MCG 2361

Engineering Materials II

Lecture 1: Introduction - polymers, ceramics, composites

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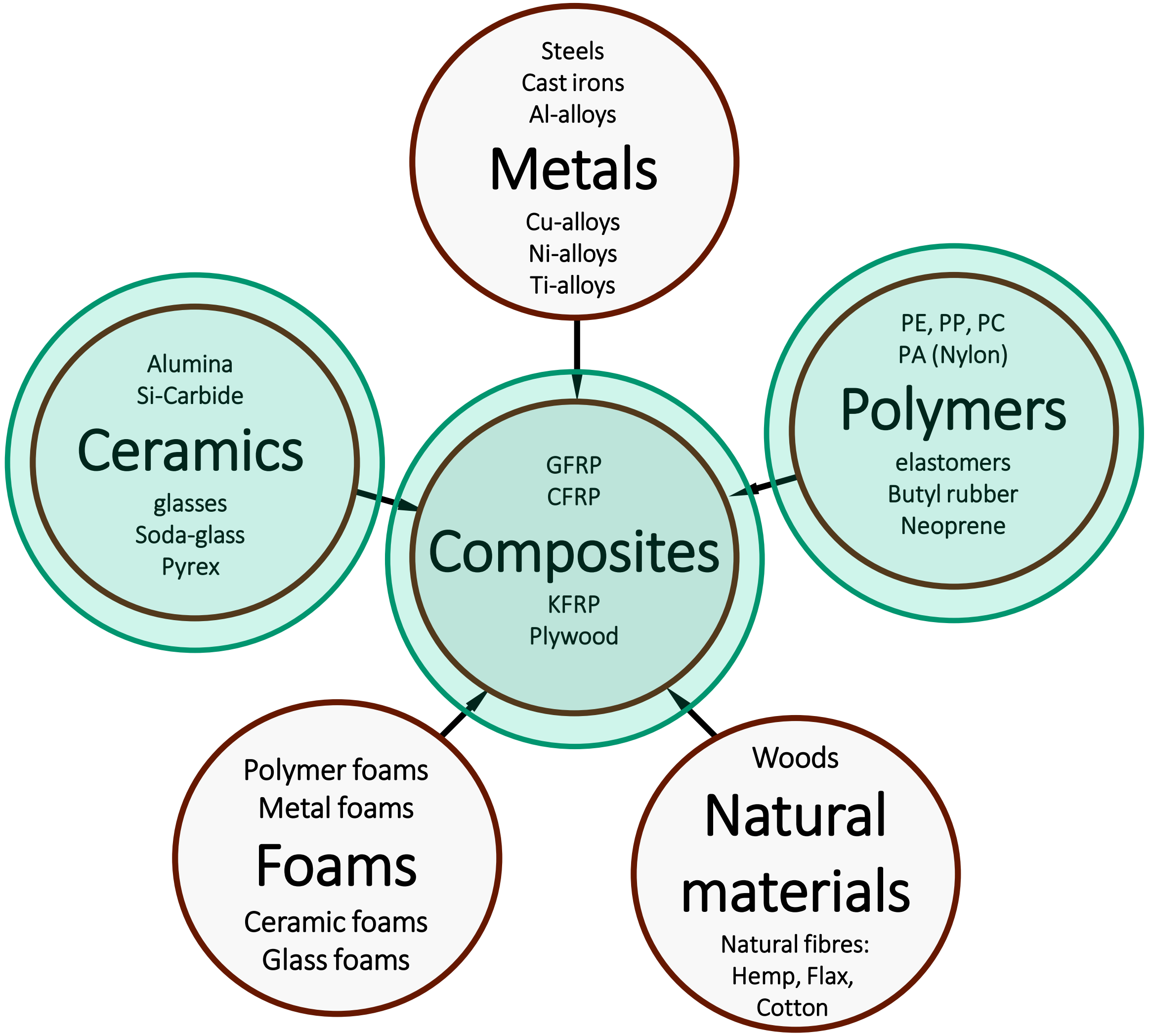
Outline

- Classification of materials
- Examples of non-metallic materials
- Importance of materials selection
- Materials tetrahedron
- Examples of applications of ceramics, polymers, composites

Materials Classification



Multiple Choice Question

Examples of non-metallic materials

Why study this?

Ceramics:

« …hmm, ceramic tiles… »

Examples of non-metallic materials

Why study this?

Polymers:

→ plastic → TOYS…

…everyday objects,
disposable, cheap, no money to make there, not environmental…

Examples of non-metallic materials

Why study this?

Composites:

Automotive applications→ carbon fibre

Importance of materials selection

Some misconceptions remain prevalent, whereby:

→ '**good**' parts are made of **metal** (= *good* material)
→ '**bad/cheap**' parts are made of **anything else** (= *bad* materials)

One major thing to learn and remember from this course is that:

There are NO fundamentally bad classes of materials!

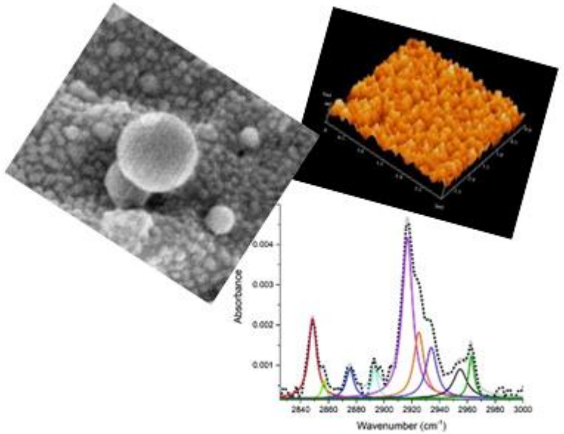
…but there **are loads of bad designs and bad material selections**

In this course, you will learn about:
→ the various classes of materials
→ The properties (mainly mechanical) of these materials

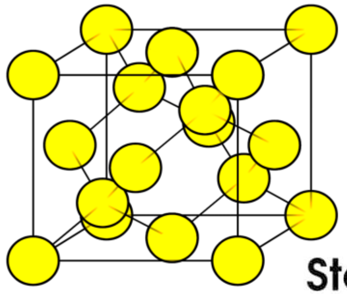
To later be able to **select** the proper material for a given application

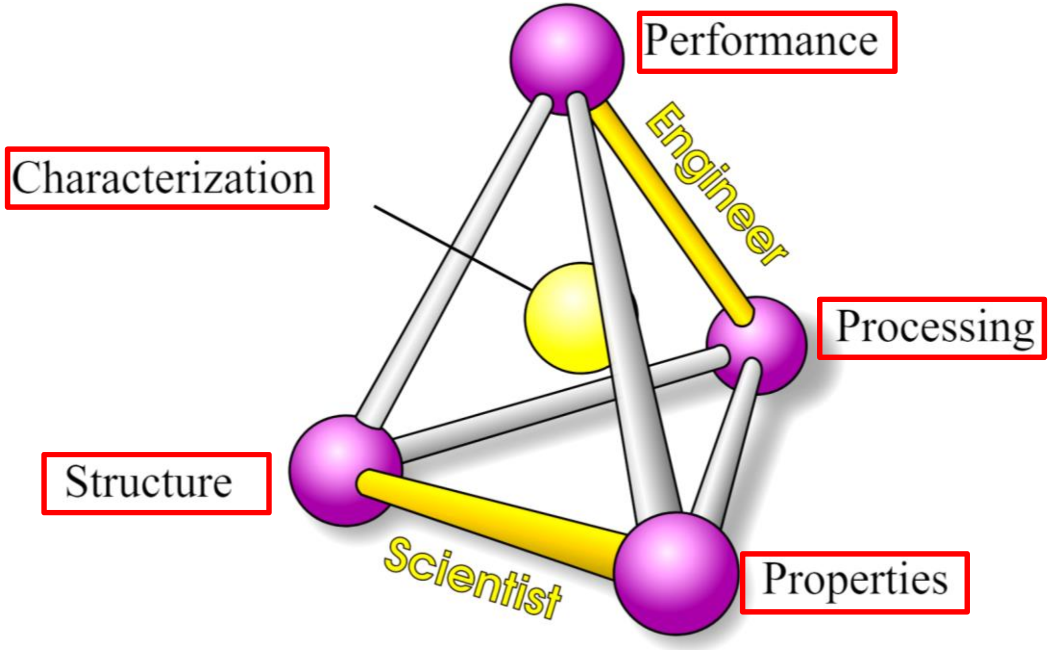
Materials Tetrahedron

Microscopy and Spectroscopy

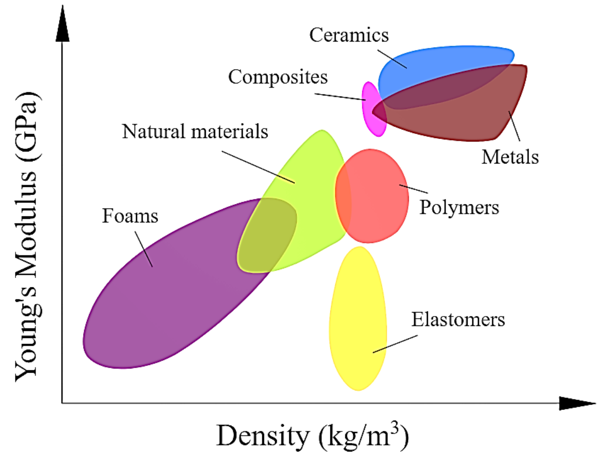


Diamond Structure



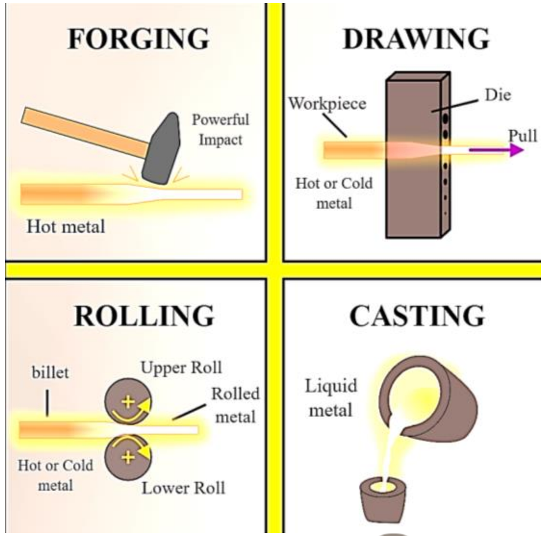


ASHBY DIAGRAM

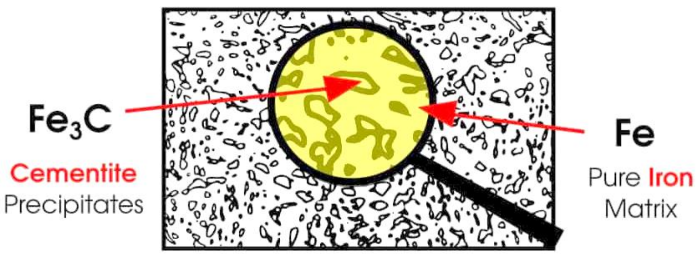


Ashby Diagrams are used for **materials selection**.

(Both axes are logarithmic!)

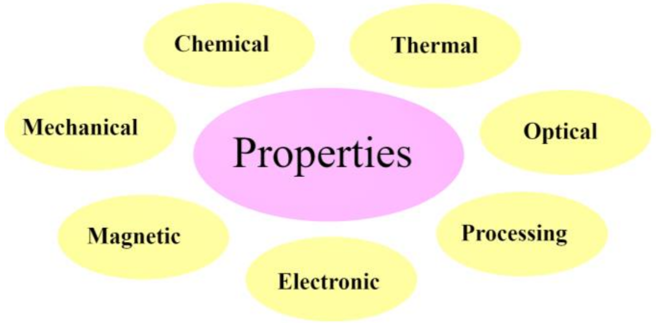


Steel Microstructure



Steel Consists of **Two Phases**:
Iron and **Cementite**

Examples of Material Properties



Ceramics: applications

Aerospace:
Space shuttle tiles, thermal barriers, high temperature glass windows, fuel cells , etc.

Consumer uses:
Glassware, windows, pottery, Corning ware, magnets, dinnerware, ceramic tiles, lenses, home electronics, microwave transducers, etc.

Automotive:
Catalytic converters, ceramic filters, airbag sensors, ceramic rotors, valves, spark plugs, pressure sensors, thermistors, vibration sensors, oxygen sensors, safety glass windshields, piston rings, etc.

Medical (Bioceramics):
Orthopedic joint replacement, prosthesis, dental restoration, bone implants, etc.

Military:
Structural components for ground, air and naval vehicles, missiles, sensors, etc.

Communications:
Fiber optic/laser communications, TV and radio components, microphones, etc.

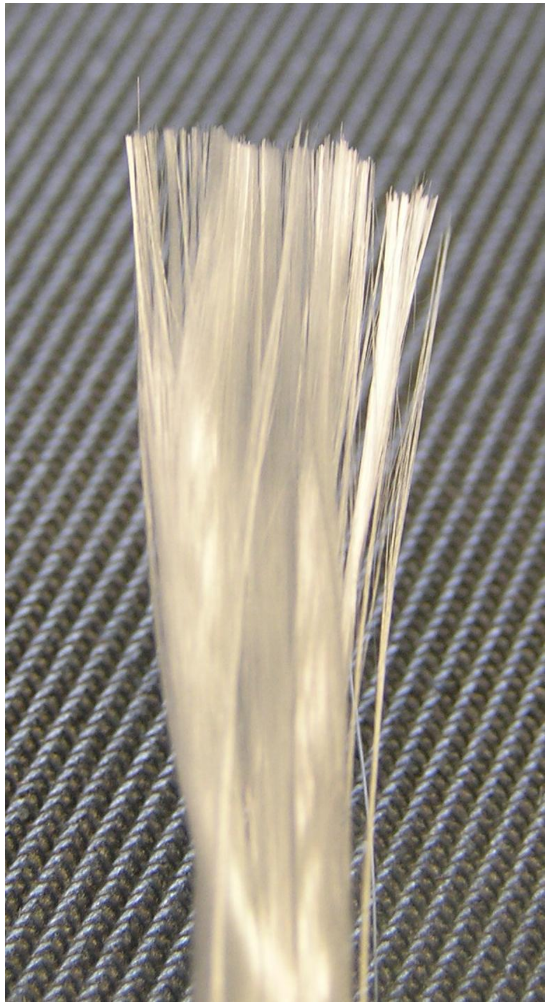
Ceramics: applications

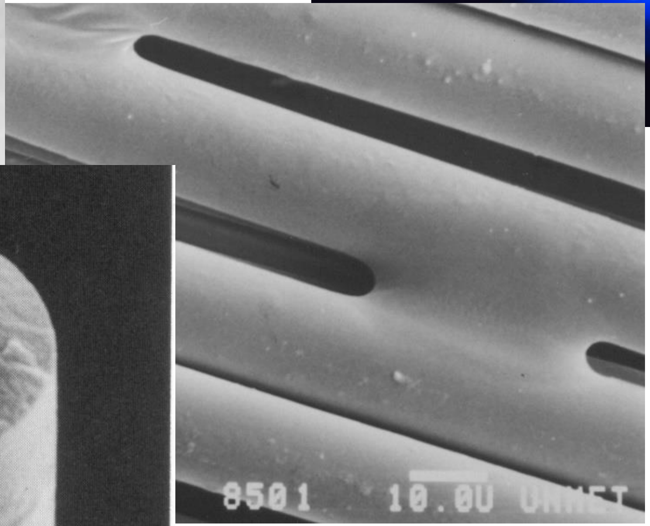
Carbon/carbon ceramic brake

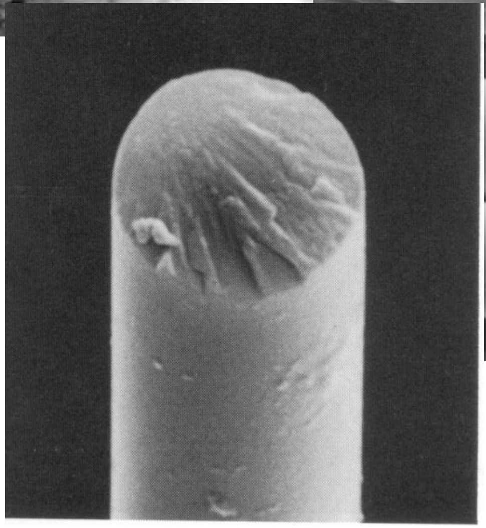
Outstanding thermal properties!

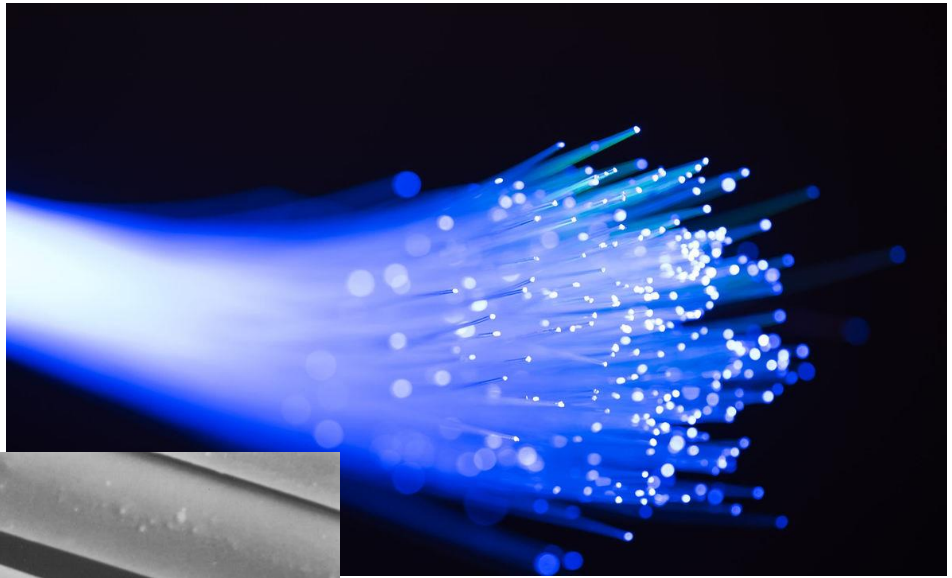
Ceramics: applications

Glass fibres









Furnaces to make glass fibres!

Furnace

Ceramics: applications

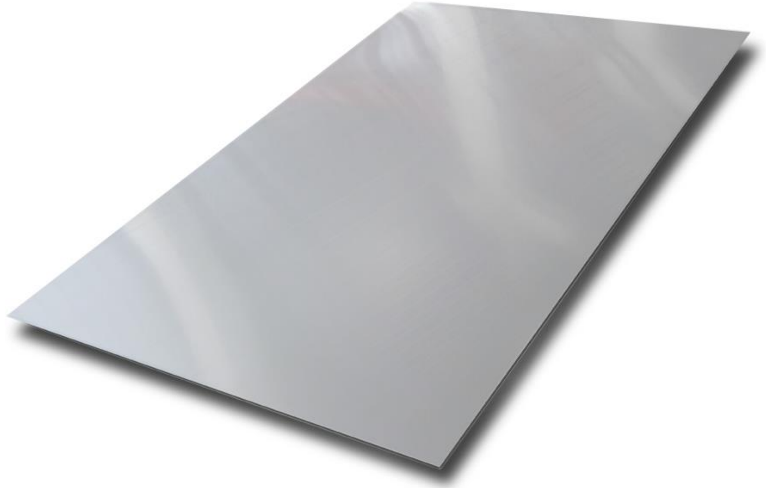
Glass:

Modulus: 70 GPa Density: ~ 2.6 g/cm^3

Typical aluminium alloy:

Modulus: 70 GPa Density: ~ 2.9 g/cm^3

→ Glass has the same stiffness as aluminum but is lighter!



Multiple Choice Question

Polymers: applications

Agriculture and Agribusiness

Polymeric materials are used in and on soil to improve aeration, provide mulch, and promote plant growth and health.

Medicine

Many biomaterials, especially heart valve replacements and blood vessels, are made of polymers like Dacron, Teflon and polyurethane.

Consumer Science

Plastic containers of all shapes and sizes. Clothing, floor coverings, garbage disposal bags, and packaging are other polymer applications.

Industry

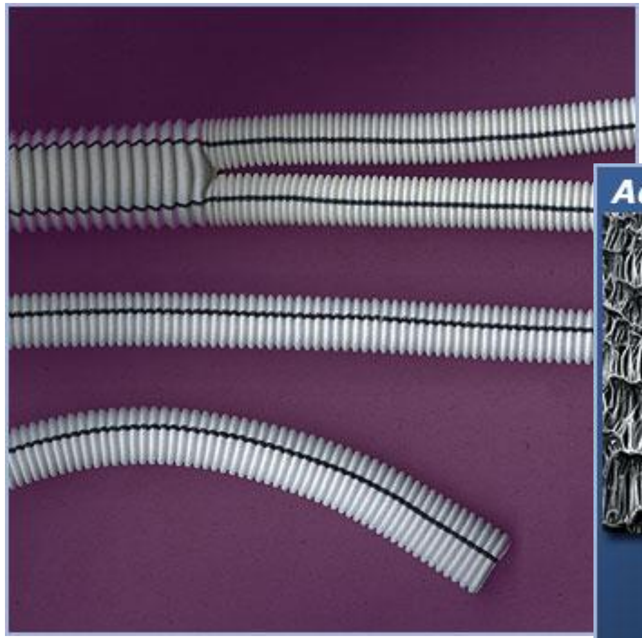
Automobile parts, windshields for fighter planes, pipes, tanks, packing materials, insulation, wood substitutes, adhesives, matrix for composites, and elastomers are all polymer applications used in the industrial market.

Sports

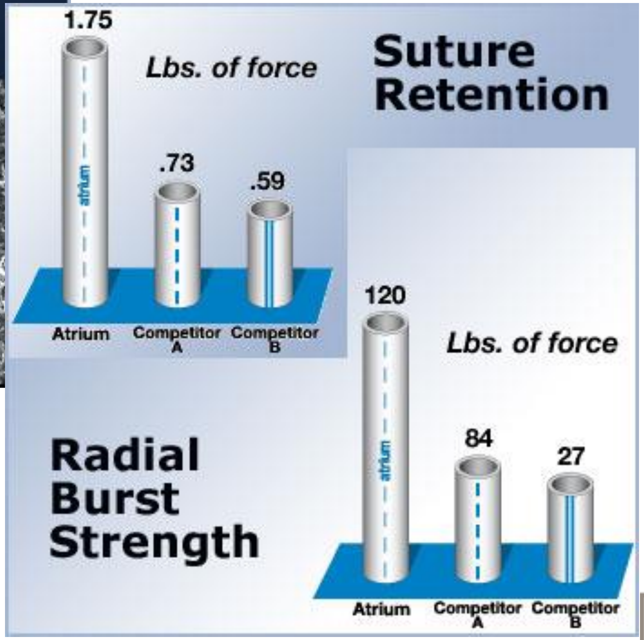
Playground equipment, various balls, golf clubs, swimming pools, and protective helmets are often produced from polymers.

Polymers: applications

Vascular implants



Porous structure enabling interaction with living tissues; controlled permeability.



Mechanical properties are *chosen by design*.

Composites: applications

Aerospace

Aircraft interior, secondary parts, radomes, rocket motor casings, fairings, satellites, missiles, antenna dishes, structural parts in high performance fighters.

Automotive

Interior headliner, air intake manifold, roof, tailgate, instrument panel, hood, air duct, airbag housing, engine cover, fender, bumper, hood frame.

Construction

Internal reinforcement of reinforced concreate (RC) structures, external strengthening of RC structures, hybrid structures (honeycomb), full composite structures

Marine

Mine sweeper, landing craft, personnel boat, sheathing of wood hulls, submarine sonar dome, submarine non pressure hull casing.

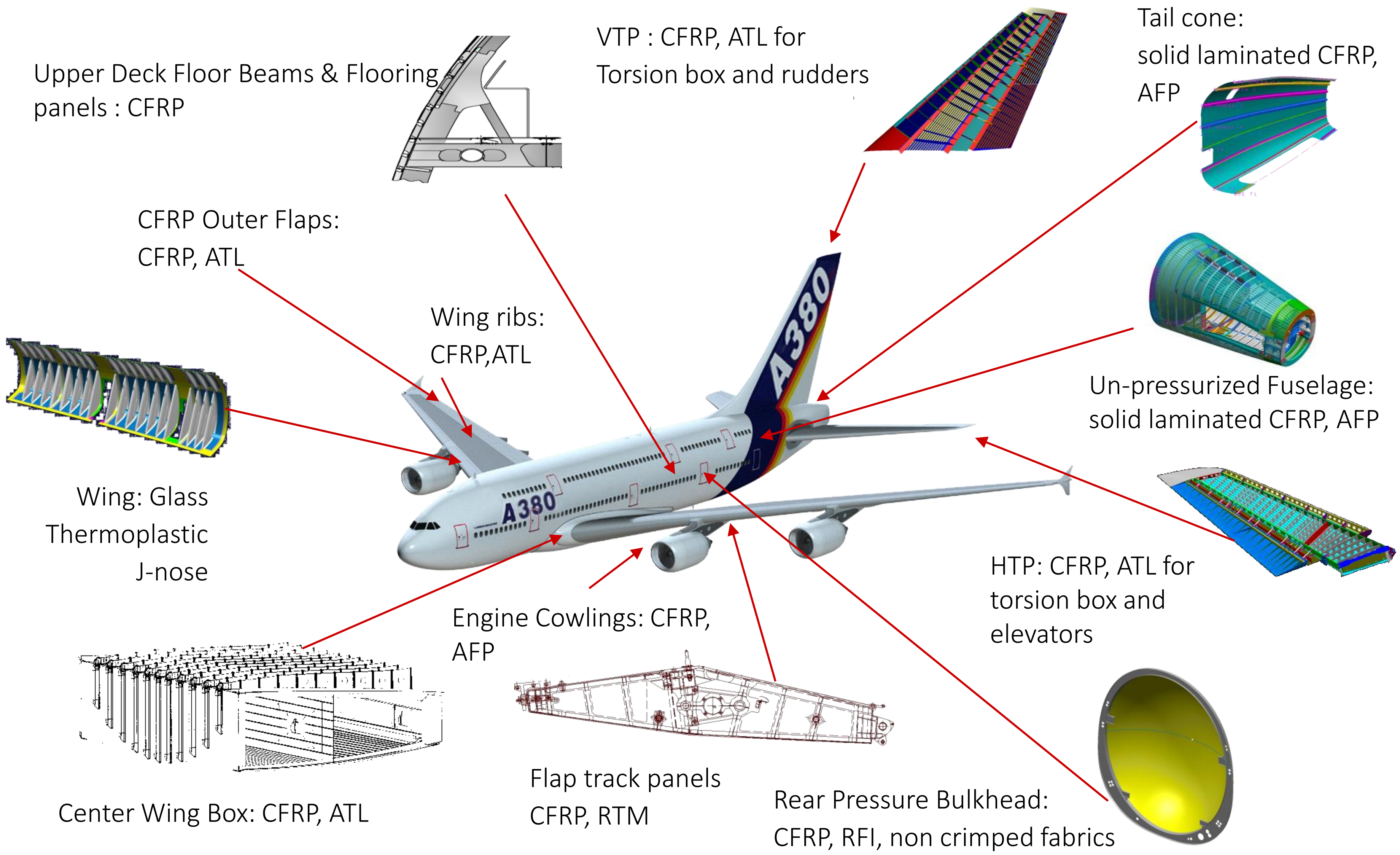
Consumer products

Skis, surfboards, windsurfing, table tennis boards, badminton, fishing rods, golf clubs, baseball bats, hockey sticks, pole shaft, all kinds of helmets, golf club heads, hull structure of various boats.

Composites: applications

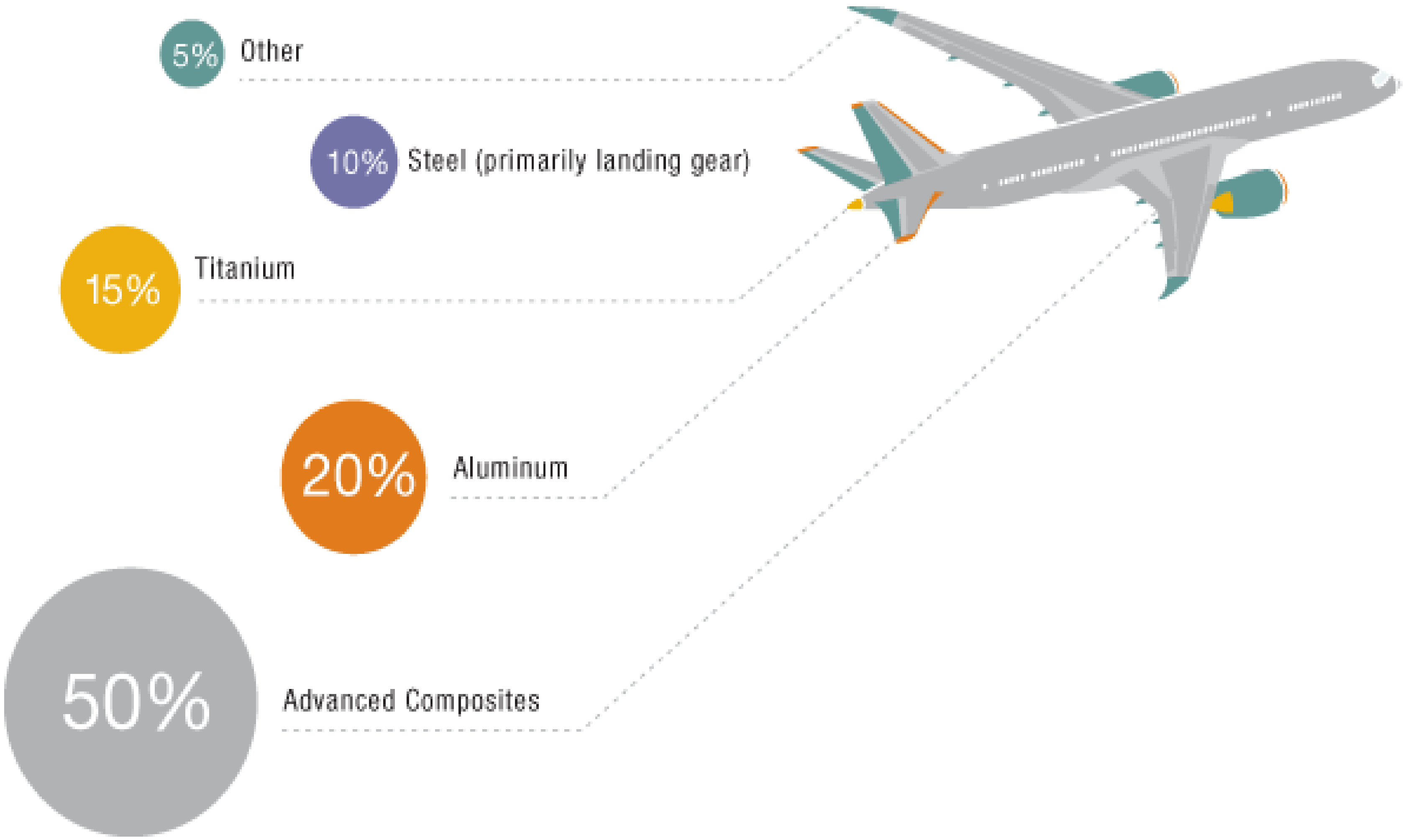
Outstanding <u>specific</u> properties!

Composites: applications



Composites: applications

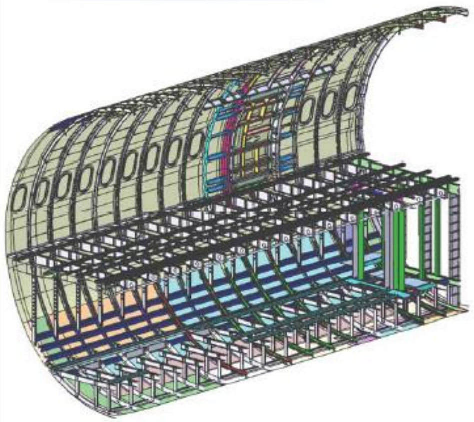
How composite solutions are applied throughout the 787 Dreamliner from Boeing



Composites: applications

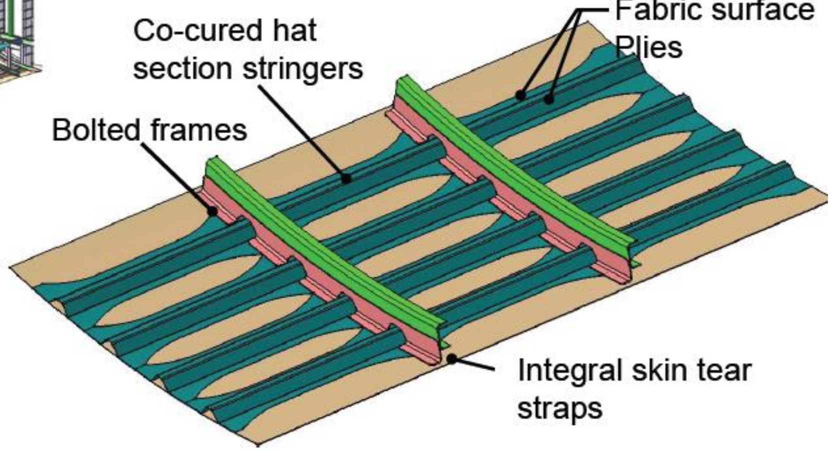
Typical Mid-Body Construction

787 DREAMLINER



Structure designed for robustness

- **Toughened CFRP materials**
- **Inter-Woven Wire Fabric (IWWF) lightning strike protection**
- **Skin/stringer shell produced as one-piece bond assembly with co-cured stringers**



Titanium seat tracks
CFRP frames, shear ties

CFRP passenger floor beams
CFRP cargo floor beams & stanchions

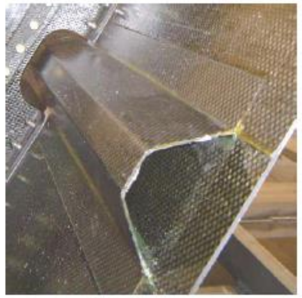
BOEING

787 Fuselage Composite Structure

787 DREAMLINER

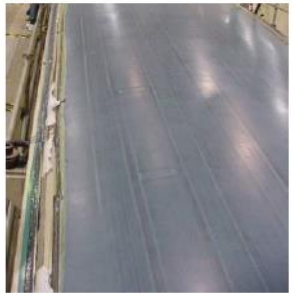
All-Composite Fuselage Structure fatigue and corrosion resistance enables

- **Higher pressure**
- **Higher humidity**
- **Bigger windows**



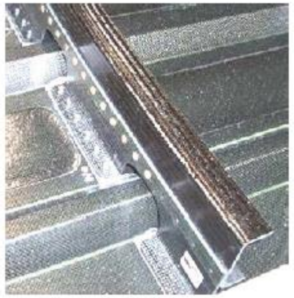
Stringer

Shear Tie



Skin

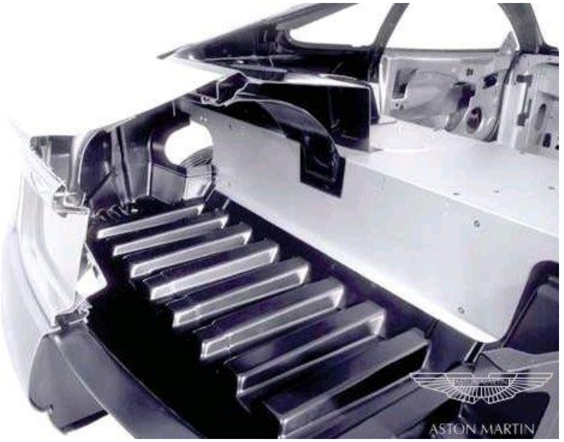
Floor Beam



Frame

BOEING

Composites: applications



Conclusions

1. There are no fundamentally bad classes of materials

2. Ceramics, polymers and composites are used in many different fields of applications

3. Concept of materials tetrahedron where:

Processing → Structure → Properties → Performance

→ Characterization ←