ASSOLOMBARDA
Confindustria Milano Monza e Brianza

Innovazione nel settore delle leghe metalliche e dei relativi processi

Speaker
Maurizio Vedani

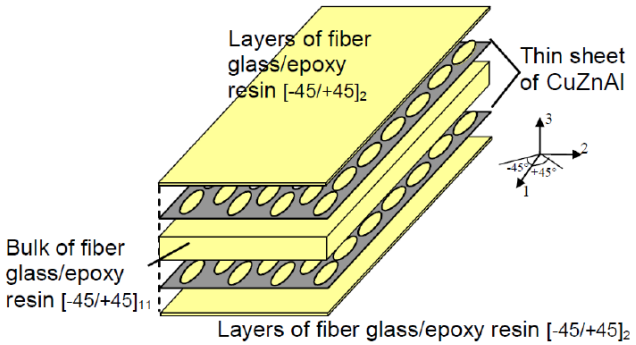
5 Luglio 2017

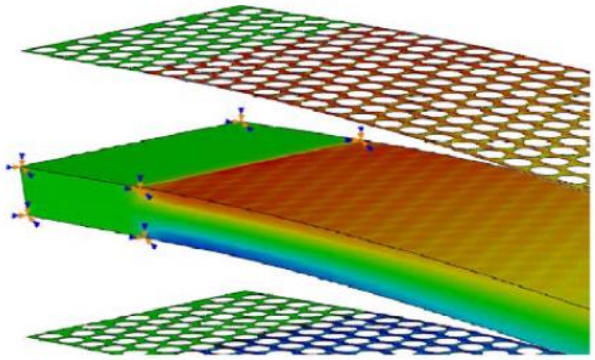
Politecnico di Milano, Dipartimento di Meccanica

Schema della presentazione

- ✓ Cosa vuole dire «nuovi materiali» nel 2017?
- ✓ Esempi di ricerche in corso sui «nuovi materiali»
- ✓ Sviluppi in ambito Industria 4.0
- ✓ Additive Manufacturing con i metalli
- ✓ Esempi applicativi e settori di maggiore interesse
- ✓ I materiali per AM e le loro caratteristiche
- ✓ Il laboratorio AddMe.Lab al Dipartimento di Meccanica

Research topic: Shape memory alloys / hybrid materials





SMA for passive/semi-active suspension

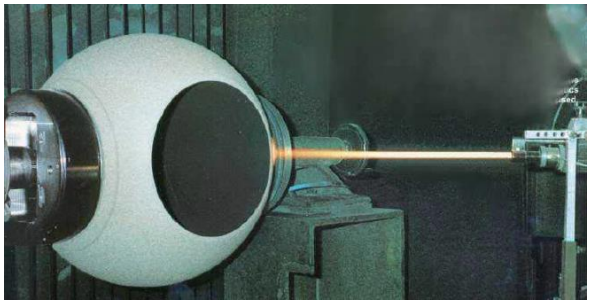
- High damping capacity of SMA (esp. low cost Copper-based alloys)
- Embedding of the damping element into a polymer composite structure ensuring stiffness and low weight
- Other similar opportunities offered by the embedding of sensors into composites or even into metals (more challenging)

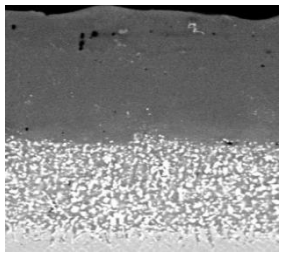
Research topic: composite-metal hybrid materials

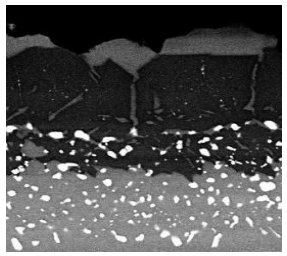
Synergy between CFC and metals for complex systems

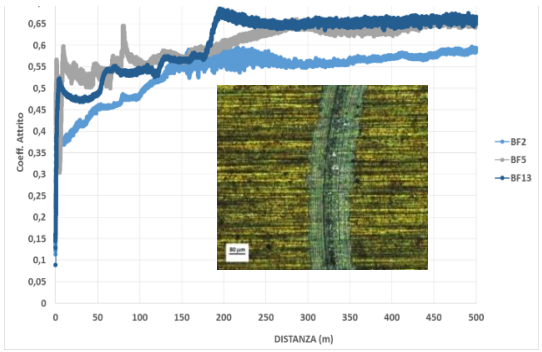
- Challenges in joining the two dissimilar materials with functional interfaces
- Embedding of inserts in the composite structure, allowing strong linkage to complex structure

Research topic: Surface coatings





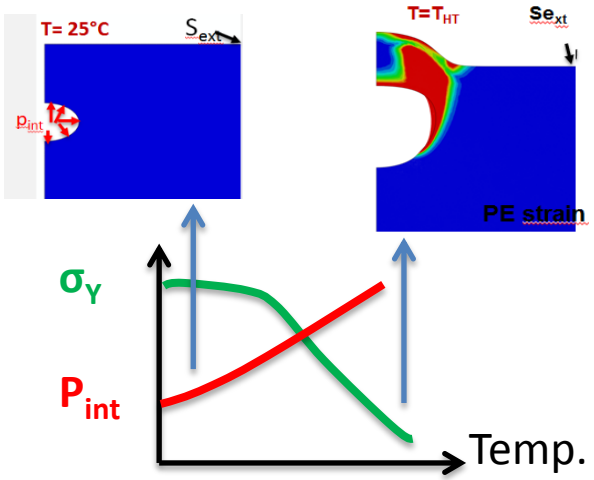


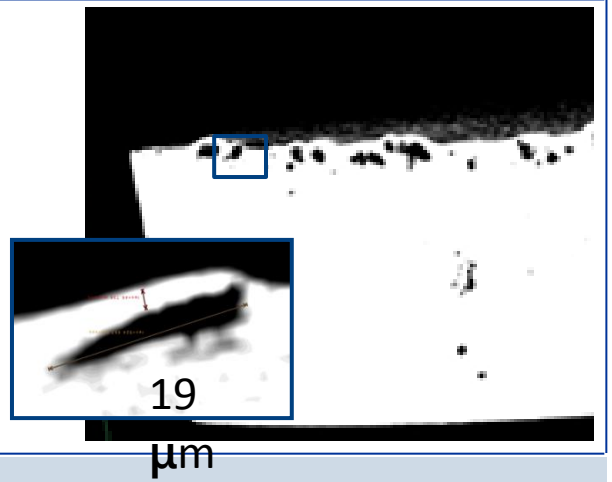


Coatings for improved service performance, control of friction and optimization of lubrication

- Thermal Spray coatings for increased-temperature applications (WC-Co-Cr, Cr_3C_2-NiCr)
- Diffusion coatings for very high-temperature service (e.g. aluminized layers on Ni-based superalloys)
- Low-friction PVD ceramic coatings (around 5μm thickness)
- Laser surface texturing for improved lubrication

Research topic: Light alloys





Optimization of heat treatments for diecasting parts

Surface degradation due to development of blisters from pressurized defects during heat treatment or high-temperature service (simulation & experimental)

Modification of Al casting alloys to improve thermal stability

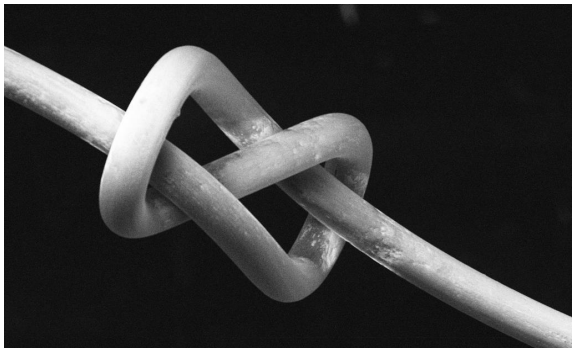
New alloys were developed by adding minor amounts of rare earth and transition elements to an A356 Al-casting alloy, causing the formation of stable strengthening dispersoids

Research topic: biodegradable metals

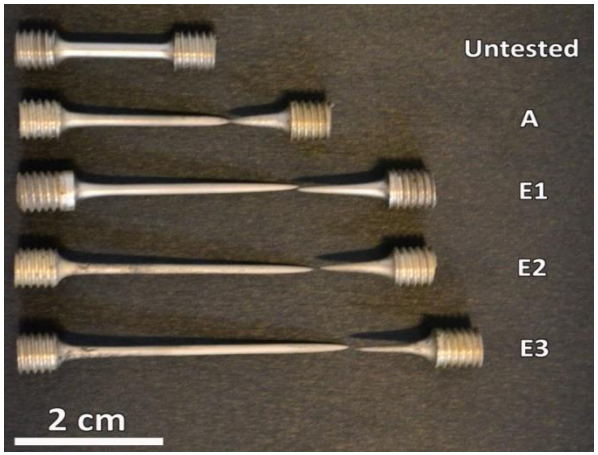
Development of metal alloys for the design of biodegradable devices

devices to be implanted in human body and fulfill their function for a defined period of time, then dissolve by corrosion without releasing toxic agents (e.g. vascular stents, orthopedic devices, wire for sutures)

- Mg-based and Zn-based alloys are specifically developed
- Selection of alloying elements is limited to ingredients that are non-toxic Mg, Zn, Mn, Ca, Ag, …)



Research topic: thermo-mechanical processing of alloys

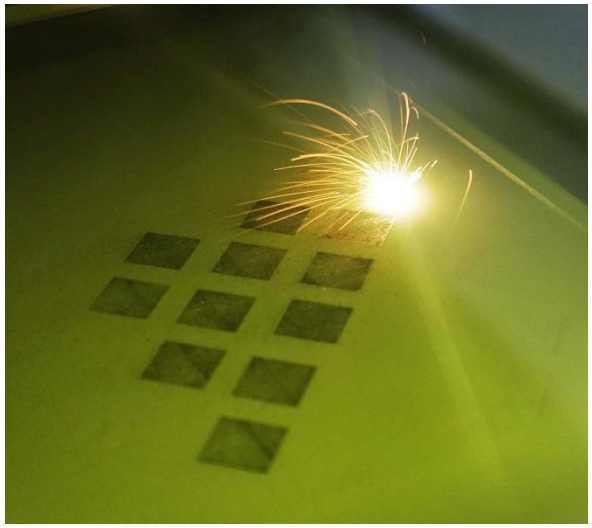


Manipulation of grain structure to achieve superior properties

- Severe plastic deformation is used to reduce grain size in the sub-micrometric or nanometric range and to reduce possible harmful crystal texture effects
- Tuning the temperature during further processing allows exploiting improved formability (e.g. superplastic formability) and keep the refined structure in the final product

In the picture A is a standard ZK60 Mg alloy, while E3 is the same alloy processed to reduce the grain size below 0,5 μm, attaining a fracture elongation exceeding 300%

Research topic: metallic alloys for Additive Manufacturing

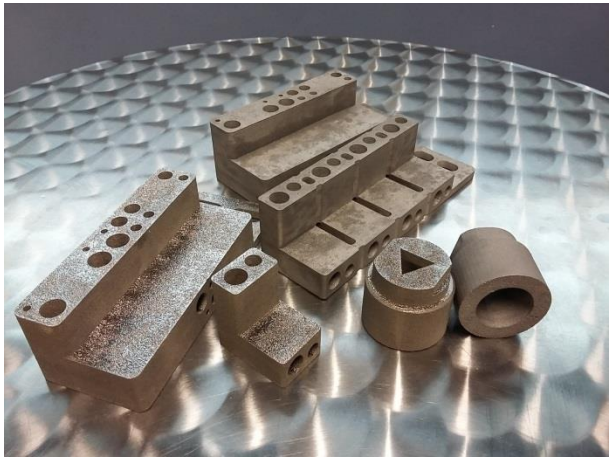


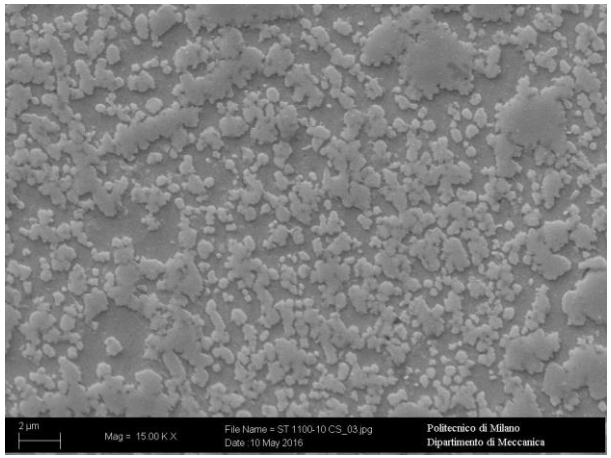
Development and characterization of parts produced by selective laser melting

Development of prototypes printed by SLM exploiting opportunities offered by weight reduction, complex shape and new functions

- Steels, high-strength steels, Al alloys, …
- Material and part characterization

Research topic: metallic alloys for Additive Manufacturing

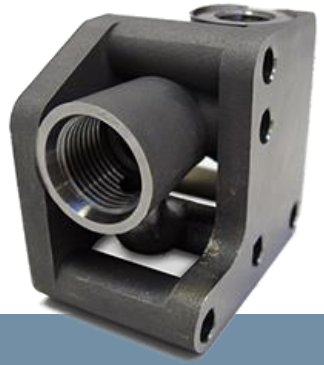




Tools and tool steels optimized for selective laser melting processing

New opportunities offered by additive manufacturing in the tooling and hydraulic sectors (free complexity, conformal cooling channels, …)

- Investigation on surface modification of internal cooling channels
- Development of hard and processable steels by a combination of carbides and borides in a ductile austenitic matrix



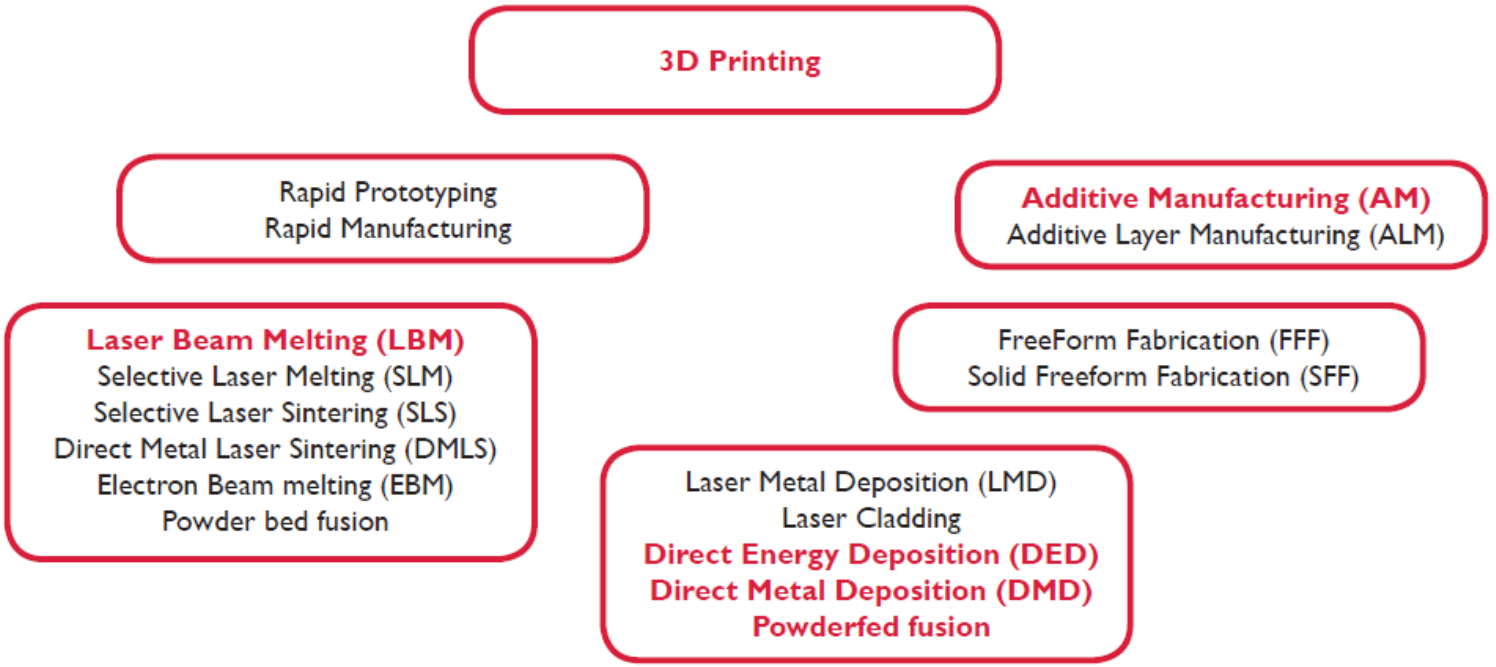
Additive Manufacturing e Industria 4.0

Diverse voci tra le tecnologie abilitanti offrono opportunità di sviluppo in ambito «materiali e processi inteligenti»:

- ✓ Advanced manufacturing solutions (additive per deposizione diretta o sistemi ibridi)
- ✓ Additive manufacturing (controllo dei processi, nuovi materiali e regole di progettazione)
- ✓ Simulation + Horizontal/Vertical Integration (progettazione già in ottica AM, proprietà nell'utilizzo, fino allo smaltimento a fine vita)
- ✓ Industrial internet (monitoraggio processi e sensorizzazione prodotti per un migliore controllo in produzione e nell'utilizzo)

Additive Manufacturing

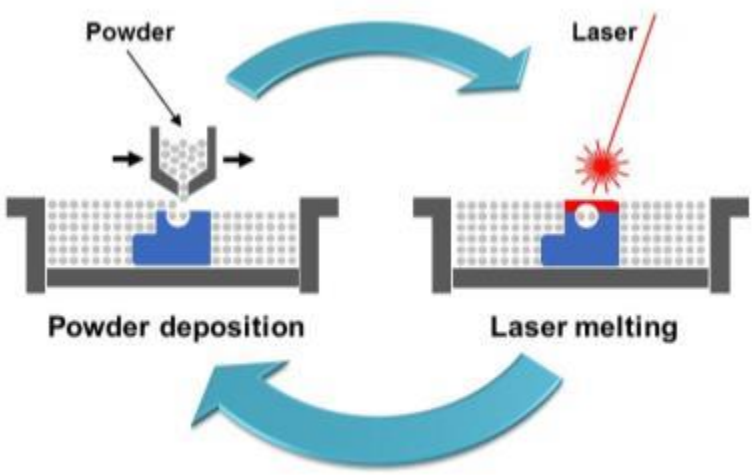
Additive Manufacturing / 3D printing / stampa 3D / Fabbricazione Additiva / ...

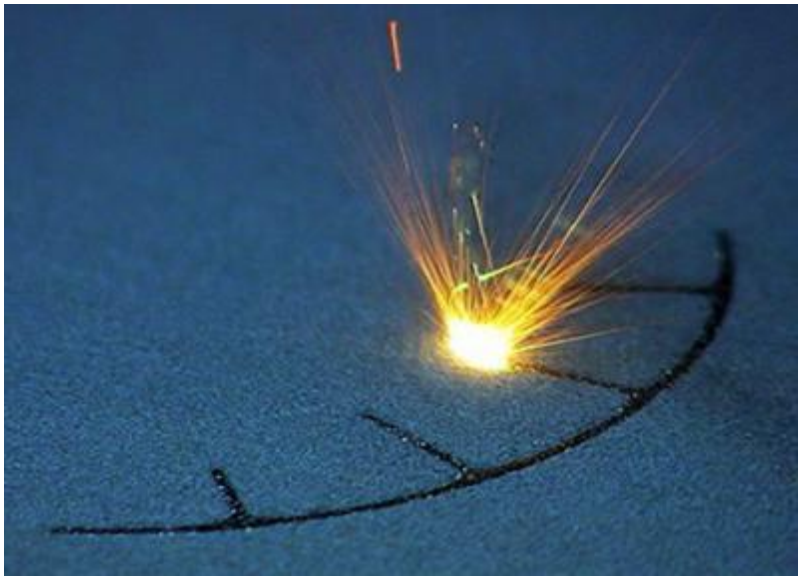


The vocabulary of Additive Manufacturing. In red, most common of standardised vocabulary

Additive Manufacturing – Selective Laser melting

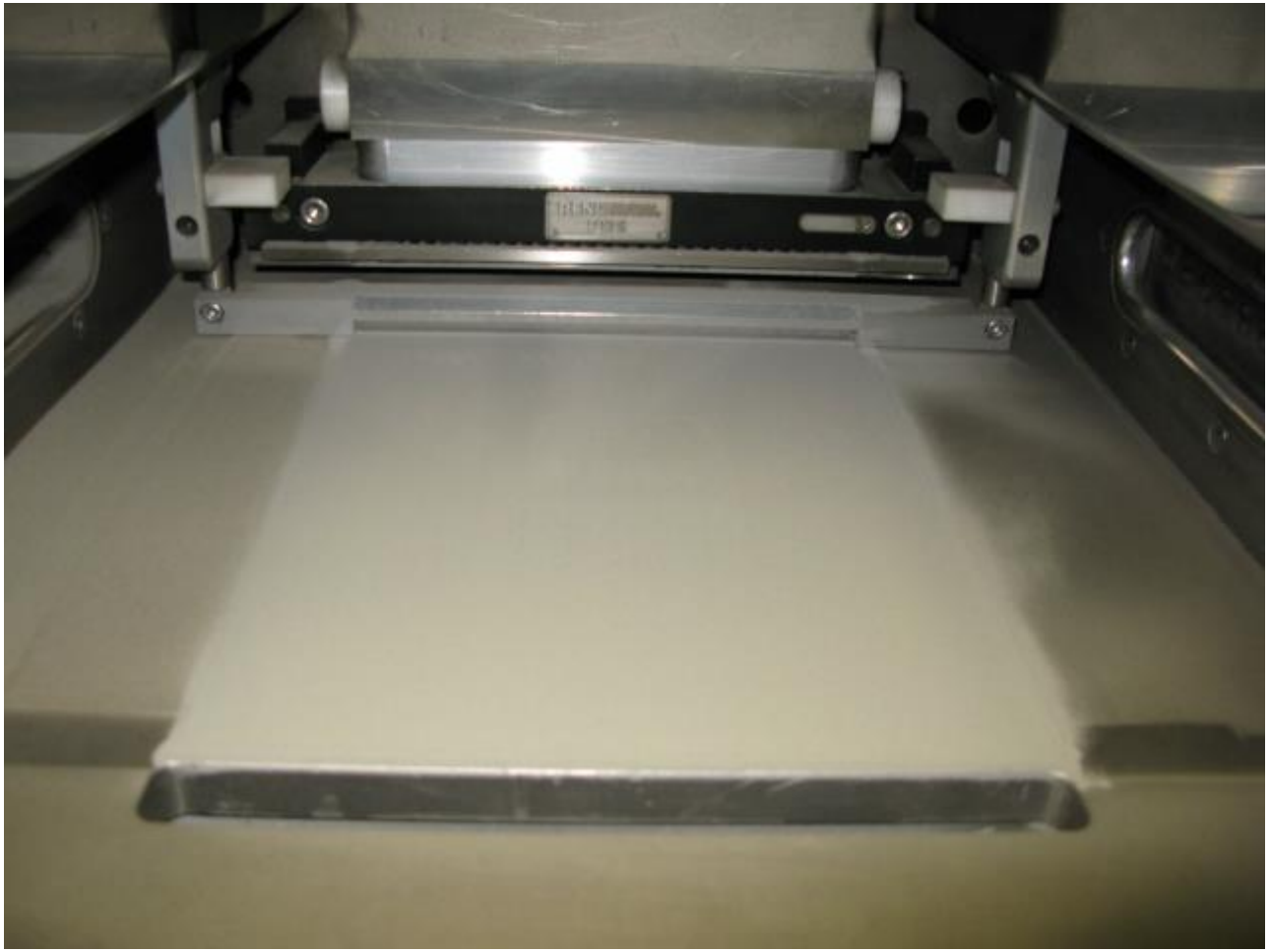
- ✓ La polvere viene consolidata attraverso un fascio laser che esegue una scansione su un'area localizzata (Selective Laser Melting)
- ✓ Il processo viene ripetuto per un numero molto elevato di strati successivamente sovrapposti per generare una forma 3D
- ✓ La deposizione del letto di polvere e la rifusione localizzata avviene in una camera protetta



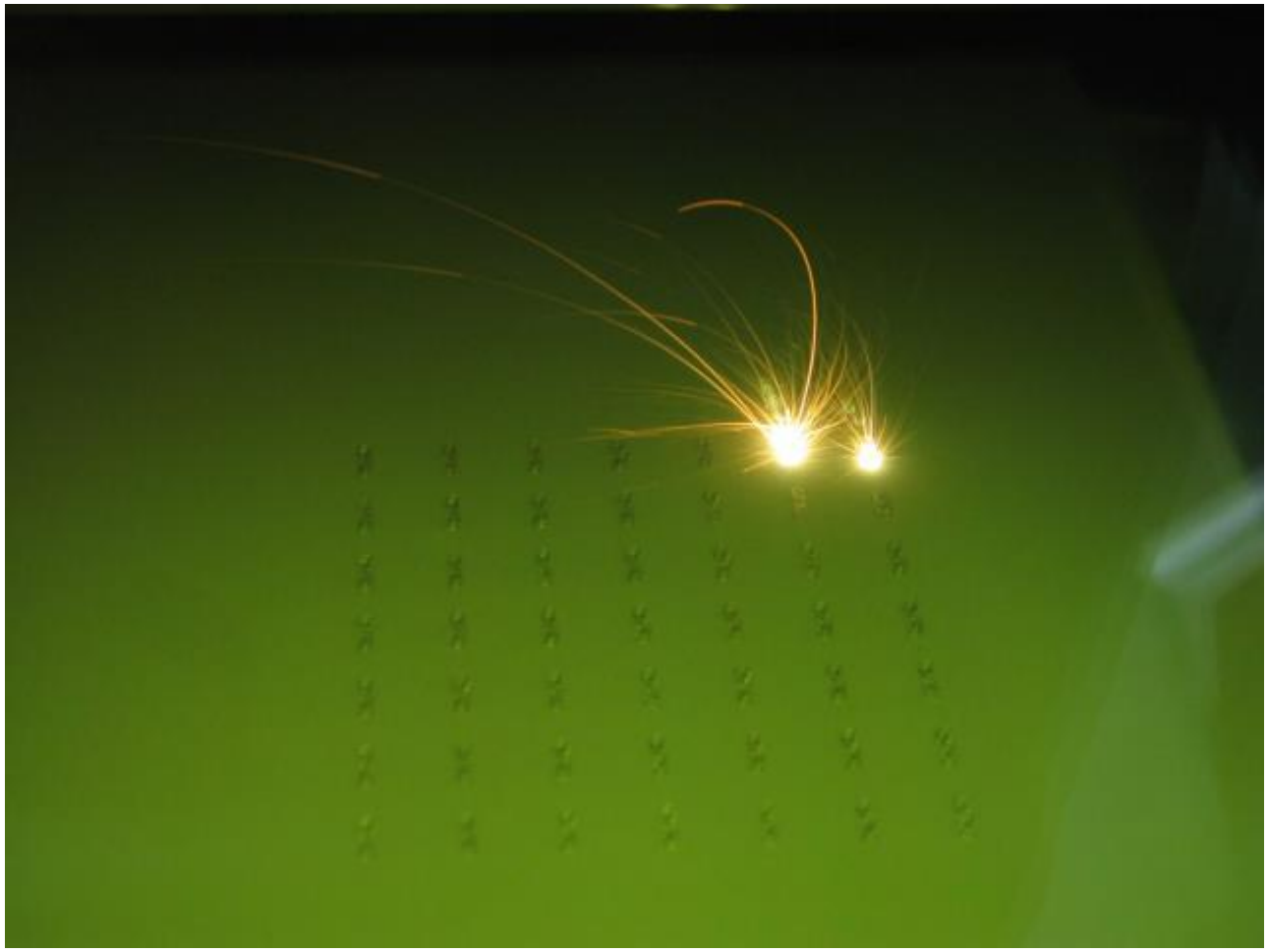


Ref: www.ge-energy.com

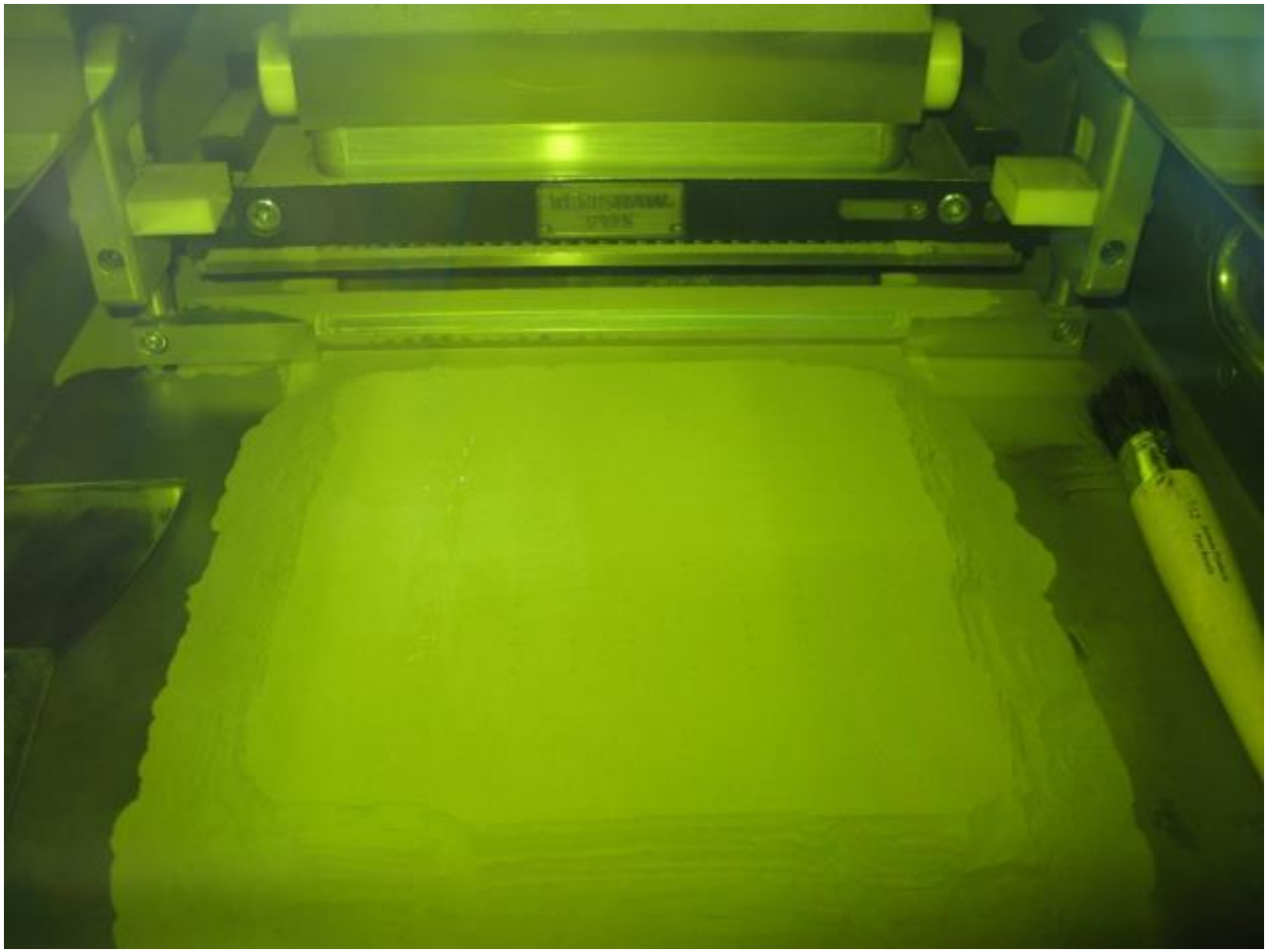
Le principali fase del processo SLM (1/5)



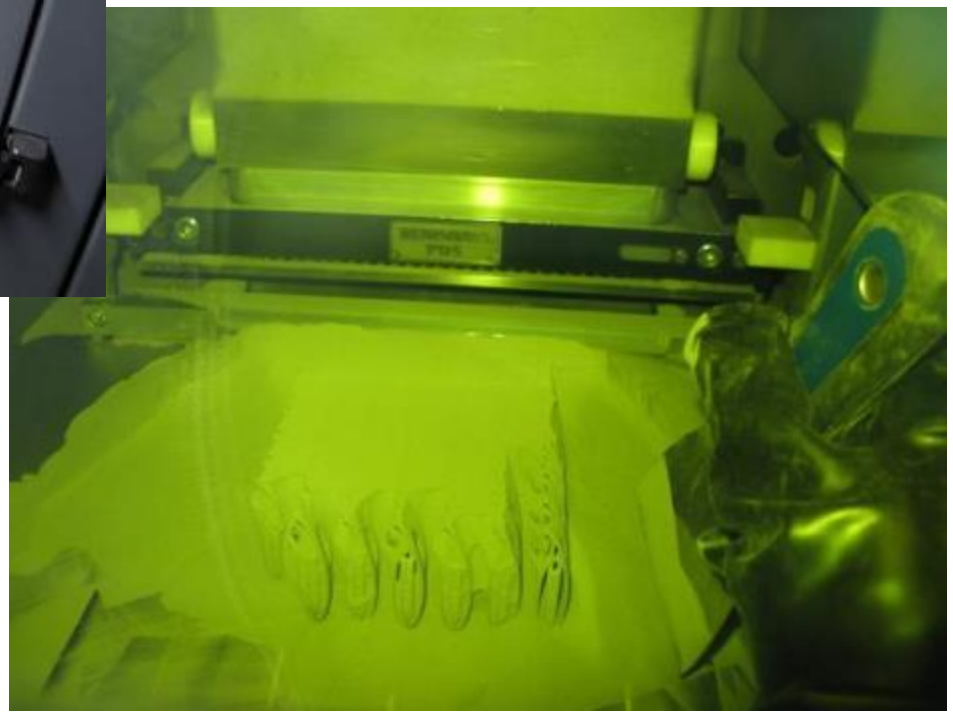
Le principali fase del processo SLM (2/5)



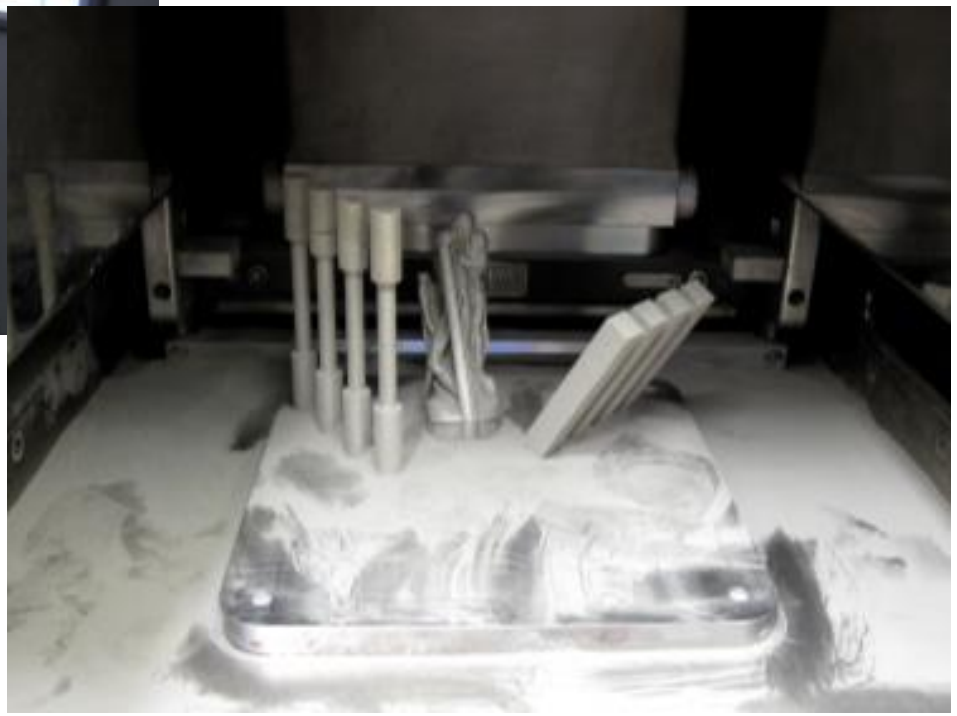
Le principali fase del processo SLM (3/5)



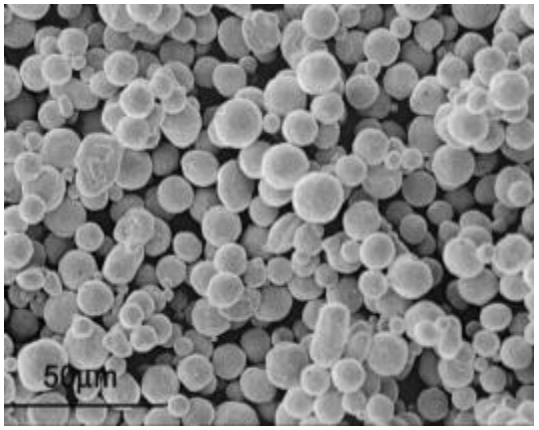
Le principali fase del processo SLM (4/5)

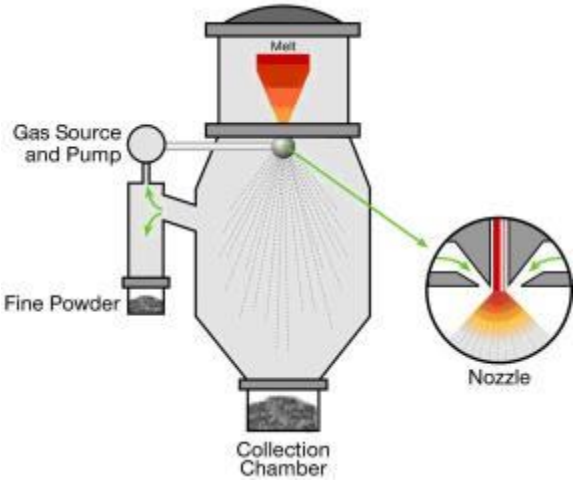


Le principali fase del processo SLM (5/5)



Polveri di leghe metalliche per SLM





- ✓ Le polveri vengono prodotte per atomizzazione in gas, ricercando una forma sferica delle particelle che ne permetta la buona scorrevolezza e dimensioni molto fini
- ✓ Vengono poi setacciate per utilizzare solo una finestra dimensionale piuttosto ristretta centrata attorno ad un valore medio di 30-40 μm
- ✓ Commercialmente sono disponibili diverse leghe in adatta forma di polveri: sono però composizioni di materiali tradizionali, non specifici per AM

Influenza del costo polvere

Le polveri sono piuttosto costose ma non incidono poi molto sul costo del prodotto, soprattutto per particolari complessi che altrimenti andrebbero lavorati per asportazione, in ottica «buy-to-fly» ratio

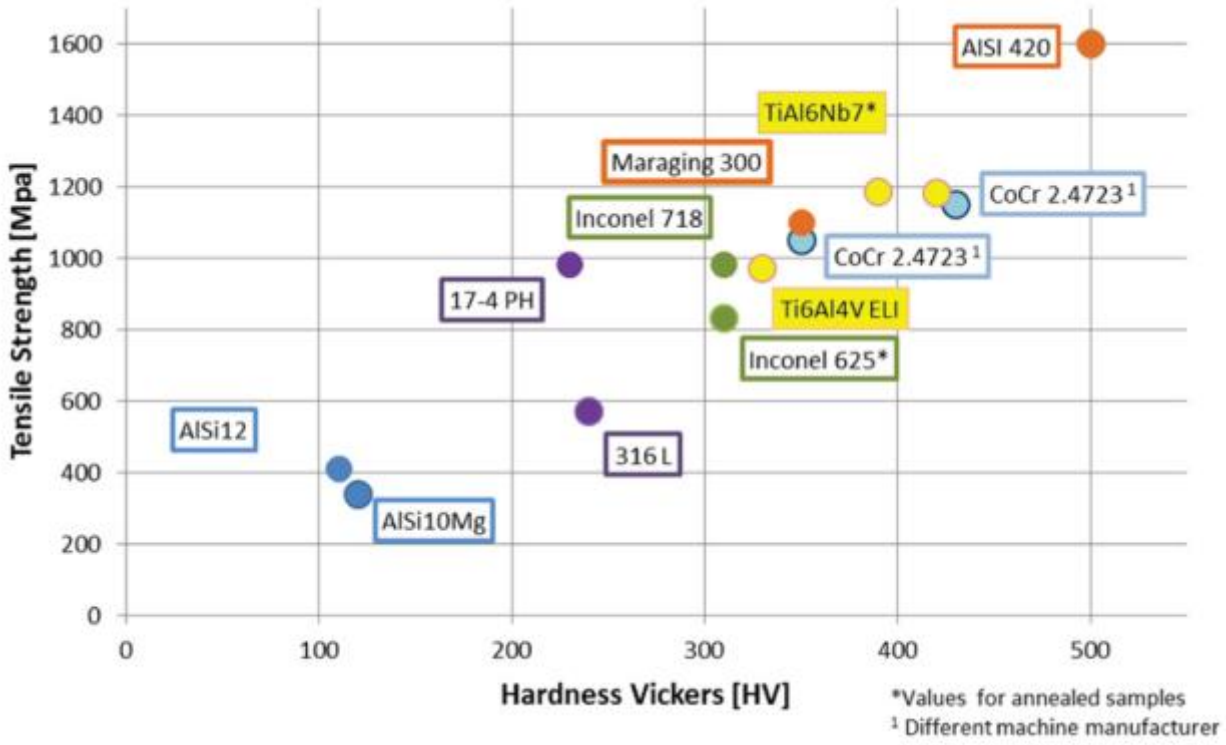
Billetta (20kg) → Asportazione (19 kg) → Pezzo finale (1 kg)

Processo standard per asportazione di truciolo, ampio scarto di materiale

Polvere (20kg) → Ri-utilizzo polvere (≈99%) → Pezzo finale (1 kg)

Processo AM con riutilizzo della polvere non consolidata, elevatissimo rendimento del materiale

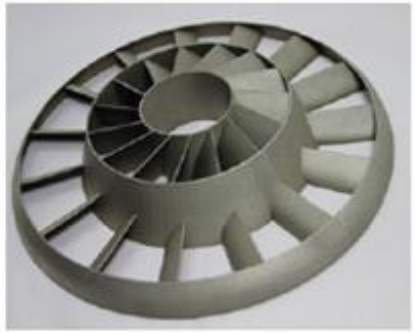
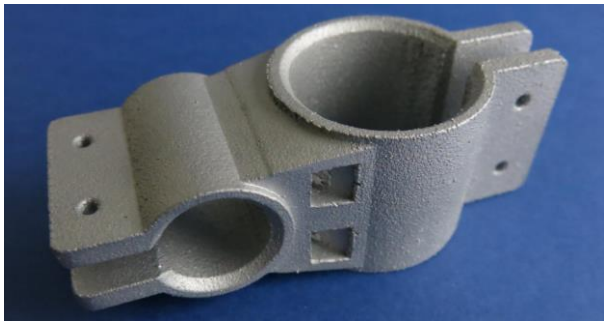
Polveri di leghe metalliche per SLM



Materiali processabili per SLM (in prima approssimazione):

- ✓ Leghe tradizionali da fonderia, leghe saldabili
- ✓ Leghe a matrice sufficientemente duttile (a caldo) che non induriscono molto con un raffreddamento rapido

Campi di applicazione: aerospazio, motorsport, attrezzature sportive

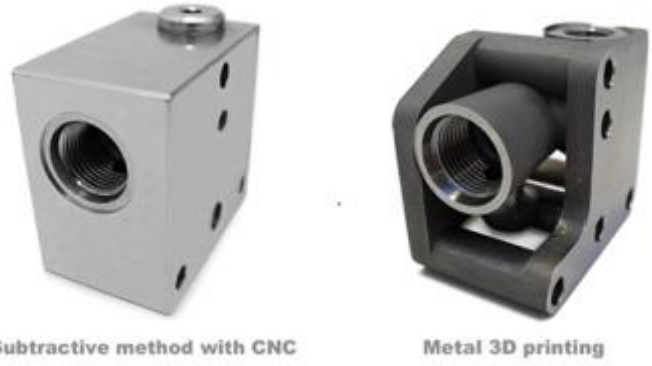
- ✓ Strutture leggere e ad alta resistenza
- ✓ Design attraverso ottimizzazione topologica
- ✓ Alleggerimento attraverso lattice 3D

Campi di applicazione: automotive, trasporti, industriale

- ✓ Sviluppo di prototipi e produzioni in serie limitate
- ✓ Forme complesse (e.g. scambio termico, collettori, scarichi)
- ✓ Elementi alleggeriti

Campi di applicazione: stampi, inserti, componenti idraulici

Source: HRS Flow - http://www.etmm-online.com



Source: Aidro Hydraulics- www.aidro.it

- ✓ «Complexity comes for free» per stampi con figure complesse
- ✓ Implementazione di canali interni sagomati (conformal cooling) per ottimizzare il condizionamento termico
- ✓ Canali con forme meglio raccordate per limitare le perdite di carico

Campi di applicazione: medicale

Dental Bridge

Acetabular cup for HIP implant

Cranial Implant

Surgical Guide

- ✓ Dispositivi creati «su misura» per ogni paziente
- ✓ Strutture porose per facilitare l'osteo-integrazione

Campi di applicazione: gioielli & design

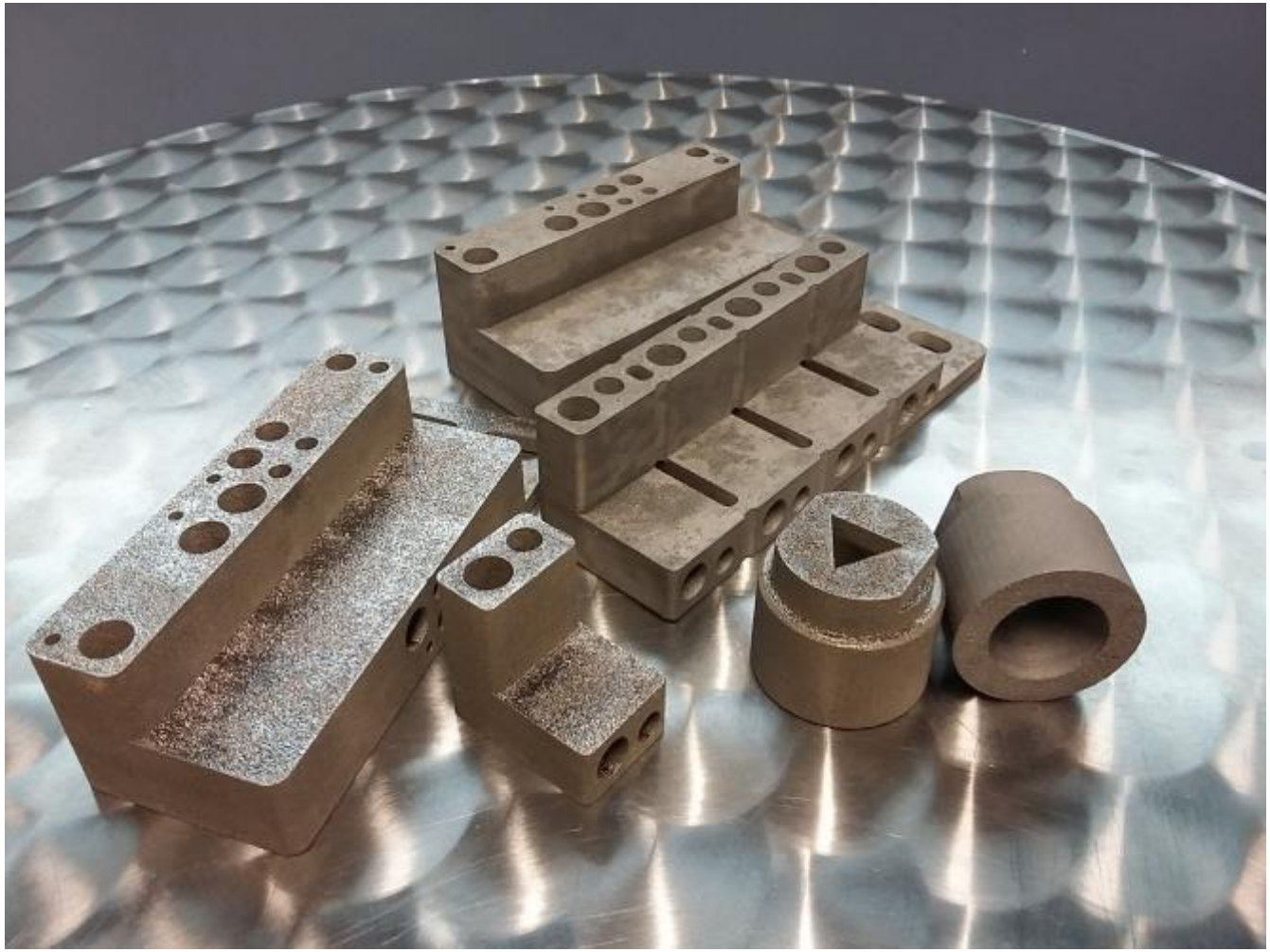
Jewels

Towe Bracelet

Design

- ✓ Libertà nell'ideazione delle forme, (quasi) senza vincoli tecnologici
- ✓ Possibilità di creare forme cave, risparmiando metallo e peso

Qualche caso studio



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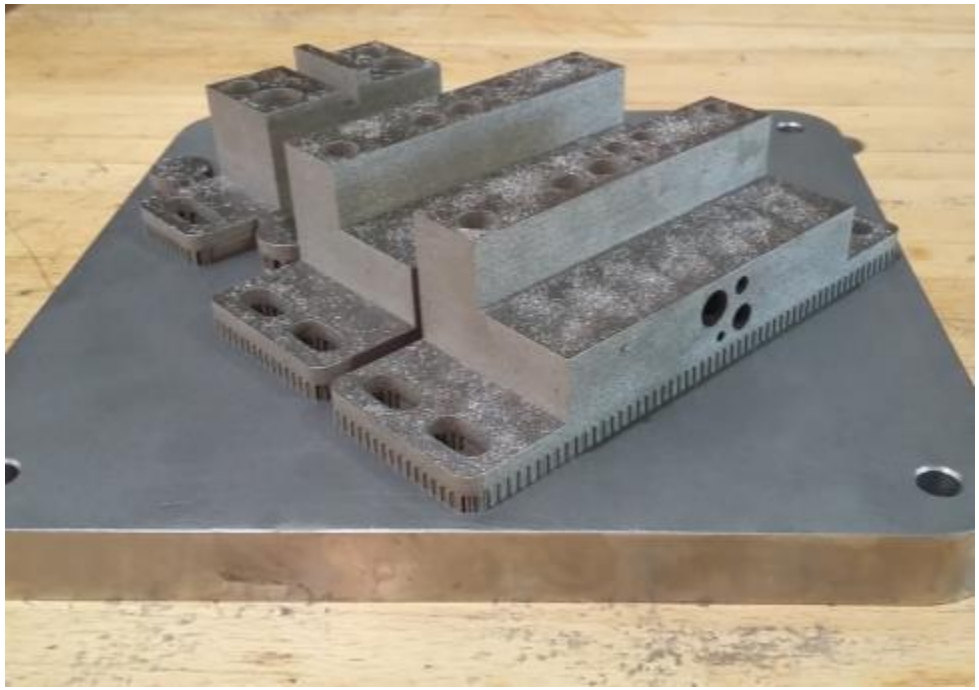
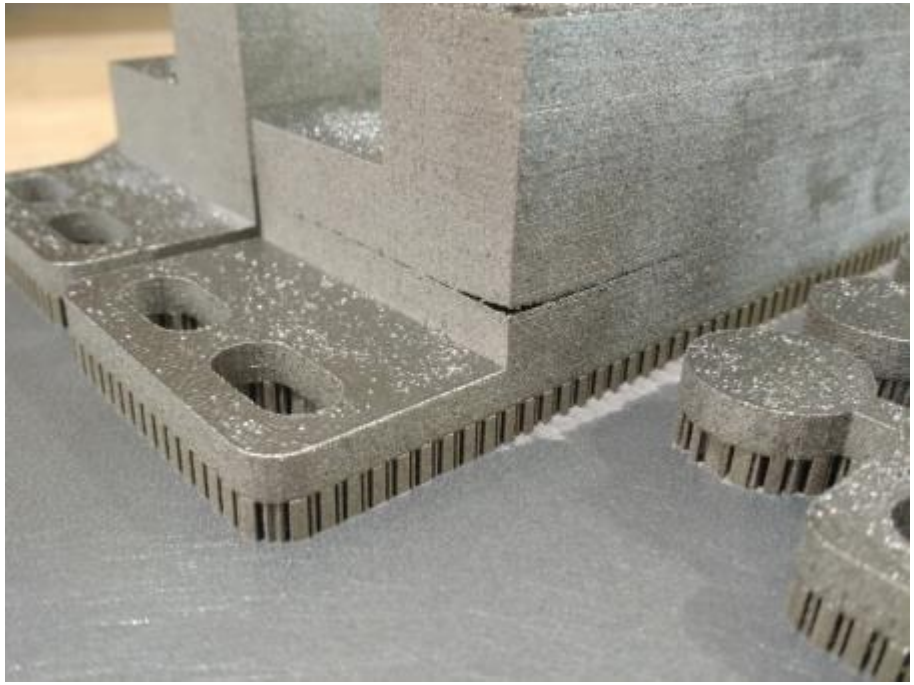
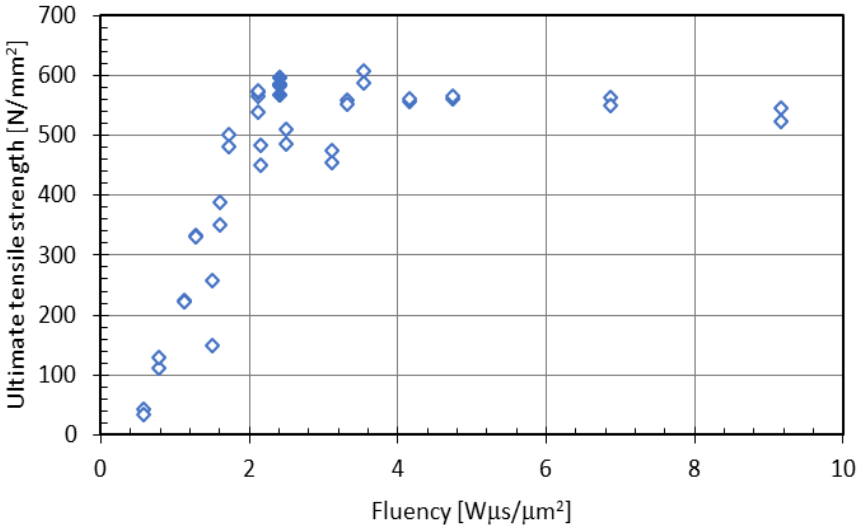


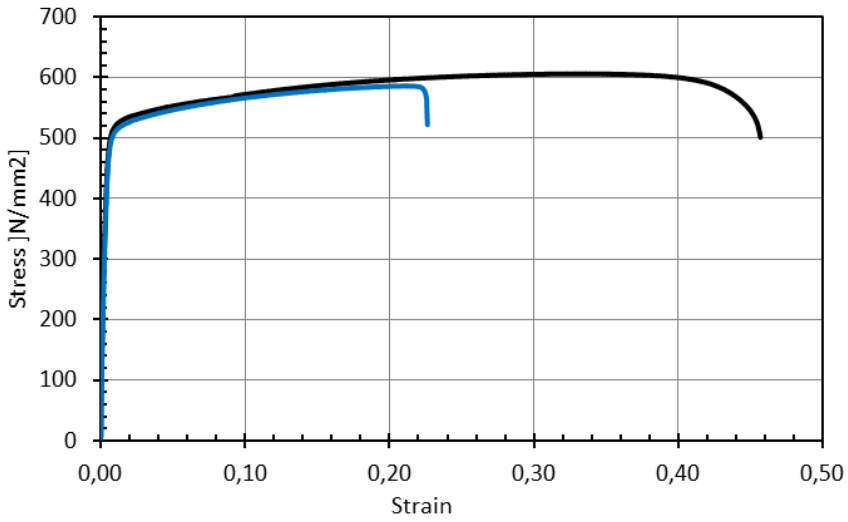


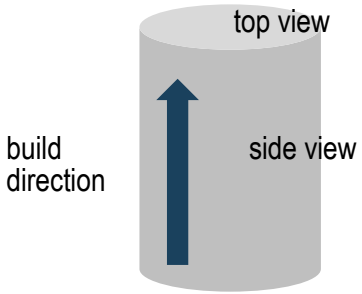
Qualche caso studio

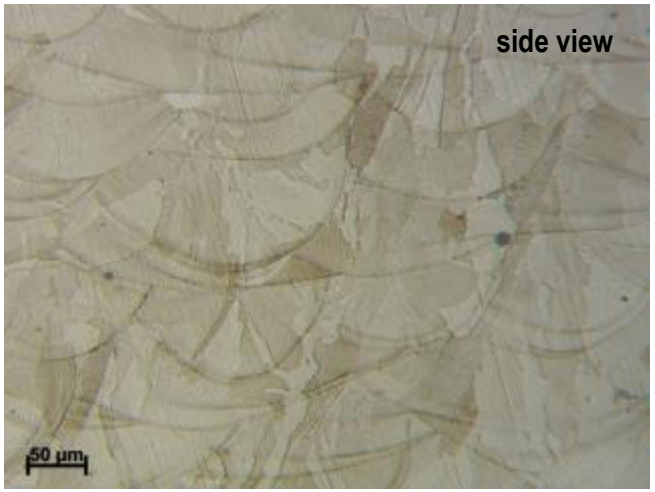
Proprietà di alcune leghe dopo processo SLM

Acciaio AISI 316L: caratteristiche e influenza dei parametri del processo



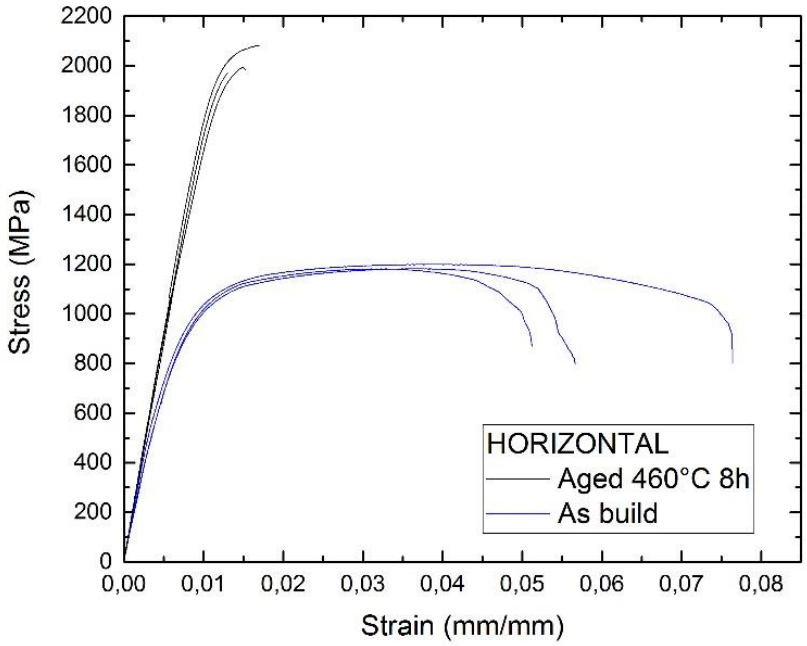


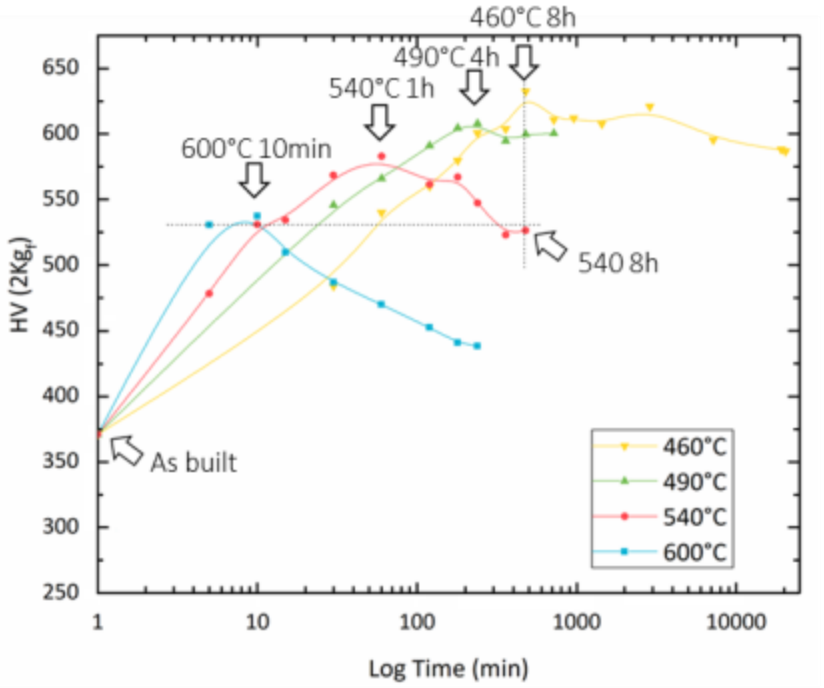




Proprietà di alcune leghe dopo processo SLM

Maraging 300Ni18 (EN 1.2709): caratteristiche ed effetto del trattamento termico dopo SLM





- ✓ Trattamento termico standard: solubilizzazione a 815°C + invecchiamento a 460°C
- ✓ Dopo SLM: niente solubilizzazione, possibilità di regolare quantità di austenite e durezza

AddMe.Lab @ Dipartimento di Meccanica

Inizio 2015: installato un sistema SLM Renishaw 250 come fulcro di un laboratorio per la produzione additiva di parti metalliche, insieme con diversi partner industriali

BLM GROUP

MARPOSS

Titalia

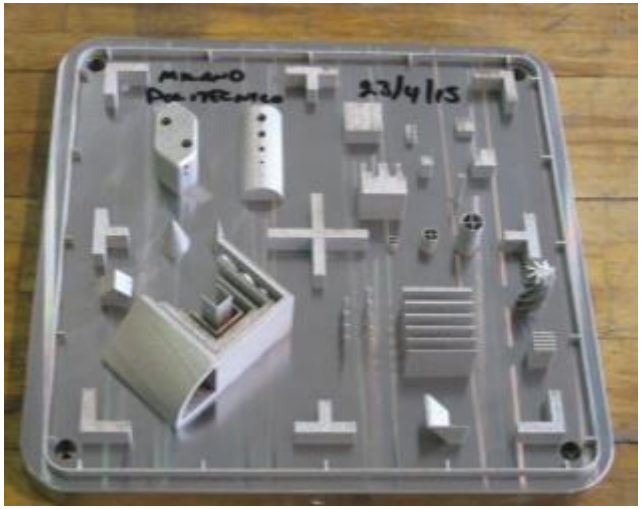
Maspero

SAPIO GRUPPO

Regione Lombardia

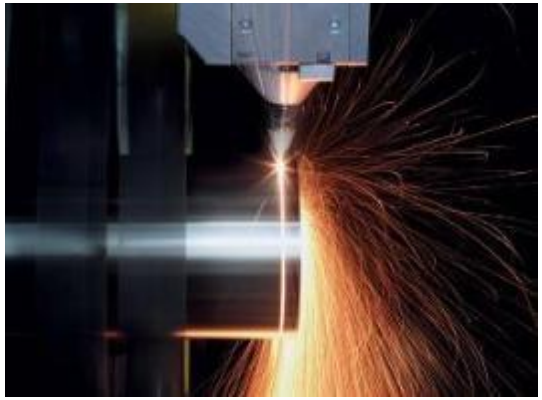
AddMe.Lab @ Dipartimento di Meccanica

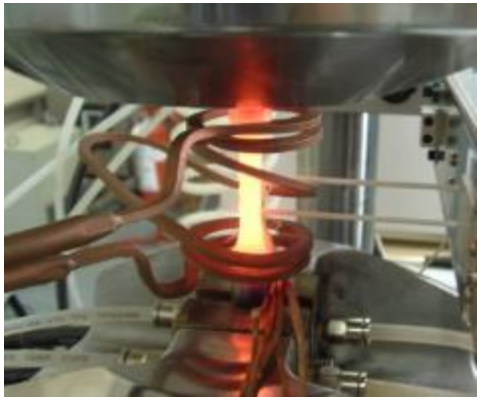
- ✓ Selective laser melting mediante un sistema Renishaw AM250



AddMe.Lab @ Dipartimento di Meccanica

- ✓ sistema 3D X-Ray CT-Scan microtomography (NSI 160 kV installazione 2015 – Laboratorio interdipartimentale PoliMi)
- ✓ laboratori per la ricerca sui materiali, di metrologia, tecnologia dei processi, ….





Grazie per la cortese attenzione

maurizio.vedani@polimi.it
www.addmelab.polimi.it
www.mecc.polimi.it

Il progetto AddMe.Lab è stato sviluppato con il contributo di Regione Lombardia