, tungsten, molybdenum.
Matrix materials	
Matrix materials	
Thermosets	Epoxy and polyester, with the former most commonly used; others are phenolics, fluorocarbons, polyethersulfone, silicon, and polyimides.
Thermoplastics	Polyetheretherketone; tougher than thermosets but lower resistance to temperature.
Metals	Aluminum, aluminum-lithium, magnesium, and titanium; fibers are graphite, aluminum oxide, silicon carbide, and boron.
Ceramics	Silicon carbide, silicon nitride, aluminum oxide, and mullite; fibers are various ceramics.

Additional materials

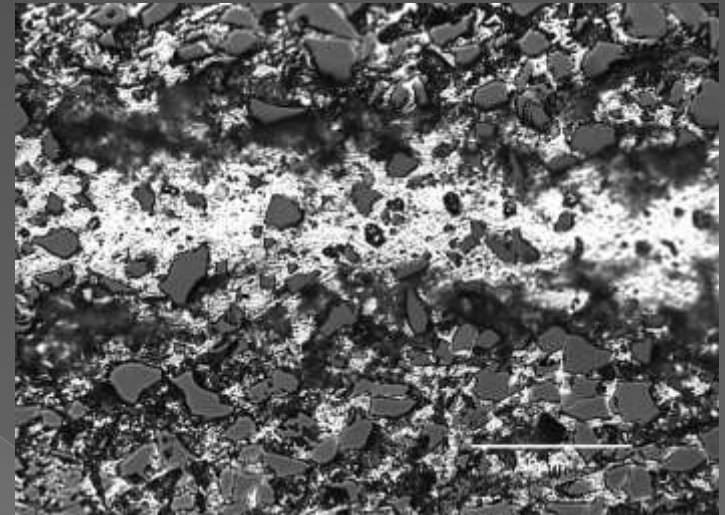
- ◎ A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination.

Types of Composites

- ◉ Fiber-reinforced plastic (FRP)
- ◉ Sandwich structured composite
- ◉ Glass matrix composites
- ◉ Ceramic Matrix Composites
- ◉ Carbon Carbon Composites
- ◉ Metal composites

➤ Metal Matrix Composites (MMCs)

Include mixtures of ceramics and metals, such as cemented carbides and other cermets, as well as aluminum or magnesium reinforced by strong, high stiffness fibers



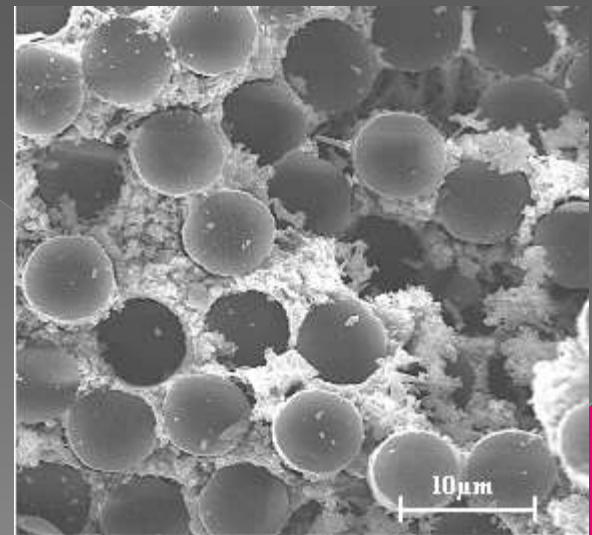
Composites – Metal Matrix

The metal matrix composites offer higher modulus of elasticity, ductility, and resistance to elevated temperature than polymer matrix composites. But, they are heavier and more difficult to process.

Fiber	Matrix	Applications
Graphite	Aluminum	Satellite, missile, and helicopter structures
	Magnesium	Space and satellite structures
	Lead	Storage-battery plates
	Copper	Electrical contacts and bearings
Boron	Aluminum	Compressor blades and structural supports
	Magnesium	Antenna structures
	Titanium	Jet-engine fan blades
Alumina	Aluminum	Superconductor restraints in fission power reactors
	Lead	Storage-battery plates
	Magnesium	Helicopter transmission structures
Silicon carbide	Aluminum, titanium	High-temperature structures
	Superalloy (cobalt-base)	High-temperature engine components
Molybdenum, tungsten	Superalloy	High-temperature engine components

➤ Ceramic Matrix Composites (CMCs)

Least common composite matrix. Aluminum oxide and silicon carbide are materials that can be imbedded with fibers for improved properties, especially in high temperature applications



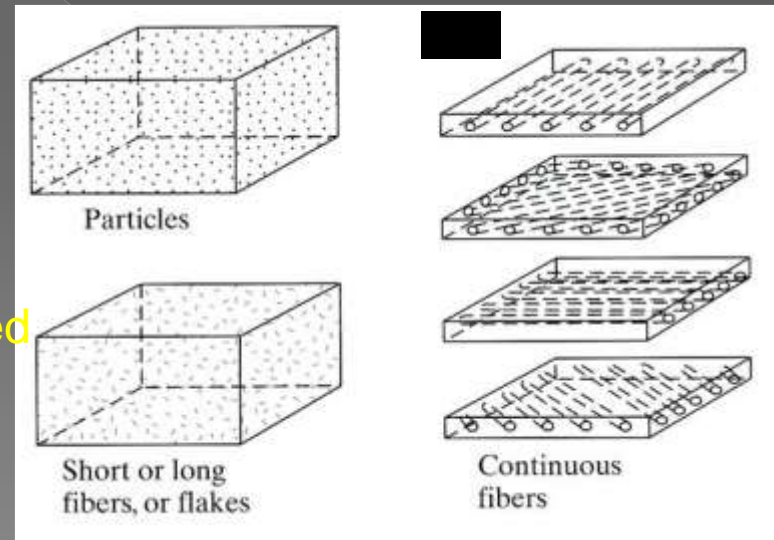
➤ Polymer Matrix Composites (PMCs)

Thermosetting resins are the most widely used polymers in PMCs. Epoxy and polyester are commonly mixed with fiber reinforcement

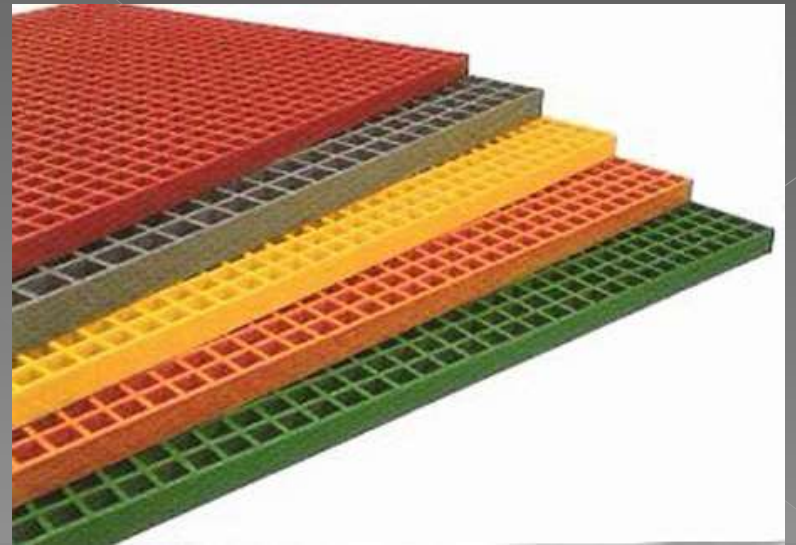
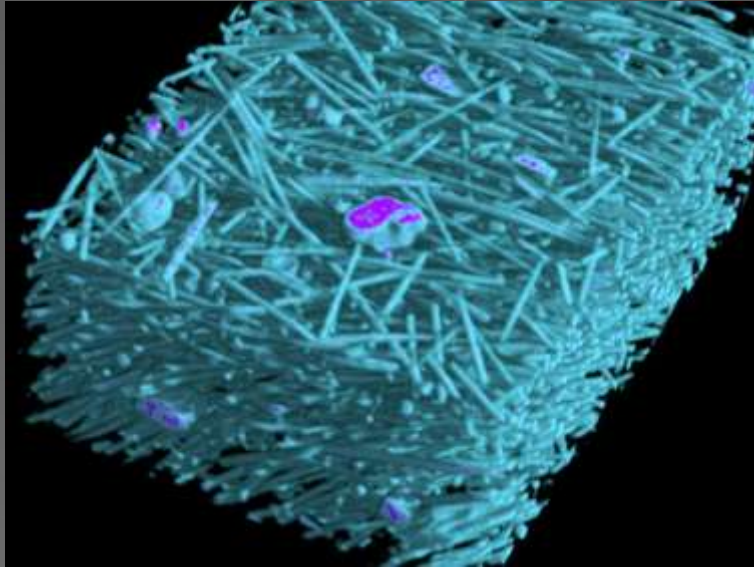
Composites – Polymer Matrix

Polymer matrix composites (PMC) and fiber reinforced plastics (FRP) are referred to as **Reinforced Plastics**. Common fibers used are glass (GFRP), graphite (CFRP), boron, and aramids (Kevlar). These fibers have *high specific strength* (strength-to-weight ratio) and *specific stiffness* (stiffness-to-weight ratio)

Matrix materials are usually thermoplastics or thermosets; polyester, epoxy (80% of reinforced plastics), fluorocarbon, silicon, phenolic.

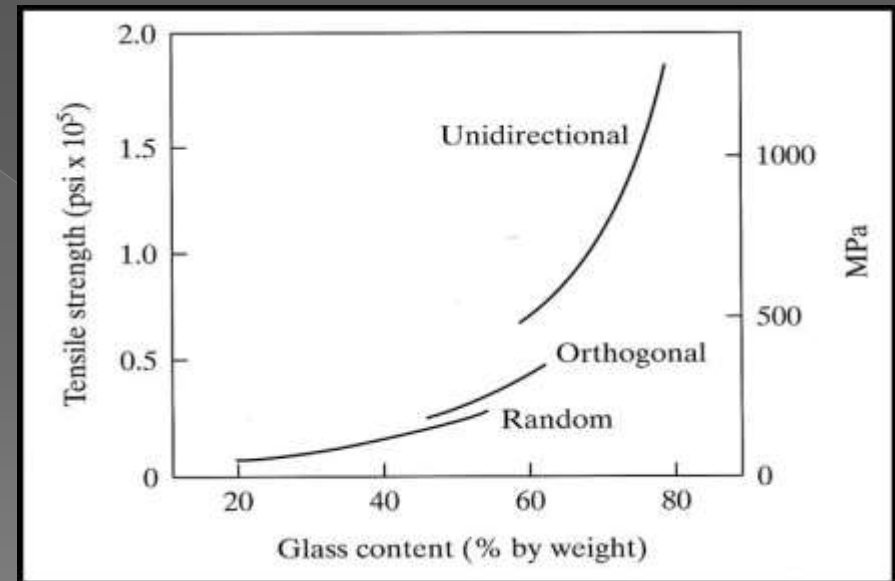
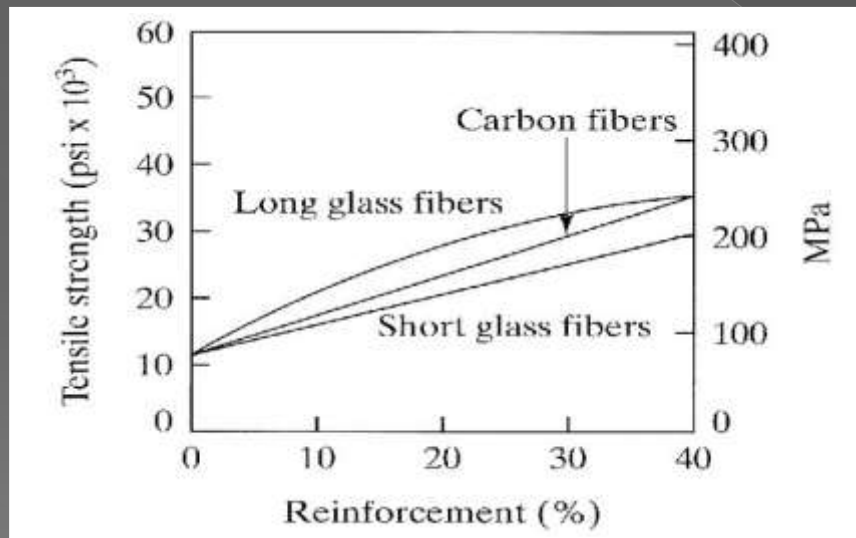


Fibre-reinforced plastic (FRP)



Properties of Reinforced Plastics

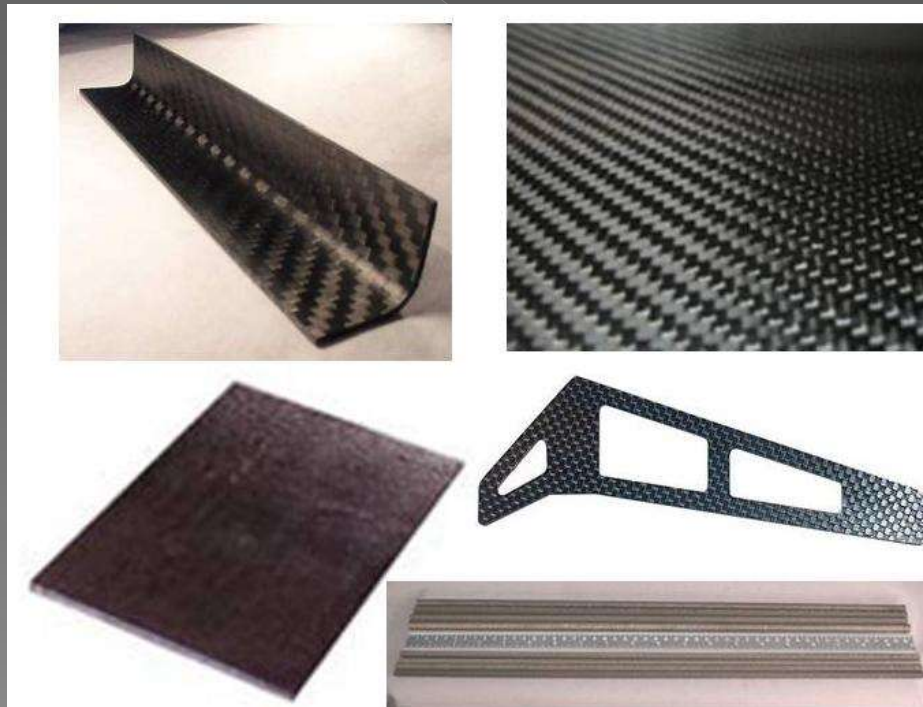
The mechanical properties of reinforced plastics vary with the kind, shape, relative volume, and orientation of the reinforcing material, and the length of the fibers.



Effect of type, length, % volume, and orientation of fibers in a fiber reinforced plastic (nylon)

Carbon Carbon Composites

The strength of carbon-carbon with unidirectional reinforcement fibres is up to 700 MPa. Carbon-carbon materials retain their properties above 2000 °C. This temperature may be exceeded with the help of protective coatings to prevent oxidation.[[]



General Properties of Composites

- ◉ High Strength to weight Ratio
- ◉ Light weight
- ◉ Fire Resistance
- ◉ Electrical Properties
- ◉ Chemical and weathering resistance
- ◉ Color
- ◉ Translucency
- ◉ Design
- ◉ Low thermal conductivity
- ◉ Manufacturing Economy

High Strength to weight Ratio

- Composites have the applications in the fields where high strength and light weight together are required. Composites have high strength to weight ratio.

Light weight

- ◉ Due to combination of two different materials having different properties composites are light weight.

Fire resistant

- Use of special Phenolic resins has allowed us to create the *only* fully tested fire resistant Composite door.

Electrical properties

- They are highly insulating materials because they have such a structure which does not allow electricity to pass through.

Chemical and weather Resistant

- Composite products have good weathering properties and resist the attack of a wide range of chemicals. This depends almost entirely on the resin used in manufacturing, but by careful selection resistance to all but the most extreme conditions can be achieved. Because of this composites are used in the manufacturing of chemical storage tanks, pipes, chimneys and ducts, boat hulls and vehicle bodies.

Color

- Almost any shade of any color can be incorporated into the product during manufacture by pigmenting the gel coat used. Costs are therefore reduced by no further finishing or painting. Soluble dyes can be used if a translucent product is desired.



Translucency

- It is the quality of allowing light to pass diffusely.
- Polyester resins are widely used to manufacture translucent mouldings and sheets. Light transmission of up to 85% can be achieved.



Design Flexibility

- Because of the versatility of composites, product design is only limited by our imagination.



this 75 foot Maori Waka (traditional war canoe) shows how adaptable composites can be

Low Thermal Conductivity

- They have such a structure that they can't conduct heat (Thermal Energy) properly.

Advantages of Composites

Higher Specific Strength (strength-to-weight ratio)

Composites have a higher specific strength than many other materials. A distinct advantage of composites over other materials is the ability to use many combinations of resins and reinforcements, and therefore custom tailor the mechanical and physical properties of a structure.

Design flexibility

Composites have an advantage over other materials because they can be molded into complex shapes at relatively low cost. This gives designers the freedom to create any shape or configuration. Boats are a good example of the success of composites.

Corrosion Resistance

Composites products provide long-term resistance to severe chemical and temperature environments. Composites are the material of choice for outdoor exposure, chemical handling applications, and severe environment service.

Low Relative Investment

One reason the composites industry has been successful is because of the low relative investment in setting-up a composites manufacturing facility. This has resulted in many creative and innovative companies in the field.

Durability

Composite products and structures have an exceedingly long life span. Coupled with low maintenance requirements, the longevity of composites is a benefit in critical applications. In a half-century of composites development, well-designed composite structures have yet to wear out.

- In 1947 the U.S. Coast Guard built a series of forty-foot patrol boats, using polyester resin and glass fiber. These boats were used until the early 1970s when they were taken out of service because the design was outdated. Extensive testing was done on the laminates after decommissioning, and it was found that only 2-3% of the original strength was lost after twenty-five years of hard service.

Disadvantages of Composites

- High cost
- Difficult to repair
- Can't be reshaped

Composites are heterogeneous

properties in composites vary from point to point in the material. Most engineering structural materials are homogeneous.

Composites are highly anisotropic

The strength in composites vary as the direction along which we measure changes (most engineering structural materials are isotropic). As a result, all other properties such as, stiffness, thermal expansion, thermal and electrical conductivity and creep resistance are also anisotropic. The relationship between stress and strain (force and deformation) is much more complicated than in isotropic materials.

Composites materials are difficult to inspect with conventional ultrasonic, eddy current and visual NDI methods such as radiography.

American Airlines Flight 587, broke apart over New York on Nov. 12, 2001 (265 people died). Airbus A300's 27-foot-high tail fin tore off. Much of the tail fin, including the so-called tongues that fit in grooves on the fuselage and connect the tail to the jet, were made of a graphite composite. The plane crashed because of damage at the base of the tail that had gone undetected despite routine nondestructive testing and visual inspections.



In November 1999, America's Cup boat "Young America" broke in two due to debonding face/core in the sandwich structure.



Uses of Composites

- Aerospace Industry
- Transporting Vehicle's body
- Air Industry





**Pedestrian bridge in
Denmark, 130 feet
long (1997)**

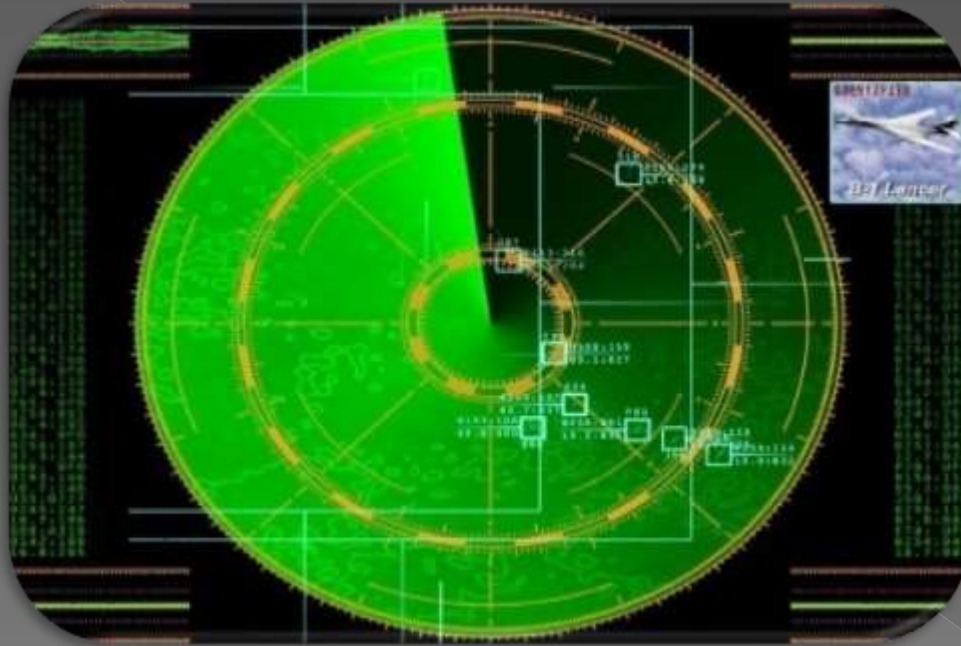
**Lance Armstrong's 2-
lb. Trek bike, 2004
Tour de France**



**Swedish Navy, Stealth
(2005)**



Military purposes:-



Military vehicles:-



Aerospace



Sports Car



Sports Industry:-



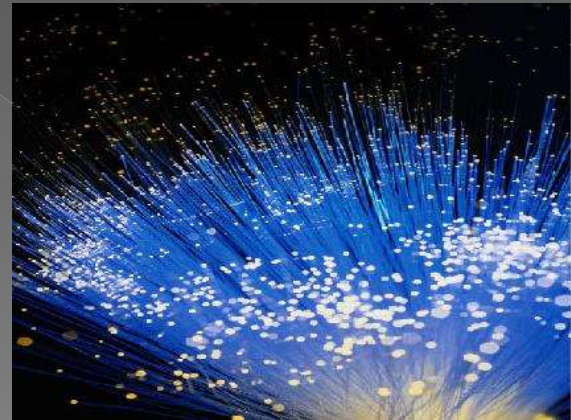
Toasting fork



Bows:-



- ◉ Medical uses
- ◉ Fiber optics



- ◉ Fire and water resistant applications
- ◉ Earthquake resistant construction material
- ◉ Sport industry



Thanks