Composite Technology MSE 440

Introduction

veronique.michaud@epfl.ch

pierre-etienne.bourban@epfl.ch

martyn.wakeman@epfl.ch

and guest speakers

Institut des matériaux (IMX)
Ecole Polytechnique Fédérale de Lausanne (EPFL),
CH-1015 Lausanne

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

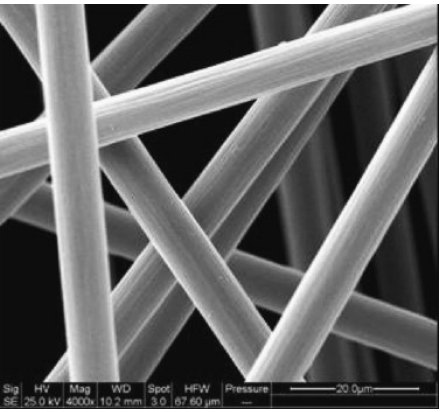
Process modeling in Composites manufacturing, S. Advani,
M. Sozer, Marcel Dekker , 2003

C. Bathias, Les matériaux composites, Dunod, 2005

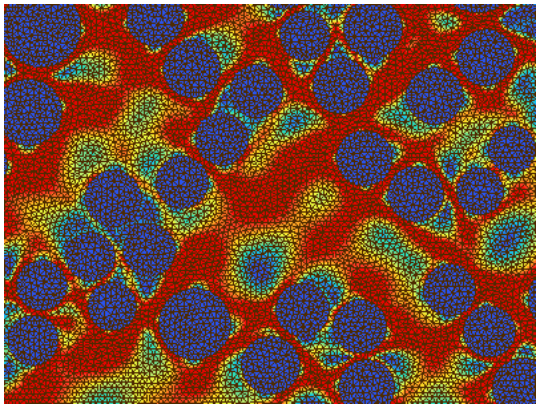
"Composite reinforcements for optimum performance", P.
Boisse, Ed, Woodhead, 2011.

And many more at the library!!!

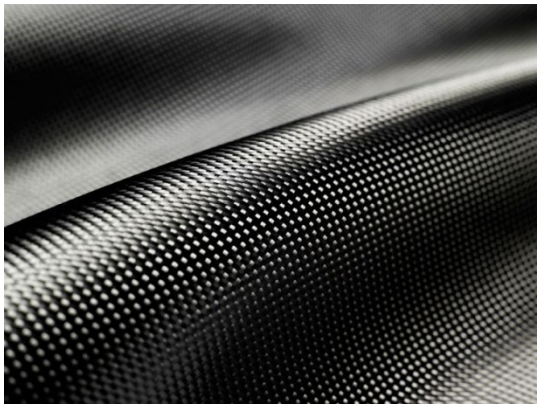
www……composites…..



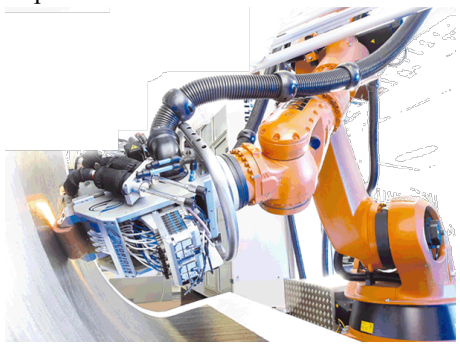
www.reinforcedplastics.com



www.onera.fr



blog.motorlegend.com



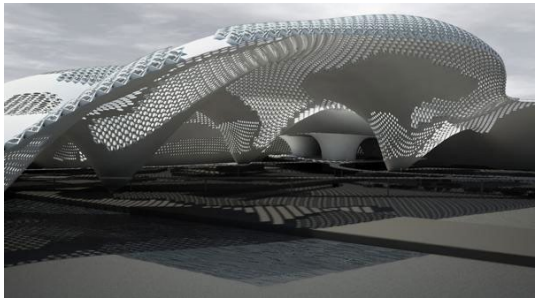
www.coriolis-composites.com

Boeing

BMW i8 automobile.challenges

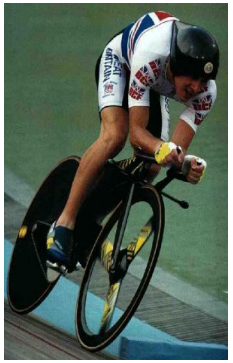
www.decision.ch

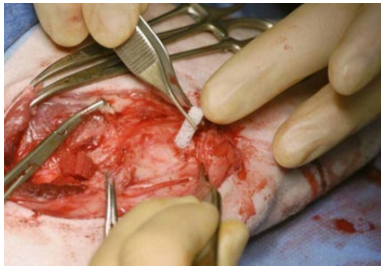
Samsonite zedomax.com



www.evolo.us

Composite materials?

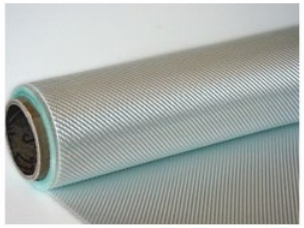




LPAC
Laboratory for Processing of Advanced Composites

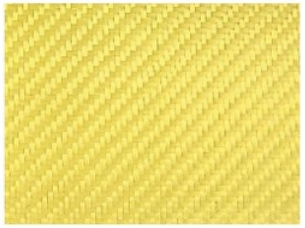
EPFL

Constituents



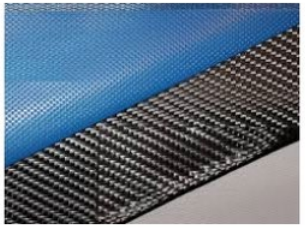
des fibres de verre

des fibres de carbone

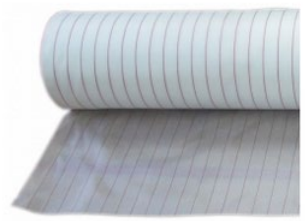


aramides

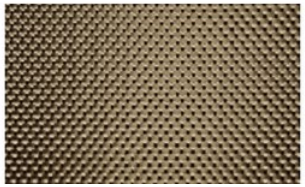
fibre mixte / hybride



Préimprégné de carbone

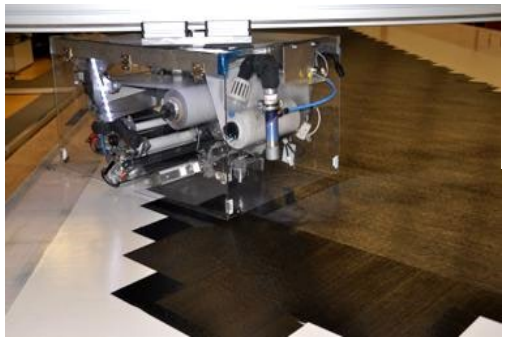


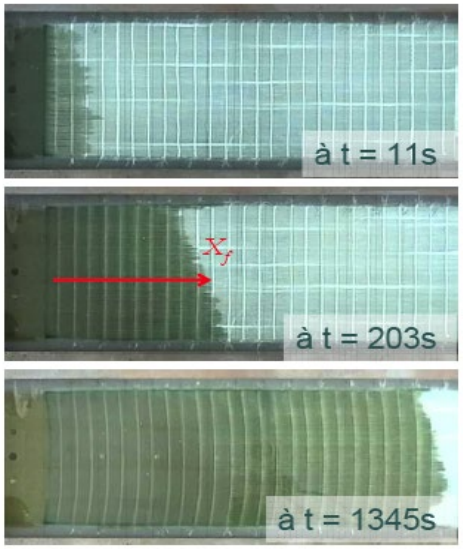
Peel ply



Short overview of fibers, reinforcements, matrices

Processing



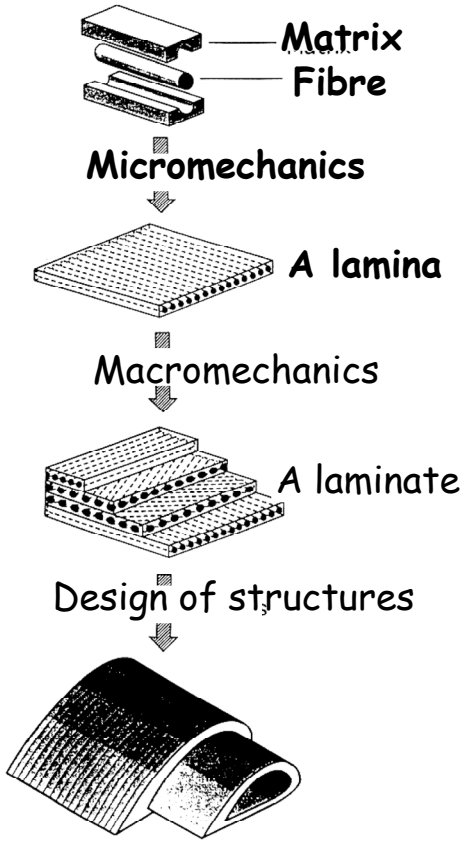


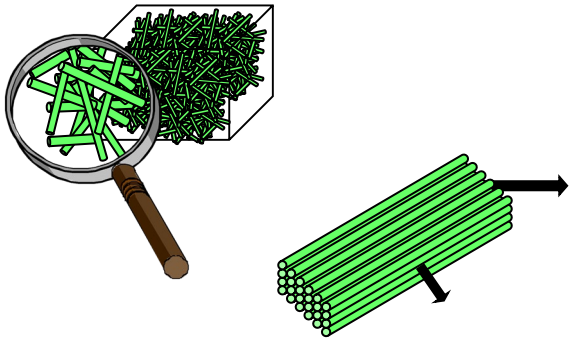
$$t_{imprégnation} = \eta \frac{(1 - V_f) L^2}{2K(P_a - \Delta P_c - P_{atm})}$$

Quick overview of the various composite production methods

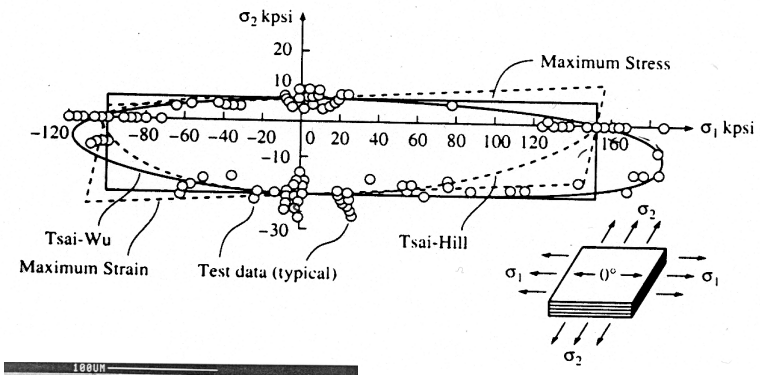
Insight into the main physical mechanisms and how to model them.

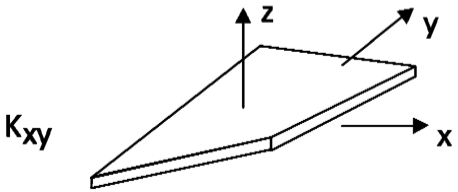
Composite mechanics

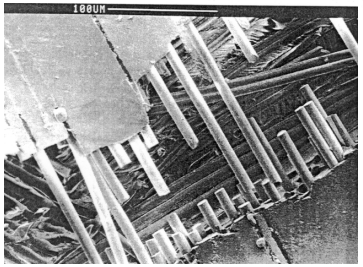


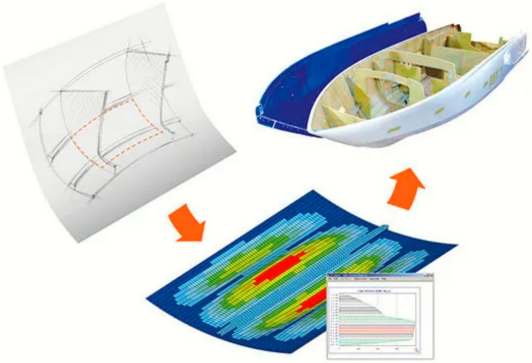


$$\begin{bmatrix} N_x \\ N_y \\ N_{xy} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} & A_{16} \\ A_{12} & A_{22} & A_{26} \\ A_{16} & A_{26} & A_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_x^0 \\ \varepsilon_y^0 \\ \gamma_{xy}^0 \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} & B_{16} \\ B_{12}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

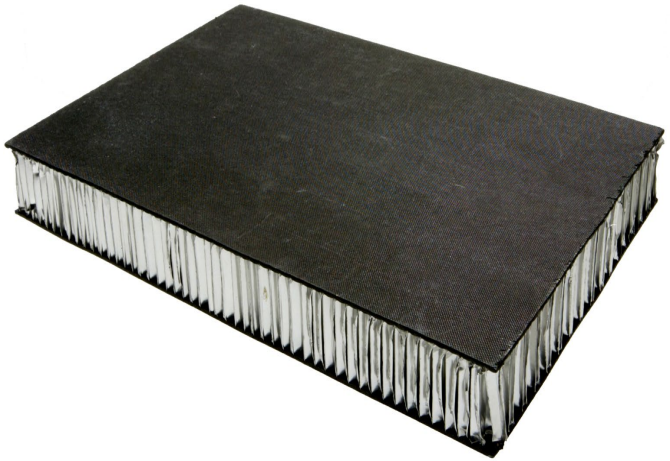


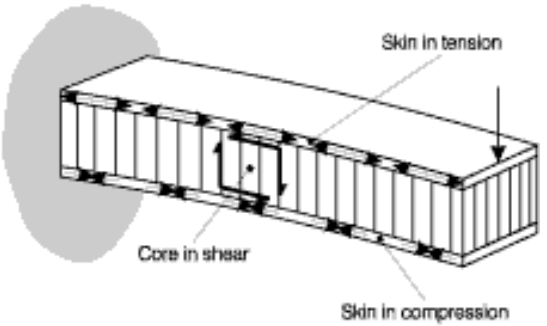


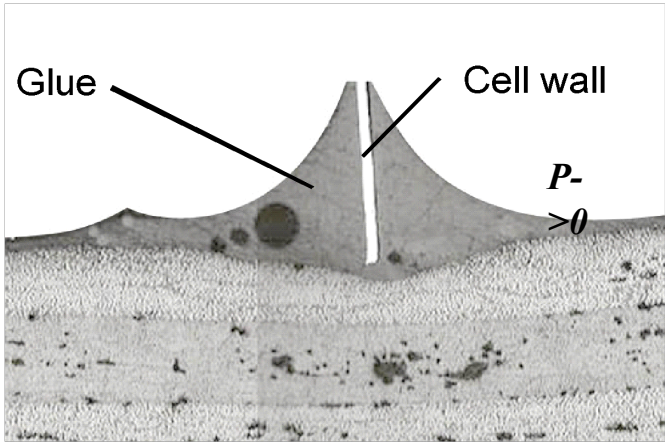




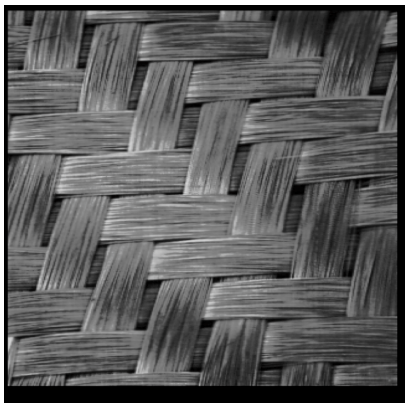
Sandwich structures

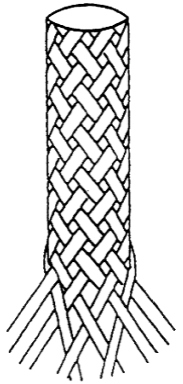


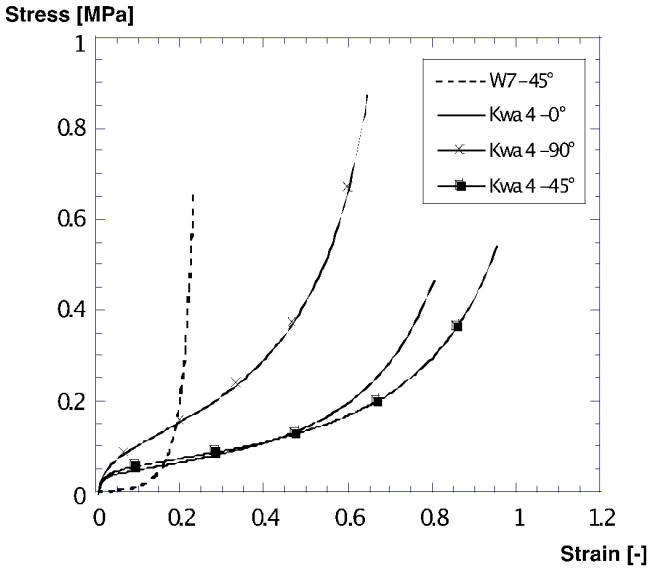


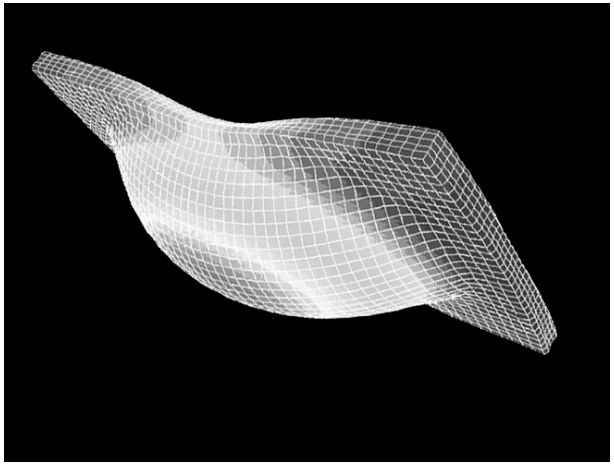


Textiles composites









Learning outcomes

Sandwich

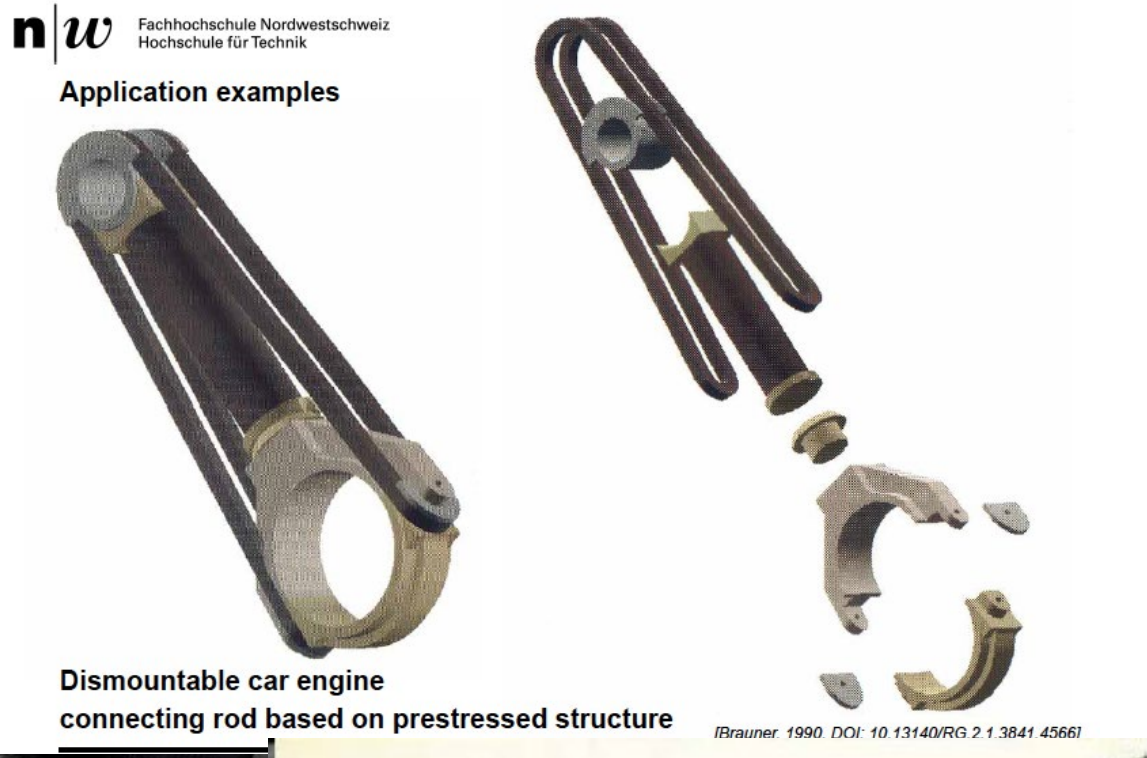
- Type of materials combined for sandwich structures
- Determination of the bending stiffness of sandwich structures
- Processing methods
- Main applications

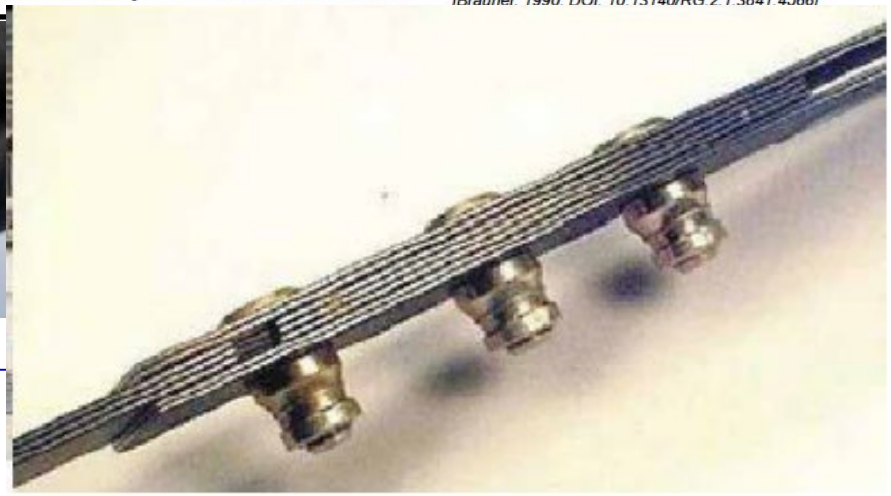
Textile composites

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

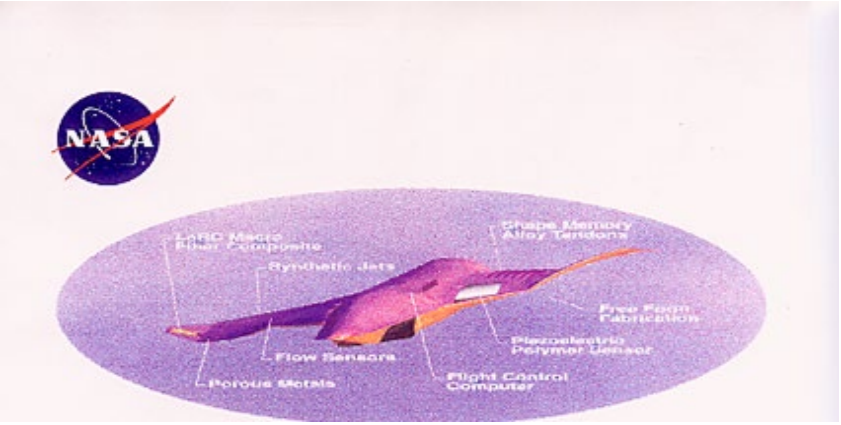
Load introduction in Design

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

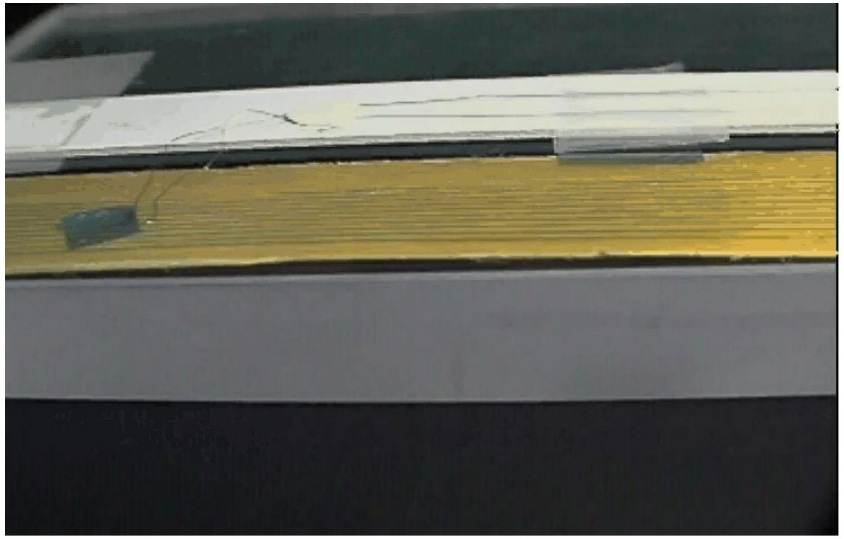




Smart Composites



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



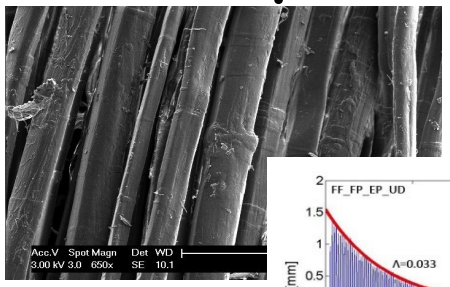
Learning outcomes

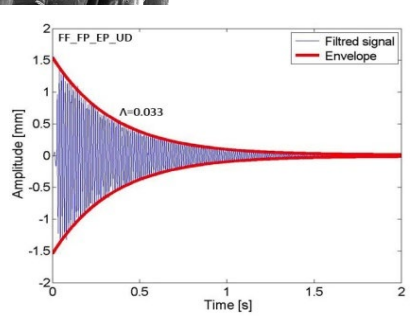
Smart Composites

- 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.

Natural biocomposites

Natural Fibre Composites



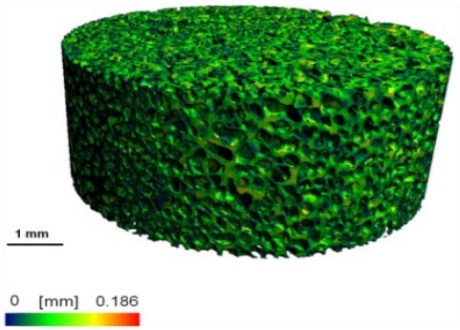


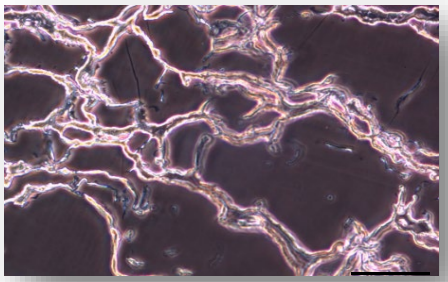
Artengo: flax(5%)/ carbon epoxy

Museeuw: flax/carbon epoxy

Stockli

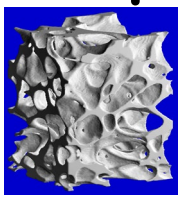
Biodegradable composite foams

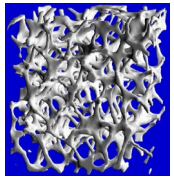


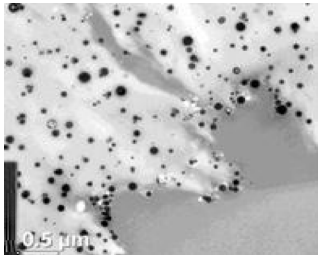


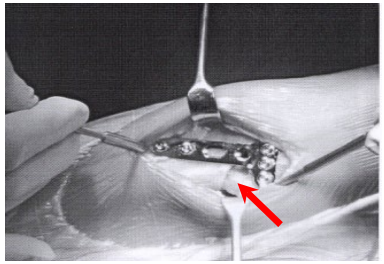
Biomed composites

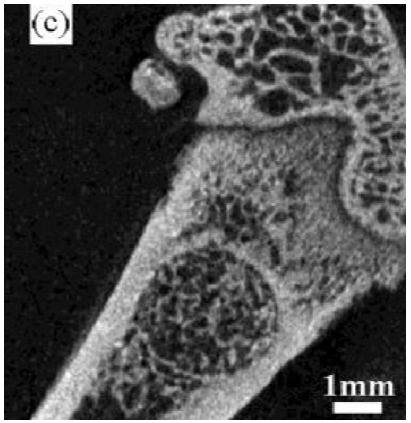
Resorbable composite foams



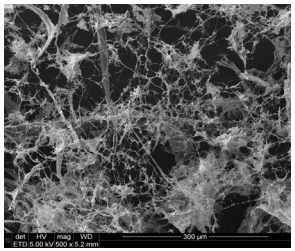


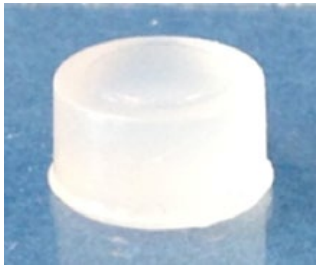


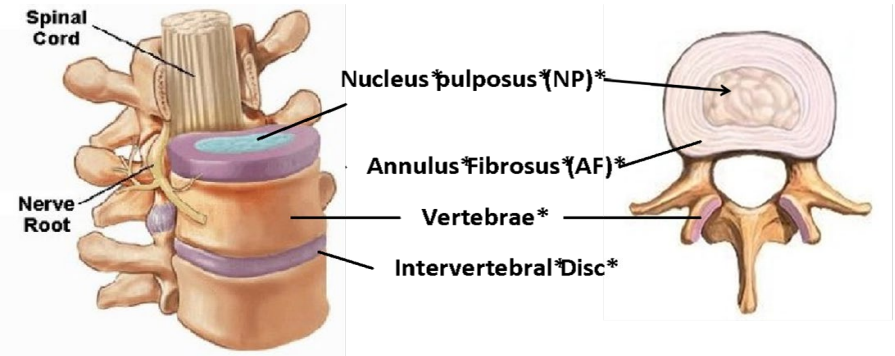




Composite hydrogels







Sport

LPAC
Laboratory for Processing of Advanced Composites

EPFL

Learning outcomes

Biocomposites

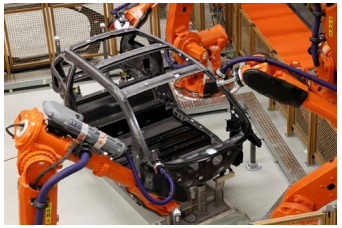
- Biodegradable composites
- Bioresorbable composites
- Selection of composites for body implants
- Composite ortheses and protheses

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

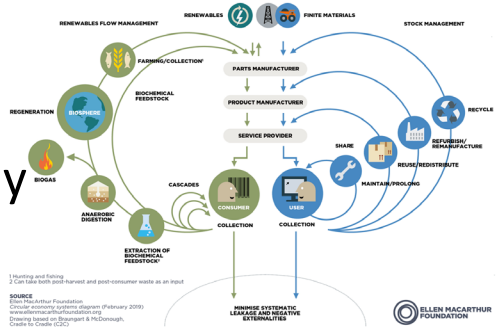
Towards sustainable composites

- 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

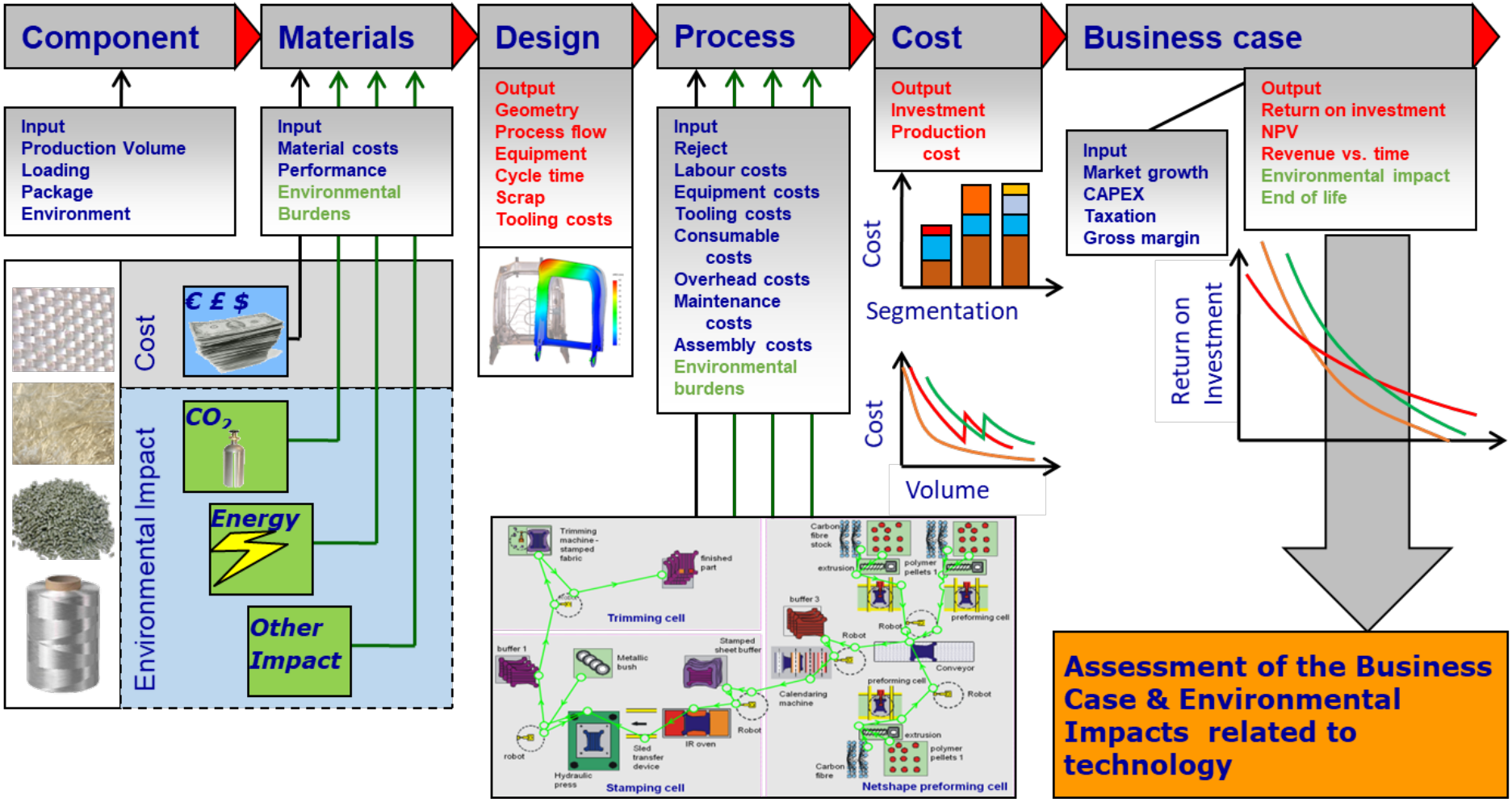
Learning outcomes

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

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

Course outline

09.09.2025	Introduction to course and learning objectives, group project, constituents	peb/vm
16.09.2025	Composites Applications and background on composite processing	vm/mw
23.09.2025	Background on composite mechanics	peb
30.09.2025	Sandwich structures and textile composites	peb
07.10.2025	Structural design/joining with composites	cb
14.10.2025	Projects follow-up session I	peb/vm/mw
21.10.2025		vacation
28.10.2025	Smart composites	vm
04.11.2025	Composites for biomed and sport	peb
11.11.2025	Cost modelling - a tool for sustainable innovation	mw/vm
18.11.2025	Towards sustainable composites	mw
25.11.2025	Projects follow-up session II	peb/vm/mw
02.12.2025	Student project week	
09.12.2025	Student project presentations	peb/vm/mw
16.12.2025	Student project presentations and exam	peb/vm/mw