Composite Technology MSE 440

Introduction

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and guest speakers

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CH-1015 Lausanne

LPAC
Laboratory for Processing of Advanced Composites

EPFL

Course outline

2024	MSE 440 Composite technology	
10.09.2024	peb/vm	Introduction to course and learning objectives, group project, constituents
17.09.2024	vm/mw	Composite applications and background on composite processing
24.09.2024	peb	Background on composite mechanics
01.10.2024	peb	Sandwich structures and textile composites
08.10.2024	peb/vm/mw	Projects follow-up session I
15.10.2024	cb	Structural design/joining with composites
22.10.2024	vacation	
29.10.2024	peb	Composites for biomed and sport
05.11.2024	mw	Towards sustainable composites
12.11.2024	mw/vm	Cost modelling - a tool for sustainable innovation
19.11.2024	peb/vm/mw	Projects follow-up session II
26.11.2024	vm	Smart composites
03.12.2024	cp	Nanocomposites
10.12.2024	peb/vm/mw	Student project presentations
17.12.2024	peb/vm/mw	Student project presentations and exam

Today

- Content of the course
- Project
- Composite materials

Course objectives

By the end of the course, you shoud be able to:

- Know and discuss the main types of composites, as well as advanced, multifunctional composites, their processing and applications,
- Apply the basic equations for process and mechanical properties modelling for composite materials,
- Propose suitable design, production and performance criteria for the production of a composite part, including cost analysis and integration of sustainability strategies and the circular economy.

Transversal skills

- Team work, project over the duration of the course, in multi-background groups.
- Pitch and convince the audience at the end of the course.

Course organisation

- slides will be available to download before the courses on Moodle MSE 440

Grading:

- A project with report and presentation, made in groups, 2/3 of the grade,
- A short written exam on the content of all lectures, during the last session, that will count for 1/3 of the grade.

Biblio

Les matériaux composites organiques
Traité des matériaux, vol 15, PPUR, Lausanne

Matériaux composites, Composites Materials
D. Gay, Hermes, 1997, CRC Press 2003

Comprehensive composite materials,
Kelly A, Zweben C. ed., Elsevier 2000

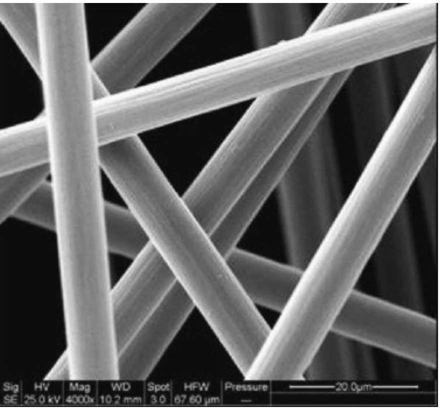
Process modeling in Composites manufacturing, S. Advani, M. Sozer, Marcel Dekker , 2003

C. Bathias, Les matériaux composites, Dunod, 2005

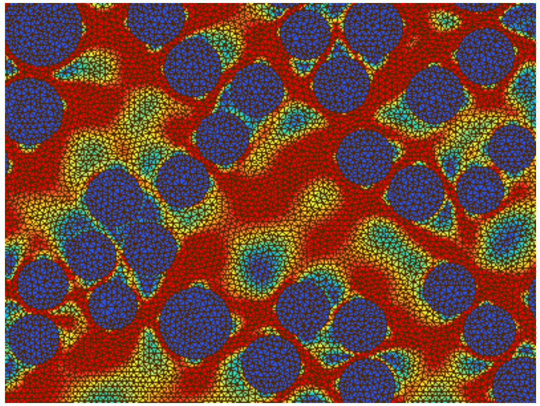
"Composite reinforcements for optimum performance", P. Boisse, Ed, Woodhead, 2011.

And many more at the library!!!

www……composites…..



www.reinforcedplastics.com



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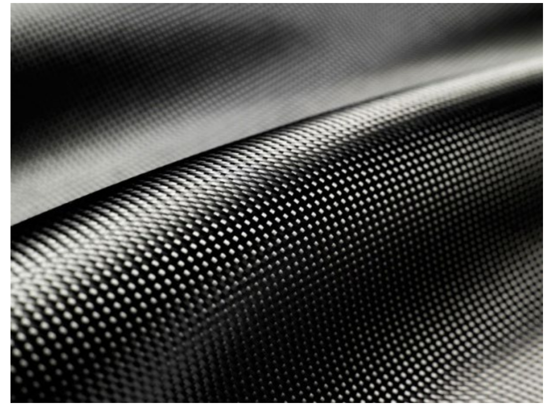
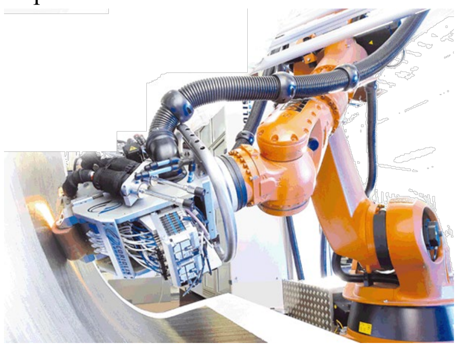


blog.motorlegend.com



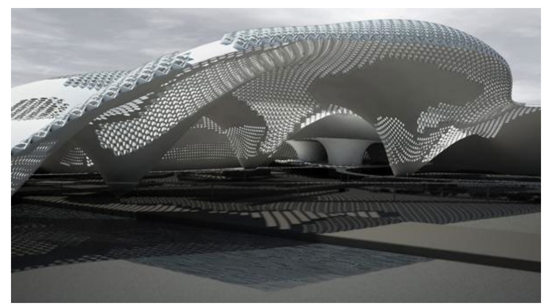
www.coriolis-composites.com

Boeing

BMW i8 automobile.challenges

www.decision.ch

Samsonite zedomax.com



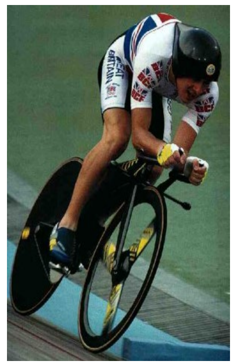
www.evolo.us

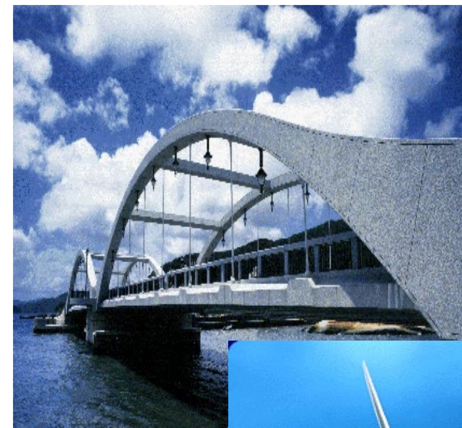
Composite materials?



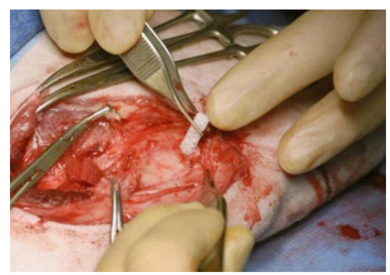




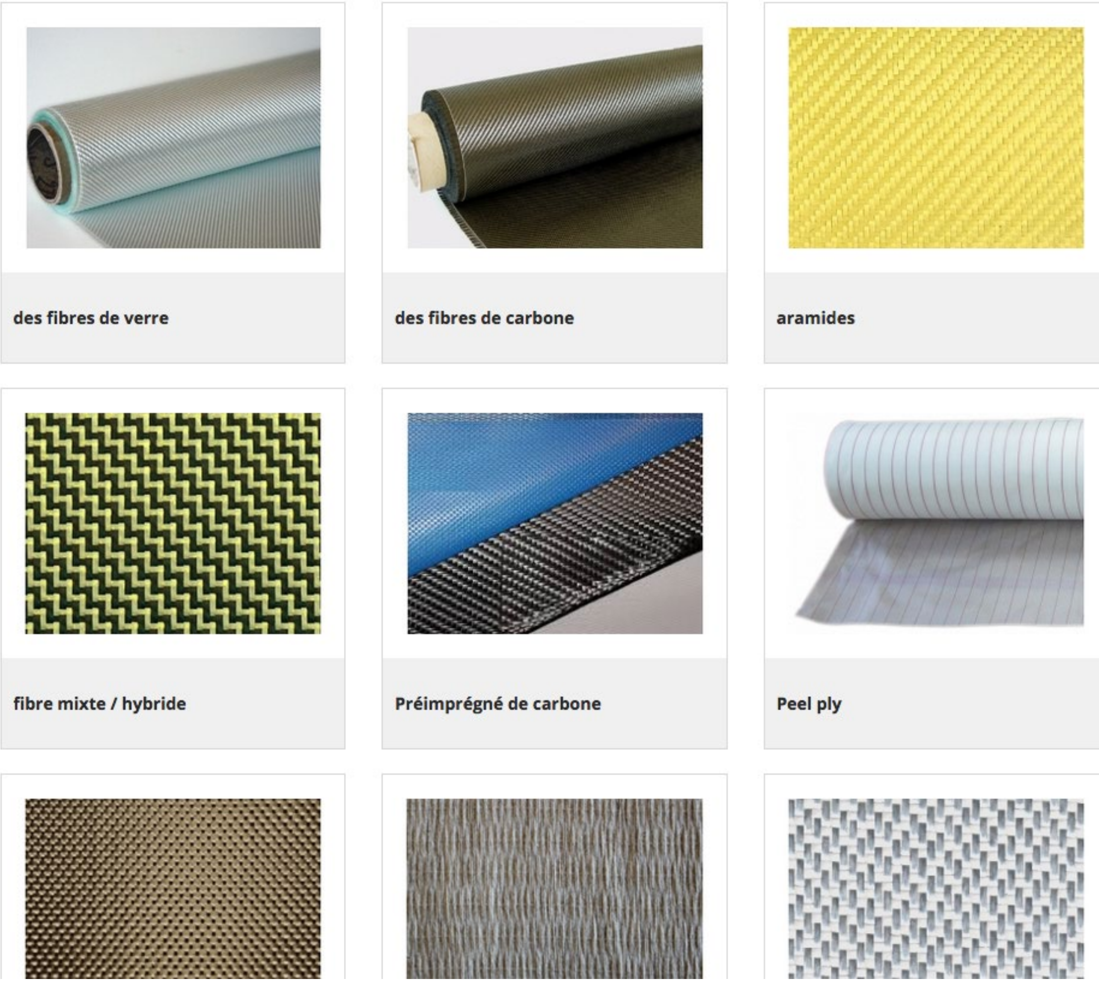




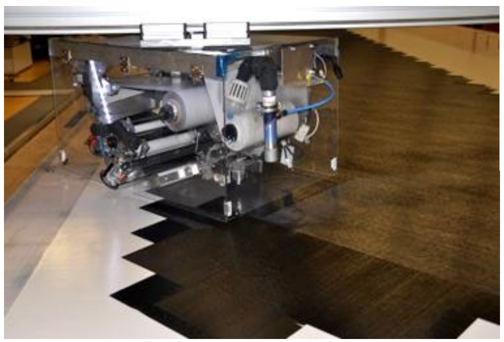


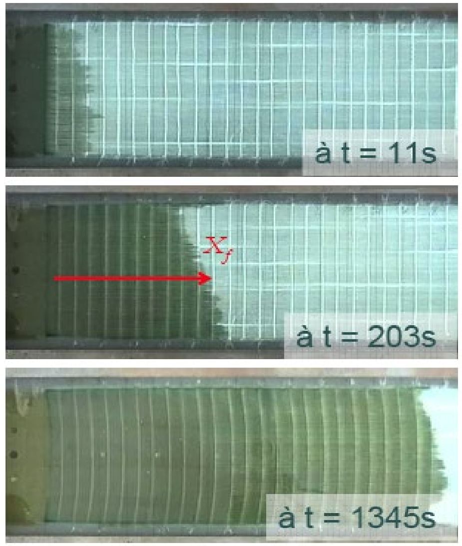
Constituents



Short overview of fibers, reinforcements, matrices

Processing



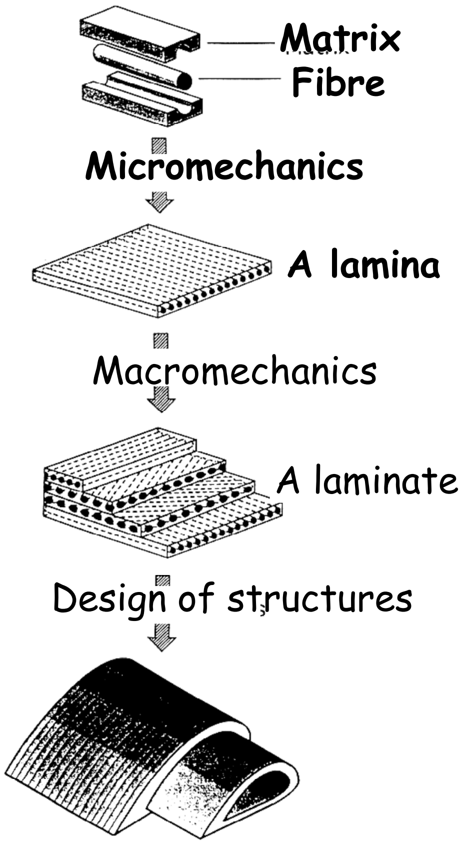


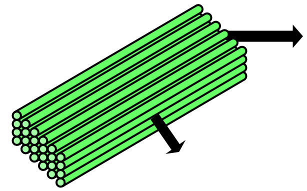
$$t_{\text{imprégnation}} = \eta \frac{(1 - V_f)L^2}{2K(P_a - \Delta P_c - P_{atm})}$$

Quick overview of the various composite production methods

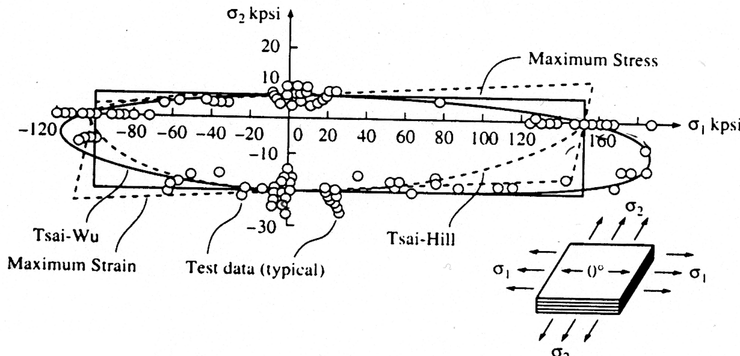
Insight into the main physical mechanisms and how to model them.

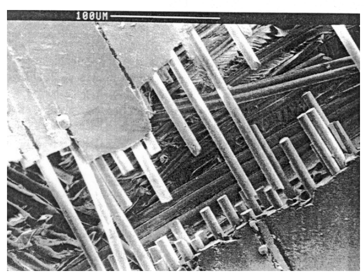
Composite mechanics

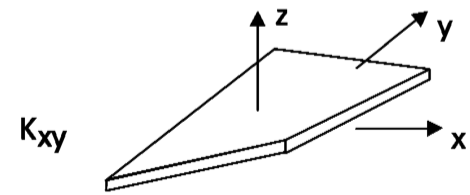


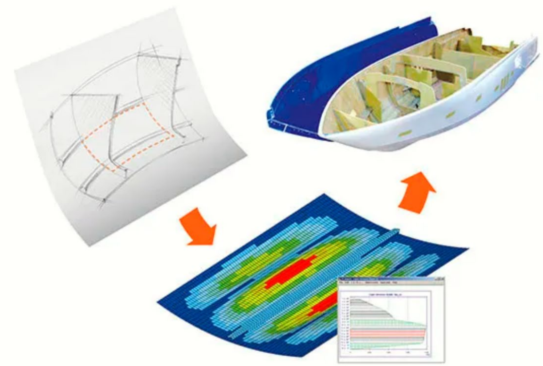


$$\begin{bmatrix} N_x \\ N_y \\ N_{xy} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{16} \\ A_{12} & A_{22} & A_{26} \\ A_{16} & A_{26} & A_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_x^0 \\ \varepsilon_y^0 \\ \gamma_{xy}^0 \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} & B_{16} \\ B_{12} & B_{22} & B_{26} \\ B_{16} & B_{26} & B_{66} \end{bmatrix} \begin{bmatrix} K_x \\ K_y \\ K_{xy} \end{bmatrix}$$

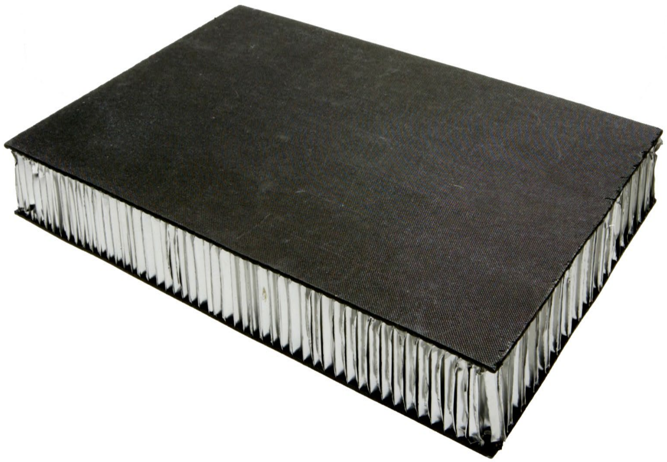


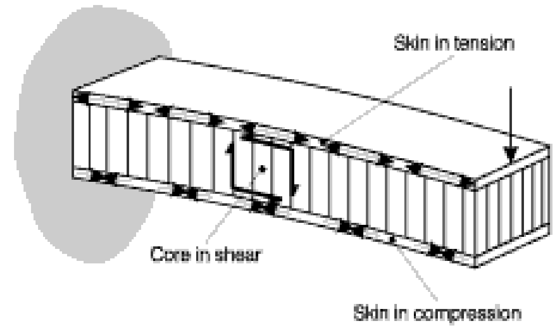


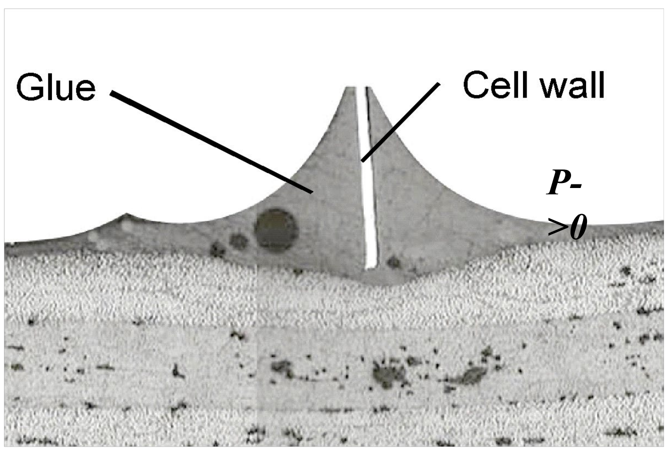




Sandwich structures







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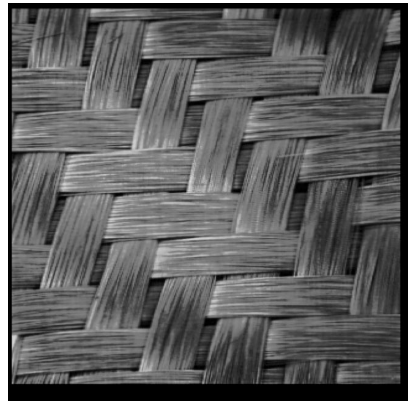
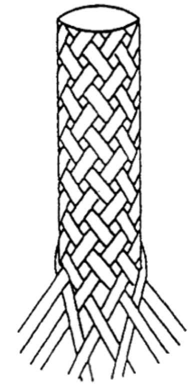
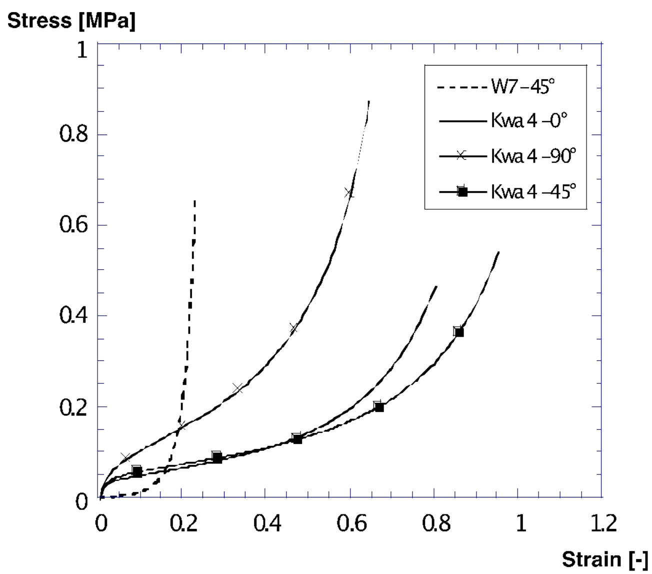
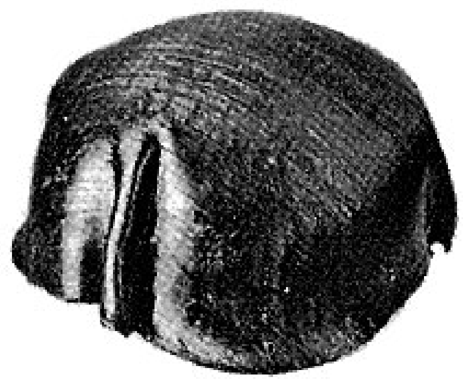
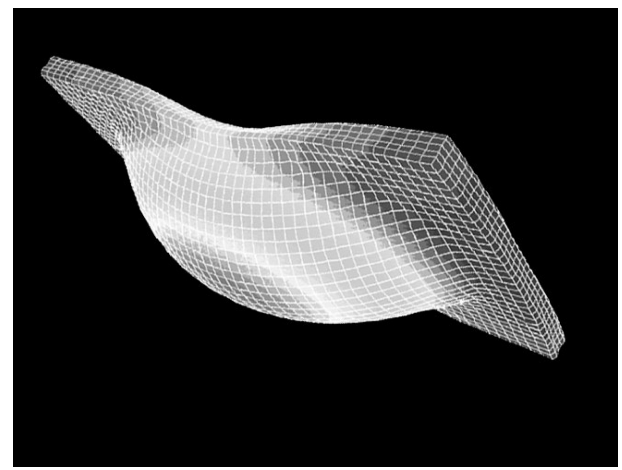
Textiles composites











Learning outcomes

Sandwich

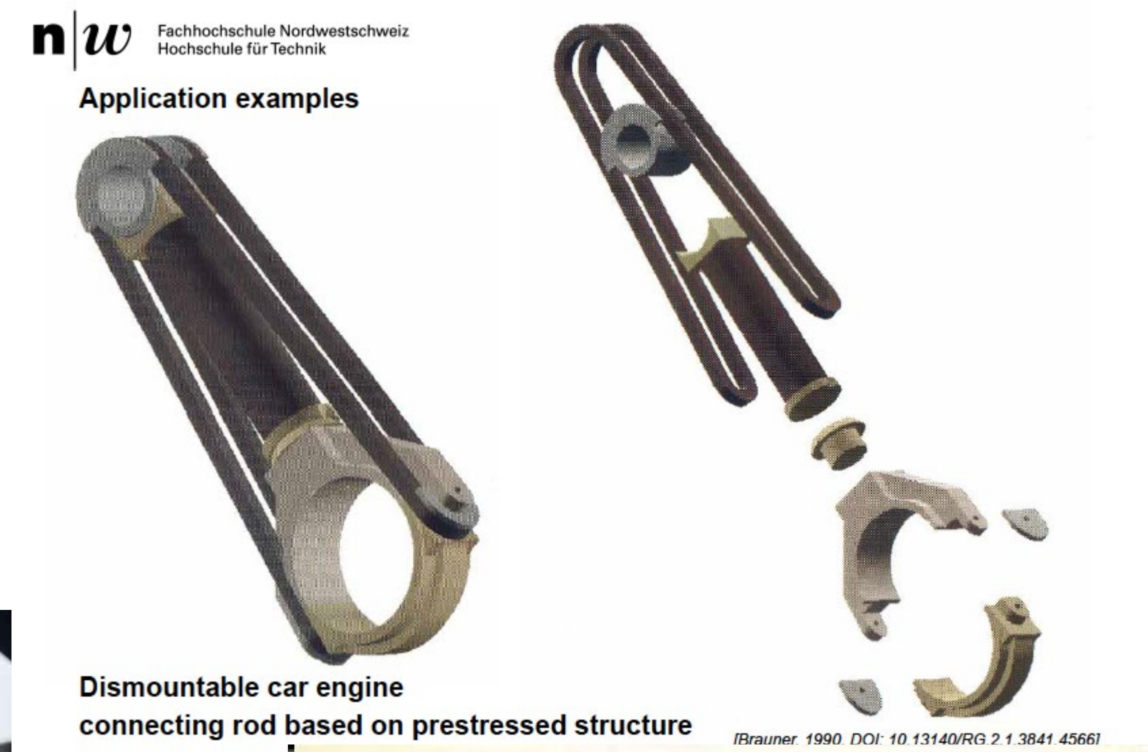
- Type of materials combined for sandwich structures
- Determination of the bending stiffness of sandwich structures
- Processing methods
- Main applications

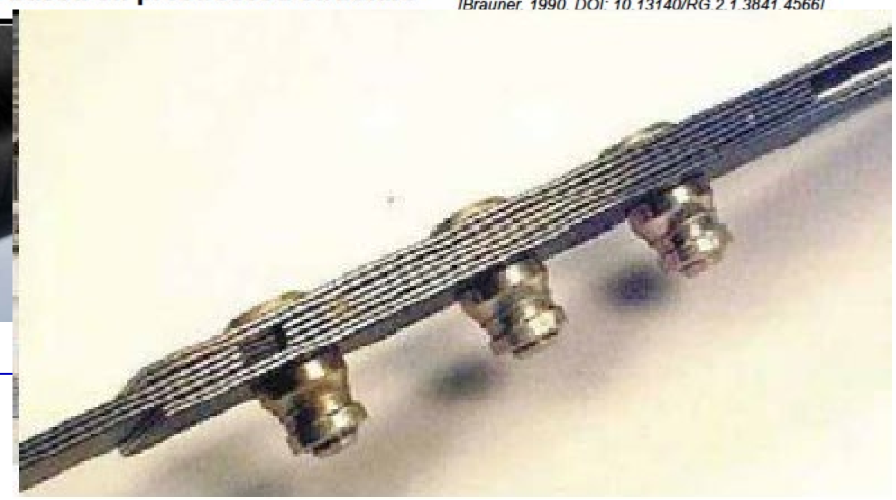
Textile composites

- Microstructures of woven, braided and knitted textiles
- Mechanical properties of textile composites
- Processing of complex shapes
- Main applications

Load introduction in Design

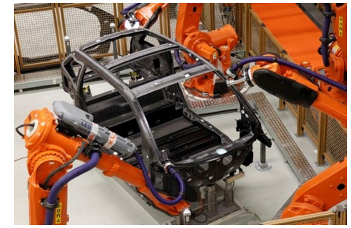
- How to join composites in an efficient way?
- Some calculation methods as well…





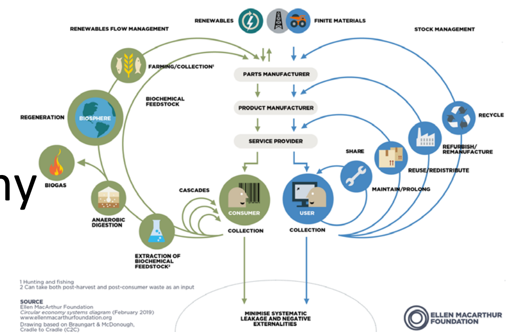
Towards sustainable composites

- Part 1: Where composites are used today
  - Materials and processes used today (linear economy)
  - Aerospace, Wind, and Automotive industrial Sectors



https://www.compositesworld.com/articles/the-making-of-the-bmw-i3

- Part 2: Introduction to sustainability strategies & circular economy
  - The Anthropocene & the great acceleration
  - The need for change, planetary boundaries, UN SDGs
  - Moving from a linear economic model to a circular economy
  - Sustainability strategies



https://ellenmacarthurfoundation.org/circular-economy-diagram

- Part 3: Towards sustainable composites …
  - Application opportunities for advanced composites, Additive manufacturing
  - Remanufacturing, Repurposing, Recovery & Recycling, Sharing, Legislation & Policy

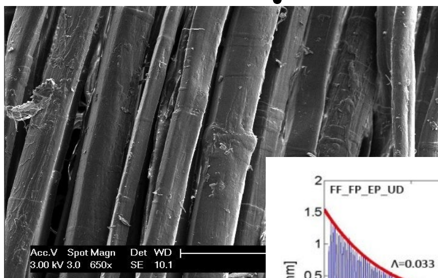
Learning outcomes

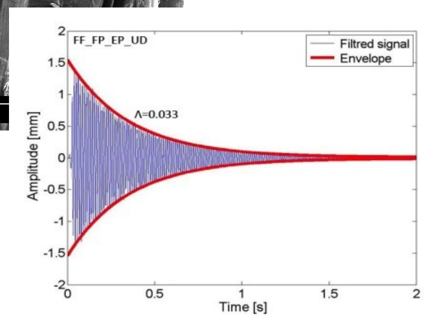
Towards sustainable composites

- Understand key sustainability issues and the challenge
- Grounding in sustainability focused around transportation and materials
- Difference between a linear and circular economy
- Need for a trans-disciplinary approach
- How composites can play a role in the journey to NetZero 2050
- Challenges for composites focused around raw materials
- Recent advances in additive manufacturing as an enabler
- Propose 3 SMART initiatives in your group project

Natural biocomposites

Natural Fibre Composites



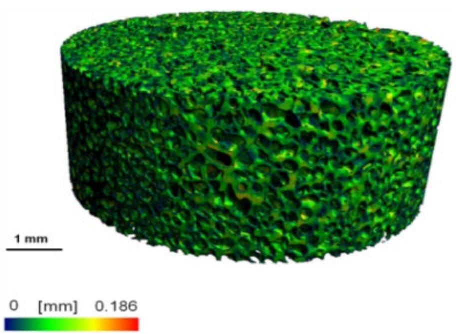


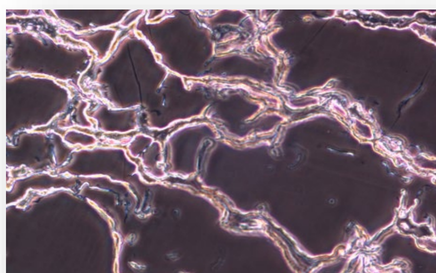
Artengo: flax(5%)/ carbon epoxy

Museeuw: flax/carbon epoxy

Stockli

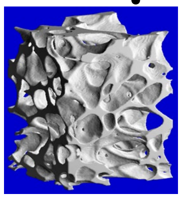
Biodegradable composite foams

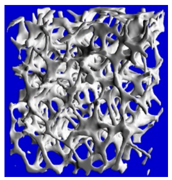


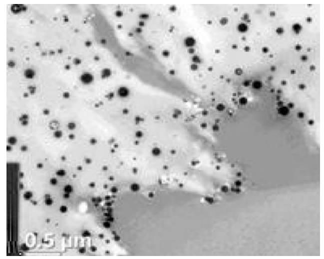


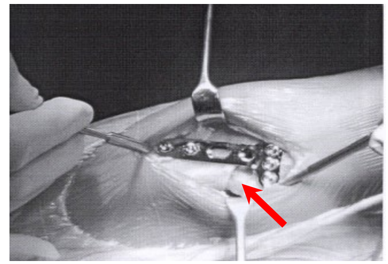
Biomed composites

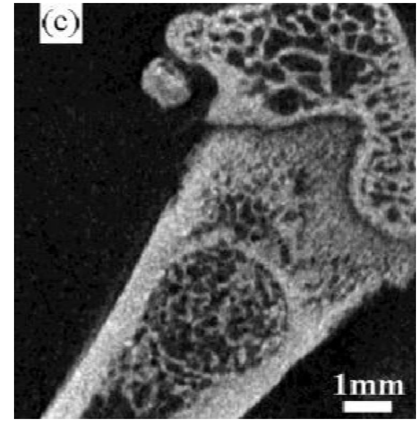
Resorbable composite foams



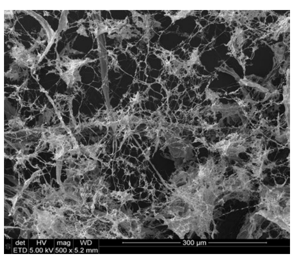


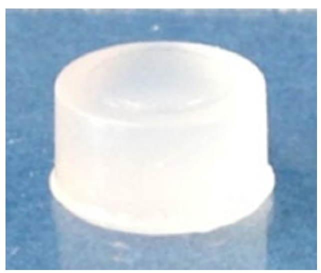


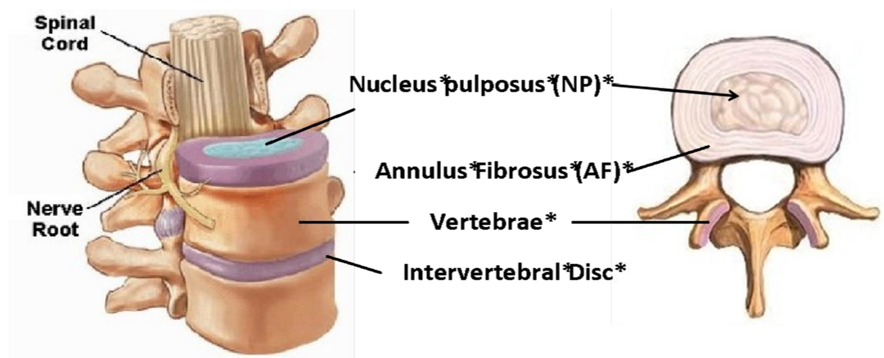




Composite hydrogels







Sport

Learning outcomes

Biocomposites

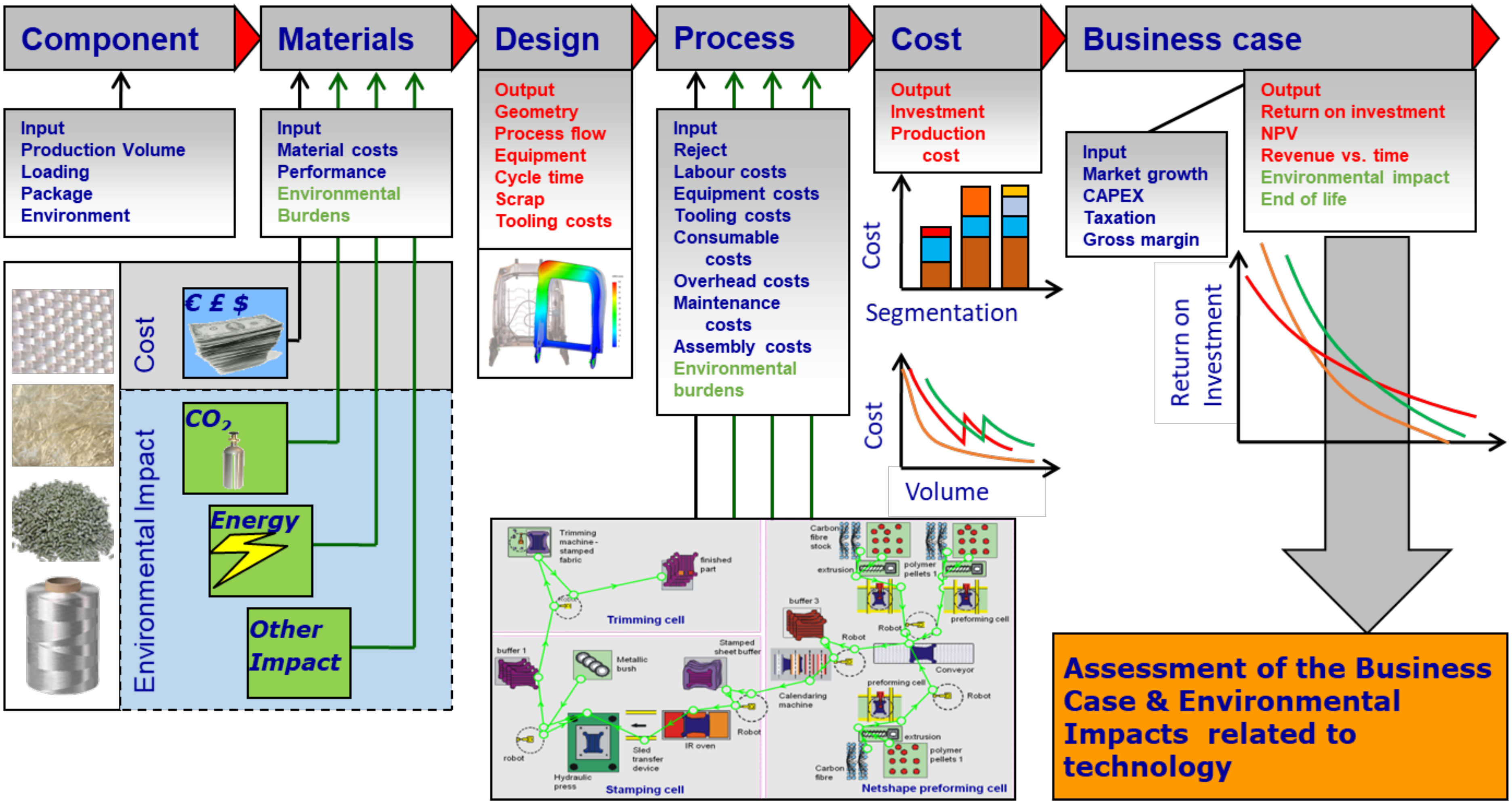
- Biodegradable composites
- Bioresorbable composites
- Selection of composites for body implants
- Composite ortheses and protheses

Sport applications

- Materials and properties for sport equipment
- Controling transfer of energies via the materials
- Processing for high performance in competition
- Feel and control, Stiffness and damping

Cost modelling – a tool for sustainable innovation

- Technical, Financial & Environmental Cost Prediction

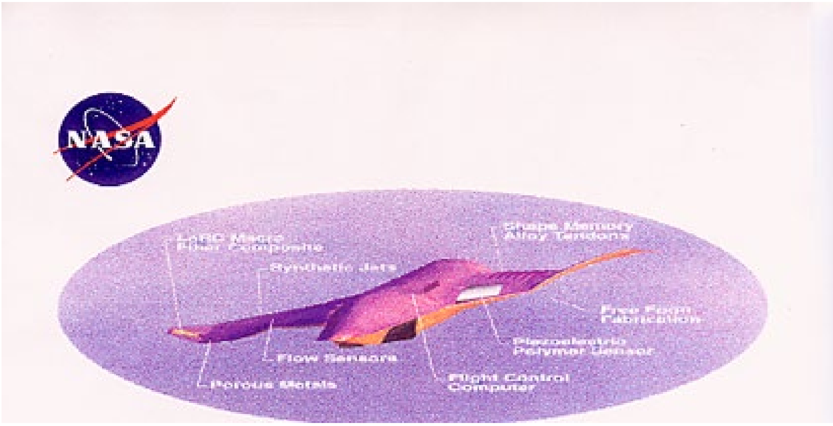


Learning outcomes

Cost modelling

- Learn how to set-up a cost model for a given process/material combination and a given volume of production
- Learn the main assumptions/data needed to set-up a cost model
- Presentation of an Excel tool which can be used for the project

Smart Composites



- Concepts
- Several types
- how to develop an active composite?

Learning outcomes

Smart Composites

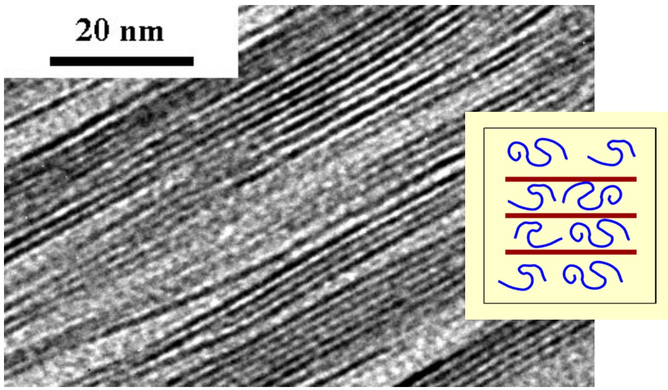
- Learn about the concept of smart composites, the definitions
- Survey various examples: integration of Shape memory alloy fibers, integration of piezo electric materials, of sensors, self-healing materials…
- Be able to propose combinations of materials which can bring functionality to composites for a given application, and to perform simple calculations to evaluate the expected effects.

Nanocomposites

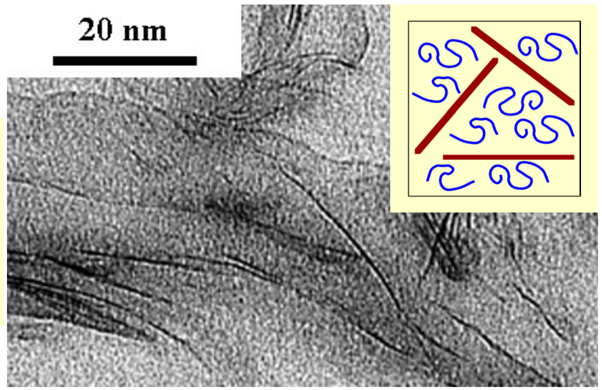
- *Cheap (native montmorillonite clay, no solvents)*
- *Expensive: carbon nanotubes…*

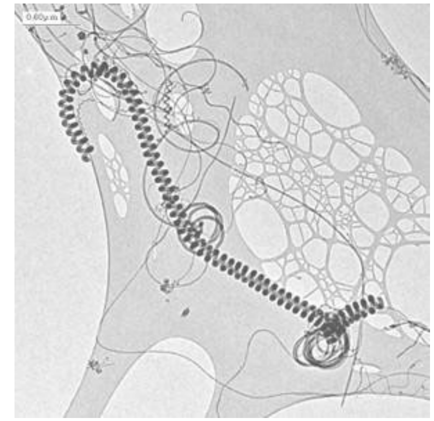
Nanocomposite structures

Without HBP

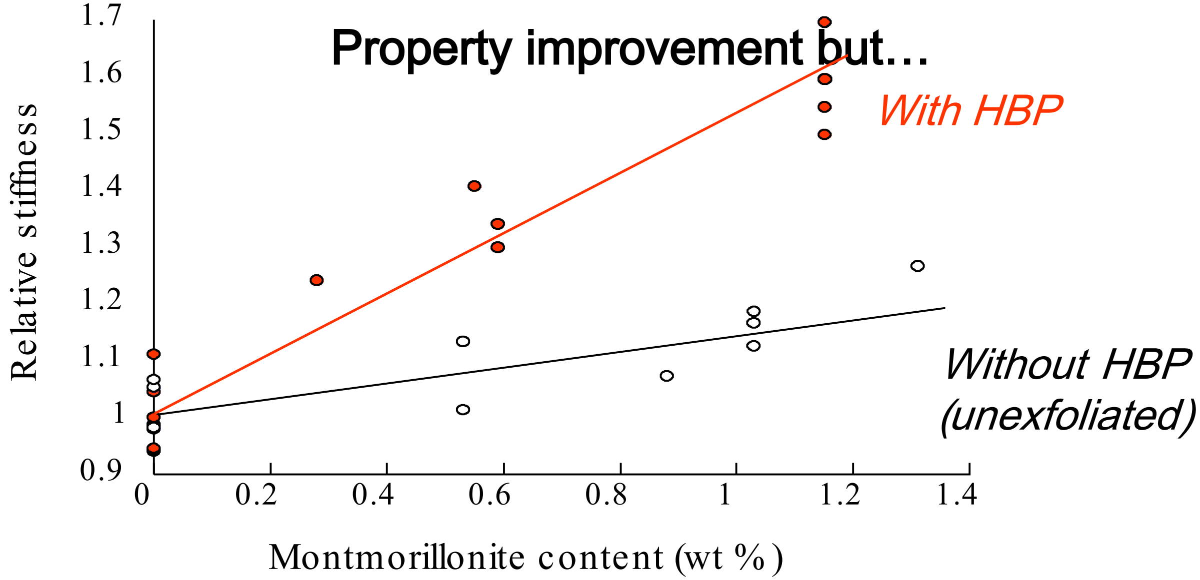


With HBP





Property improvement but…



…difficult to process!