L'evoluzione dello sviluppo delle tecnologie additive: Processi, componenti e sistemi di produzione. L'esperienza del politecnico di Torino

POLITECNICO
DI TORINO

Prof. P. Fino

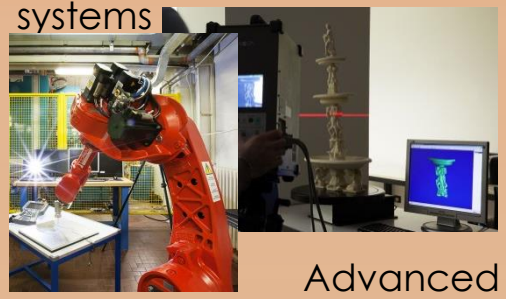
Dipartimento DISAT, Politecnico di Torino

AM @ Politecnico di Torino

Luca Iuliano

Politecnico di Torino
Department of Management and Production Engineering
AMTech Research Group

CAD/CAE/CAM and 3D scanning systems



Advanced CNC machining and additive manufacturing

Paolo Fino

Material Science and Technology

Politecnico di Torino
Applied Science and Technology Department
DiSAT science meets engineering

TEAM di Ricerca

- **13 ricercatori strutturati;**
- **18 assegnisti di ricerca/dottorandi**

AM @ Politecnico di Torino

POLITECNICO DI TORINO

Politecnico di Torino
Department of Applied Science and Technology

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Daniele Ugues
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Research fellow

Istituto Italiano di Tecnologia
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CSF@PoliTo

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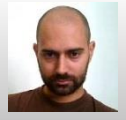
Researcher Technologist

Diego Manfredi
Researcher Technologist

Flaviana Calignano
Researcher



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Researcher

Francesco Trevisan
Research fellow

Jukka Pakkanen
Research fellow

Giulio Cattano
Research fellow

POLITECNICO DI TORINO

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Eleonora Atzeni
Assistant Professor

Paolo Minetola
Associate Professor

Alessandro Salmi
Assistant Professor

Manuela Galati
Research fellow

Politecnico di Torino
Department of Management and Production Engineering

ISTITUTO ITALIANO DI TECNOLOGIA
CENTER FOR SPACE HUMAN ROBOTICS

Arcam A2
Intermetallics
Superalloy
Ceramics

Polito @ Tecnogrnada Spa

M250 EOS
CoCr alloy

M270 EOS
Lightweight
Composites
SMA

2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015

EBM - TiAl Intermetallics

Partnership AVIO – Polito
Regional research project

Blow Powder Tech.
Large components

BOREALIS PRIMA INDUSTRIE

Partnership Prima Industrie – Polito
European research project

- E-Break
- Great2020-F2
- AMAZE
- Cluster
- TiAl-Charger
- Helmet
- Borealis

M290 EOS
M400 EOS

Arcam A2
Intermetallics
Superalloy
Ceramics

Hot Isostatic Pressing

Gas atomization system

2015 2016 2017 2018 2019

Avio Aero
A GE Aviation Business

PRIMA INDUSTRIE

POLITECNICO DI TORINO

HUB - DIMA

Cluster – P. Fino

Borealis – M. Lombardi

Helmet – D. Ugues

4D-Hybrid – S. Biamino

STAMP – M. Lombardi

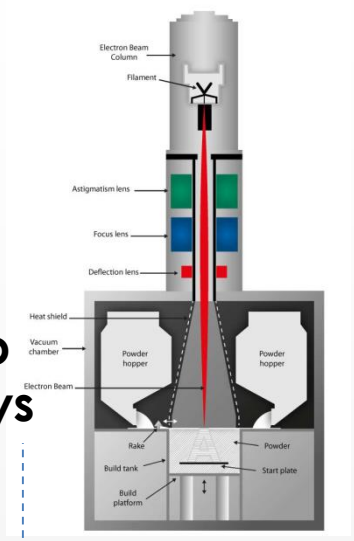
Metal: POLITO field of interest

POLITECNICO DI TORINO

EBM

HT Mat

TiAl 4822
TiAl Hi Nb
Superalloys



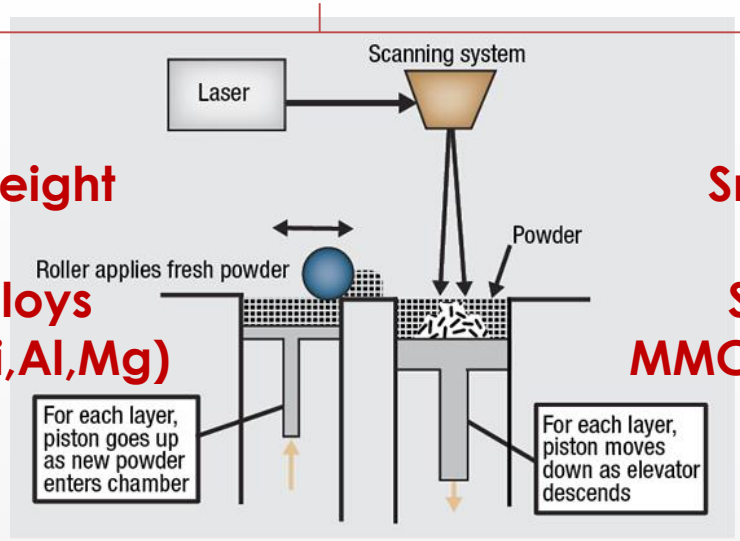
SLM

Lightweight

Al Alloys
MMC (Ti,Al,Mg)

Smart

SMA
MMC + Piezo

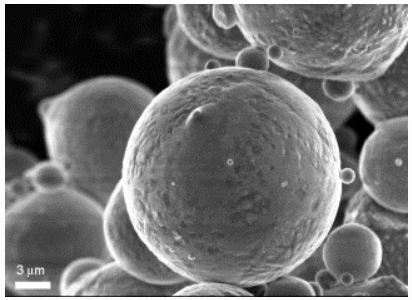


Avio Aero
A GE Aviation Business

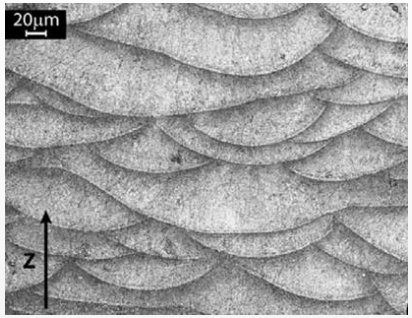
ThalesAlenia Space
A Thales / Finmeccanica Company

Approach

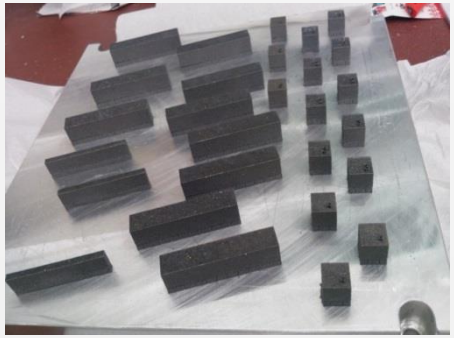
DMLS design and production → **Alloy selection and design** → **Process optimization**



Heat treatmet setup and surf. finishing → **Microstruc-tural selection** → **Optimal microstructure definition**

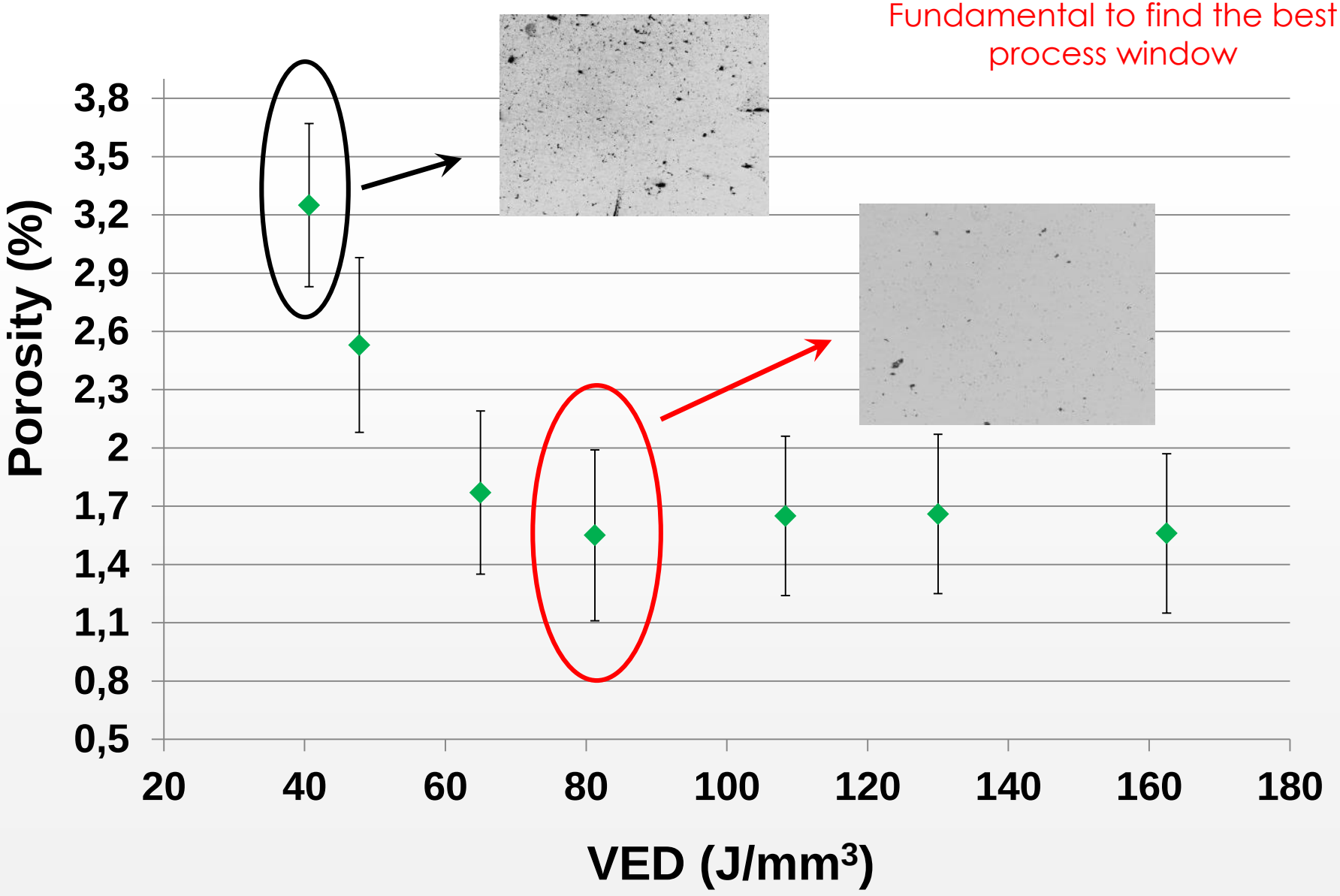


Mechanical and thermal properties tests

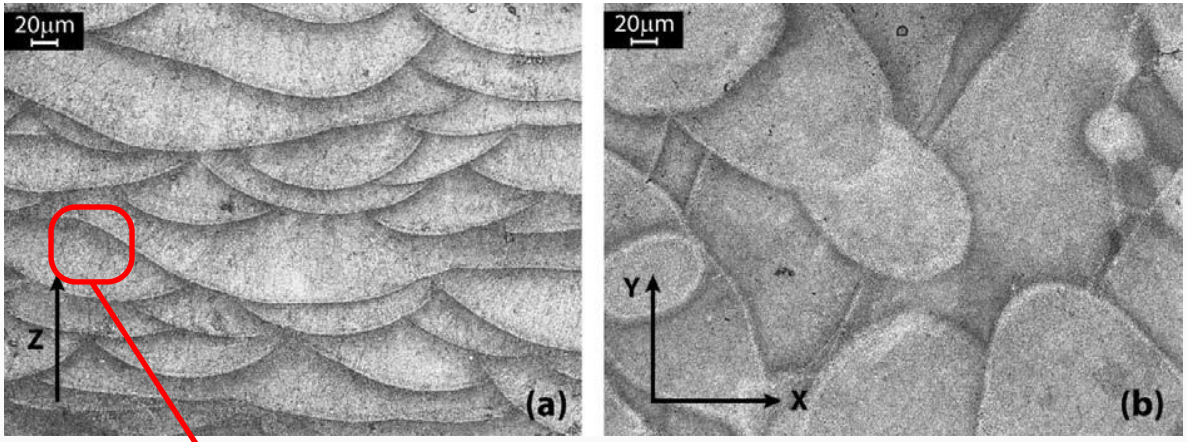


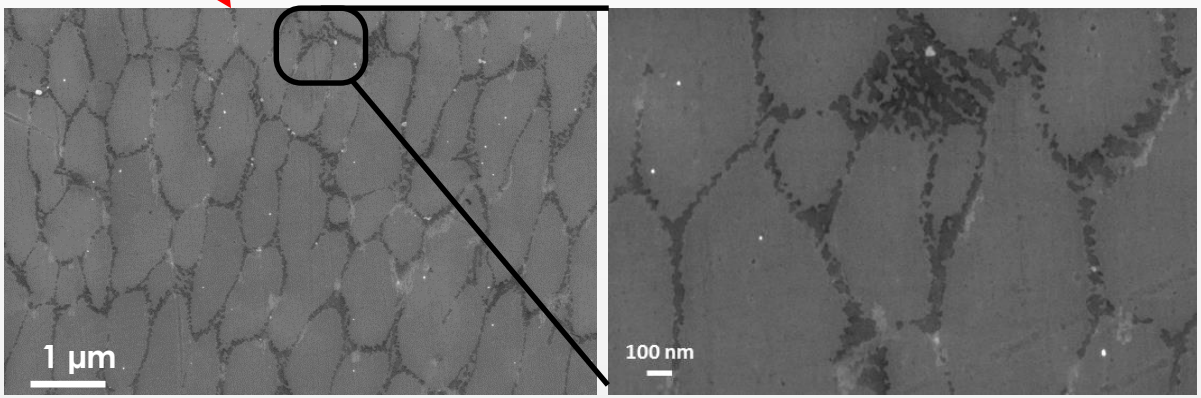
Process optimization

Fundamental to find the best process window

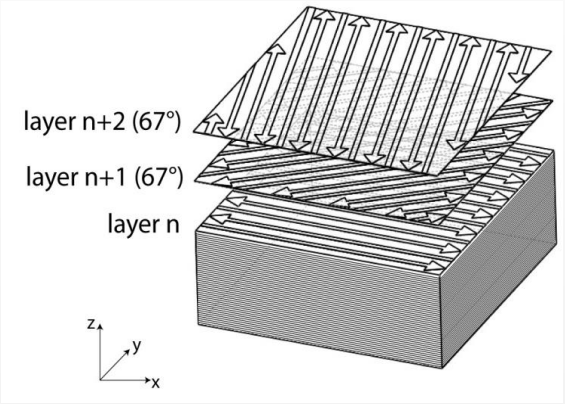


DMLS microstructures





Typical microstructural details of the Al alloy by DMLS highlighted by chemical etching:
(a) scan tracks signs, **melt pools** (along z axis)
(b) melt pools on xy section



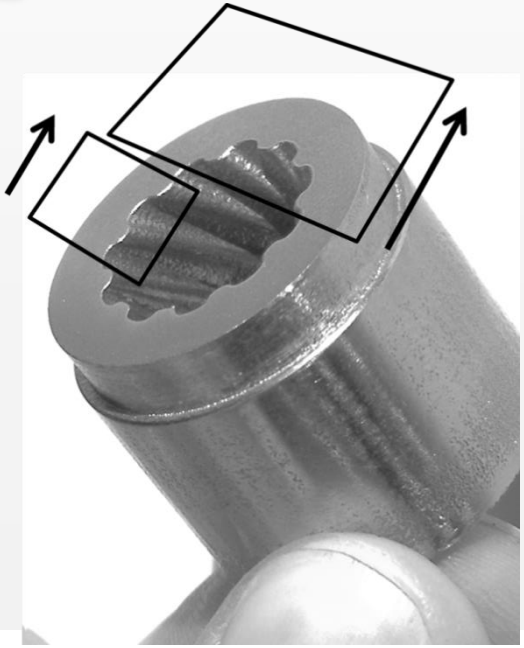
EXTREMLY FINE

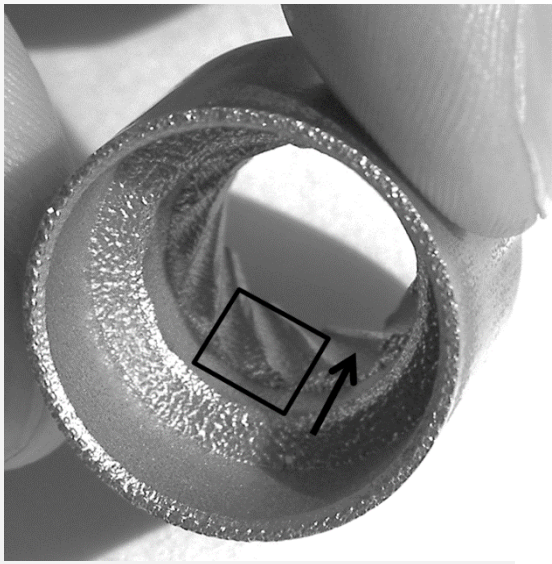
Darker areas → Si rich
Grey areas → Al euctectic zones

Surface post processing

Combination of mechanical and electrochemical polishing, abrasive flow machining (AFM)

Surface post processing
→ and subsequent stereomicroscope analysis
and 3D scanning



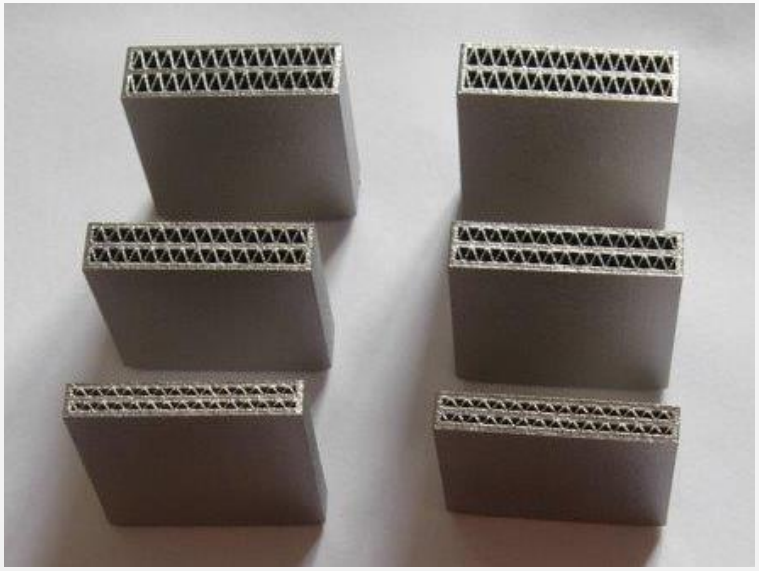


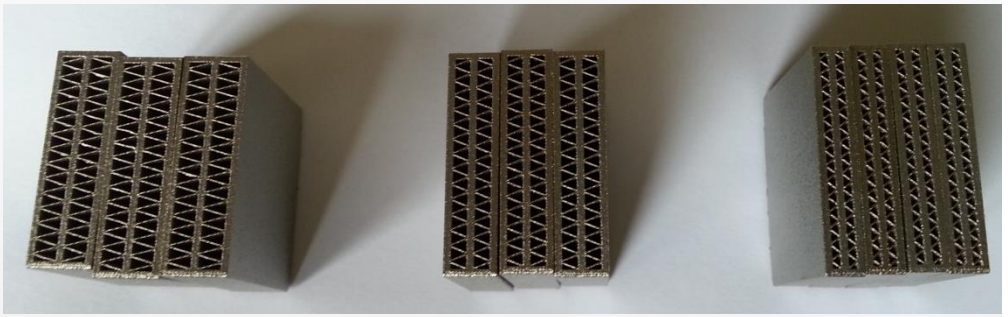
AM for heat exchangers

EU Project – FPVII **HELMETH** “Integrated High-Temperature Electrolysis and Methanation for Effective Power to Gas Conversion”

Design and fabrication of fins and heat exchanging elements by DMLS: complex shapes and hollow structures to work at high T (800 °C) and in a corrosive gas environment (H_2)

In718 @ IIT-PoliTo



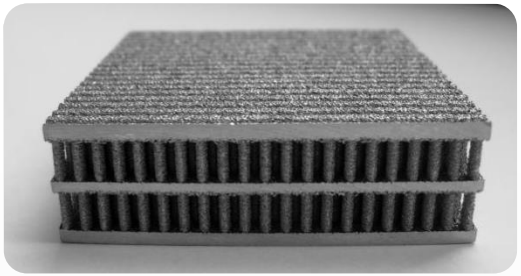


Scale up → assembly of modules with different heights

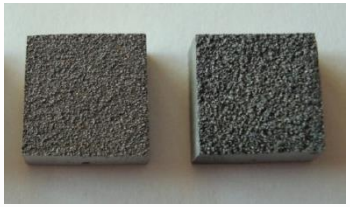
AM for heat exchangers

Produced in AlSi10Mg @ IIT-PoliTo

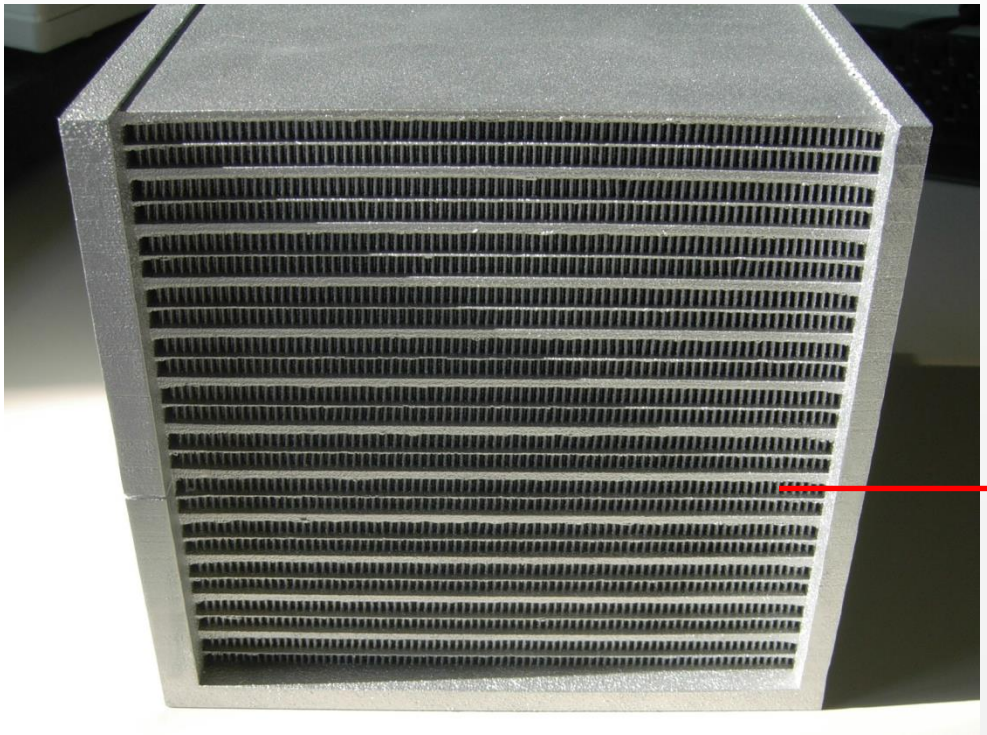
From single module to scale up



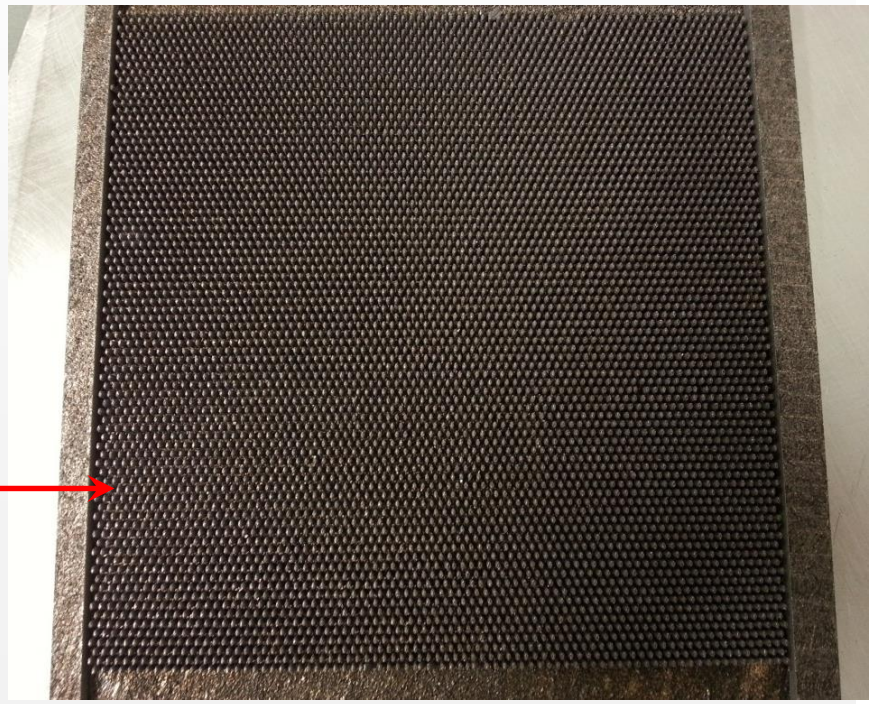
Microstructured Roughness



High Ra → increase efficiency



160 cm x 160 cm x 170 cm

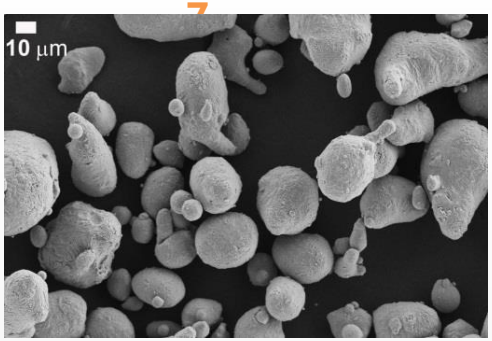


For each layer 6320 ellyptical fins

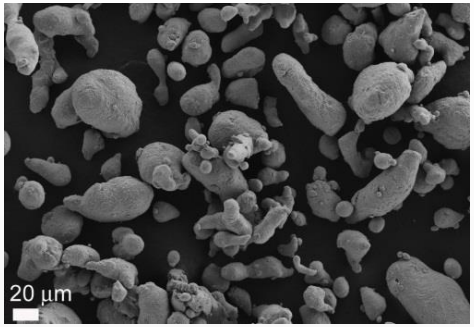
AM in Polito/iit DMLS machine

MATERIALS DEVELOPED @ CSHR

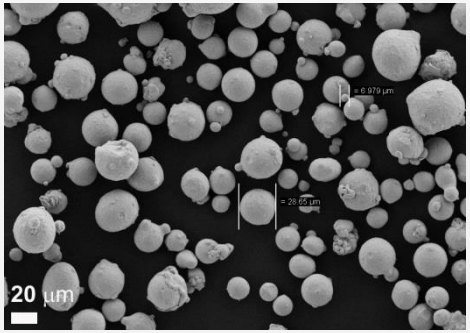
A35



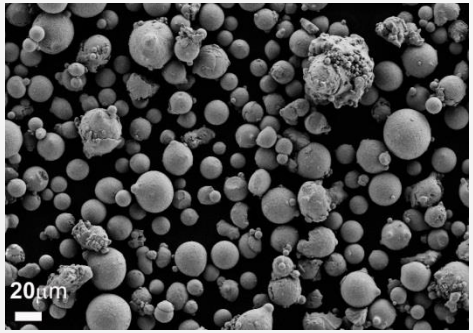
7075



In718



In625



MATERIALS TO BE DEVELOPED

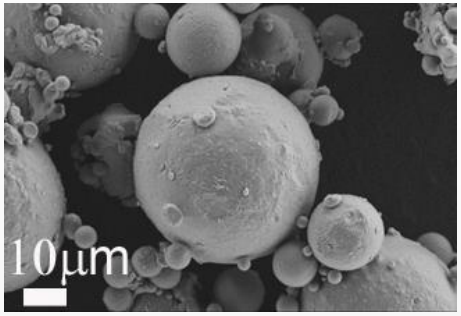
- Other Al alloys for aerospace (2xxx, 6xxx, etc)
- Other Al based Composites
- Ti based Composites
- Functional materials (e.g. SMA)

Way to composites

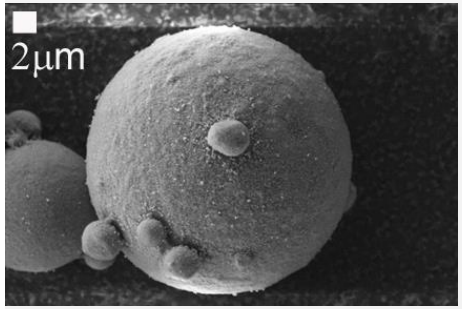
Aluminum powder + **Reactive ceramic powder** / **Inert ceramic powder** = ?

- Homogeneity
- Stability
- Flowability
- Densification parameter
- Reactivity control

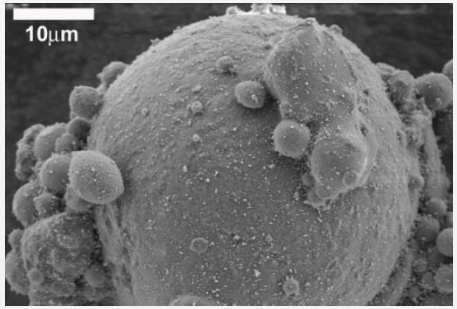
AlSi10Mg

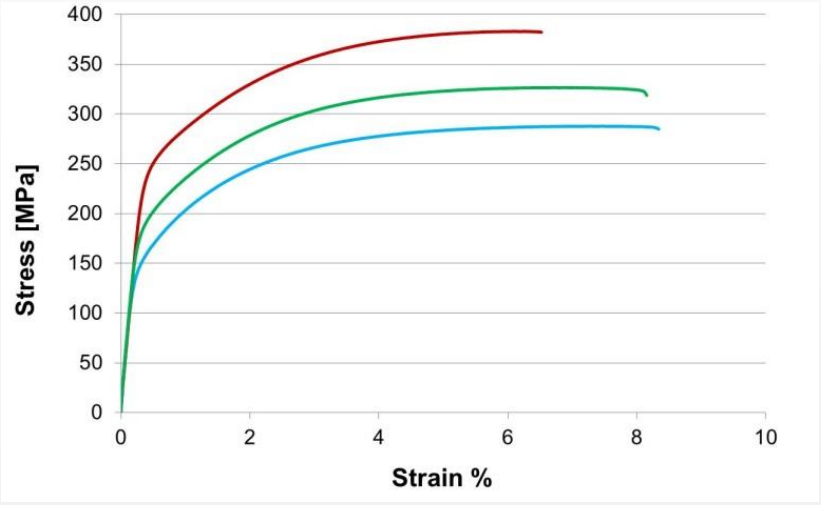


AlSiMg / nano$MgAl_2O_4$

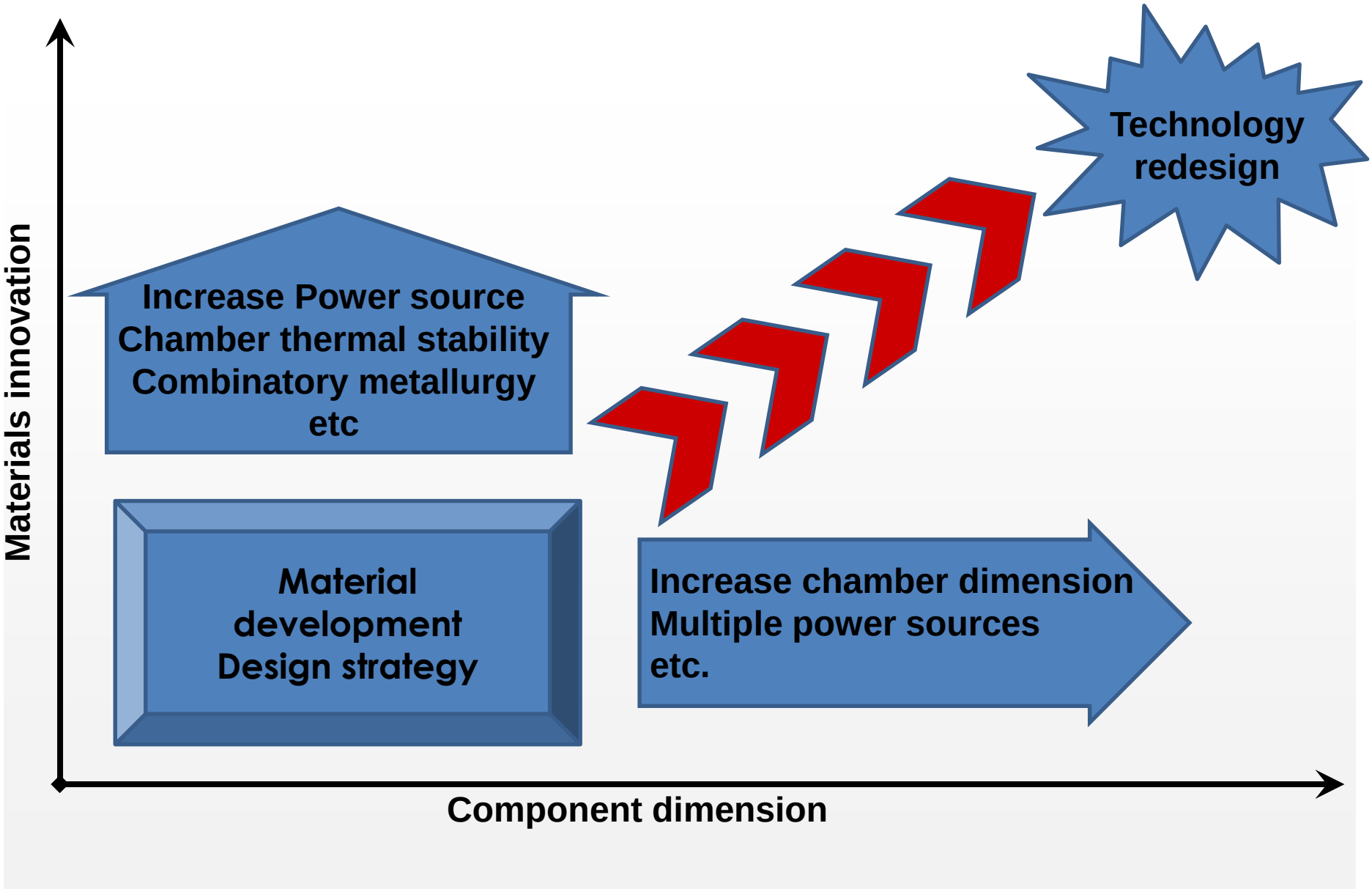


AlSiMg / nanoTiB_2

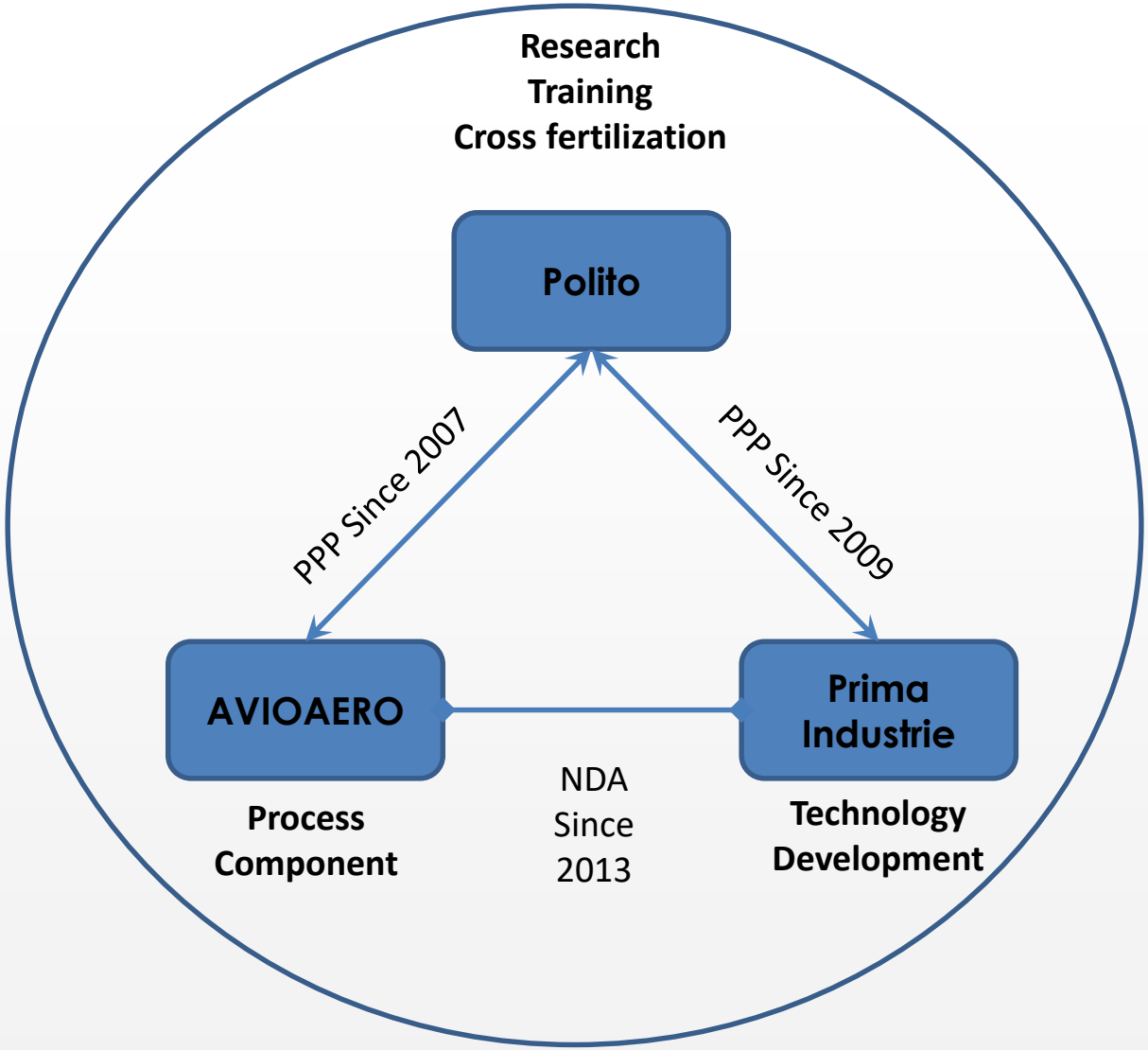




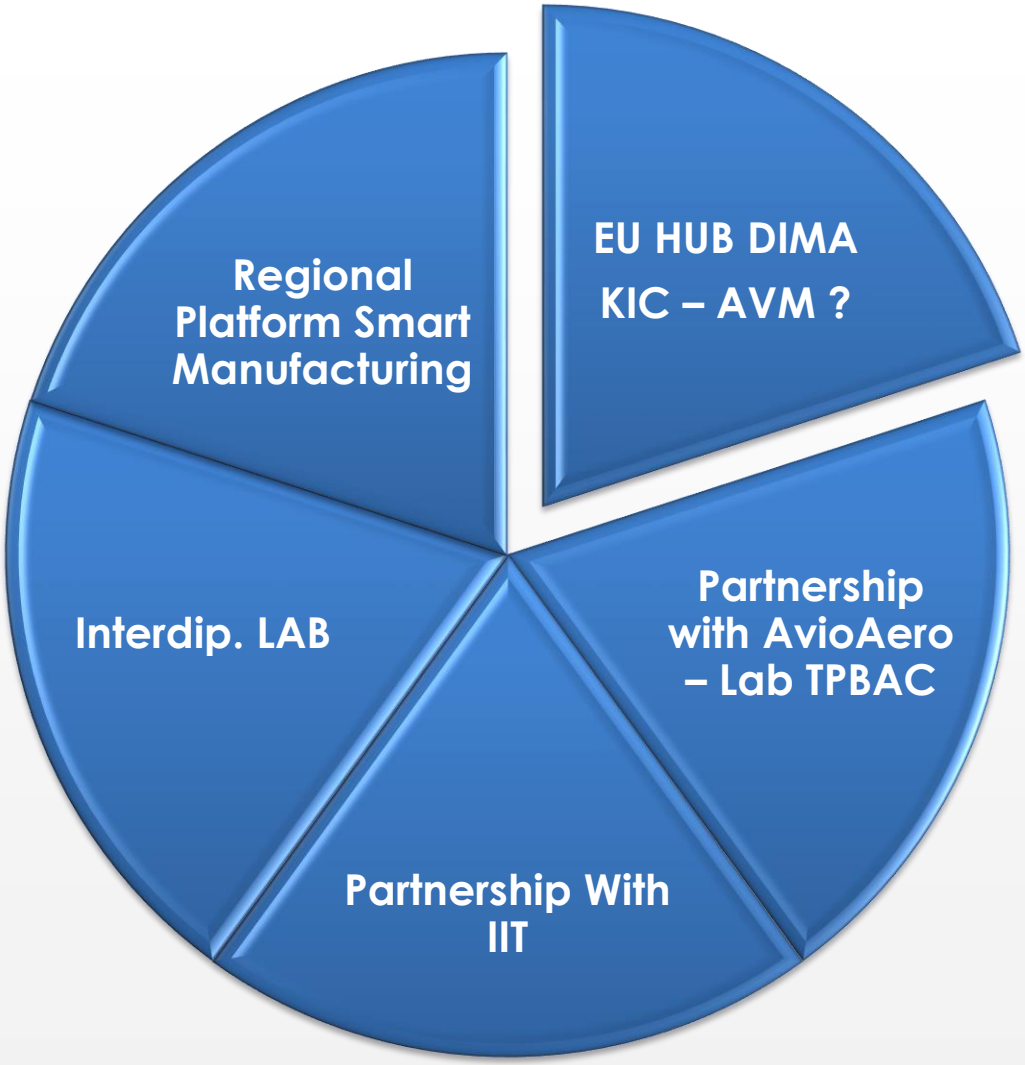
Strategy for the growth



PP Platform


Research
Training
Cross fertilization
Polito
PPP Since 2007
PPP Since 2009
AVIOAERO
Prima Industrie
Process Component
NDA Since 2013
Technology Development

Current Environment



To redesign the designer….

Corso di Laurea Magistrale in Ingegneria Meccanica: Orientamento in Fabbricazione Additiva

Titolo	CFU	SSD
Progettazione finalizzata alla FA con elementi di ottimizzazione topologica	10	ING-IND 13, ING-IND 14
Tecniche di FA e integrazione con i processi convenzionali	10	ING-IND 16
Materiali per FA e trattamenti termici	8	ING-IND 22

MASTER UNIVERSITARIO DI II LIVELLO IN "ADDITIVE MANUFACTURING"

INSEGNAMENTO	ORE	Ore Azienda	CFU
Progettazione per l'additive manufacturing	64	10	7
Materiali per l'additive manufacturing	44	10	5
Sistemi di l'additive manufacturing	60		6
Sensori per il controllo di sistemi di additive manufacturing	36	10	4
Intergrazione dei sistemi di additive manufacturing con i processi convenzionali	40		4
Sistemi di validazione dei prodotti realizzati con additive manufacturing	36	10	4
Programmazione e gestione della produzione integrata con i sistemi di additive manufacturing	16	10	2
La supply chain integrata con i sistemi di additive manufacturing	16	10	2
La piattaforma ICT dell'azienda che integra l'additive manufacturing con i processi convenzionali	16	10	2
Formazione manageriale (Skillab)	72	10	8
Project work		720	22
Totale	400	800	66

Progetto di Formazione - FONDIMPRESA

Avio Aero
A GE Aviation Business

PRIMA INDUSTRIE

POLITECNICO DI TORINO

Ellena

Skillab
CENTRO VALORIZZAZIONE RISORSE UMANE

IRIS

COMAU

2016: two multidisciplinary projects in the ASP educational programme (XII cycle), in which students of Politecnico di Torino and Politecnico di Milano may practice the process of envisioning, framing, planning and implementing innovation.

Finishing processes for additive manufactured metal components

Eleonora Atzeni, Alessandro Salmi, *Sara Biamino, Mariangela Lombardi*, Maurizio Vedani, *Luigi De Nardo*, Flaviana Calignano, Elisa Paola Ambrosio

The main objective of the project is the study and development of a surface finishing technology for improving the surface quality of the components fabricated by additive manufacturing.

Challenging 3D food printing

Monica Bordegoni, *Barbara Del Curto*, Francesca Montagna, *Paolo Fino*, Fabrizio Cassotta

The objective of the project is to analyse the potential use and impact of 3D printing in the food industry, investigating new possible printer configurations and architectures, new materials (mixtures) and printing processes, and also possible stakeholders and business models for new markets for Barilla.

Structural founding opportunity

POLITO and IIT are officially involved in
Metallurgy EUROPE - EUREKA

WORK PROGRAMS in H2020 INVOLVING
ADDITIVE MANUFACTURING

Future and Emerging Technologies (FET)

Enabling and industrial technologies (LEIT)

Information and Communication Technologies

Nanotechnologies, Advanced Materials (NMP, FoF),

Biotechnology and Advanced Manufacturing and Processing

Space

Innovation in small and medium-sized enterprises

Smart, green and integrated transport

KIC AVM - EIT

Projects

GREAT 2020 – GReen Engine for Air Traffic 2020 – Regional project (2009-2012).

ProTiAl – Developing of a new concept for optimal Production and machining of aerospace components in TiAl (2009-2012).

AMAZE – Additive Manufacturing Aiming Towards Zero Waste and Efficient Production of High-Tech Metal Products – UE Project, VII FP (2012-2015).

E-BRAKE – Demonstration of breakthrough sub-systems enabling high overall pressure ratio engine – UE Project, VII FP (2012-2015).

TiAl Charger – Titanium Aluminide Turbochargers – Improved Fuel Economy, Reduced Emissions – UE Capacities Project, VII FP (2012 – 2014).

EXOMET – Physical processing of molten light alloys under the influence of external fields – UE Large-scale integrating collaborative project, VII FP (2012-2015).

HELMET – Integrated High-Temperature Electrolysis and Methanation for Effective Power to Gas Conversion - New generation of high temperature electrolyser, UE Project, VII FP (2014-2016).

BOREALIS - the 3A energy class Flexible Machine for the new Additive and Subtractive Manufacturing on next generation of complex 3D metal parts – UE Horizon2020 Project (2015-2018).

GETREADY - HiGh spEed TuRbinE cAsing produced by powDer HIP technologY – UE JTI Cleansky (2014-2015)

GREAT 2020 phase 2– GReen Engine for Air Traffic 2020 – Regional project (2009-2012).

Cluster Aerospazio – Greening the propulsion – National project (2014-2017).

POP3D – Progetto ASI - Validazione del livello di maturità tecnologica di un sistema di fabbricazione additiva polimerica in microgravità per utilizzo a bordo della Stazione Spaziale Internazionale (2014-2016).

Several new proposal focused on AM tech under evaluation (Redemption, Ramlight, Lotsize1, Made in Nephos, Optimus, Levante).

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luca.iuliano@polito.it

POLITECNICO DI TORINO