Time Table

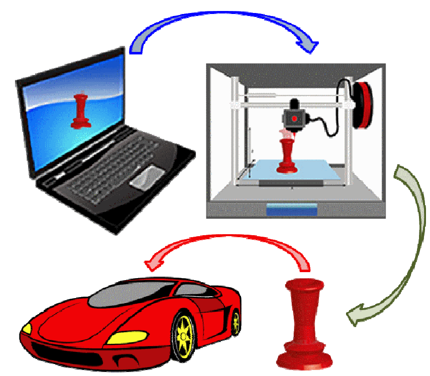
	Jan. 24 Sunday		Jan. 25 Monday	Jan. 26 Tuesday	Jan. 27 Wednesday	Jan. 28 Thursday
		9.00 – 9.30	**1st lecture** (UPT library) Prof. Liviu Marsavina *Presentation of the SIRAMM project*	**5th lecture** (UPT library) Prof. D. Constantinescu *"Experimental Fracture Mechanics"*	**9th lecture** (online) Prof. A. Sedmak *"Application of Fracture Mechanics parameters on structural integrity assessment"*	**10th lecture** (online) Prof. F. Berto *"Local approaches in fatigue"*
		9.30 – 11.00	**2nd lecture** (online) Prof. Jan Torgensen *"Opening the design space by removing constraints with Additive Manufacturing and Topology Optimization"*			
		11.00 – 11.30	Break (UPT library)	Break (UPT library)	Break (UPT library)	Break (UPT library)
		11.30 – 13.00	**3rd lecture** (online) Prof. R. Brighenti Prof. A. Spagnoli *"Review on AM of polymeric materials"*	**6th lecture** (online) Dr. S. Tavernini (*) *"How to apply for research funding: funding opportunities for Early Stage Researchers and grant writing tips"*	**Practical session 1** (Faculty of Mech. Eng. Lab. Belgrade & online) *Designing and Manufacturing of Specimens*	**11th lecture** (UPT library) Prof. Roxana Ghita *"Gender (im)balance in science and engineering across cultures"*
		13.00 – 15.00	Lunch	Lunch	Lunch	Lunch
14.30 – 16.30	Welcome reception & registration (UPT library)	15.00 – 16.30	**4th lecture** (online) Prof. Ludvik Kunz *"Fatigue properties of metallic materials produced by AM"*	**7th lecture** (online) Dr. A. Grbovic *"Numerical simulation of fatigue crack growth"*	**Practical session 2** (Faculty of Mech. Eng. Lab. UPT & online) *Testing of specimens (static, fracture toughness)*	15.00 – 16.00 **Final exam** (UPT library & online) 16.00 – 17.00 **Discussion session** (UPT library & online) Research, future perspectives and international collaborations on AM in engineering
16.30 – 17.00	Opening of the winter School (UPT library & online):	16.30 – 17.15		**8th lecture** (online) Prof. F. Auricchio *"Simulation for additive manufacturing: opportunities and challenges"*	(*) 16.30-18.00 (online) Dr. S. Tavernini will be available to discuss and answer questions by the winter school attendee on research funding and related tips	
17.00 – 18.00	**Presentation of some of the participants on their backgrounds and current activities** (UPT library & online)		16.30 – 18.00 **Discussion session** (UPT library & online) Speakers will be available online for Q&A	17.15 – 18.00 **PhD presentations** (UPT library & online)		17.00 – 17.15 **Closing of the winter School** (UPT library & online)

SIRAMM

H2020-WIDESPREAD-2018, Grant No. 857124

1st Winter School on

Trends on Additive Manufacturing for Engineering Applications



Universitatea Politehnica Timişoara

Polytechnical University of Timișoara (UPT)

Timisoara, Romania, 24-28 January 2021

in presence & online

Winter school info

The winter school on **Trends on Additive Manufacturing for Engineering Applications** will be held in Timisoara, 24-28 January 2021. The main aim of the Winter School is to involve PhDs and young researchers in the field of AM with an engineering perspective. The winter school is an annual key activity of the European Twinning Project **SIRAMM**, funded by the European Union's Horizon 2020, H2020-WIDESPREAD-2018-03 under the grant agreement No. 857124.

The winter school will consider both scientific aspects concerning Additive Manufacturing as well as soft skills in research such as scientific and grant proposal writing, gender aspects, etc. Practical sessions concerning designing, manufacturing and testing of 3D-printed objects will be organized.

Venue

Univ. Politehnica Timisoara (UPT), Central Library & Online
4 Bulevardul Vasile Pârvan, Timișoara, Romania
http://library.upt.ro/
http://www.siramm.unipr.it/Events.htm

Winter school Fees

Participation in the winter school is free!
Coffee breaks will be included
A limited number of places are available (max. 30)
The selection process for participating to the winter school will be based on the participant's country, with a preference for east European countries. Participation of PhDs, post-docs and young researchers as well as women will be especially preferred. Gender equality and equal opportunities will be key-aspects in the selection of the participants.

Prospective Key Dates

Registration:	15 January 2021
Confirmation to participants:	20 January 2021

Speakers

Prof. Liviu Marsavina, UPT Timișoara, Romania
Prof. Jan Torgensen, NTNU Trondheim, Norway
Prof. Dan Constantinescu, UP Bucharest, Romania
Prof. Roberto Brighenti, Univ. of Parma, Italy
Prof. Andrea Spagnoli, Univ. of Parma, Italy
Prof. Aleksander Sedmak, Univ. of Belgrade, Serbia
Dr. Aleksander Grbovic, Univ. of Belgrade, Serbia
Prof. Ferdinando Auricchio, Univ. of Pavia, Italy
Dr. Silvia Tavernini, Univ. of Parma, Italy
Prof. F. Berto, NTNU Trondheim, Norway
Prof. Ludvík Kunz, IPM Brno, Czech Rep.
Prof. Dan Constantinescu, UP Bucharest, Romania
Dr. Roxana Ghita, UPT Timișoara, Romania

Accommodation

In Timișoara there are plenty of possibilities for accommodation. Please refer to http://hoteltimisoara.ro/ for more info. Affordable accommodation are provided by the UPT hotels:
- Casa Casa Politehnicii 1
https://www.upt.ro/Informatii_casa-politehnicii-1_273_ro.html
- Casa Casa Politehnicii 2
https://www.upt.ro/Informatii_casa-politehnicii-2_413_ro.html
- Hotel Perla http://hotelperla.ro/

Registration (Winter School Office)

For registration & info please send an email to:
Prof. Liviu Marsavina: liviu.marsavina@upt.ro
University Politehnica Timișoara,
Dept. of Mechanics and Strength of Materials
Blvd. M. Viteazu, No. 1, Timișoara 300222, Romania
or to the SIRAMM staff: SIRAMM.Twin@gmail.com

Lectures

All lectures will be given in English.

ECTS credits

3 ECTS will be recognized for the participation (for at least 70% of the lectures) to the winter school.
2 more ECTS will be recognized upon the positive evaluation of the final assessment test.

Lectures details

1st lecture – **Prof. Liviu Marsavina**, University Politehnica Timișoara, Romania

Presentation of the SIRAMM project

This lecture presents the main activities and goals of the H2020 SIRAMM project and the future perspectives related to the structural integrity and reliability of materials obtained through additive manufacturing.

2nd lecture – **Prof. Jan Torgensen**, NTNU Trondheim, Norway

Opening the design space by removing constraints with Additive Manufacturing and Topology Optimization

Additive Manufacturing (AM) has found its way towards major industrial utilization. Particularly the manufacturing of end use parts with unprecedented performance triggers interest from the major players in aerospace, automotive and biomedical engineering. The manufacturing technology is mature enough, however, the process of infusing innovation into future designs possible with AM is yet limited. The lack of user friendly design software, poor interfaces to the AM process chain and, particularly, the limited amount of people capable of working with respective tools can be seen as the main challenges. After a short intro into AM, and the related potential of design innovation, this lecture will present two types of topology optimization (TO) methods, namely stress level homogenization and compliance-based optimization. The lecture will give an intro in how to construct a simple code performing Topology Optimization in 2D, where the objective function and boundary conditions will be explained. Furthermore, it will be shown how to treat numerical problems such as mesh dependency and the checkerboard problem. At the end of the lecture, software environments for TO will be presented. If time permits, the attendees will also get a hands-on experience on one software tool getting an idea of what weight savings are possible when optimizing a simple real world component. Bring your own laptop! Please make sure that you install the tools before class. Instructions will follow.

3rd lecture – **Prof. R. Brighenti**, **Prof. A. Spagnoli**, Univ. of Parma, Italy

Review on AM of polymeric materials

Nowadays, AM technology is applied in a variety of engineering and industrial fields ranging from aerospace, automotive, human organs production and medical implants, stimuli-responsive materials, etc. This review focuses on the AM techniques related to polymers and polymers-like materials, which have attracted much less attention compared to metallic counterparts. In particular, Fusion Deposition Modeling (FDM), Selective Laser Sintering (SLS) and Stereolithography (SL) are considered. Firstly, in this review lecture, several empirical studies aiming at investigating the effects of AM process parameters on the mechanical behaviour of the printed component are discussed. Then, some engineering approaches based on mathematical formulations of AM processes are reviewed. The main goal of this review is to highlight the importance of theoretical models recently proposed, aiming at predicting the mechanical properties of an AM component by describing the real chemical-physical mechanisms occurring in an the AM process. The lecture is organized as follows: overview on AM technologies for polymers; state of art on the effect of AM process parameters on mechanical properties of components; review on theoretical models available in the literature for predicting mechanical properties of AM components.

4th lecture – **Dr. Ludvík Kunz**, Institute of Physics of materials, Czech Academy of Sciences, Brno, Czech Republic

Fatigue properties of metallic materials produced by AM

Participants of the course will become familiar with the issue of properties and microstructure of metallic additively manufactured (AM) materials depending on manufacturing parameters. The attention will be focused on materials prepared by direct metal laser sintering (DMLS), which is the most commonly used powder bed AM method. The advantages and disadvantages of AM production will be presented.

The content of the course will be devoted to static, but mainly fatigue properties, which are critical for the reliability of load bearing components exposed to cyclic loading. It will be demonstrated that in contrast to the static performance, the fatigue behavior of AM materials is much more susceptible to the details of microstructure, surface quality, residual stresses and material defects, which are directly related to the AM process parameters and post-processing treatment. Examples of the fatigue properties and microstructure of DMLS manufactured lightweight Ti6Al4V alloy, which dominates in the aerospace industry and biomedical applications and a high-strength corrosion resistant nickel chromium superalloy IN 718 for high temperature applications will be presented.

5th lecture – **Prof. D. Constantinescu**, UP Bucharest, Romania

Experimental Fracture Mechanics

A brief overview of some experimental methods is given considering the following approaches: strain gauge measurements, 3D photoelasticity, digital image correlation (DIC). Sanford's solution in which series expansion of complex functions up to 12 terms was successfully used for determining the strain and stress fields around the crack tip. It is shown that by using three or four terms of the series expansion the mode I stress intensity factor (SIF) can be established directly by positioning the strain gage in a precise location determined by the elastic constants of the material. The 3D photoelasticity (frozen-stress method) and a specific algorithm can be used to establish the mode I and mode II SIFs even when mixed mode is present. Also accounts on mixed mode crack initiation are given. The use of DIC is effective for studying phenomena of delamination at the interface in sandwich materials or in hybrid (composite-metal) joints. Examples are given to demonstrate the effectiveness of these experimental approaches.

6th lecture – **Dr. Silvia Tavernini**, Univ. of Parma, Italy

How to apply for research funding: funding opportunities for Early Stage Researchers and grant writing tips

The lecture will deal with the main research European and international funding opportunities for PhD and Post-Doc fellows considering grants and fellowships to help early stage researcher carry out their research projects, get additional skills, and boost their career. Subsequently some basic best practices on grant writing process, from prospecting to final draft, will be discussed, with a special focus on the European Marie Skłodowska-Curie actions.

7th lecture – **Prof. Aleksandar Grbovic**, Faculty Mechanical Engineering, Univ. of Belgrade, Serbia

Numerical simulation of fatigue crack growth

In this lecture, the fatigue life of structural elements with single and multiple discontinuities (holes, cracks, and inclusions) under cyclic loading conditions will be evaluated by extended finite element method (XFEM) and finite element method (FEM). The goal is to show to winter school participants how numerical models are nowadays used for evaluation of stress intensity factors (SIFs) and, consequently, the remaining life of the damaged structure. Initially, SIFs will be evaluated for standard specimens' models (three-point bending, compact tension, etc.) and results will be compared to analytical solutions and values proved in experiments. Then, single and multiple discontinuities of arbitrary sizes in the actual elements (mostly parts of airframe structures) will be presented and numerically analyzed. The SIFs values will be extracted from the XFEM and FEM solutions and standard Paris fatigue crack growth law will be used for the life estimation of various models. The effect of the cracks' sizes, boundary conditions, and loads' sequences on the fatigue life of the structural elements will be discussed in detail.

8th lecture – **Prof. Ferdinando Auricchio**, Dept. of Civil Eng. & Architecture, Univ. of Pavia, Italy

Simulation for additive manufacturing: opportunities and challenges

Additive Manufacturing (AM) – also known as 3D printing – is taking off in many industrial realms. In particular, powder bed fusion for metal manufacturing has definitively changed the way of prototyping metal parts but also plastic 3D printing is changing modern engineering in many aspects. Accordingly, AM is opening the doors to new innovative applications and to a different way of approaching, designing, solving modern engineering problems.

On the other hand, AM is a complex process, involving different physical phenomena at very different scales, resulting in a complex coupled thermo-mechanical physics and simulation is fundamental to predict temperature and stress distributions during and after the printing process. Furthermore, AM allows for new unknown freedom in terms of complex shapes which can be manufactured, opening the door to a new set of optimization problems, requirements, and constraints. After a short introduction to the technology and possible applications, the presentation will focus on the experience of the University of Pavia strategic theme (entitled "3D@UniPV. Virtual modeling and additive manufacturing for advanced materials") and in particular on some research directions on the design of industrial components as well as on innovative computational approach to describe the complex physics (in particular on a technique related to the Fat Boundary method as a possible alternative to describe the different scales present in AM processes) and to solve optimization problems related to the new freedom now possible thanks to AM (introducing a novel graded-material design based on phase-field and topology optimization).

9th lecture – **Prof. Aleksandar Sedmak**, Faculty Mechanical Engineering, Univ. of Belgrade, Serbia

Application of fracture mechanics parameters on structural integrity assessment

Basic fracture mechanics parameters under static loading are introduced and explained, such as K_I, CTOD and J integral, as well as their roles in fracture mechanics triangle, i.e. in structural integrity assessment (crack driving force vs. material resistance to cracking). Critical values of these parameters are defined and explained as material property. Linear elastic vs. elastic-plastic fracture mechanics is explained, with reference to more complex material behavior (visco-plastic). In the scope of linear elastic material behavior, the stress intensity factor, $K_I = Y\sigma\sqrt{\pi a}$ is elaborated and its evaluation by use analytical and numerical methods explained with examples. Standard procedure for fracture toughness testing is introduced and explained. Plasticity has been introduced to explain Crack Tip Opening Displacement (CTOD) and J integral, both as crack driving force and material resistance to crack initiation and growth. Analytical and numerical methods used for CTOD and J integral evaluation are introduced, as well as standard procedures for their critical values. As for dynamic loading, fatigue crack growth is analyzed in the scope of Paris law, correlating crack growth rate with the stress intensity factor amplitude. Both experimental and numerical evaluation methods are explained. For all aforementioned methods and procedures examples are provided, including AM components.

10th lecture – **Prof. Filippo Berto**, NTNU Trondheim, Norway

Local approaches in fatigue

The first part of the course will be a brief introduction to fracture and notch mechanics. Starting from a deep historical overview the concepts of elastic stress intensity factor, Griffith energy, J integral will be introduced. Attention will be given to the experimental determination of the fracture toughness and of the threshold stress intensity factor range under cyclic loading. Emphasis will be placed on modern numerical methods for determination of stress intensity factors, critical crack sizes and fatigue crack propagation rate. Some aspects related to three-dimensional effects will be discussed. The second part of the course will treat notch mechanics in more detail presenting different advanced local criteria for fracture and fatigue assessment under static and fatigue loadings. Starting from traditional solutions the course will give a complete overview of the analytical and numerical tools available up to now also discussing some practical example of engineering interest.

11th lecture – **Prof. Roxana Ghita**, University Politehnica Timișoara, Romania

Gender (im)balance in science and engineering across cultures

From Maria Merian to Mary Anning, from Henrietta Leavitt to Lisa Meitner, from Rita Levi-Montalcini to Chien-Shiung Wu, from Ana Aslan to Rana El-Kaliouby, what these women scientists and engineers have in common is that they have forever changed the way we see our world. However, it took far too long for their discoveries to be acknowledged and too often books and academic courses that explore the history of science neglect the remarkable, groundbreaking women whose work has changed the world. And to a certain extent, the situation is not very different for women in science and engineering nowadays. The aim of this interactive lecture is to explore gender gaps leading to a career in science and engineering, from the decision to enroll in a degree, to the scientific fields that both genders pursue and the sectors in which they work. Moreover, the lecture sets out to outline the combination of factors which leads to the emergence of this gender imbalance at each stage of a scientific career: the graduate-level environment, performance evaluation criteria, the lack of recognition, lack of support for leadership skills development and conscious or unconscious gender bias. The lecture focuses on both a national, as well as a trans-national and trans-cultural perspective of gender imbalance in science and engineering. Participants are encouraged to bring their own input on this topic, based on both their personal and cultural experience, as there are regions that encounter even more barriers as a result of cultural norms that discourage women from taking traditionally male roles, thus generating an even greater gender imbalance. The final part of the interactive lecture aims to discuss policies for gender equality that have already been created and their efficacy, as well as other approaches that can be taken in order to ensure an equitable and diverse work environment in science and engineering. Gender balance is more than just a question of justice and equity. Countries, businesses and institutions which create an enabling environment for women increase their capacity for innovation and competitiveness, as they can benefit to a greater extent from the interaction of different perspectives and expertise, encouraging new solutions and expanding the scope of research. This should be regarded as a global priority and we should contribute to the best of our ability in reaching this next set of development goals.
