
: Romania

: Serbia

: Czech Rep.

: Italy

: Norway

Eastern European twinning on Structural Integrity and Reliability of Advanced Materials obtained through additive Manufacturing - SIRAMM

Prof. Liviu MARSAVINA – University Politehnica Timisoara, Romania


H2020-WIDESPREAD-2018
Project No. 857124

SIRAMM - Project

http://www.siramm.unipr.it/

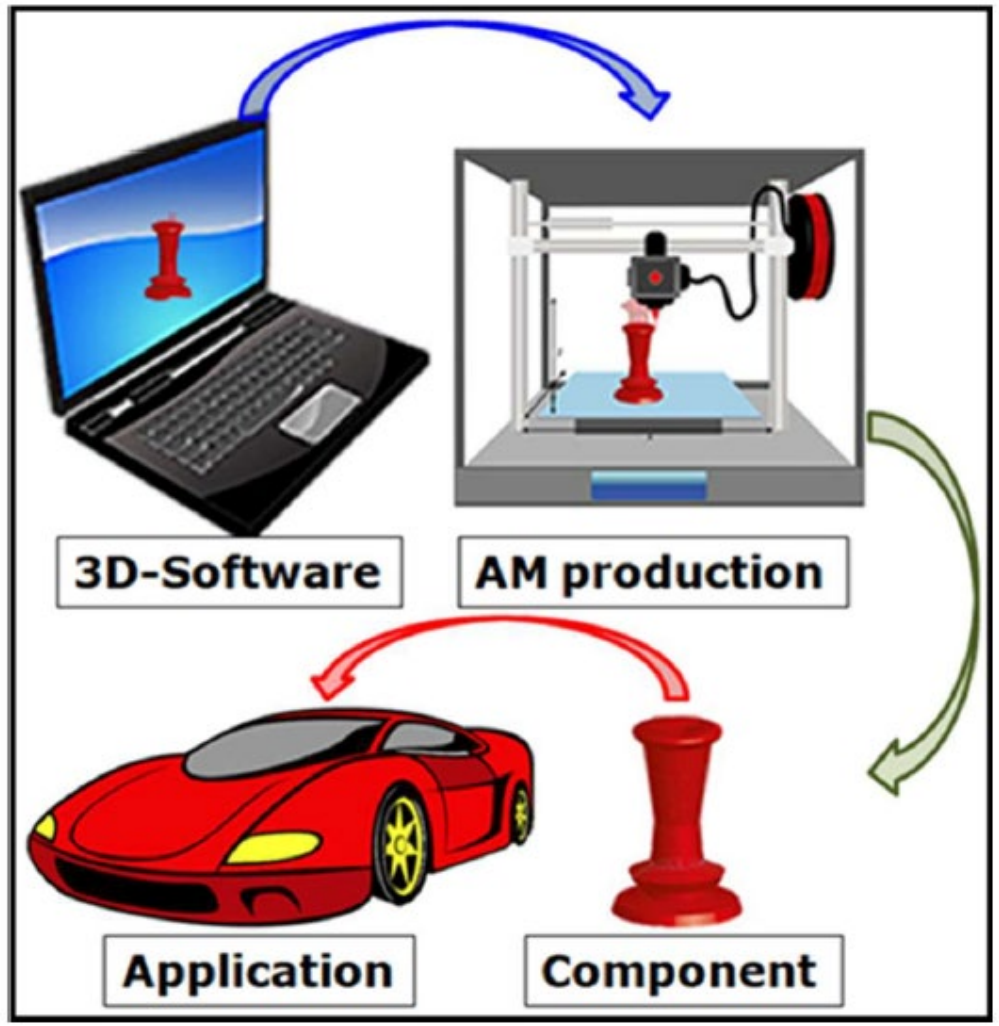
- H2020 – CSA – Widespread – Twinning

Project No. 857124

- Duration: 36 months + 6 months
- Starting date 01.10.2019
- Budget: ≈ 800.000 Euro
- Cooperation between ESIS:

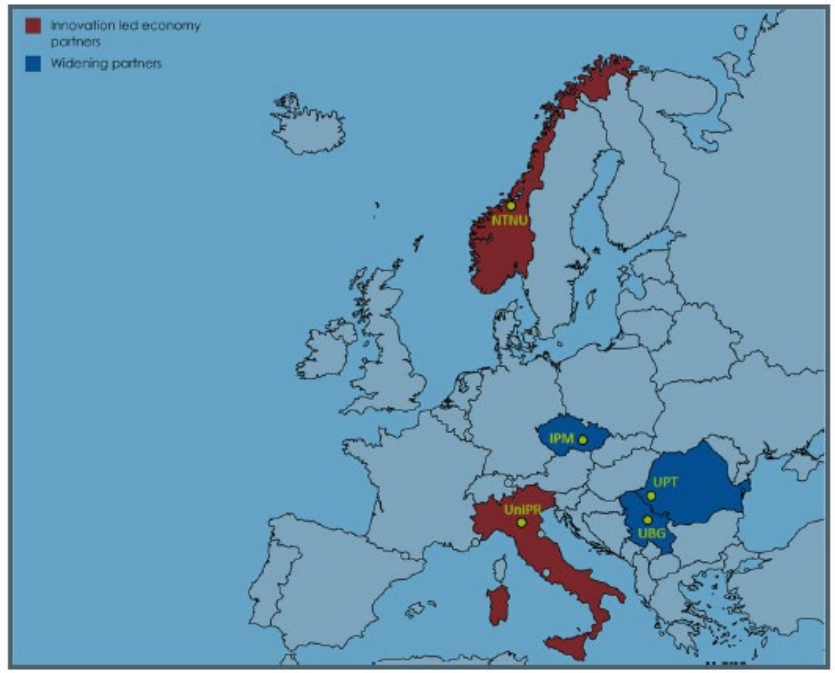
TC13: **Education and Training**

TC15: **Structural Integrity of Additive Manufactured Components**



SIRAMM - List of participants

1.Coordinator: Politehnica University of Timisoara (UPT), Romania
2. Faculty of Mechanical Engineering, University of Belgrade (UBG), Serbia
3. Institute of Physics of Materials, Academy of Sciences of the Czech Republic (IPM), Czech Republic
4. University of Parma (UniPR), Italy
5. Norwegian Univ. of Science and Technology (NTNU), Norway



Universitatea Politehnica Timișoara

UNIVERSITÀ DI PARMA

NTNU Norwegian University of Science and Technology

SIRAMM

H2020-WIDESPREAD-2018
Project No. 857124

SIRAMM - Objective

- The **overall objective** of the SIRAMM project is to significantly strengthen research in the AM field at the **Politehnica University of Timisoara** (UPT, Romania). To achieve this aim, SIRAMM will build upon the existing science and innovation base of UPT, creating a network with two internationally-leading counterparts at EU level: **Norwegian University of Science and Technology** (Norway) and the **University of Parma** (Italy).

- In the long term, the project aims at laying the foundations for creating a pole of excellence on AM in Eastern Europe. For this reason, other two partners from low R&I performing countries, the **University of Belgrade** (Serbia) and the **Institute of Physics of Materials**, Academy of Sciences (Czech Republic) will also take part in this Twinning project.

- To reach its goals, this 3-year project will be focused on the implementation of knowledge transfer activities such as workshops and staff exchange, training events (i.e. summer schools, seminars) for early stage researchers, and dissemination and communication actions (i.e. web site, videos, open access publications, public engagement activities) for different audiences. To keep maintaining the knowledge transfer well beyond the duration

SIRAMM – Specific Objective

SO1: To enhance the scientific and technological capacity of UPT and contribute to increase its fundamental knowledge in the field of AM.

SO2: To help raise the research profile of the leading institution as well as the research profile of staff and young scholar from all the 3 widening countries participating in the project: Romania, Serbia and Czech Republic.

SO3: To create a hub of excellence on AM in Eastern Europe, by engaging with the scientific community, industry and society of the three different widening countries involved in SIRAMM.

SO1: Enhance the scientific and technological capacity of UPT in the field of AM

- Development and implementation of a Research Quality Assessment Plan for UPT based on key research indicators.

- Acquisition of competence on an advanced innovative design methodology for AM production implemented by the two internationally-leading partners UniPR and NTNU

- Regular staff exchanges have been planned as the privileged tool to share and transfer the knowledge among the participants.

SO2: Raise the research profile for all the 3 widening countries participating in the project

- Implementation of training activities such as workshop and seminars to improve methodological skills and contribute to professional development of research staff and technicians of UPT, UBG and IPM.

- Organization of dedicated training events (i.e. summer schools, seminars) for MSc and PhD students involved in the project and early stage researchers (ESRs) from different institutions.

- Establishment of a course on AM within the post-graduate program of UPT, to keep maintaining the knowledge transfer well beyond the duration of the project.

- Organization and active involvement of the research staff in the dissemination and exploitation activities, such as the publication of the scientific results in peer-reviewed journals, speeches at international conferences and workshops addressed to the relevant stakeholders.

SO3: Create a hub of excellence on AM in Eastern Europe.

- This project plans to spread the acquired knowledge among different stakeholders, not only the scientific community but also the general public and the industry, especially the automotive-related companies present in Romania, Serbia and Czech Republic.

- A detailed survey on the state of the art in the field of AM will be carried out at the beginning of the project in order to identify the research challenges and the directions to follow to bridge the gap between the internationally leading institutions and the participating widening countries in terms of knowledge and competences in the field of AM.

- Different communication and dissemination activities (e.g. website, social media, videos, participation in international conference etc.) will be implemented to reach the widest possible audience. In particular, workshops and on-site demonstrations will be organized to make the companies aware of the use of the AM.

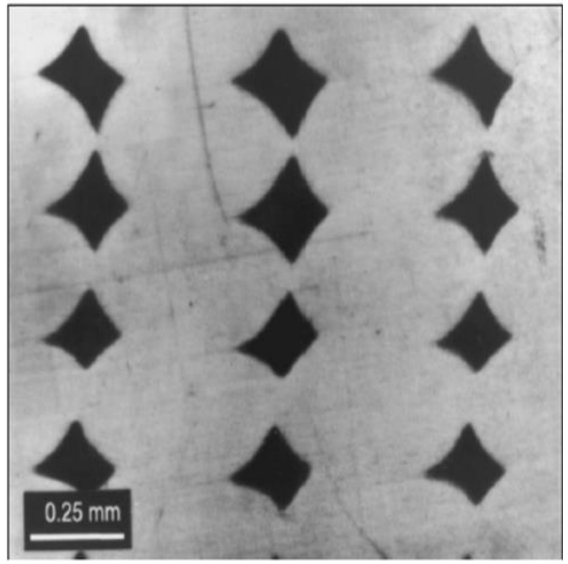
SIRAMM - Scientific ideas and models

- Relatively short manufacturing time and possibility of remote production with a very low human contribution make AM technology very attractive for modern industry.
- AM makes it possible to obtain parts with complex shapes and high precision characteristics.
- AM permits the assembly of materials with different physical properties to create a single element having superior qualities.
- AM processes range from advanced metal alloys to produce jet engine parts to food matters to get food items. Thermoplastic polymers (such as acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), polycarbonate (PC), water-soluble polyvinyl alcohol (PVA), etc.), metals, ceramics (such as alumina and tricalcium phosphate, zirconia, etc.), biochemicals (biological inks, soft elastomers, etc.) are among the different type of materials that can be used in AM production.

- **up to 90% saving in material !**
- **up to 85% reduction in lead time from design to approval !**

SIRAMM - Scientific ideas and models …challenges for mechanical property characterization

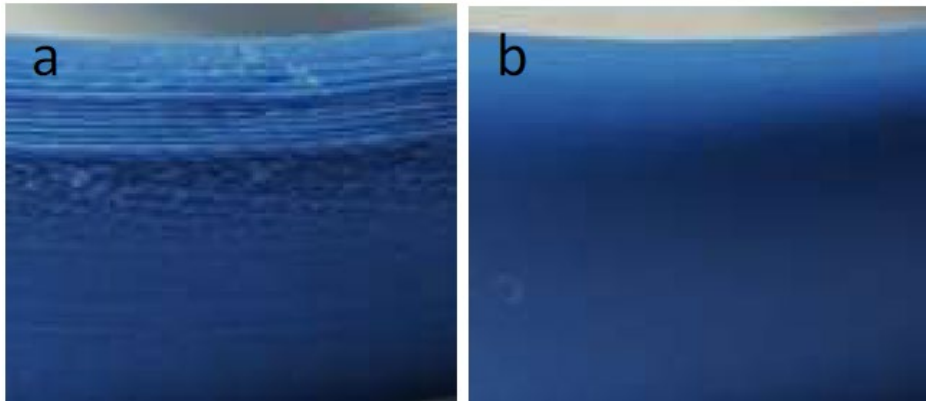
- AM processes differ from traditional processing in that not all of the material is melted and homogenized.
- the AM process of depositing layers of polymeric material results in parts with anisotropic properties, residual stress and structural and fatigue problems.
- complexity in relating material properties, AM mesostructure, and part design for standardized testing.

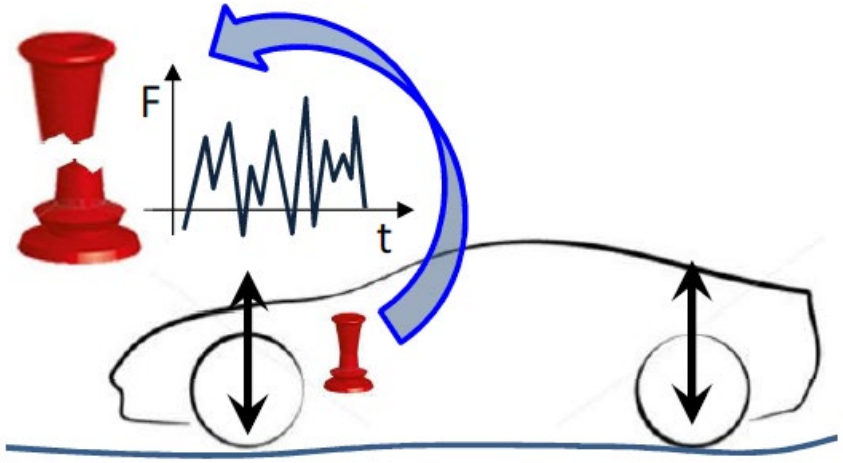


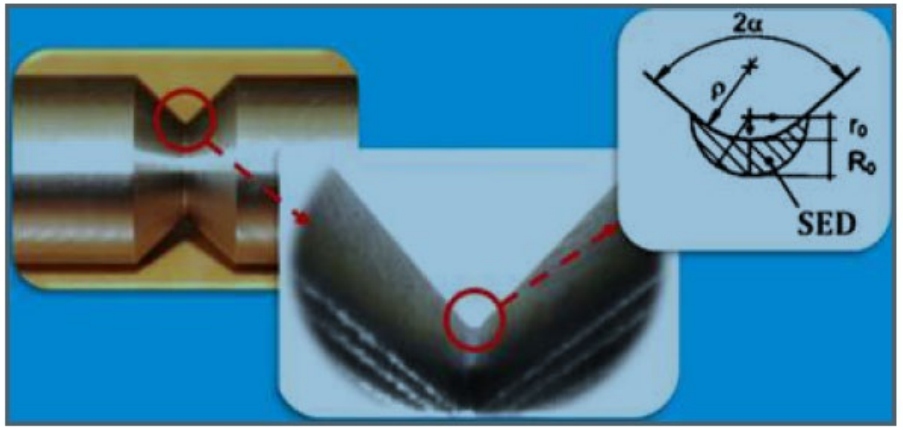
Rodriguez et al., "Characterization of the mesostructure of styrene materials, *Rapid Prototyping Journal*, 6 (3) 175–185, 2000.

SIRAMM - Scientific ideas and models …questions about structural integrity of AM

- low quality surface of an AM polymeric material
- scatter in results
- dispersion in data
- variability of lifetimes
- notch and size effect
- …

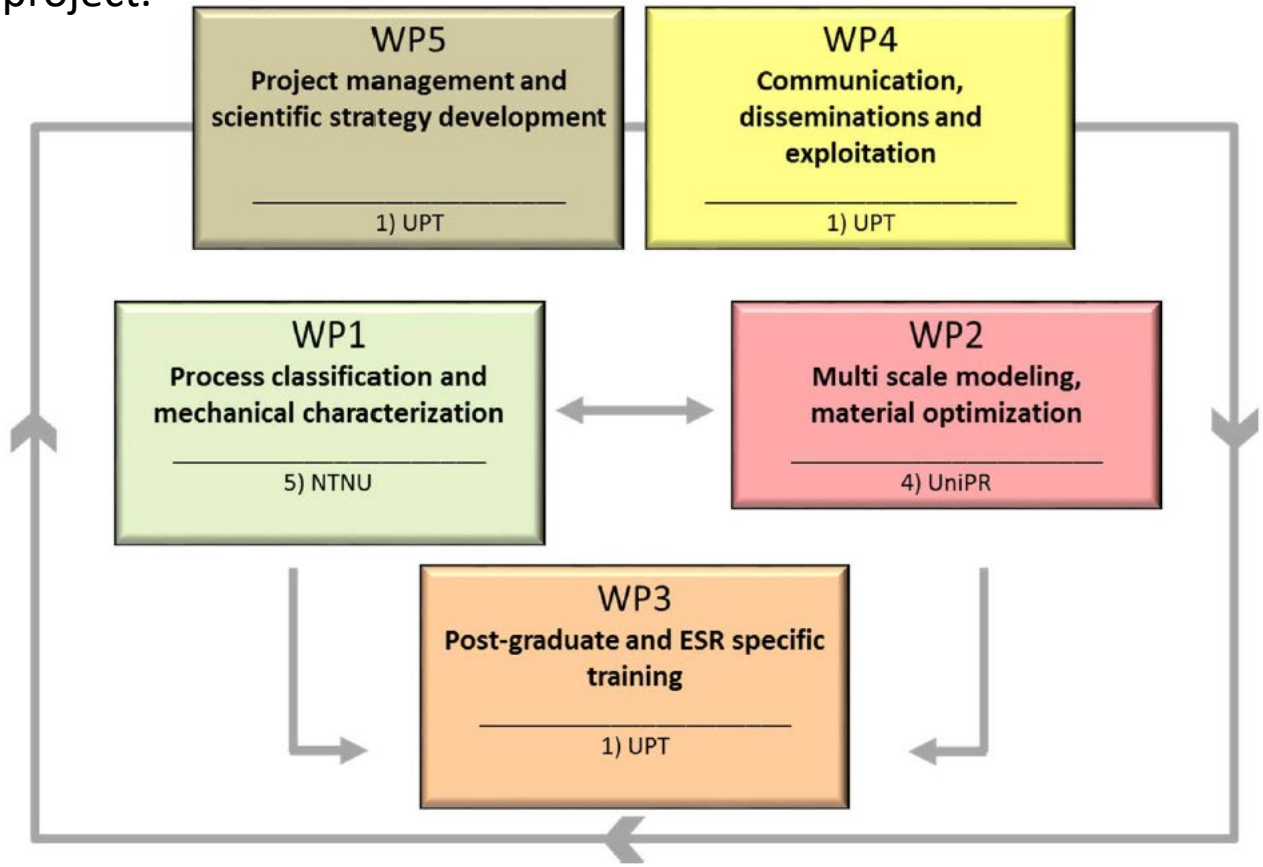






Work plan – Work packages and deliverables

WP5 will deal with the coordination and management of all scientific, contractual, financial, and legal aspects of the project.



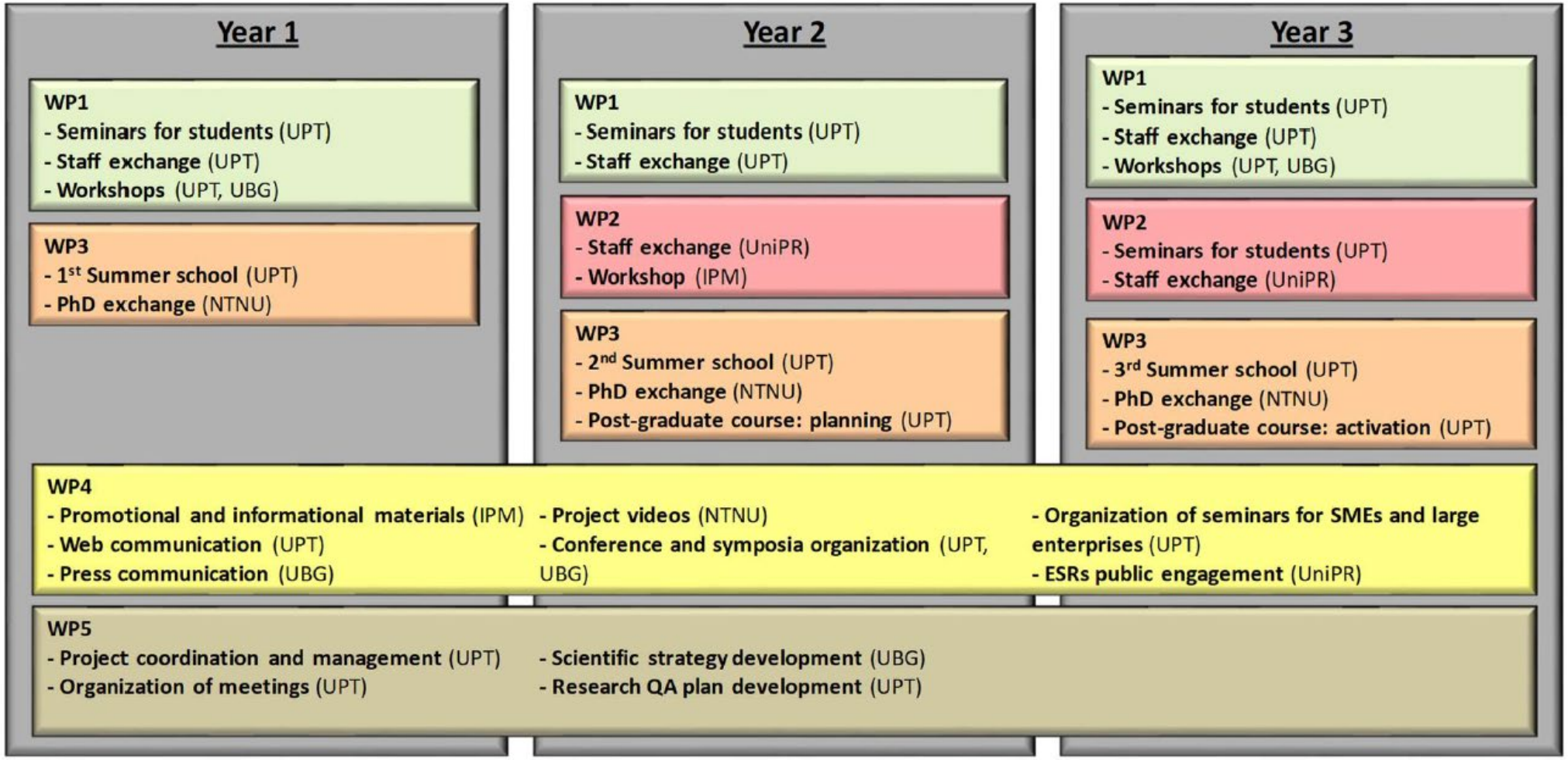
WP3 Training of young scholar and ESRs, implementing 3 summer schools, a regular course on AM technologies and PhD exchanges among the partner organizations.

WP4 will be dedicated to the communication, dissemination and exploitation of the project results. ESRs will have a specific role in this WP, being involved in the development of short YouTube videos and public engagement activities within the European Researcher Night.

WP1 will be devoted to the transfer of knowledge and acquisition of competences on the application of different AM technologies for the production of AM specimens, their analysis and interpretation.

WP2 will be focused on the transfer of knowledge and acquisition of competences on multi scale modelling and material optimization. WP2 will take care of formulating suitable physics-based theoretical models to describe the static and fatigue behaviour of AM materials.

Work plan – Work packages and deliverables



SIRAMM
Staff and PhD exchange during the project implementation

Staff Exchange (Faculty)	1st year					2nd year					3rd year				
From to →	RO	RS	CZ	IT	NO	RO	RS	CZ	IT	NO	RO	RS	CZ	IT	NO
Romania				✓	✓				✓	✓				✓	✓
Serbia	✓							✓							✓
Czech Republic		✓				✓								✓	
Italy	✓						✓						✓		
Norway		✓						✓			✓				

PhD Exchange															
From to →	RO	RS	CZ	IT	NO	RO	RS	CZ	IT	NO	RO	RS	CZ	IT	NO
Romania				✓	✓				✓	✓				✓	✓
Serbia	✓							✓						✓	
Czech Republic	✓						✓								✓
Italy					✓	✓						✓			
Norway				✓		✓							✓		

RO: Romania RS: Serbia CZ: Czech Rep. IT: Italy NO: Norway

SIRAMM
Events organized during the project implementation

Event	1st year	2nd year	3rd year
Seminar for students	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓ ✓ ✓
Seminar for companies	✓	✓	✓ ✓ ✓
Summer school (5 days)	✓	✓	✓
Workshop (2 days)	✓	✓	✓
East Europe conference		✓	
International Conference			✓

: Romania : Serbia : Czech Rep. : Italy : Norway

SIRAMM
Other actions

Participation at International conferences:

- UPT: 6 conferences (3/year x 2 staff)
- UB: 6 conferences (3/year x 2 staff)
- IPM: 6 conferences (3/year x 2 staff)
- UniPR: 3 conferences (1/year x 1 staff)
- NTNU: 3 conferences (1/year x 1 staff)

SIRAMM Other actions

Open access publications:

- UPT: 5 papers
- UB: 4 papers
- IPM: 4 papers
- UniPR: 3 papers
- NTNU: 3 papers

Course for Master students: “Theory and applications of AM materials” – started this semester at UPT

SIRAMM – Effect of manufacturing parameters on tensile properties

NTNU
Norwegian University of Science and Technology

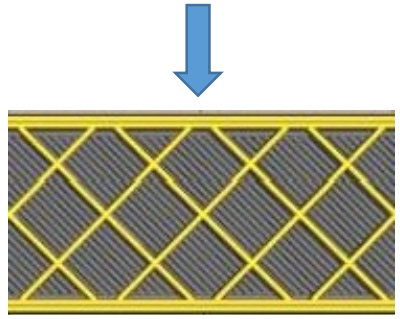
Universitatea Politehnica Timișoara

Prusa MK3

3D Platform

SIRAMM – Effect of manufacturing parameters on tensile properties

Printer	Temp. Build plate [^{0} C]	Temp. Print [^{0} C]	Max. Speed [mm/s]	Average Speed [mm/s]	Layer thickness [mm]	Infill	Infill density [%]
Prusa MK3	60	220	80	45	0.15	Rectilinear +/-45 grade	100
3D Platform	60	220	120	75	0.40	Rectilinear +/-45 grade	100
Cube Pro	60	220	80	55	0.20	Rectilinear +/-45 grade	100

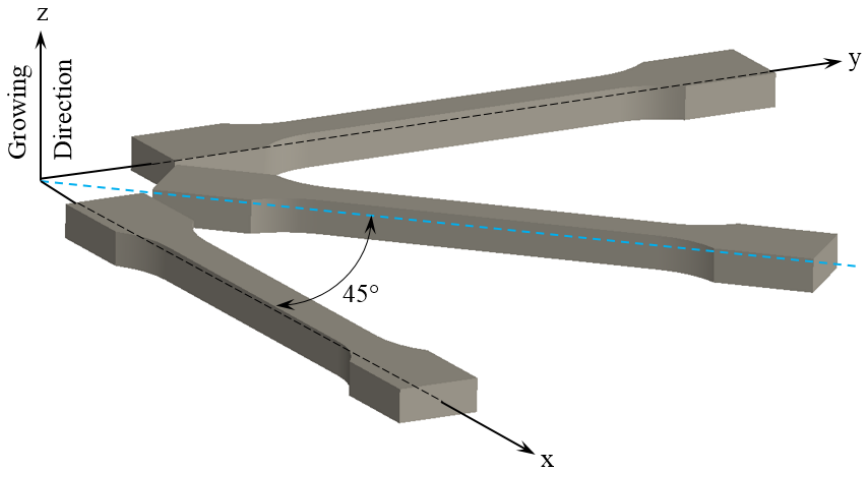


- Effect of printing direction and orientation
- Effect of specimen thickness (number of layers)
- Effect of filament color

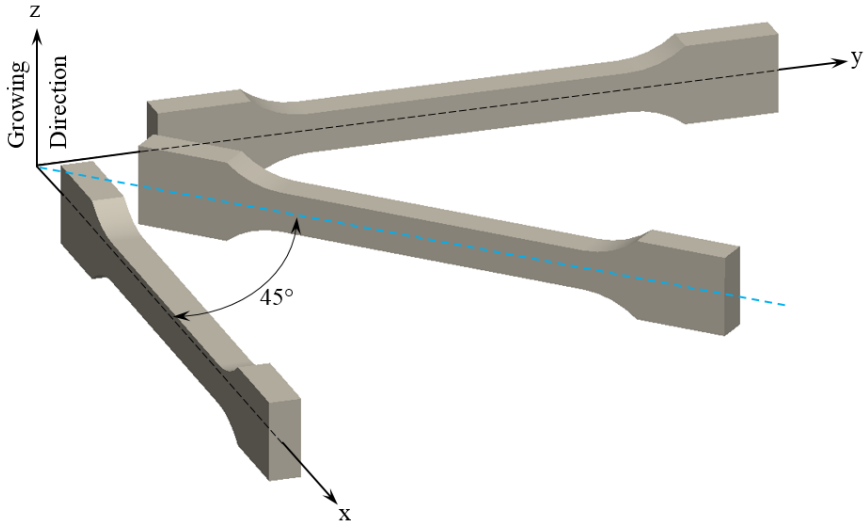
SIRAMM – Effect of manufacturing parameters on tensile properties

Directions

Horizontal (In plane)

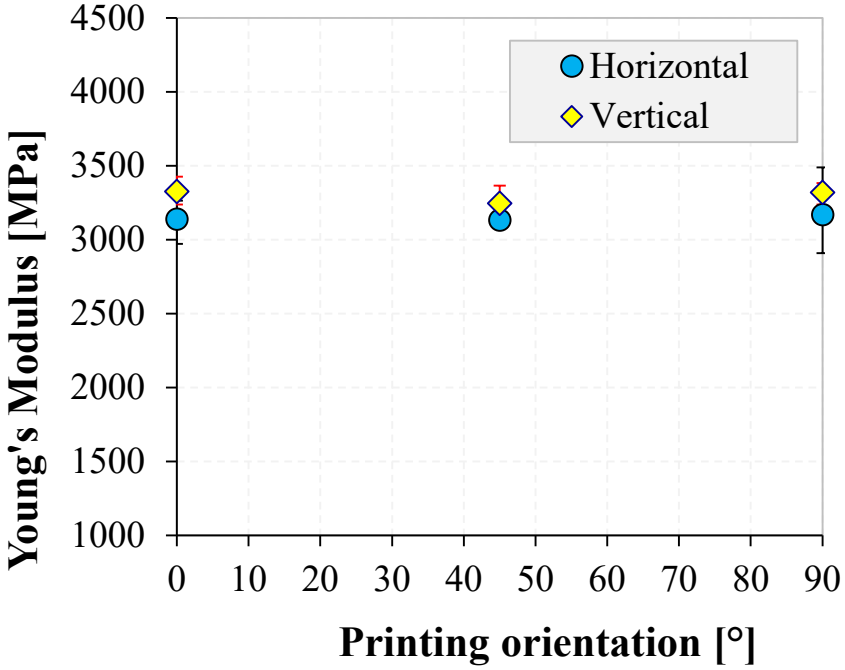


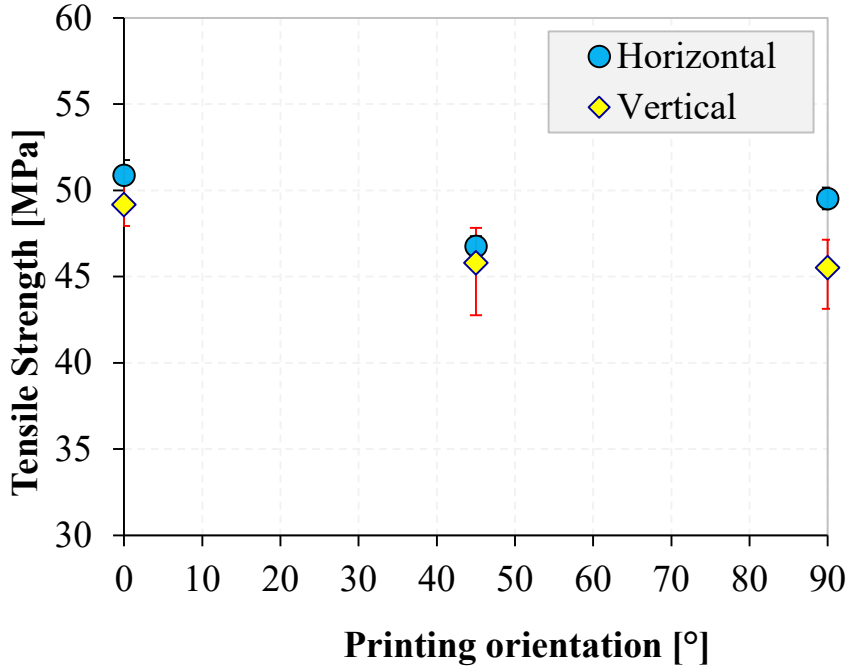
Vertical (Out of plane)



Orientations: 0 deg., 45 deg., 90 deg.

SIRAMM – Effect of manufacturing parameters on tensile properties

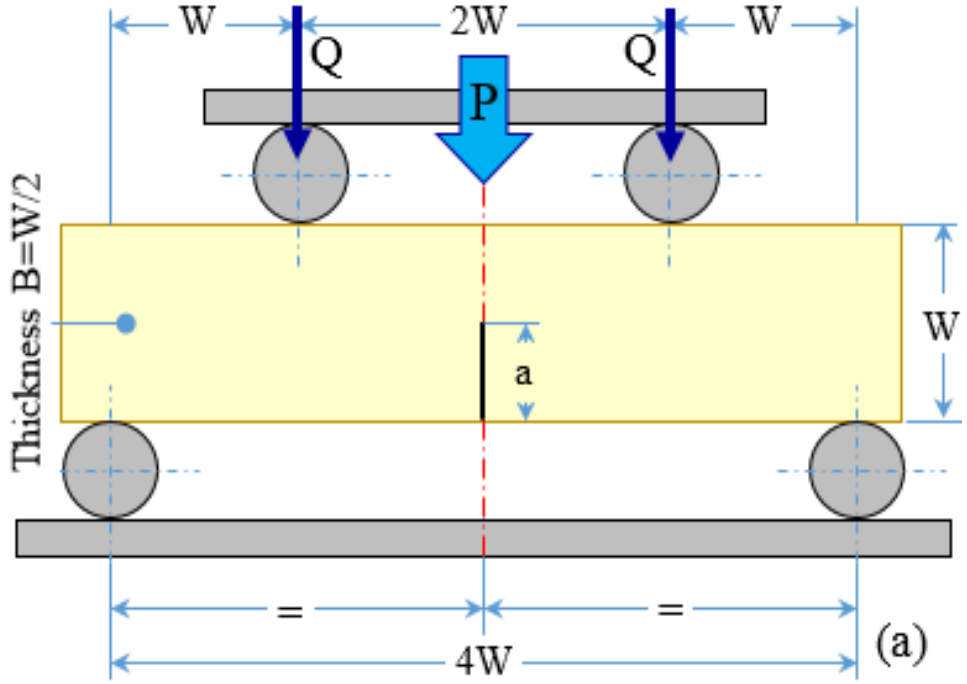




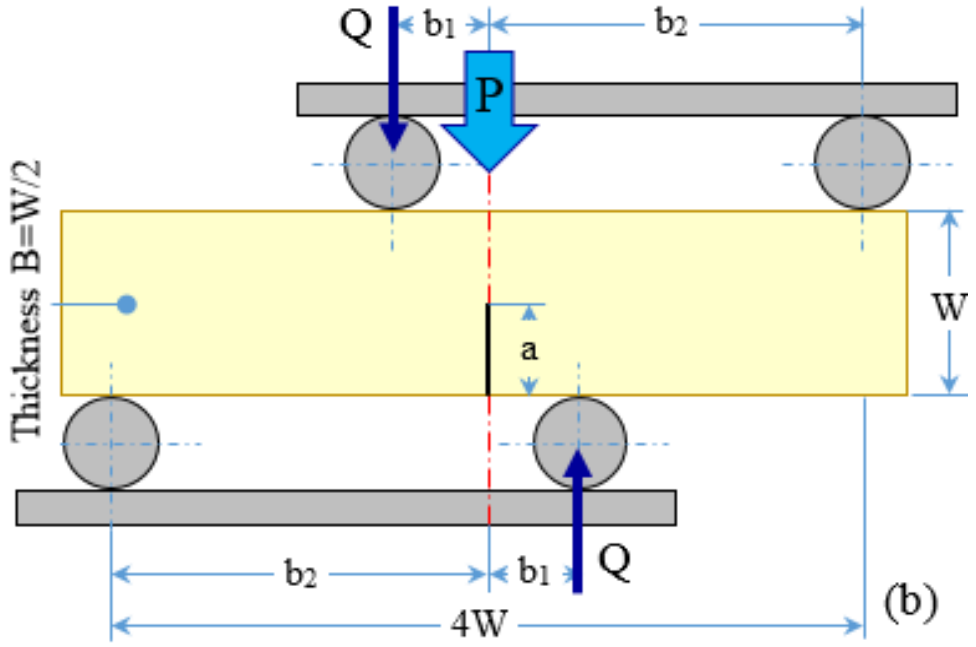
- Higher stiffness and low tensile strength on vertical orientation
- Lower properties for 45^0 orientation
- Higher scatter on vertical direction

SIRAMM – Effect of manufacturing parameters on fracture toughness

Symmetric four point bending tests - Mode I

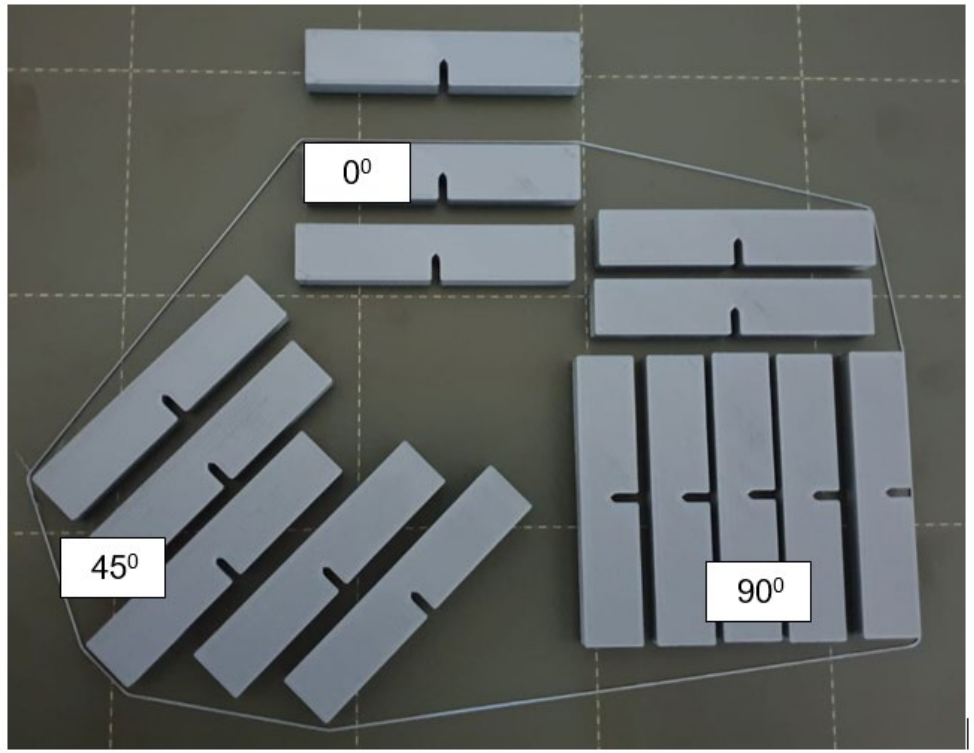


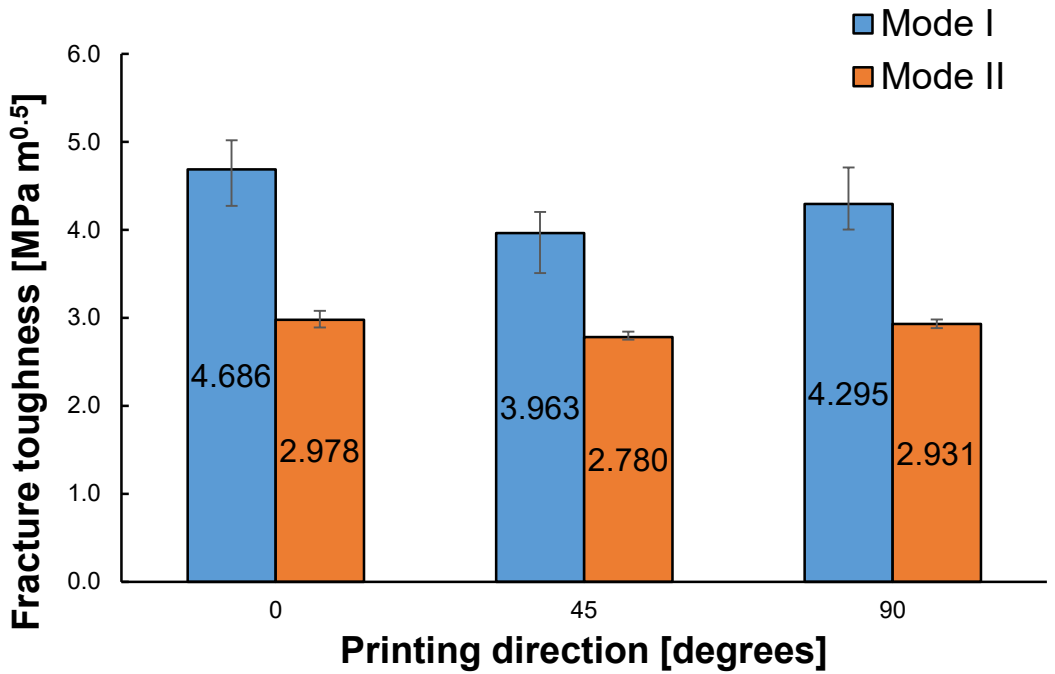
Asymmetric four point bending tests - Mode II



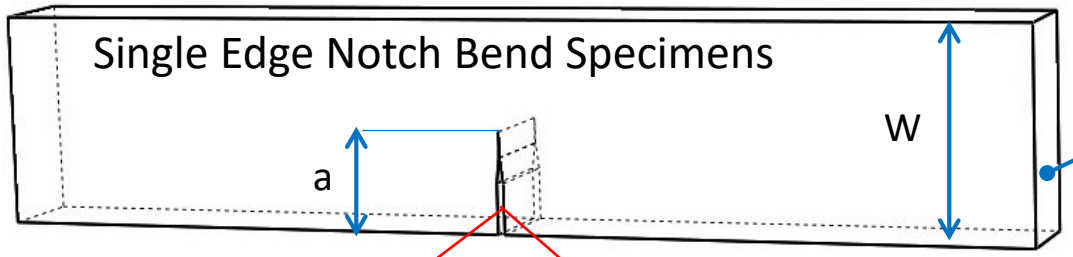
SIRAMM – Effect of manufacturing parameters on fracture toughness

- Effect of printing orientation

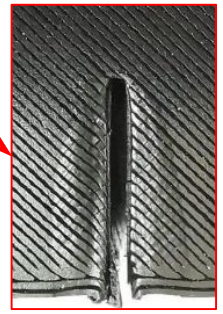




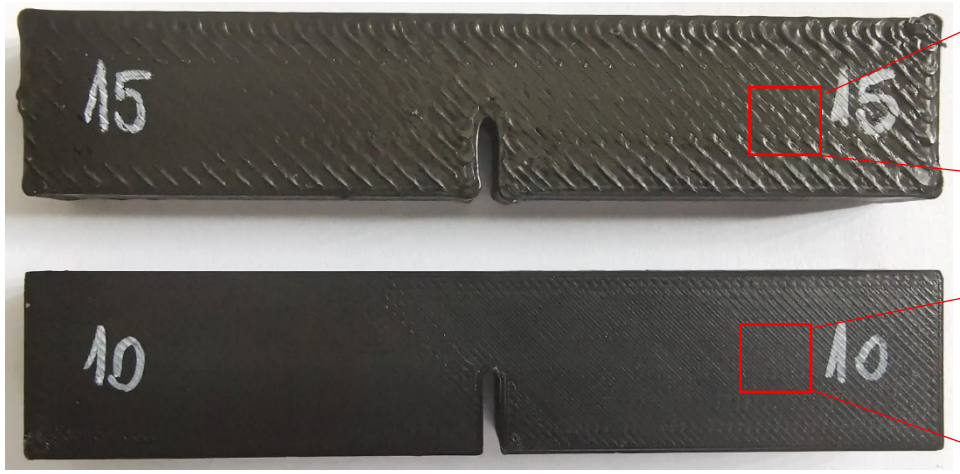
SIRAMM – Effect of manufacturing parameters on fracture toughness

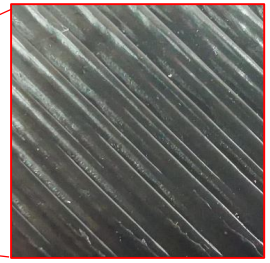


Printed notch



Milled notch



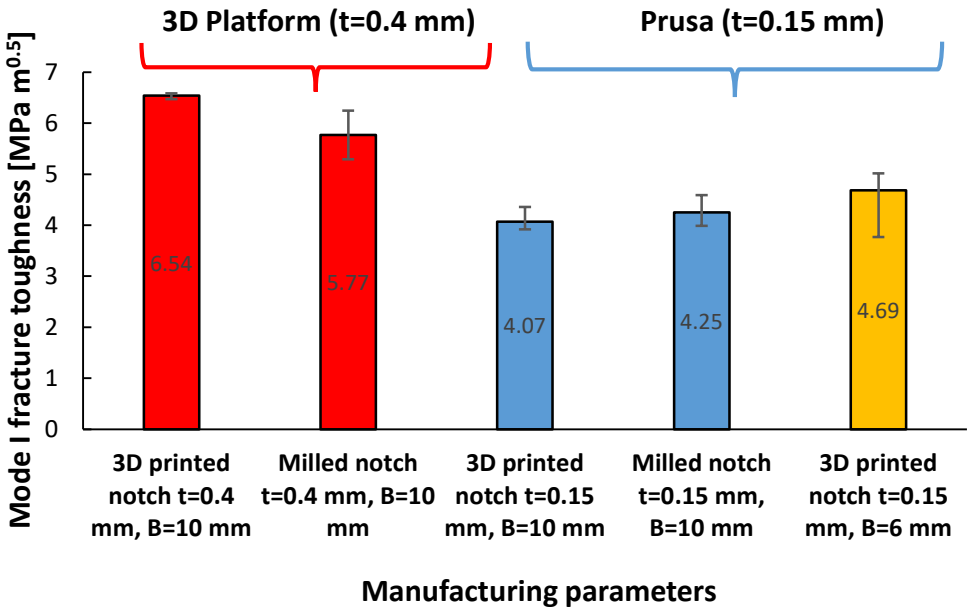


3D Platform
(t=0.40 mm)

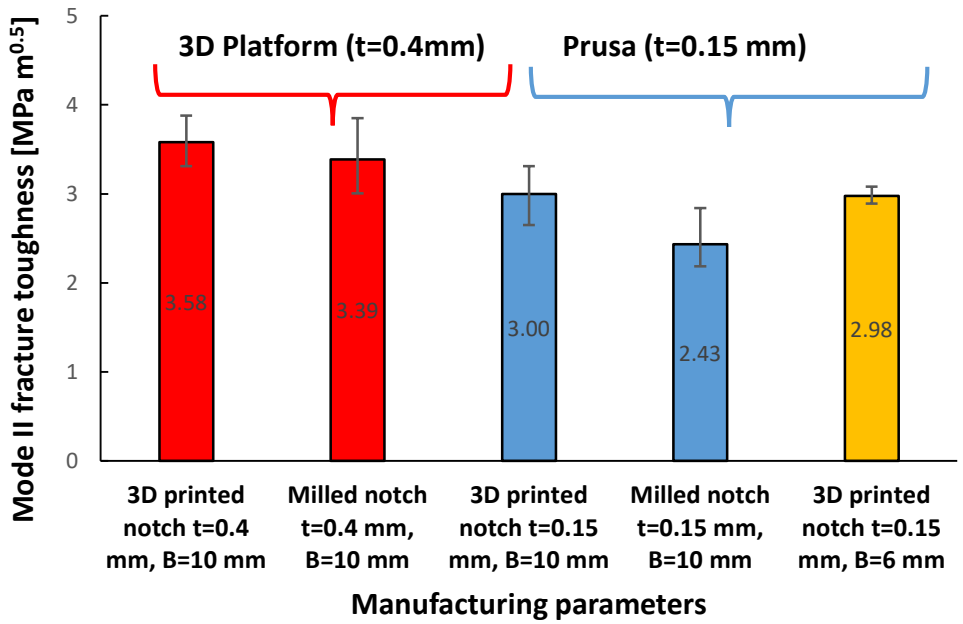
Prusa
(t=0.15 mm)

SIRAMM – Effect of manufacturing parameters on fracture toughness

Symmetric four point bending tests - Mode I



Asymmetric four point bending tests - Mode II



Published papers – Journal papers

All open access available at http://www.siramm.unipr.it/Publications.htm

- **Brighenti R., Li Y., & Vernerey F.J.** (2020). Smart polymers for advanced applications: a mechanical perspective review. ***Frontiers in Materials***, *7*: 196, 1-18, doi: 10.3389/fmats.2020.00196
- **Brighenti R., Cosma M.P., Marsavina L., Spagnoli A., Terzano M.** (2020). Laser-based additively manufactured polymers: a review on processes and mechanical models. ***Journal of Materials Science***, 1-38, doi: 10.1007/s10853-020-05254-6.
- **Marsavina L., Linul E.** (2020). Fracture toughness of rigid polymeric foams: A review. ***Fat. & Fract. of Eng. Mat. & Struct.***, (in press): 1-32, doi: 10.1111/ffe.13327
- **Linul E., Marsavina L., Stoia D. I.** (2020). Mode I and II fracture toughness investigation of Laser-Sintered Polyamide. ***Theoretical and Applied Fracture Mechanics***, *106*: 102497, doi: 10.1016/j.tafmec.2020.102497
- **Stoia D. I., Marsavina L., Linul E.** (2020). Mode I Fracture Toughness of Polyamide and Alumide Samples obtained by Selective Laser Sintering Additive Process. ***Polymers***: *12*(3), 640, doi: 10.3390/polym12030640

Published papers – Conference papers

All open access available at http://www.siramm.unipr.it/Publications.htm

- **Valean C.**, **Marsavina L.**, **Marghitas M.**, **Linul E.**, **Razavi J.**, **Berto F.**, Effect of manufacturing parameters on tensile properties of FDM printed specimens, ***Procedia Structural Integrity***, 26, 2020, p.313-320 - presented at *1st Mediterranean Conference on Fracture and Structural Integrity, Athens, February 2020.*

- **Valean C.**, **Marsavina L.**, **Marghitas M.**, **Linul E.**, **Razavi J.**, **Berto. F**, **Brighenti R.**, The effect of crack insertion for FDM printed PLA materials on Mode I and Mode II fracture toughness, ***Procedia Structural Integrity***, *28,* 2020, p.1134-1139 - presented at *1st Virtual European Conference on Fracture, June 2020.*

- **Galatanu S.-V.**, **Scano M.**, **Pietras D.**, **Pirvulescu L.-D.**, **Porcu M.C.**, **Marsavina L.**, **Sadowski T**. (2020). Bending behavior of AM50 Magnesium alloy under static and dynamic loading. ***Structural Integrity Procedia***, *26*, 2020, p. 269-276. - presented at *1st Mediterranean Conference on Fracture and Structural Integrity, Athens, February 2020.*

Organisation of minisymposiums at conferences

- 1st MEDFRAC conference, Athens, 26 February 2020: **SESSION 2: CHAIR L. MARSAVINA & A. SEDMAK MINISYMPOSIUM: INTEGRITY OF AM COMPONENTS**

- 1st VECF, online : **TC15 - Additive Materials, Chair: J. Razavi, C. Gao**

⇒ **VSI Engineering Fracture Mechanics: Fracture behavior of additively manufactured materials and structures**

Next events on SIRAMM – 1st Workshop

1st Workshop on

Structural Integrity of Additively Manufactured Materials

SIAMM21

Universitatea Politehnica Timişoara

Polytechnical University of Timisoara (UPT), Timisoara, Romania, 25-26 February 2021

the workshop will be held in presence & online

Workshop chairmen:

Prof. Liviu Marsavina - Univ. Politehnica Timisoara, Romania
Prof. Roberto Brighenti – Univ. of Parma, Italy
Prof. Filippo Berto – NTNU, Norway

Workshop Fees: Participation in the workshop is free!

Important Dates:

Registration & submission of abstracts: **15 February 2021**
Confirmation to Authors: **20 February 2021**
Preliminary Program: **23 February 2021**
Submission of papers: **31 March 2021**

Proceedings:

Material Design & Processing Communications (Wiley open access journal).

TWINNING

HORIZON 2020

SIRAMM

H2020-WIDESPREAD-2018
Project No. 857124

Next events on SIRAMM

- East Europe Conference on AM materials – EECAM (2nd year), Belgrade, Serbia

- Final International Conference (3rd year), Timisoara, Romania

Acknowledgments

- European Commission

- European Structural Integrity Society

THANK YOU FOR ATTENTION!