Short introduction to Composites

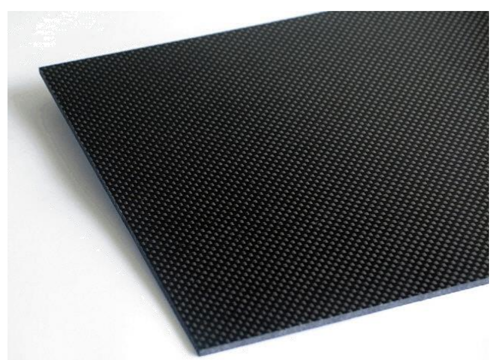
Definition

“A **composite** material can be defined as a combination of two (or more) materials that results in better properties than those of the individual components used alone”

“The two constituents are a **reinforcement** and a **matrix**”

Carbon fiber

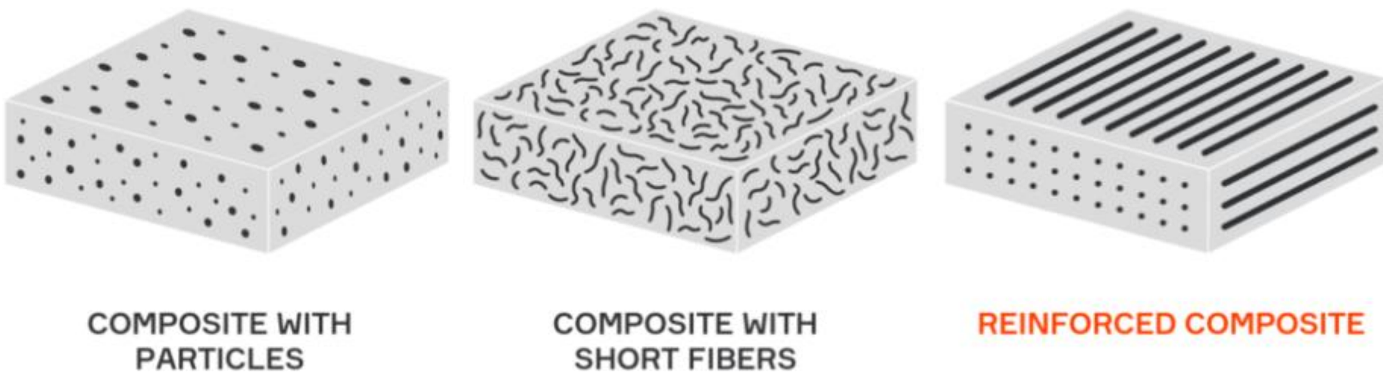
Resin



CFRP plate

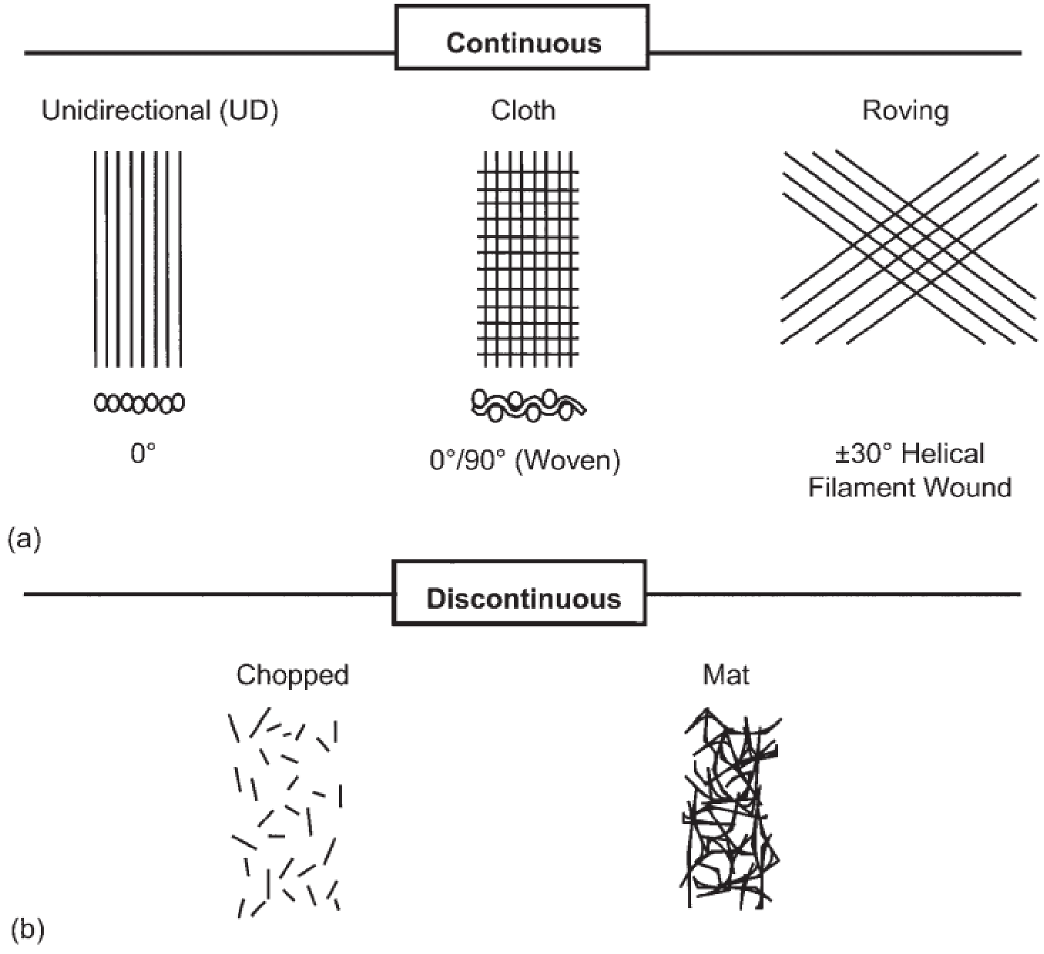
Short introduction to Composites

Understanding Composites

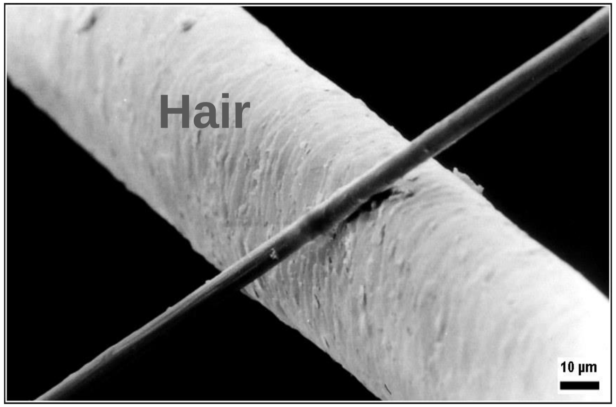


Short introduction to Composites

Reinforcements



Carbon Fiber



Typical reinforcement fibers are:

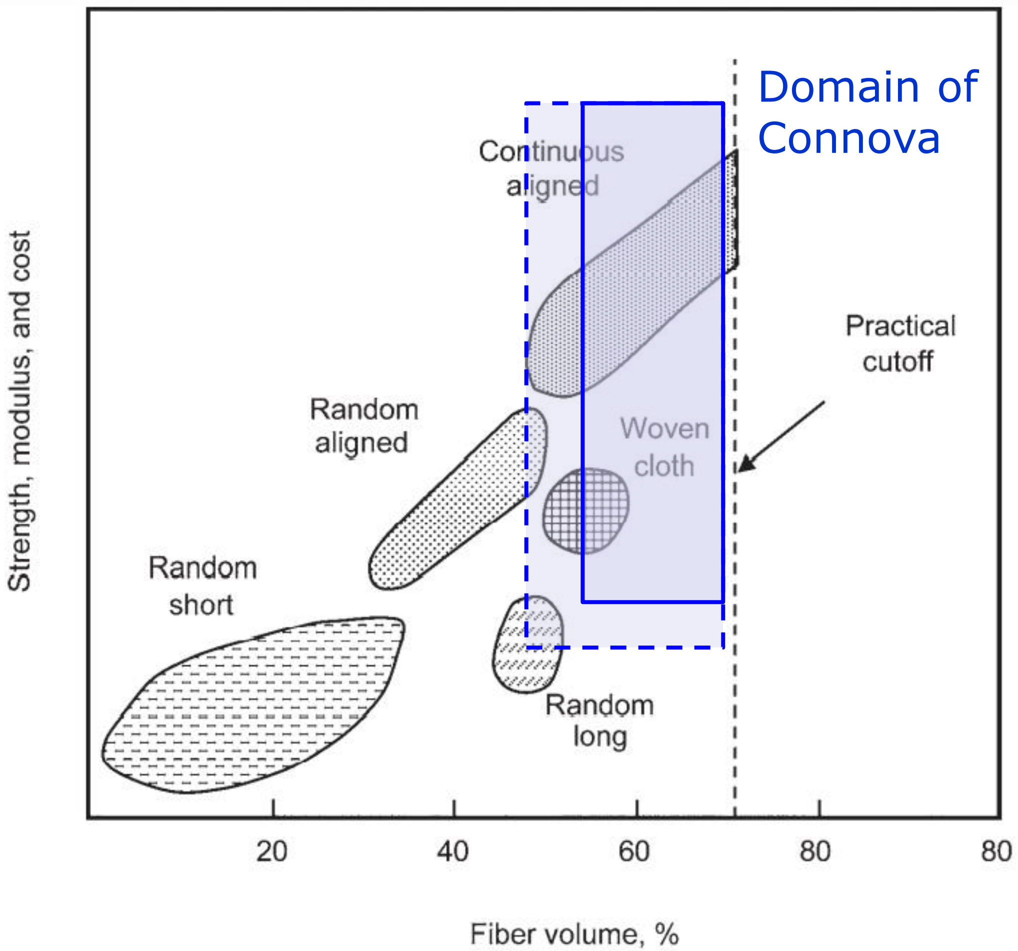
- Carbon
- Glass
- Aramid
- Natural

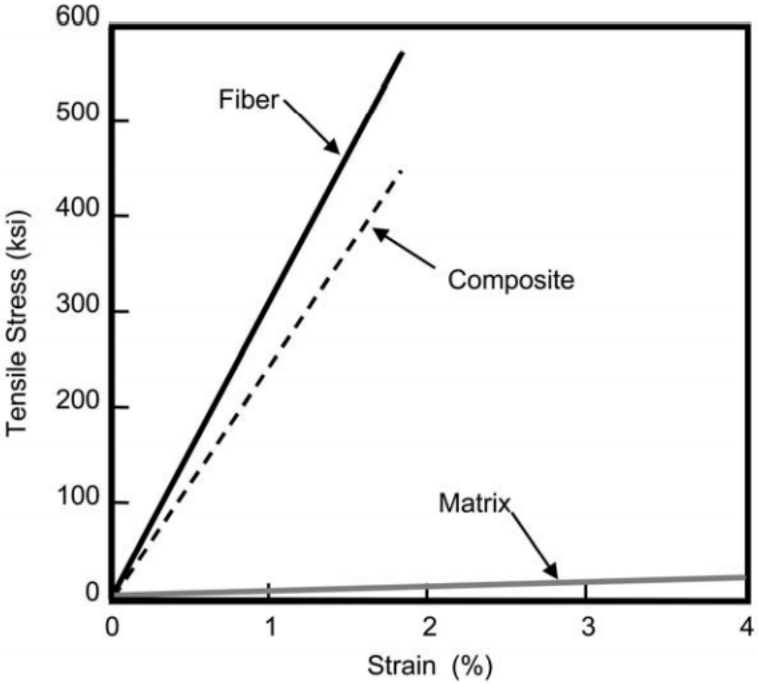
There are different specifications for CF:

- High strength HT
- Intermediate IM
- High modulus HM
- Ultra high mod. UHM

Short introduction to Composites

Reinforcements





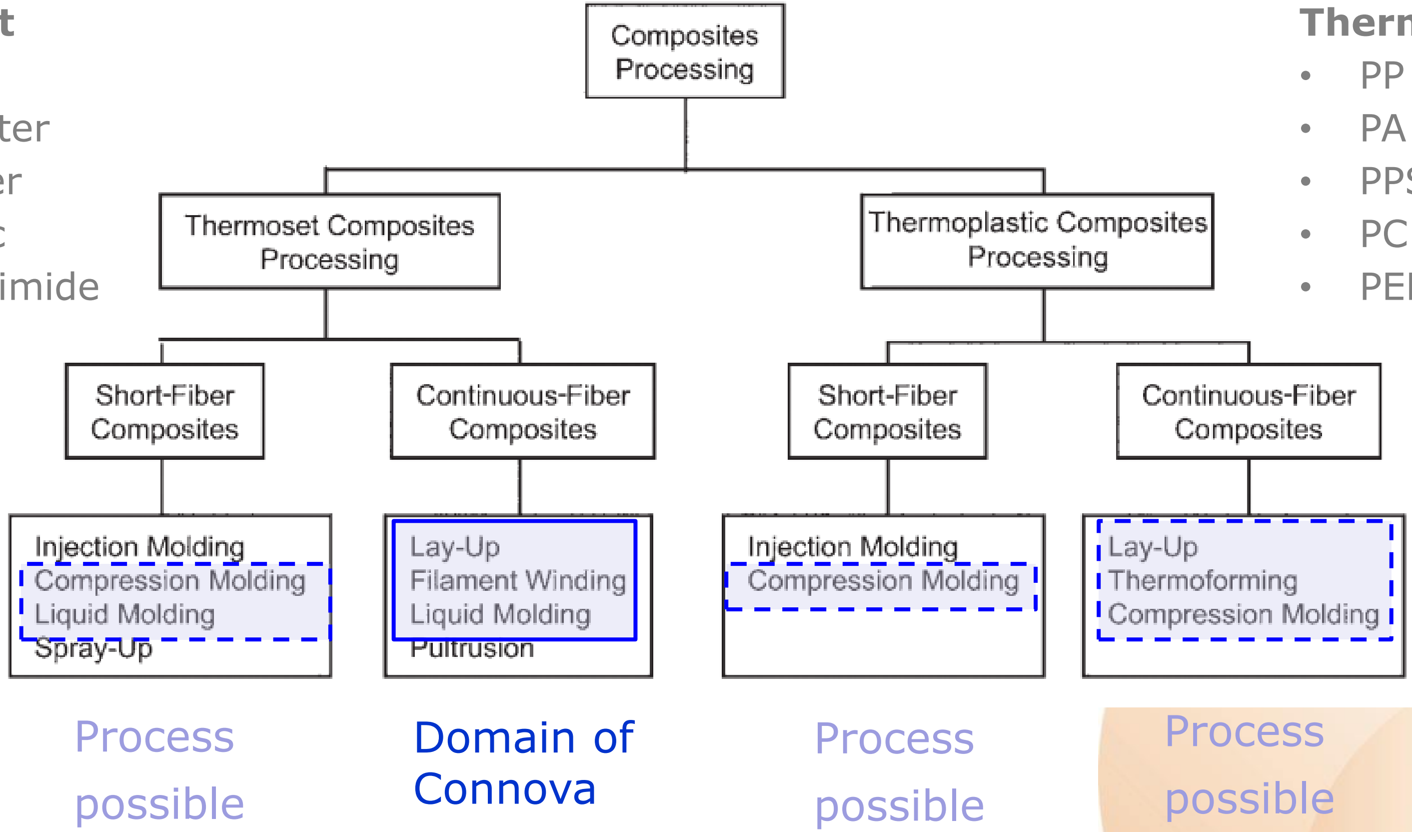
The mechanical properties and the cost are mainly dominated by the fiber and less by the resin.

Short introduction to Composites

Overview by Fibre and Resin Types

Thermoset
- Epoxy
- Vinyl ester
- Polyester
- Phenolic
- Bismaleimide

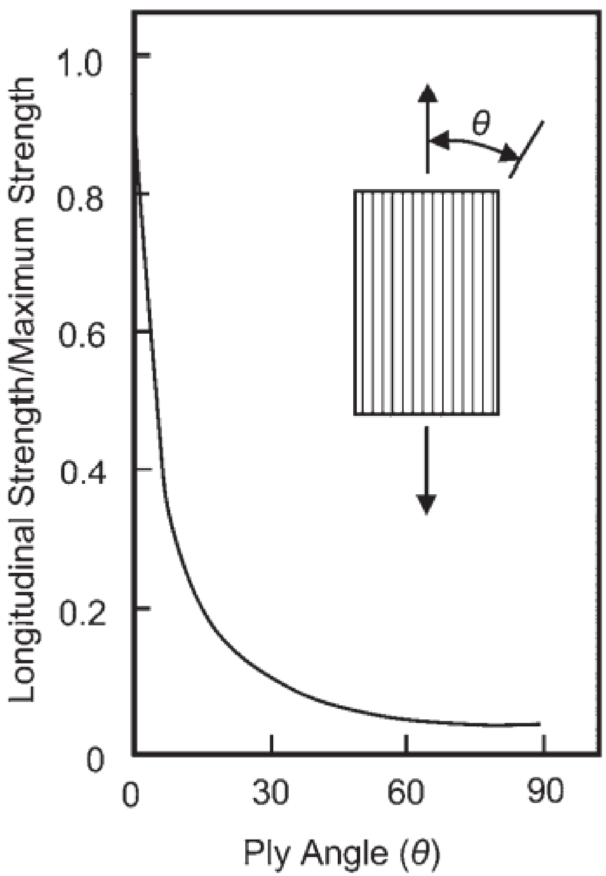
Thermoplastic
- PP
- PA
- PPS
- PC
- PEEK

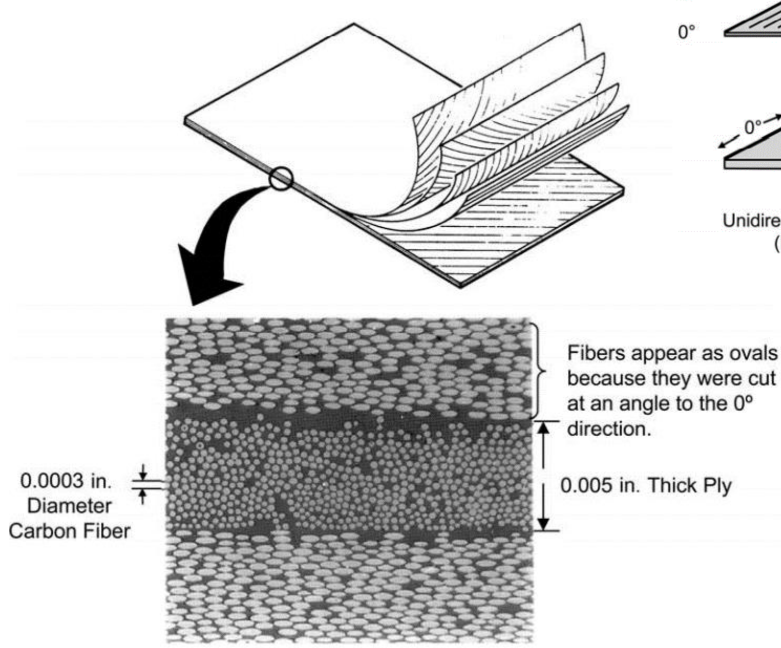


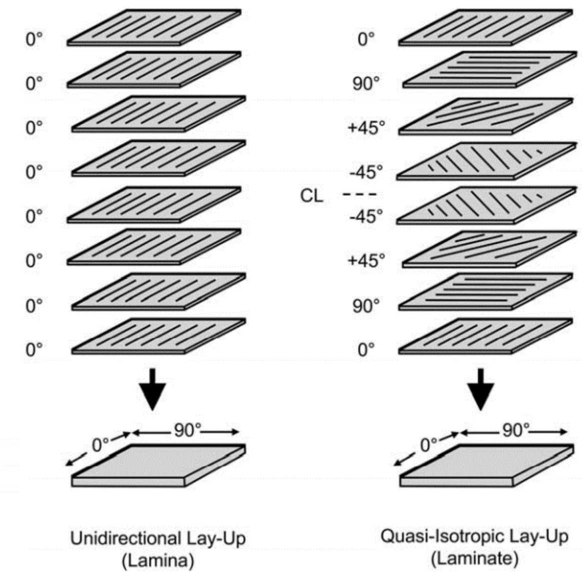
Short introduction to Composites

Basics of Laminates

Relevance of Fibre Orientation



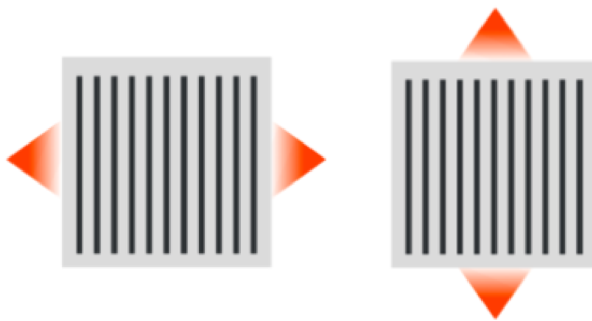


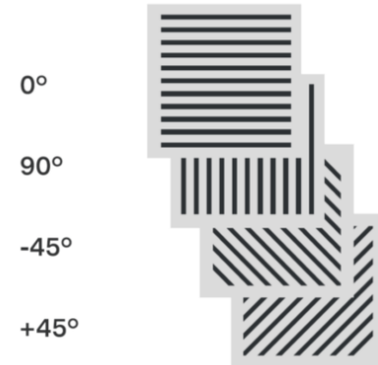


The combination of different fibre angles result in specific properties of laminates (stack of layers)

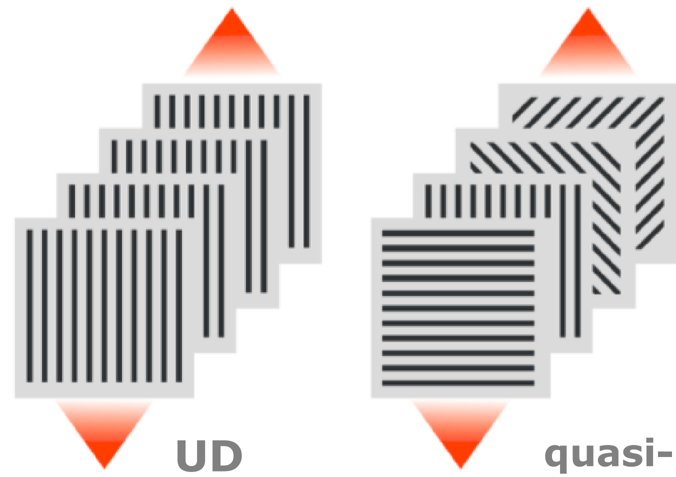
Short introduction to Composites

Mechanical Properties of Laminates (made of a standard HT fibre)





	LAYER	
STRENGTH (MPA)	50	2100
MODULUS (GPA)	10	140
	lateral	parallel



	LAMINATE	
	UD	quasi-isotropic
STRENGTH (MPA)	2100	300
MODULUS (GPA)	140	54

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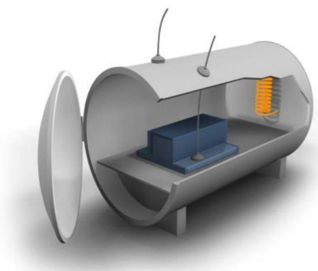
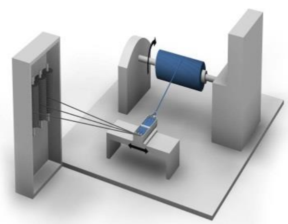
Production Technologies for Composites



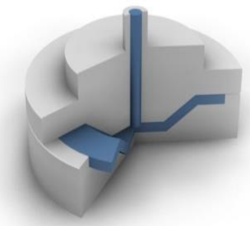
Autoclaving

- Component quality
- Reproducibility
- Design freedom
- Costs



Filament winding

- Automation
- Low tool costs
- Rotational symmetrical

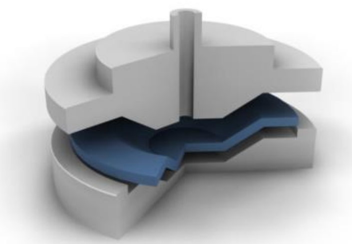


RTM

- Component quality
- Reproducibility
- Serial production

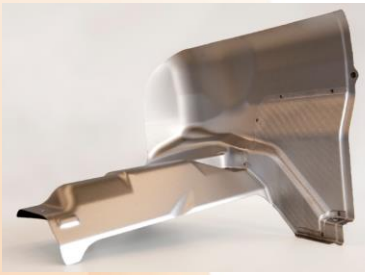
Infusion

- Big components
- Fiber volume
- Lower numbers of parts



Hot-pressing

- Component quality
- Flat components
- Serial production



Applications of Composites

Typical Industries & Market Segments

– Aviation – Aircraft and UAV Manufacturers

– Space – Launchers, Satellites, Space Vehicles, Space Telescopes

– Racing – Formula1 and all other racing classes incl. Motorbikes

– Automotive – GT cars, super cars, premium cars and more & more EVs

– Medical – X-Ray transparent products, light-weight products

– Automation – Robotic arms, fast moving or turning components

– Oil & Gas – Pipelines, vessels, tanks

– Energy – Wind rotor blades, high-pressure gas storage (esp. H2 tanks)

– Marine & Yachting – Sailing boats, race boats

– Sports & Leisure – Bikes, boards, tennis rackets, golf clubs, fishing connova

Advantages of Composites

Typical Characteristics

- Lighter weight due to superior specific strength/modulus (esp. true for continuous fibre)
- ability to tailor the lay-up for optimum strength and stiffness
- no corrosion compared to metals
- Excellent resistance to a variety of chemicals and harsh conditions
- much higher fatigue life (less sensitive to fatigue)
- higher degree of integral design (w.r.t. number of components)

Advantages of Composites

Flame Retardancy

- Chemically all polymeric materials comprise of hydro-carbon chains and when they are exposed to fire, they burn rapidly with the release of high amount of heat, flame and smoke
- Synthetic fibers like glass, carbon, ceramic fibers are inherently flame retardant (except natural fibers which are highly flammable)
- There are two basic principles of achieving flame retardancy
  1. To mix FR-additives into the polymeric matrix (e.g., metal hydroxides)
  2. To apply an FR-coating to the surface of the composite part
- Today, there are many different FR-polymers and FR-resins on the market for both, thermoset (duroplastic) as well as thermoplastic materials
- Also, FR-coatings and paints become more and more available, however, tend to be more costly – mostly intumescent based coatings are applied
- For extreme conditions, a combination of both principles may be feasible

Back-up: UL 94 (from Wikipedia)

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UL 94, the Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances testing, is a plastics flammability standard released by Underwriters Laboratories of the United States.

The standard determines the material's tendency to either extinguish or spread the flame once the specimen has been ignited.

UL-94 is now harmonized with IEC 60707, 60695-11-10 and 60695-11-20 and ISO 9772 and 9773.

Classifications from lowest (least flame-retardant) to highest (most flame-retardant):

- HB slow burning on a horizontal specimen;
burning rate < 76 mm/min for thickness < 3 mm or burning stops before 100 mm
- V-2 burning stops within 30 seconds on a vertical specimen;
drips of flaming particles are allowed.
- V-1 burning stops within 30 seconds on a vertical specimen;
drips of particles allowed as long as they are not inflamed.
- **V-0 burning stops within 10 seconds on a vertical specimen;
drips of particles allowed as long as they are not inflamed.**