POLITECNICO
MILANO 1863

DEPARTMENT OF MECHANICAL ENGINEERING

Laser E-mobility Workshop 2022

Application driven research for the development of laser-based manufacturing processes

10-11 March 2022, Bologna

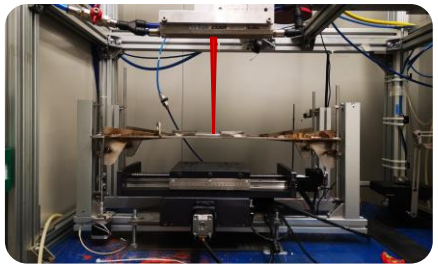
Dr. Leonardo Caprio
Dr. Valentina Furlan
Prof. A.G. Demir
Prof. B. Previtali

DIPARTIMENTO DI ECCELLENZA
MIUR 2018-2022

SITEC – LABORATORY FOR LASER APPLICATIONS

POLITECNICO
MILANO 1863

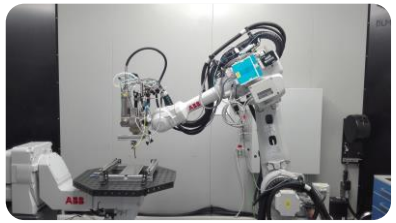
Faculty	Students
Engineering	35 645
Architecture	7231
Design	4294
Tot.	47 170



2021 – Laser e-mobility cell

2020 – Robotic Laser Welding Cell

2018 – Robotic Laser Cutting

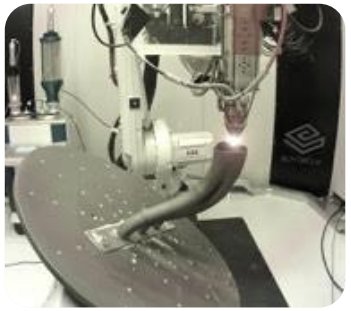


2017 – AddiTube LMD Cell

2016 – First SLM Prototype

2013 – First LMD Cell

2011 – First Stainless Steel and Biodegradable Mg Stents



2007 - Moved to Mecc Polimi in Bovisa, Milan. First Own Fiber Laser

2000 – First Fiber Laser in an Italian University

1999 – Founded in Lecco

SITEC – LABORATORY FOR LASER APPLICATIONS

SITEC
Laboratorio per le Applicazioni Laser

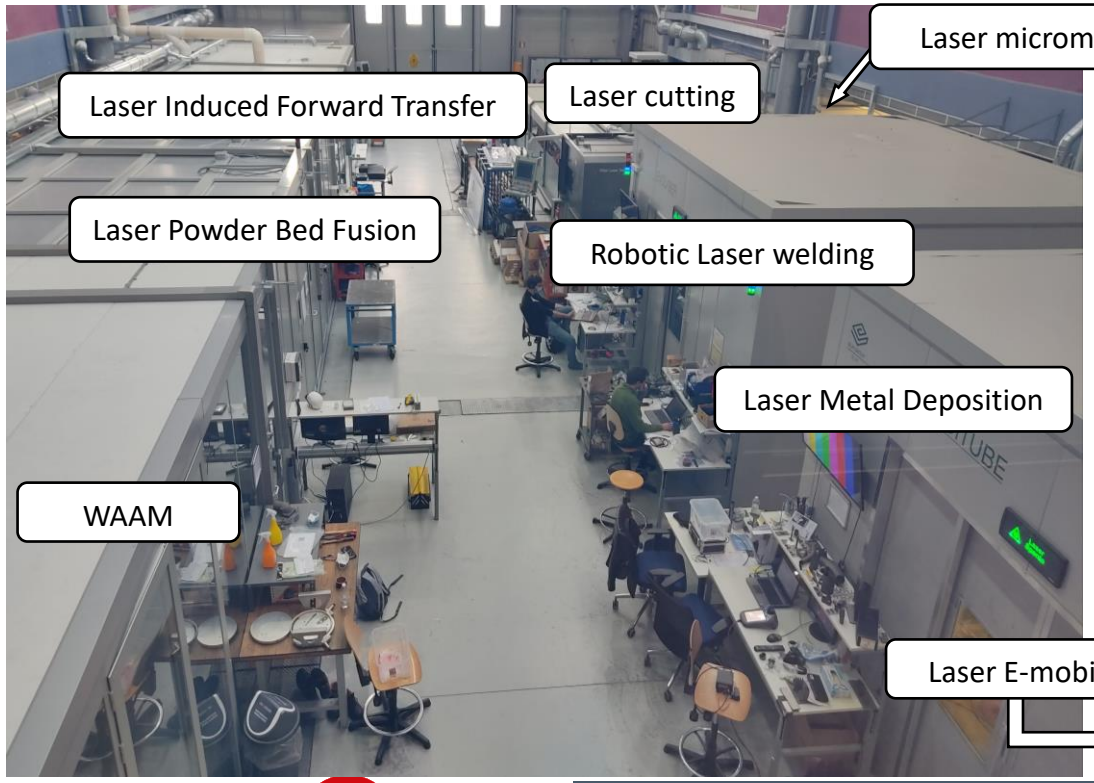
TEAM

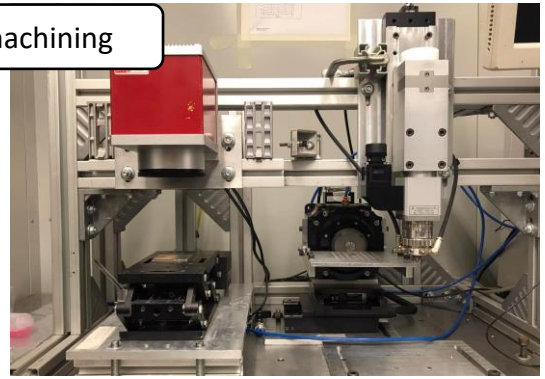
1 full professor
1 associate professor
2 assistant professors

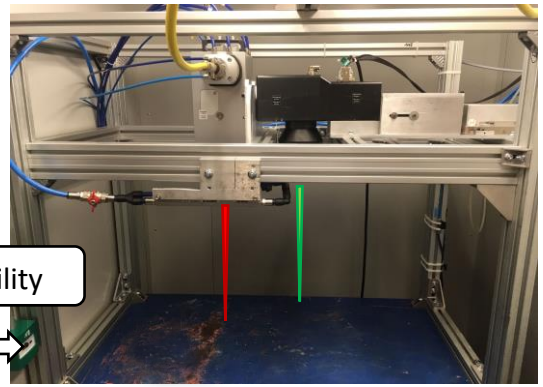
5 PhD students
4 Research fellows
20+ thesis students

LAB

- Laser Cutting
- Laser Micromachining
- Robotic laser Welding
- Laser Metal Deposition
- Laser Powder Bed Fusion
- Laser Induced Forward Transfer
- Laser E-mobility

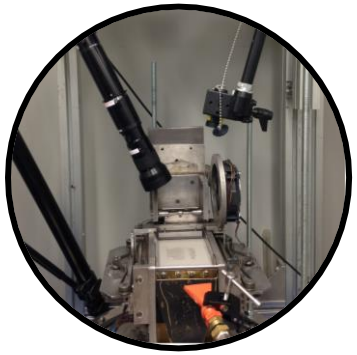




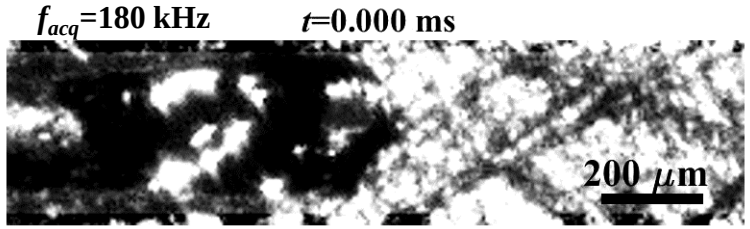


RESEARCH ACTIVITIES IN SITEC

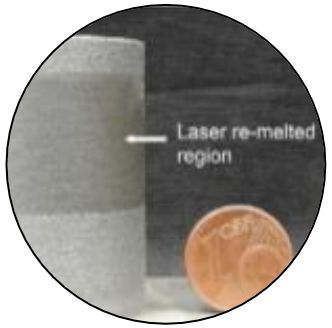
Fundamental research



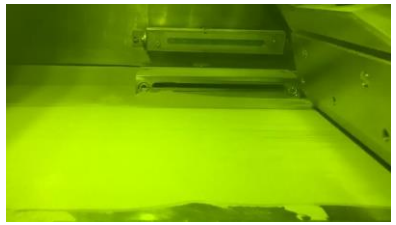
LOW TRL
Politecnico di Milano
National & international collaboration
Other academies & research organizations



Funded projects



MEDIUM-HIGH TRL
Regional
National
European & international



Projects with private companies

HIGH TRL
Public funding
Private funding
High confidentiality

250+ publications in peer-reviewed journals & international conferences

15+ patents with different industrial partners

COLLABORATIONS IN THE PRIVATE SECTOR

Laser equipment manufacturers

IPG PHOTONICS, nLIGHT, RAYLASE, ELEN elengroup.com, COHERENT, TRUMPF, TERADIODE A Panasonic Company, LUMENTUM

Application developers & machine tool manufacturers

BLM GROUP, IMA, AUTOMATION ATOP, PRIMA INDUSTRIE, OPTOPRIM, +GF+, RENISHAW apply innovation™, ABB, GIVI MISURE, SOVEMA GROUP ENGINEERING & EQUIPMENT FOR BATTERY MANUFACTURING

End-user

BERETTA, HITACHI Inspire the Next, TECHNOPROBE Wafer Probing Technologies, SAIPEM, ALCAR YOUR WHEEL PARTNER, Pomini TENOVA, ANSALDO ENERGIA, Baker Hughes, tenova, PIAZZAROSA, COSTAMP GROUP, Fubri, scm, AgustaWestland A Finmeccanica Company, CASALE, Sice Previt, saes group, LAFRANCONI SILENZIATORI

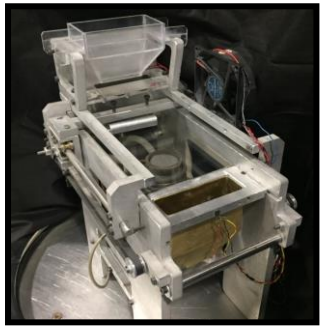
SITEC LAB: LASER POWDER BED FUSION

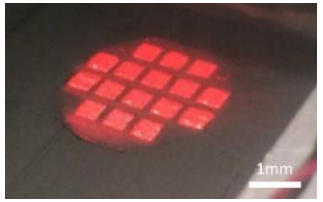
Prototypal systems

LPBF prototype

Colopi *et al., Procedia CIRP,* (2018)

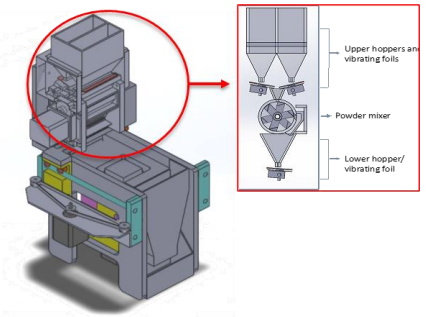
High-T LPBF

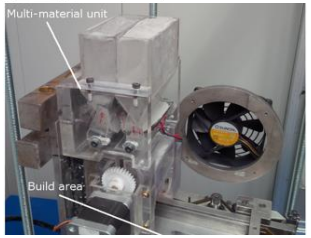




Caprio *et al., J Phys Photonics,* (2021)

Multi-material LPBF



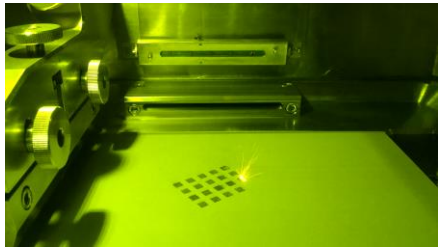


Scaramuccia *et al., Pow Tech* (2021)

- From system design to its realization
- Testing of innovative concepts
- Fundamental research on new technologies

Industrial machine

nLIGHT AFX-1000

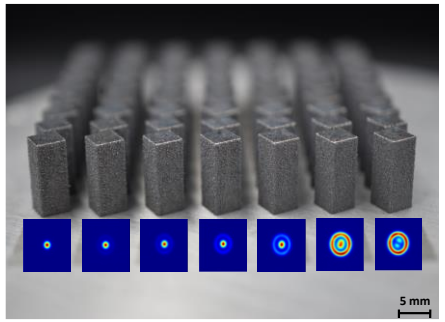


Open LPBF architecture:

- Advanced scan strategies
- NIR and VIS laser sources
- Ø150 mm x 150 mm build volume

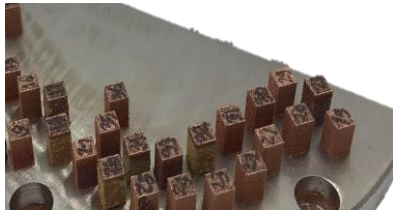
Currently ongoing research

Spatial beam shaping



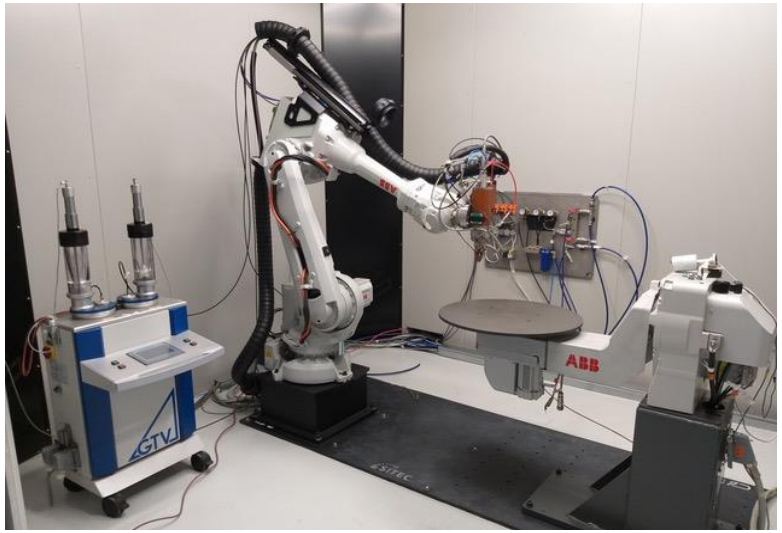
LPBF of various materials:

- Al alloys
- Pure Cu & its alloys
- FeSi alloys

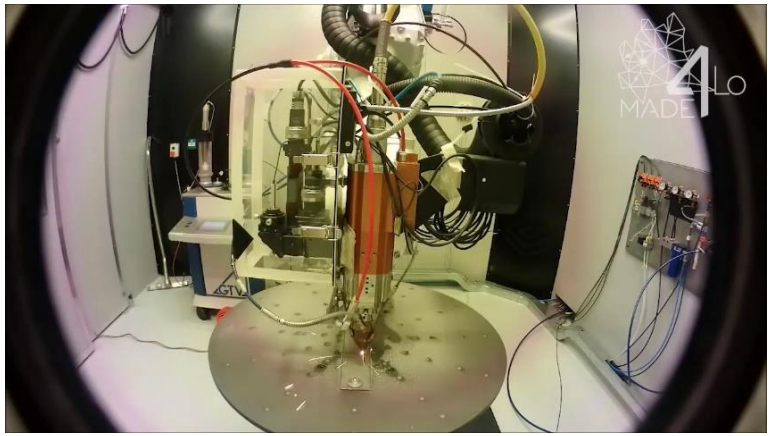


SITEC LAB: ROBOTISED CELLS

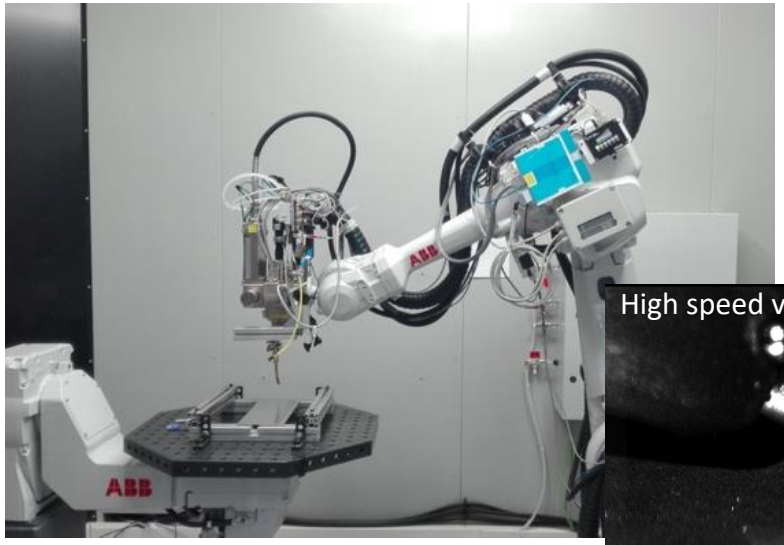
Additube – Laser Metal Deposition



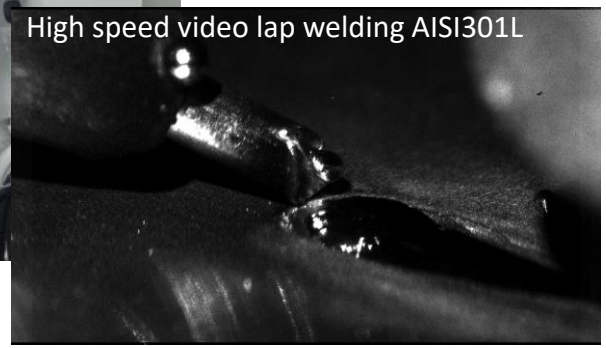
- 3 kW fiber laser
- Wobble head
- Powder hopper
- Wire feeder
- 6 axis robot



Alphetta – Laser Welding

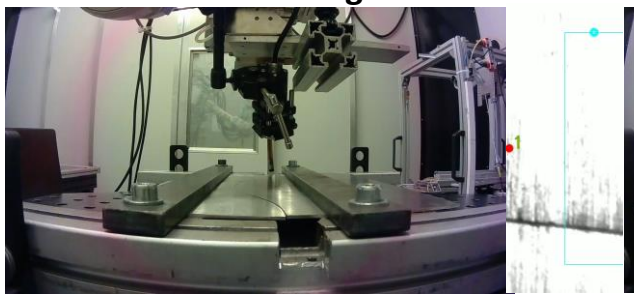


- 6 kW fiber laser
- Wobble head
- Wire feeding
- 6 axis robot
- Machine vision

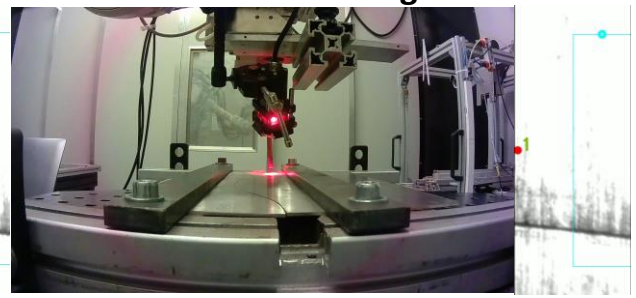


Boldrin et al., *LiM* (2021)

No seam tracking

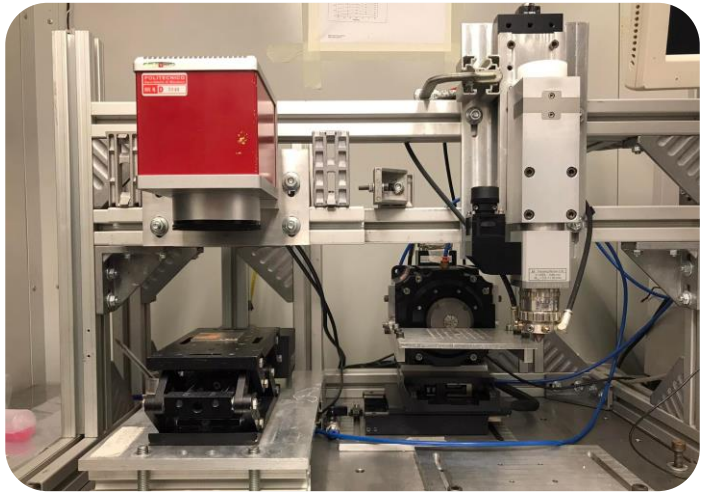


Active seam tracking



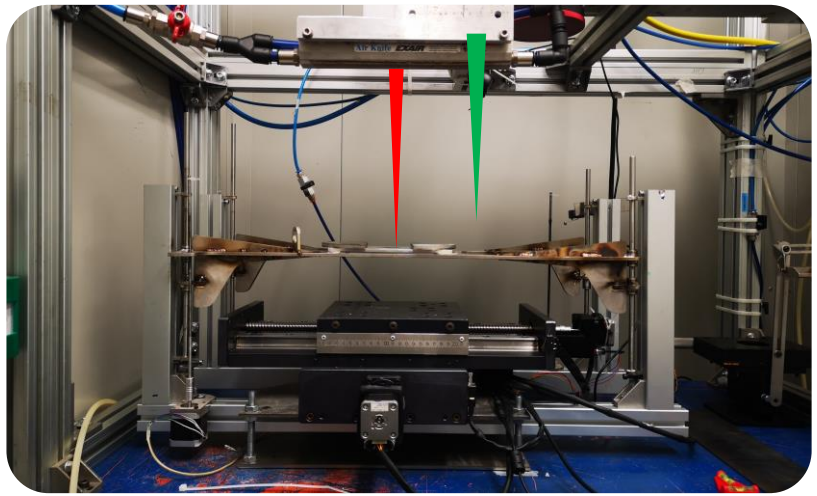
SITEC LAB: FROM MICROMACHINING TO E-MOBILITY & BEYOND

Laser micromachining



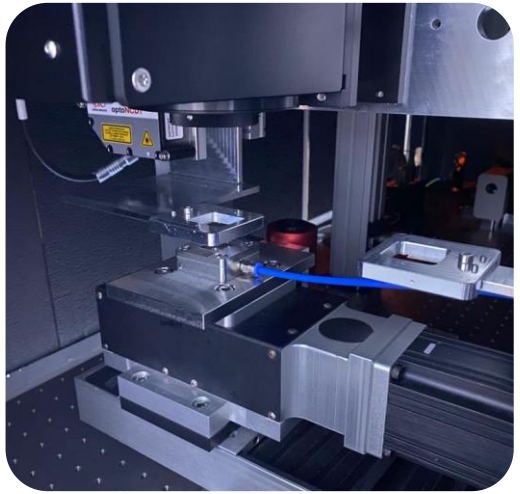
- 50W ns pulsed IR fiber
- 5 W ns pulsed Green
- Remote scanner head
- Proximity cutting head
- DLIP system

Laser e-mobility

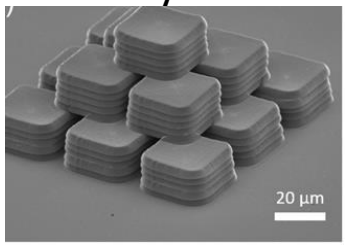


- 1kW IR fiber laser
- 100 W QCW Green fiber laser
- 2 remote scanner heads
- Flexible fixturing system
- In-source & off-axis monitoring

Laser Induced Forward Transfer



- UV fs pulsed fiber laser
- Multi-material deposition in nm range
- System currently under development



Piqué *et al*, *J Phys D* (2016)

DIDACTICS: FROM ACADEMIC TO CORPORATE LEVEL

Fundamental courses in Mechanical Engineering

- Tecnologia Meccanica
- Advanced Manufacturing Processes
- Advanced Manufacturing Processes Laboratory

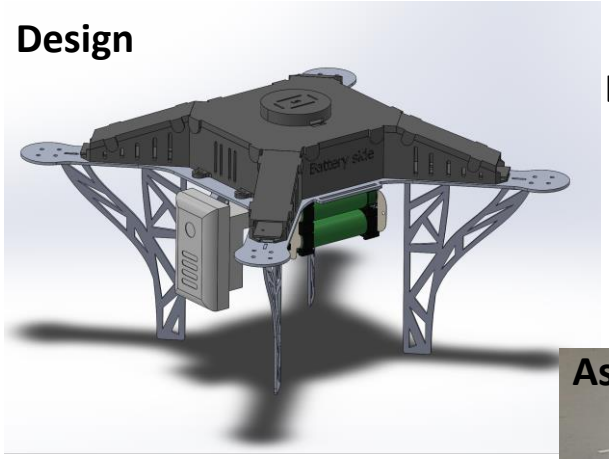
Master of second level

MP POLITECNICO DI MILANO GRADUATE SCHOOL OF BUSINESS

Dedicated training for the private sector

- Guided laboratory activities & experimental training
- Theoretical lessons on laser fundamentals

BERETTA tenova Baker Hughes ABB ALCAR YOUR WHEEL PARTNER



AMP Lab project A.Y. 2021/2022
Drone laser-based manufacturing

PROMOTING LASER TECHNOLOGY WITHIN THE INDUSTRY

Partnership between:

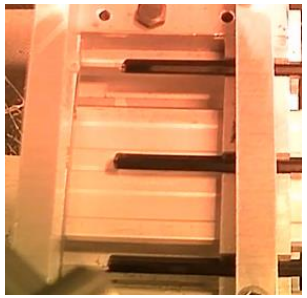
- 20+ universities
- 10 industrial companies

Main activities:

- Create training courses
- Endorse technical research activities
- Collaborates with international organisations & standardization bodies

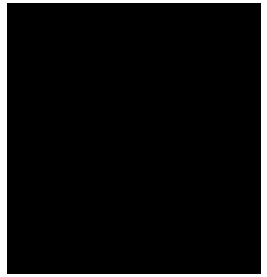
LASER APPLICATIONS IN SITEC FROM THE E-MOBILITY SECTOR

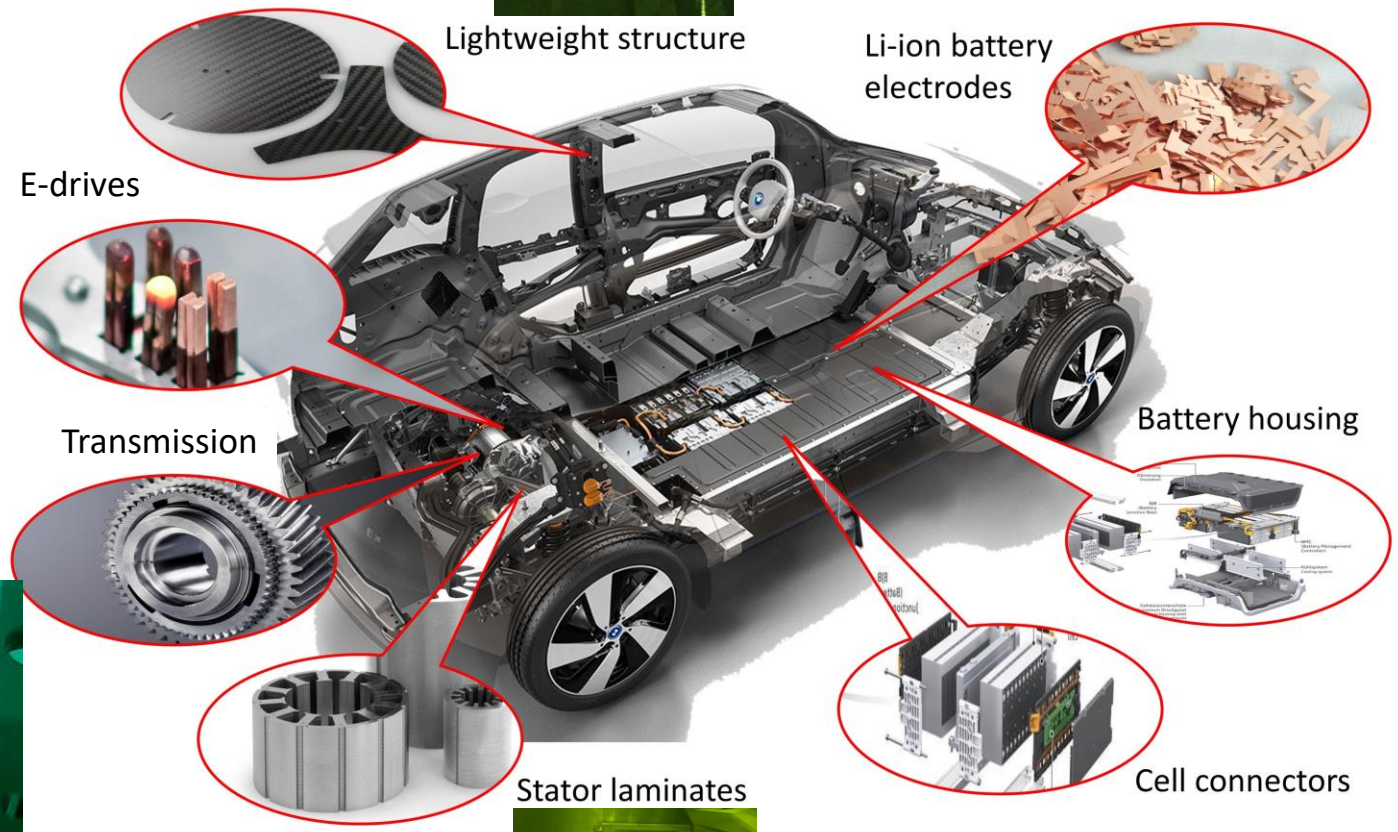
Hairpin stripping



CFRP cutting

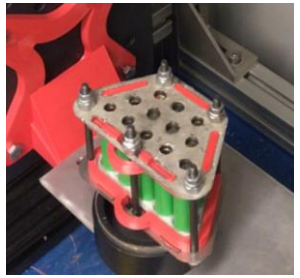
Electrode cutting





Hairpin welding

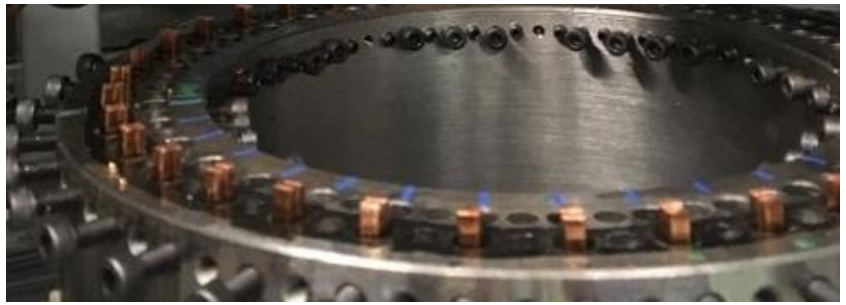
Battery pack welding



QUALIFICATION OF LASER BASED PROCESSES IN STATOR MANUFACTURING

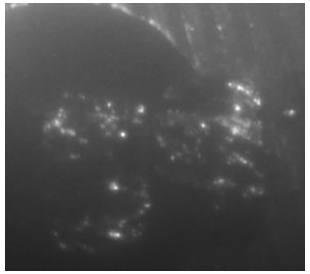
Main activities

- Process development
- Technological benchmarking
- Materials characterization



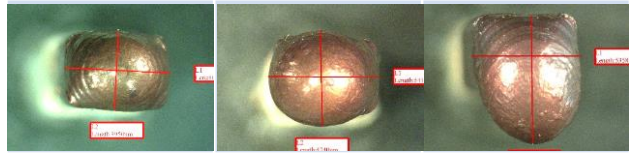
Hairpin welding

Coaxial vision



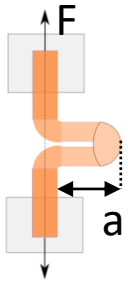
Optical microscopy

1: Weak	2: Sound weld	3: Excessive

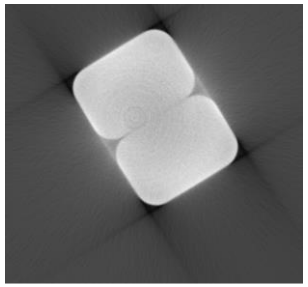


Process in real time

Tensile testing

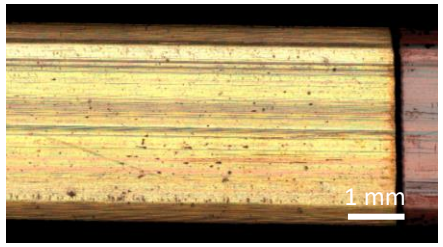


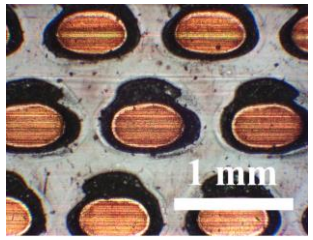
CT-scan



Hairpin stripping

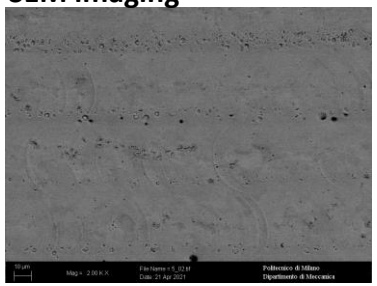
Optical microscopy



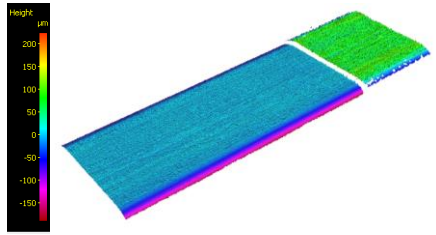


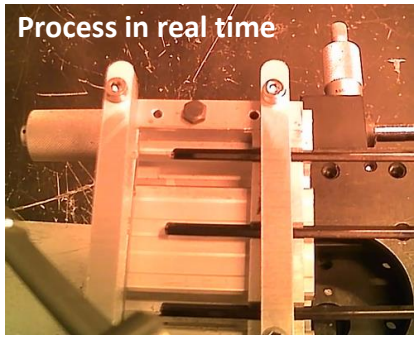
Samples

SEM imaging



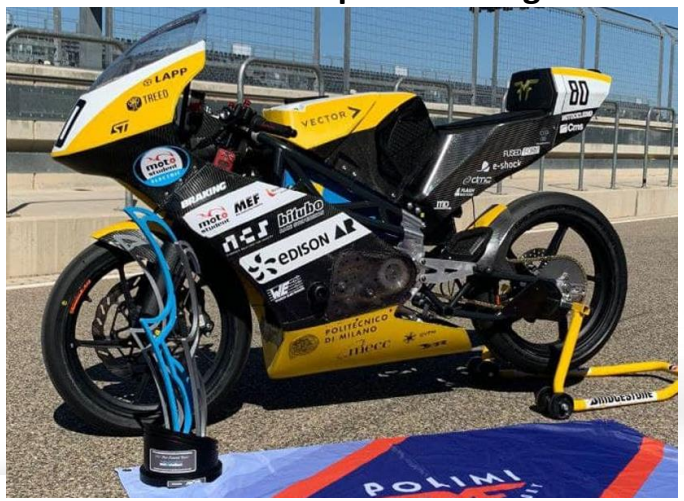
3D surface reconstruction



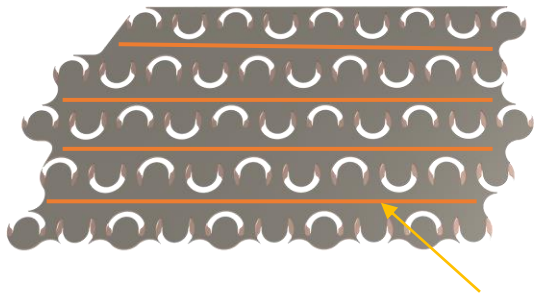


A CASE STUDY FROM THE LAB

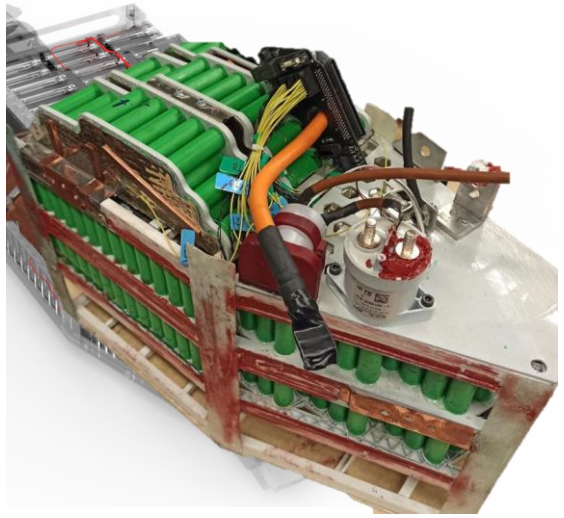
Motostudent competition Aragon 2021

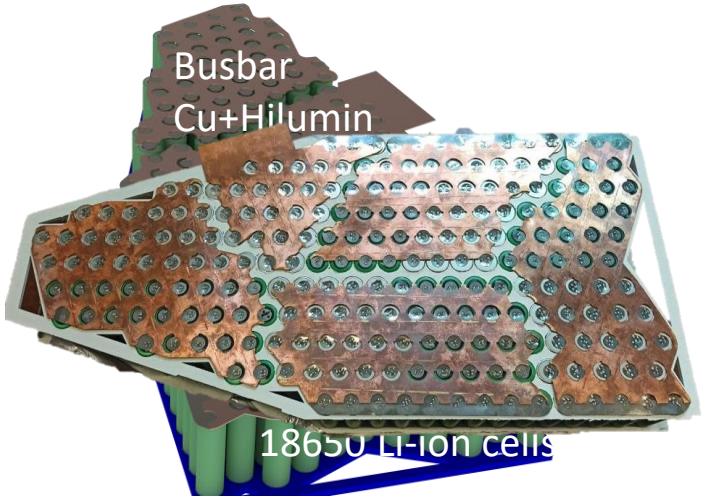


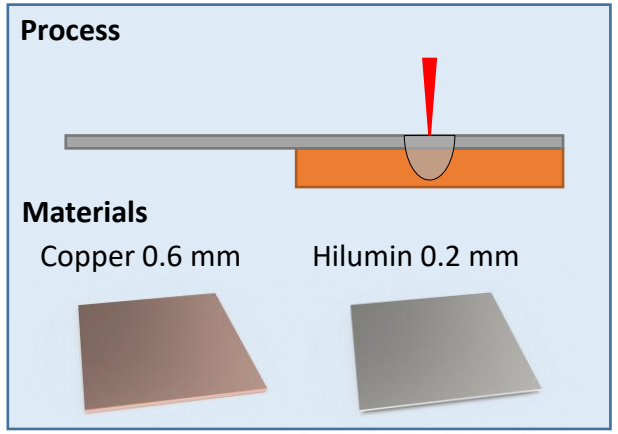
Parameter	Value
Power	50 kW
Voltage	126 V
Peak current	450 A
Rating	8.1 kWh
Cell type	18650
N° cells	750



Weld path

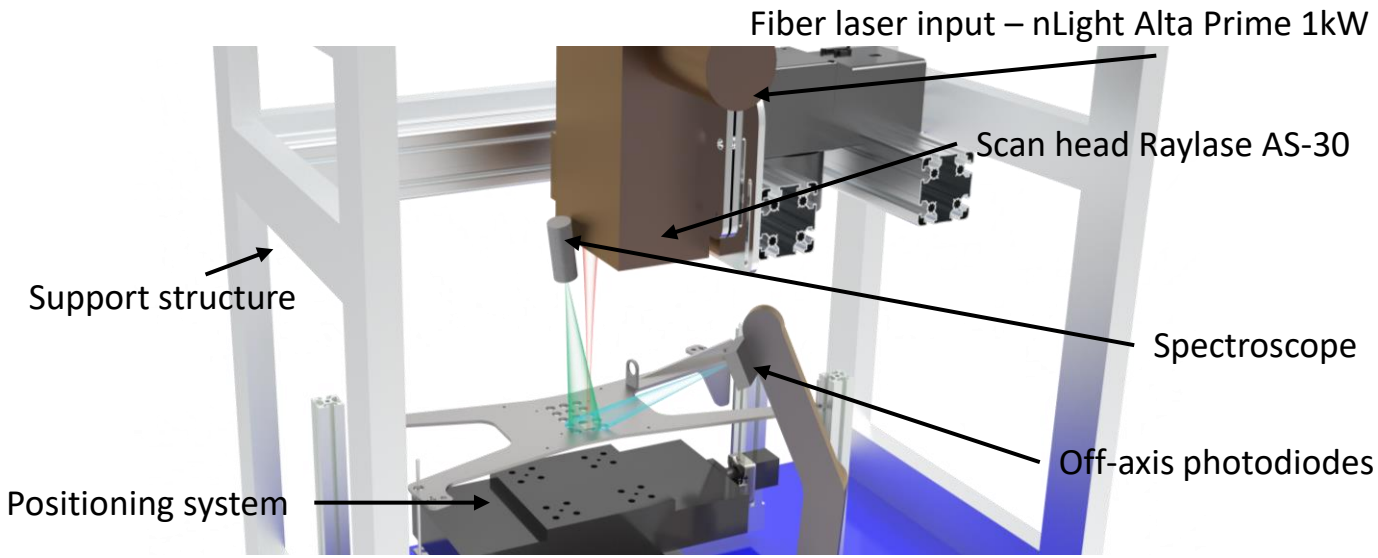




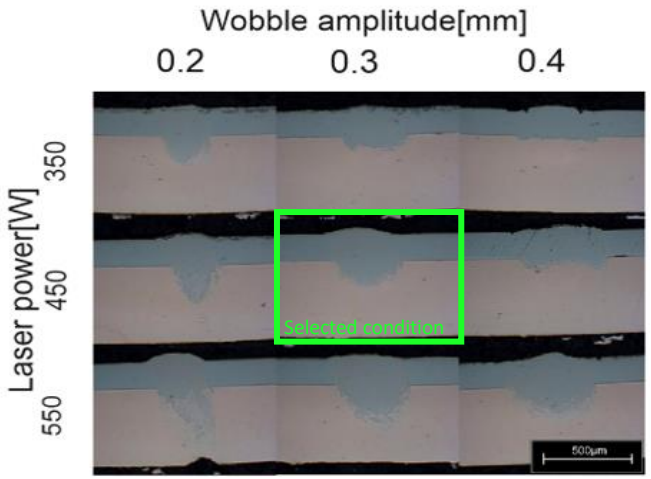


A CASE STUDY FROM THE LAB

Experimental set up – E-mobility cell

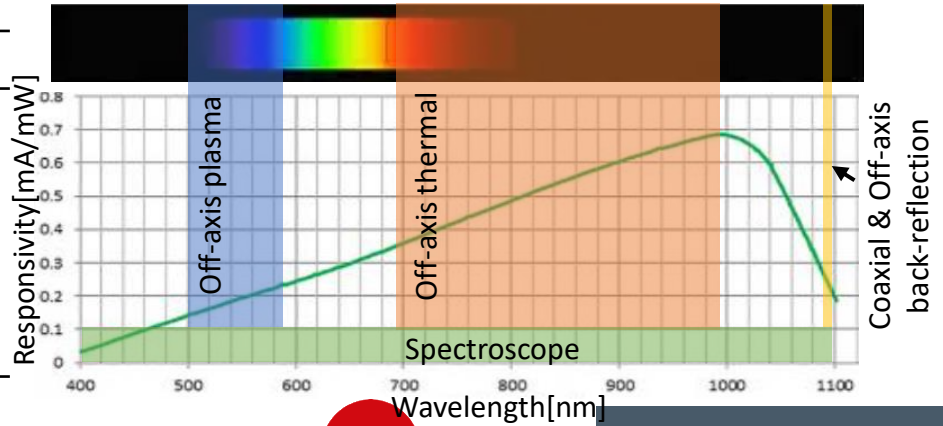


Optimisation of process parameters

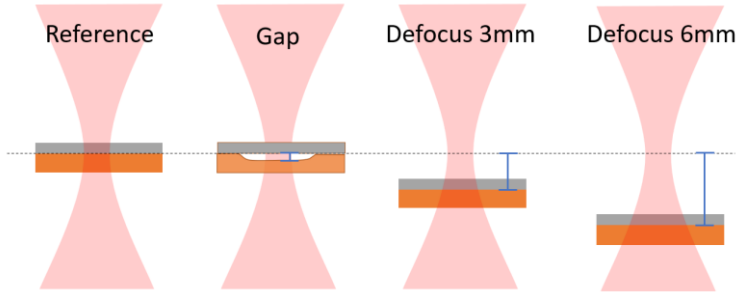


Configuration of the monitoring system

Sensors	Value
Coaxial back-reflection [nm]	1078
Off-axis back-reflection [nm]	1078
Off-axis plasma [nm]	500-567
Off-axis thermal [nm]	700-1000
Spectroscope [nm]	118-1100

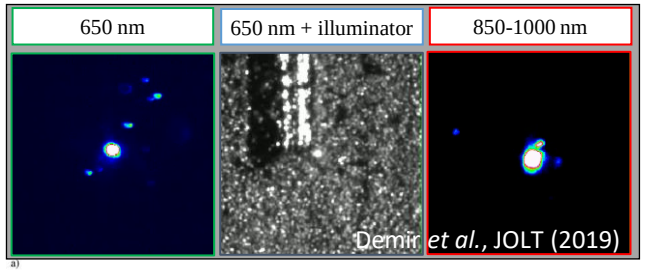


Identification of typical defects

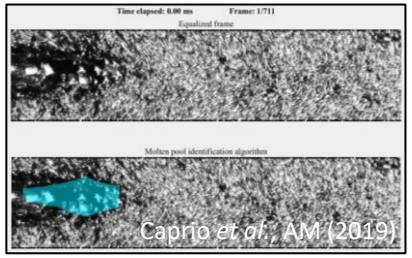


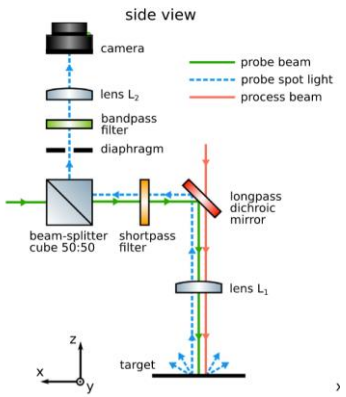
FUTURE RESEARCHES IN SITEC

Advanced process diagnostics & control

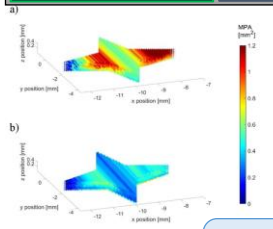


Demir *et al.*, JOLT (2019)


Caprio *et al.*, AM (2019)



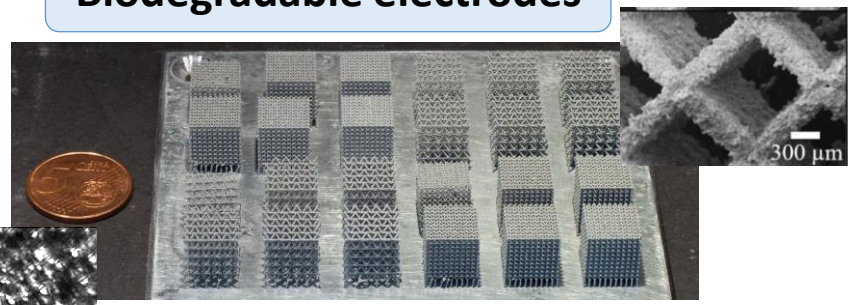
Donadello *et al.*, *Opt Las Eng*, (2019)

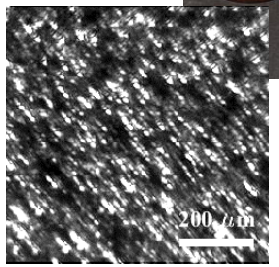


Monitoring & control of different processes:

- Laser Powder Bed Fusion (various publications)
- Laser Metal Deposition (patents with BLM)
- Laser cutting (patents with BLM & IPG)

Biodegradable electrodes



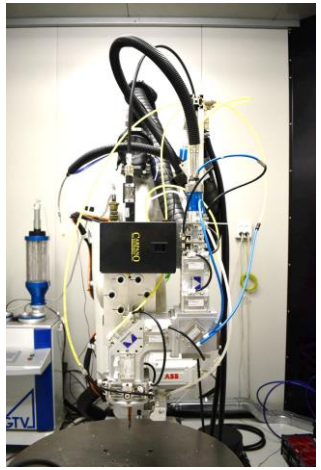


Guaglione *et al.*, *AM*, (2021)

Novel approach developed for LPBF of Zn:

- Spatial & temporal beam control
- Deposition of controlled porosity structures

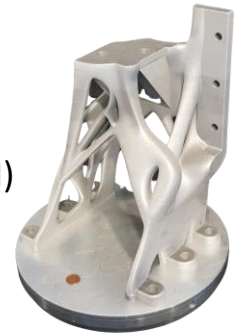
Large size Additive Manufacturing



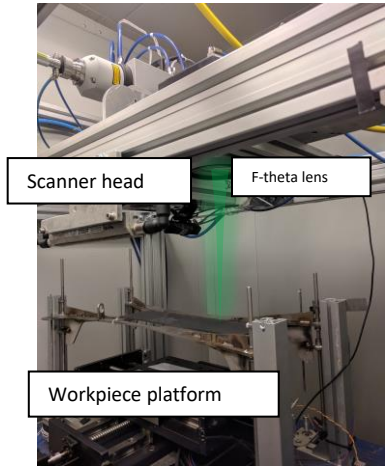
Laser E-mobility Workshop 2022
Dr. Caprio, Dr. Furlan, Prof. Previtali, Prof. Demir

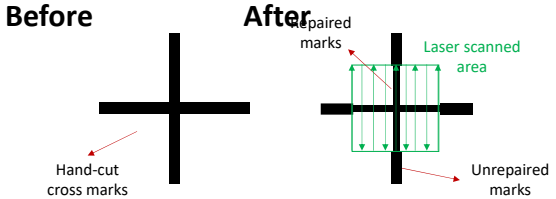
Cells under development:
Laser Metal Wire Deposition (LMWD)
Wire Arc Additive Manufacturing (WAAM)

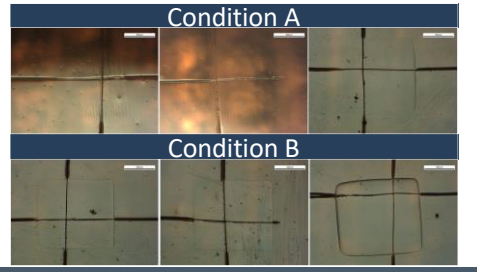
Assad *et al.*, *LiM*, (2021)


Run2Rail EU project

Laser healing of CFRP







mecc

DIPARTIMENTO DI ECCELLENZA
MIUR 2018-2022

THANKS FOR THE ATTENTION

SITEC Laboratorio per le Applicazioni Laser

POLITECNICO MILANO 1863

CONTACTS

Dr. Leonardo Caprio - leonardo.caprio@polimi.it
Prof. Ali Gökhan Demir - aligokhan.demir@polimi.it
Prof. Barbara Previtali - barbara.previtali@polimi.it

Sitec – Laboratory for Laser Applications
Dipartimento di Meccanica
Politecnico di Milano

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POLIMI MOTORCYCLE FACTORY
IPG PHOTONICS
IMA AUTOMATION ATOP
BLM GROUP
OPTOPRIM
DMC DIRECT MACHINING CONTROL
nLIGHT
RAYLASE