



Go ahead, print my day!

Syllabus

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Lecturers

Name: André Studart

Academic Background: Professor Complex materials

Field of Specialization: Bio-inspired complex materials

Employer: ETH Zürich

Previous Positions:

2007 – 2008: Researcher at Harvard University in the group of Prof. David A. Weitz in the area of inorganic materials obtained using microfluidic techniques

2002 – 2007: Member of Prof. Ludwig J. Gauckler's group, mechanical properties of dental materials and ceramics processed through colloidal routes

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Name: Rafael Libanori

Academic Background: BSc in Chemistry and MSc and PhD in Materials Science

Field of Specialization: Senior researcher

Employer: ETH Zürich

Previous Positions: Postdoctoral fellow at UC Berkeley (Messersmith's lab)

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CV: https://scholar.google.ch/citations?user=VYmXZ_QAAAAJ&hl=en

Name: Mariana Popescu

Academic Background: Master architecture, non-standard and interactive architecture within Hyperbody

Field of Specialization: PhD Researcher at Block Research Group, NCCR Digital Fabrication.

Employer: ETH Zürich

Previous Positions:

2013 – 6/2015: Parametric design specialist at Zwarts and Jansma Architects, Amsterdam.

2012 – 2013: Hive Systems, start-up developing a platform enabling designers and architects to quickly conceptualise, visualise and build complex interactive environments using distributed algorithms.

2011 – 2012: ReVolt House team, which built a fully self-sustaining house

2008 – 2010: Nuon Solar Team, a multidisciplinary team designing, building and racing a solar car across the Australian Outback.

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Name: Andrei Jipa

Academic Background: Master of Architecture Parametric Design, Distinction, University of Westminster

Field of Specialization: PhD student NCCR Digital Fabrication

Employer: ETH Zürich

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Name: Ana Anton

Academic Background: Master of Architecture, Technical University Delft

Field of Specialization: PhD student NCCR Digital Fabrication

Employer: ETH Zürich

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Name: Enrico F. Marchesi

Academic Background: Master of Advanced Studies in Marketing

Field of Specialization: Innovation Manager, Empa NEST

Employer: Empa

Previous Positions:

3/2011 – 11/2014: Head Marketing & Sales, ESPROS Photonics AG

11/2007 – 12/2010: Product Line Manager Elevator Systems, ELGO Electronic GmbH

7/2005 – 6/2007: Head Special Elevators Switzerland, Schindler Elevators

5/2002 – 6/2005: Section Manager, R&D - Hoistway Technologies, Schindler Elevators

2/1999 – 2/2002: Project Manager R&D – Technology Management, Schindler Elevators

12/1997 – 2/1999: Research associate, Engine Systems Laboratory, ETH Zürich

8/1996 – 11/1997: Research assistant, University of California, Davis

1/1996 – 8/1996: Research associate, Institute of Textile Machinery, ETH Zürich

1993 – 1995: Research assistant, Automatic Control Laboratory, ETH Zürich

1992: Intern, ABB Turbosystems

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Name: Michael Hausmann

Academic Background: Master of science Material Science, EPFL

Field of Specialization: PhD student Cellulose and wood materials

Employer: Empa

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Name: Graule, Thomas Josef

Academic Background: Professor for Nanoparticle Synthesis and Processing of Nanocomposites

Field of Specialization: Head of Laboratory for High Performance Ceramics

Employer: Empa

Previous Positions:

02/1995 – 06/1999: Katadyn Produkte AG, Wallisellen, Switzerland
Head of Technique and Logistics,
Member of the Executive Board

02/1989 – 01/1995: Swiss Federal Institute of Technology (ETH) Zurich, Switzerland,
Assistant Professor (Oberassistent) at Institute of Nonmetallic
Inorganic Materials

07/1988 – 12/1988: Fraunhofer-Institut für Angewandte Materialforschung, Bremen,
Germany

Scientist

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Name: Jakob Heier

Academic Background: PhD. Material Science & Engineering

Field of Specialization: Group Leader Functional polymers

Employer: Empa

Previous Positions:

07/1999 – 02/2003: Research Scientist Papyron BV

04/2003 – 04/2004: Research scientist BiOMaDeTechnology Foundation

05/2004 – 10/2006: Development Engineer Plastics & Elastomers Philips DAP

11/2006 – 12/2016: Research scientist Empa

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Name: Viktor Lindström

Academic Background: Master of Science, Applied Physics / Chemical Engineering with Engineering Physics, Chalmers University of Technology

Field of Specialization: PhD student in additive manufacturing of highly reflective and conductive metals

Employer: Empa

Previous Positions: ABB Corporate Research – Internship semiconductor packaging

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Name: Patrik Schürch

Academic Background: Master of Science

Field of Specialization: PhD student in Mechanics of Materials and Nanostructures

Employer: Empa

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Name: Fabio Bargardi

Academic Background: Master of science Materials, ETH Zürich

Field of Specialization: PhD student Complex materials

Employer: ETH Zürich

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Name: Pascal Jenni

Academic Background: Master of Business Administration, Kalaidos University of Applied Sciences, Zürich

Field of Specialization: Consultant

Employer: Combined Solutions GmbH, Neuhausen SH

Previous Positions:

08/2016 – 04/2019: Head of Additive Manufacturing, Pi2Process AG, Freienbach SZ

11/2016 – 07/2018: Tutor, Impuls Nachhilfezentrum GmbH, Zug ZG

11/2015 – 04/2016: Project Leader, POLYGENA AG, Pfäffikon ZH

08/2015 – 11/2015: Project Leader, Molnar AG, Pfäffikon ZH

02/2015 – 06/2015: Scientific Assistant, ZHAW School of Engineering, Winterthur ZH

08/2014 – 02/2015: Internship, Molnar AG, Pfäffikon ZH

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Name: Rani Boons

Academic Background: Master of science Bio-engineering, KU Leuven

Field of Specialization: PhD student Cellulose and wood materials

Employer: Empa

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Course Description

Title: Go ahead, print my day!

Fields of activity: Biological/Biotechnical/Gene Engineering, Biomedical Engineering, Chemical Engineering, Chemistry / Chemical Technology, Electrical / Electromechanical Engineering, Electronic / Electrotechnical Engineering, Materials Engineering

Examination type: Project work

Number of ECTS credits issued: –

Learning Goals and Objective:

- ♣ Get an introduction additive manufacturing techniques and materials.
- ♣ An overview and some deeper understanding of current state of the art research in 3D printing will be provided.
- ♣ Getting introduced into the possibilities and also drawbacks of the technique.
- ♣ Learning to critically asses methods and improve quality of additive manufacturing.
- ♣ Using the basic knowledge to think several steps further for starting of a company.
- ♣ Creative and critical thinking about problems and working proactively in a multidisciplinary and -cultural team.

Syllabus

Name of activity	Biologically-inspired materials in additive manufacturing
Number of working hours	3 hours
Type of activity	Lectures
Lecturer	André Studart, Rafael Libanori
Short summary of content	This introductory lecture on additive manufacturing of biologically-inspired materials is comprised of three main blocks. In the first block, we demonstrate the crucial role of natural selection in the microstructural optimization of biological materials and present selected examples of successful integration of biological design principles into synthetic materials and systems to enhance their performance. Next, we show the current trends in additive manufacturing technologies that bring us closer to the manufacturing capabilities of living organisms and opens new ways for the digital fabrication of advanced materials with superior performance, lower environmental impact and new functionalities. The last block is reserved for the summer school attendees to get started in their week project about applications of additive manufacturing techniques to provide bio-inspired solutions to real-world problems.
Bibliography	Studart, André. (2016). Additive manufacturing of biologically-inspired materials. <i>Chemical Society reviews</i> . 45. 10.1039/c5cs00836k. Additive manufacturing of biologically-inspired materials
Expected effect	The students will gain insight in biological systems, and how they are used as inspiration for human-built structures, and specifically in additive manufacturing.

Name of activity	Digital fabrication and construction
Number of working hours	2,5 hours
Type of activity	Lecture and Project work
Lecturer	Mariana Popescu, Ana-Maria Anton, Mihail-Andrei Jipa
Short summary of content	<p>The PhD students of Blok research group(BRG)/NCCR Digital Fabrication and Digital Building Technologies will show the current research of their groups and what they specifically are working on.</p> <p>Research at the BRG focuses on several core areas, including analysis of masonry structures, graphical analysis and design methods, computational form finding and structural design, discrete element assemblies, and fabrication and construction technologies. The central goals of our geometry-based approach are to understand the real demands of complex structural design and engineering problems and to develop new algorithms and efficient, accessible tools for structurally informed design.</p> <p>The chair for Digital Building Technologies researches in new building technologies based on the seamless integration of computational design methods, digital fabrication and new materials. In this context, DBT investigates additive manufacturing strategies in architecture, which have the potential to challenge traditional paradigms of construction. The aim is not only to rationalise the fabrication process and improve the quality of buildings, but also to open up radically new design-solutions.</p> <p>A task or case study will be given to the students to use the gained information in a real life or theoretical problem.</p>
Bibliography	<p>Popescu M., Rippmann M., Liew A., Van Mele T. and Block P. Concrete shell built using a cable-net and knitted formwork, <i>DETAIL structure</i>, 1: 10-11, 2019.</p> <p>Concrete shell built using a cable-net and knitted</p>

	<p>formwork 3D printing in construction</p>
Expected effect	<p>By providing information via current research, the students will gain understanding in necessities of materials and build-up of large scale structures using digital fabrication and construction.</p>

Name of activity	Company visit Empa
Number of working hours	5 hours
Type of activity	Company visit
Lecturer	Enrico Marchesi, Matthias Nagel, Michael Hausmann, Thomas Graule, Jakob Heier, Viktor Lindtström, Patrik Schürch
Short summary of content	<p>The students will have the possibility to meet professionals in the field, and the current research and ongoing research at Empa. Several labs will be visited as well as the NEST building, an example of digital fabrication.</p> <p>Matthias Nagel To start the day of the company visit a general introduction is given about Empa. Explaining the goal and main research of the company and give the red wire throughout the lab visits and presentations of some researchers at Empa.</p> <p>Marchesi Enrico The NEST building is an example of different manufacturing techniques and material use. First a general introduction will be given after which the chance is given to visit 2 units.</p> <p>Michael Hausmann Structural properties of structures depend on the inner structural elements. In order to have nicely organised inner structures, the particles of the ink need to be aligned, which is the main topic of his PhD research.</p>

	<p>Jakob Heier</p> <p>Printed electronics is aiming to combine large area roll-to-roll manufacturing with electronic devices, and demonstrates success with expanding device sets and application ranges. At the same time, in printed electronics, direct-write printing techniques are developed further. This enables to merge printed electronics and additive manufacturing.</p> <p>At the Coating Competence Center at Empa state-of-the-art printing technologies are used to follow both trends: with a gravure and flexo printing unit we develop processes for roll-to-roll manufacturing, with an aerosol jet printer conformal circuitry directly onto complex-shaped structures can be printed.</p> <p>Thomas Graule</p> <p>An introduction will be given into the processing of high performance ceramics, starting from nano-powder synthesis and</p>
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	<p>powder handling, advanced shaping techniques and sophisticated sintering technologies. A focus will be set on recently developed Additive Manufacturing technologies and applications of those materials in machine and watch industry, battery research and hydrogen generation as well as in filtration and catalysis.</p> <p>Viktor Lindström</p> <p>-Lab visit: In the Additive Manufacturing lab show the group's commercial AM machines will be shown. He will discuss the possibilities and challenges related to AM and have a look at some intricate metal parts which can be manufactured in the machines.</p> <p>-Research: His research is focused on additive manufacturing of highly reflective and conductive metals, like gold and copper alloys. He works with different alloying strategies as well as process modification to overcome the incomplete melting which is typical of AM-parts from these materials.</p> <p>Patrik Schürch</p>
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	Investigation of mechanical materials properties from the nano to macro-scale using experimental, analytical, and computational techniques. For this purpose, metallic model materials are developed either via electrodeposition and push resolution frontiers of materials microanalysis instrumentation.
Bibliography	N/A
Expected effect	An overview of advantages and drawbacks of 3D printing will be provided as well as a broader perspective of current work and future goals in many different 3D printing fields.

Name of activity	3D modelling
Number of working hours	2,5 hours
Type of activity	Tutorial and Workshop
Lecturer	Fabio Bargardi
Short summary of content	3D modelling is an non skippable step in 3D printing. In order to print structures one has to realise what is necessary for 3D printing and how this is implemented in the digital design. An introduction in 3D modelling is given, as well as a tutorial how to use the programme. In groups the students will afterwards try out the modelling programme themselves.
Bibliography	N/A
Expected effect	The first steps in 3D modelling are taught to provide the students with basic knowledge how to create 3D structures digitally.

Name of activity	How to get your company started with AM
Number of working hours	3 hours
Type of activity	Lecture and Group seminar
Lecturer	Pascal Jenni
Short summary of content	The way to a successful implementation of additive manufacturing into an already existing manufacturing environment. You will see the steps necessary, starting at the point you decide your company wants to get involved with additive manufacturing, to how to proceed once the first machine is implemented.
Bibliography	N/A

Expected effect	After the lecture the students will have a better understanding of starting an additive manufacturing company, and the different aspects that are important to have a sustainable product.
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Name of activity	Exam
Number of working hours	4 hours
Type of activity	Project work
Lecturer	André Studart, Rafael Libanori, Rani Boons
Short summary of content	A review paper is given at the start of the course, with instructions for the expectations for the exam. During the course the students will have the time to experience additive manufacturing in different fields, and will get inspiration for solving the task, as well as the time to sit together as a team and discuss. Finally, the groups will have to present their findings and thought process as final evaluation for this course.
Bibliography	N/A
Expected effect	The students are expected to use the experience and knowledge gained during the course to solve the problem given at the start of the course. With the task in mind they will have had the time to pick up what they need to get to a solution. Further, also creativity, teamwork and critical thinking will be required to bring the task to a good end.

Pre-materials

Links:

Name	Beginner's Guide for additive manufacturing
Topic/field	Introduction into Additive manufacturing
Short description	This site gives a broad overview of 3D printing, from its history to the materials used.

Name	Understanding the basics of additive manufacturing
Topic/field	Basics of two Additive manufacturing techniques
Short description	Two well known 3D printing techniques, FDM and SLA, are explained and compared in more detail.

Name	Additive Manufacturing Guide
Topic/field	Additive manufacturing in industry
Short description	The following report shows how the additive manufacturing technology is implemented into industrial applications using several case studies.

Name	Democratisation of AM technologies
Topic/field	Potential of Additive Manufacturing
Short description	Slides about the Potential Democratization of the Production of Physical Goods using several applications as examples

Name	3D printing in construction
Topic/field	Additive Manufacturing in the construction industry
Short description	The website gives an overview of the history of construction and the role of additive manufacturing in this field.

Articles:

Name	Additive manufacturing of biologically-inspired materials
Topic/field	Review additive manufacturing techniques and bio-inspirations
Professor/Author	André R. Studart

Name	Concrete shell built using a cable-net and knitted formwork
Topic/field	Digital fabrication and construction
Professor/Author	Mariana Popescu