

COMPOSITE MATERIALS



COMPOSITE MATERIALS

- A composite material can be defined as a combination of a matrix and a reinforcement, which when combined gives properties superior to the properties of the individual components.
- In the case of a composite, the reinforcement is the fibres and is used to fortify the matrix in terms of strength and stiffness.
- The reinforcement fibres can be cut, aligned, placed in different ways to affect the properties of the resulting composite.
- The matrix, normally a form of resin, keeps the reinforcement in the desired orientation. It protects the reinforcement from chemical and environmental attack, and it bonds the reinforcement so that applied loads can be effectively transferred.

Type of Composites

- Carbon fibre-reinforced polymers (CFRP)
- Glass fibre-reinforced polymers (GFRP)
- Aramid products (e.g. Kevlar)
- Bio-derived polymers (or biocomposites as they are sometimes referred)

Type of Composites

Carbon fibre-reinforced polymers (CFRP)



Type of Composites

Glass fibre-reinforced polymers (GFRP)



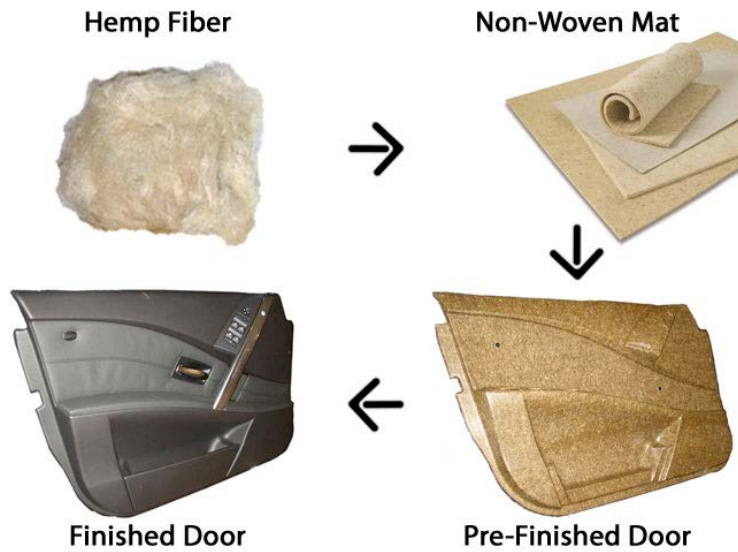
Type of Composites

Aramid products



Type of Composites

Bio-derived polymers



Why Use Composites?

- The primary reason composite materials are chosen for components is because of weight saving for its relative stiffness and strength. For example, carbon-fibre reinforced composite can be five times stronger than 1020 grade steel while having only one fifth of the weight. Aluminium (6061 grade) is much nearer in weight to carbon-fibre composite, though still somewhat heavier, but the composite can have twice the modulus and up to seven times the strength.

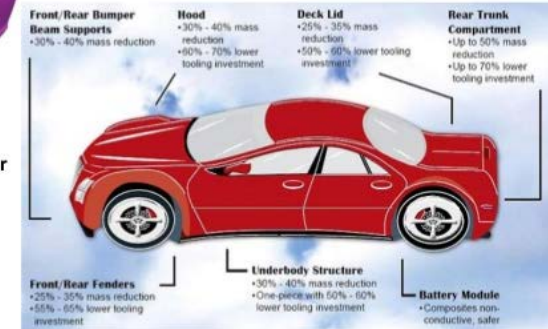


What is needed for broader automotive use of Carbon Fiber Composites?

- Lower cost carbon fiber & intermediate products
- High throughput / low cost manufacturing technologies

Why use carbon composites?

	Carbon Fiber	UD Carbon Composite	Steel	Aluminum
Strength (MPa)	4150	~ 2200	~ 690	~ 415
Modulus (GPa)	245	~ 132	~ 207	~ 69
Density (g/cc)	1.81	~ 1.54	~ 7.8	~ 2.7

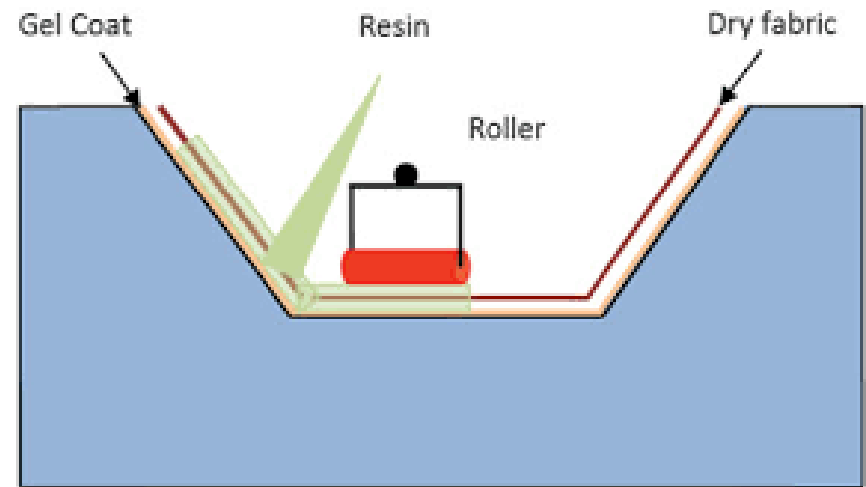


Methods of composite manufacture

- **Wet Lay-Up**

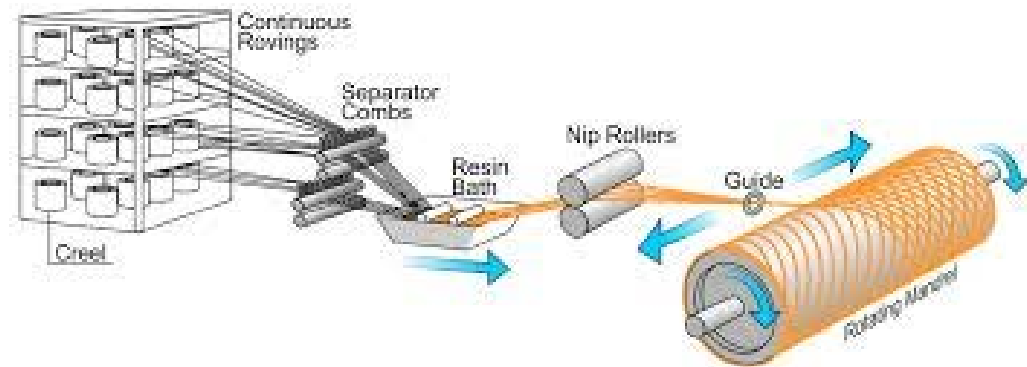
A mould in the shape of the final component is required. The reinforcement (as a woven fabric) is carefully laid into this mould and the matrix (resin) is poured on and spread, usually with the aid of a roller. This is then left to cure.

A gelcoat can be added to the mould before the reinforcement is placed into it depending on what surface finish is required (the top surface is the side which is face down in the mould). A release agent can also be applied to the mould to assist with removing the part after curing.



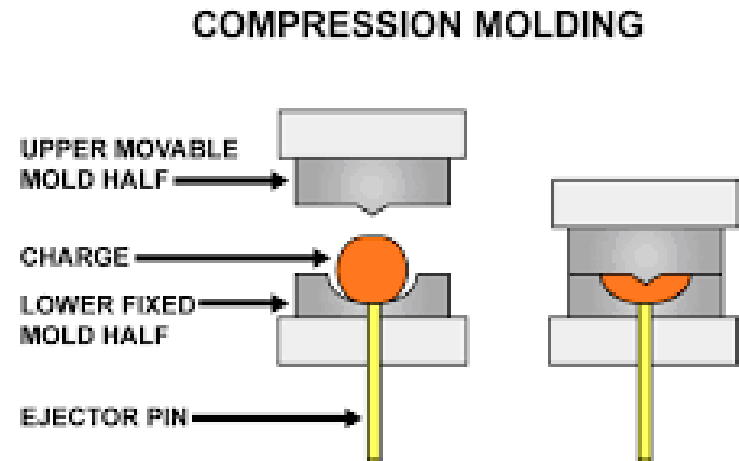
- **Filament Winding**

This process is used for producing hollow tubes. The reinforcement (as strands) are taken through a resin bath, coating them with the matrix. The excess resin is squeezed out by rollers and the reinforcement fibres are then wound onto a mandrel to form the round, hollow shape. The direction the fibres are wound contributes to the performance properties required of the finished part.



- **Compression Moulding**

Compression moulding is normally used with pre-preg – reinforcement fibres already impregnated with resin. The pre-preg is placed in an open, heated female mould. The male mould is then placed down on to this with the combination of heat and pressure shaping and curing the component. Parts are then allowed to cool before removing from the mould.



- **Vacuum Bagging**

This process can be used as an extension of the wet lay-up technique. The reinforcement (as woven fabric) is placed into a mould, which can be pre-coated with a release agent and/or gel coat. The resin is then rolled on top.

A plastic film is placed over this and is fully sealed at the edges. A vacuum then extracts the air from process helping to consolidate the part. It ensures that the resin is evenly spread.



Alumina

- Alumina (Al_2O_3) is to technical ceramics what mild steel is to metals – cheap, easy to process, the work horse of the industry. It is the material of spark plugs and electrical insulators. In single crystal form it is sapphire, used for watch faces and cockpit windows of high speed aircraft. More usually it is made by pressing and sintering powder, giving grades ranging from 80 to 99.9% alumina; the rest is porosity, glassy impurities or deliberately added components. Pure aluminas are white; impurities make them pink or green. The maximum operating temperature increases with increasing alumina content. Alumina has a low cost and a useful and broad set of properties: electrical insulation, high mechanical strength, good abrasion and temperature resistance up to 1650 c, excellent chemical stability and moderately high thermal conductivity, but it has limited thermal shock and impact resistance. Chromium oxide is added to improve abrasion resistance; sodium silicate, to improve processability but with some loss of electrical resistance. Competing materials are magnesia, silica and borosilicate glass.
- Typical Uses Insulators, heating elements, micro-electronic substrates, radomes, bone replacement, tooth replacement, tank armour, spark plug insulators, dies for wire drawing, nozzles for welding and sandblasting.



Boron Carbide

- Boron carbide (B_4C) is nearly as hard as diamond and vastly less expensive (though still not cheap). Its very low density and high hardness make it attractive for the outer layer of bulletproof body armor and as an abrasive. Typical Uses Lightweight armor, bulletproof surfaces, abrasives, sandblasting nozzles, high temperature thermocouples.

Boron Carbides 60 and 120 Grits



Copyright © 2006 SandblastingAbrasives.com - All Rights Reserved



Tungsten Carbide

- Tungsten carbide (WC) is most commonly used in the form of a “cemented” carbide, or cermet: a metal carbide held by a small amount (5–20%) of metallic binder, usually cobalt. Its exceptional hardness and stability make it an attractive material when wear resistance is essential. Its properties are governed by the type of carbide, grain size and shape and the proportion of carbide to metal. Cermets are expensive but, as cutting tools, they survive cutting speeds ten times those of the best tool steel. Shaping is usually done by pressing, sintering and then grinding; the tool bit is brazed to a shank or blade made from a cheaper steel. Tungsten carbide can be vapor-coated with Ti-nitride to improve wear resistance even further. Typical Uses Cutting tools, saw blades, dental drills, oil drilling bits, dies for wire drawing, knife edges.



Silicon Carbide

- Silicon carbide (SiC, carborundum), made by fusing sand and coke at 2200 c, is the grit on high quality sandpaper. It is very hard and maintains its strength to high temperature, has good thermal shock resistance, excellent abrasion resistance and chemical stability, but, like all ceramics, it is brittle. Silicon carbide is a blue-black material. High strength SiC fibers such as Nicalon, made by cvd processes, are used as reinforcement in ceramic or metal matrix composites. Typical Uses Cutting tools, dies and molding materials, catalytic converters, engine components, mechanical seals, sliding bearings, wear protection sleeves, heat exchange tubes, furnace equipment, heating elements.



Glass



Attributes of Soda-lime Glass

Price, \$/kg	0.68-1
Density, mg/m ³	2.44-2.5

Technical Attributes

El. modulus, GPa	68-72
Elongation, %	0
Fr. toughness, MPa·m ^{1/2}	0.55-0.7
Vickers hardness, H _v	440-480
Tensile strength	31-35
Service temp., °C	-270-250
Specific heat, J/kg·K	850-950
Th. conduct., W/m·K	0.7-1.3
Th. expansion, 10 ⁻⁶ /K	9-9.5

Eco-Attributes

Energy content, MJ/kg	20-25
Recycle potential	High

Aesthetic Attributes

Low (o), High Pitch (1o)	7-8
Muffled (o), Ringing (1o)	8-9
Soft (o), Hard (1o)	7-8
Warm (o), Cool (1o)	5-6

Features (Relative to Other Glasses)

- Optically clear
- Easy to mold
- Low cost



Soda-Lime Glass

Soda-lime is the glass of windows, bottles and light bulbs, used in vast quantities, the commonest of them all. The name suggests its composition: 13–17% NaO (the “soda”), 5–10% CaO (the “lime”) and 70–75% SiO₂ (the “glass”). It has a low melting point, is easy to blow and mold, and it is cheap. It is optically clear unless impure, when it is typically green or brown. Windows, today have to be flat and that was not – until 1950 – easy to do; now the float-glass process, solidifying glass on a bed of liquid tin, makes “plate” glass cheaply and quickly.

Typical Uses Windows, bottles, containers, tubing.





Borosilicate Glass

When most of the lime in soda lime glass is replaced by borax, B_2O_3 , it becomes borosilicate glass (“Pyrex”). It has a higher melting point than soda lime glass and is harder to work; but it has a lower expansion coefficient and a high resistance to thermal shock, so its used for glass wear and laboratory equipment.

Typical Uses Laboratory glassware, ovenware, headlights, electrical insulators, metal/glass seals, telescope mirrors, sights, gages, piping.

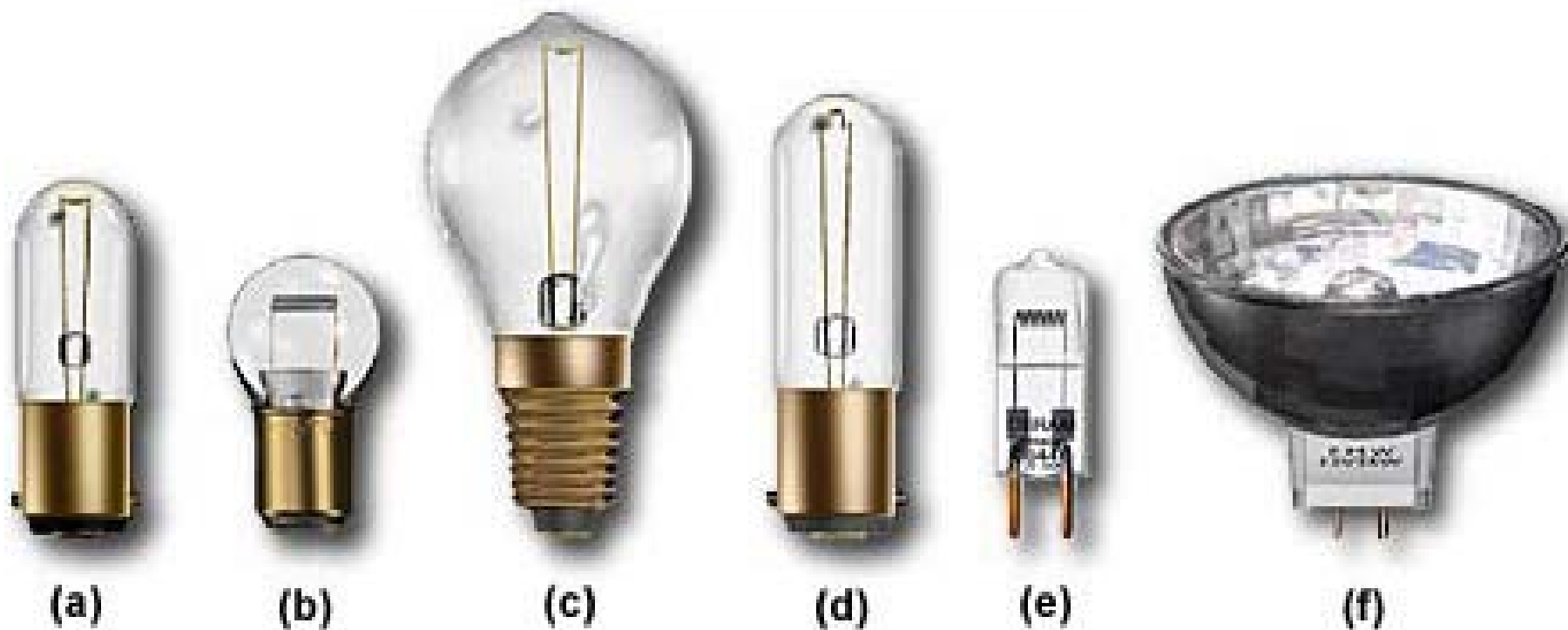




Silica Glass

Silica is a glass of great transparency. It is nearly pure SiO_2 , it has an exceptionally high melting point and is difficult to work, but, more than any other glass, it resists temperature and thermal shock.

Typical Uses Envelopes for high-temperature lamps.



Glass Ceramic

Glass ceramics are glasses that, to a greater or lesser extent, have crystallized. They are shaped while in the glassy state, using ordinary molding methods and then cooled in such a way that the additives they contain nucleate small crystals. It's sold for cooking as Pyroceram and is used for high performance heat-resisting applications.

Typical Uses Cookware, stove surfaces, high performance heat-resisting applications



TRANSPARENT SOLAR CELL

- In August 2014, researchers at Michigan State University have created a fully transparent solar concentrator, which could turn any window or sheet of glass (like your smartphone's screen) into a photovoltaic solar cell.
- The researchers — and Ubiquitous Energy — are confident that the technology can be scaled all the way from large industrial and commercial applications, down to consumer devices, while remaining affordable. So far, one of the larger barriers to large-scale adoption of solar power is the intrusive and ugly nature of solar panels — obviously, if we can produce large amounts of solar power from sheets of glass and plastic that look like normal sheets of glass and plastic, then that would be incredible.

