METAL ONE

DLMS 3D PRINTER
HANDBOOK



SHAREBOT

Introduction

MetalONE is a DMLS (Direct Metal Laser Sintering) 3D printer specially designed to bring companies and the world of research and education closer to metal 3D printing with a limited budget.

DMLS is one of the most advanced technologies that will revolutionize the mechanical sector in the future.

Another peculiarity of metalONE is that thanks to a smart design, it has been possible to control the costs and therefore to realize a 'democratic' project accessible not only to large companies but also to company and educational world with low budgets.

Not only the printer cost is accessible but most important spare parts and consumable are affordable as they are standard and can be found locally.

metalONE is open, it means that all the process parameters are available to the user and in addition it uses a standard and open language (Gcode) for defining the laser paths.

All that and the low quantity of powder required to start building test allows researcher the to test their own powders and alloy.

metalONE can use Nitrogen or Argon as inert gas for the process.



Features

Printer build area	65x65x100mm | 100 x100 x100mm
Printer dimension	74x63x100cm
Weight	~270kg
Laser	300W fiber (1070nm) available also with 500W or 1kW
Spot dimension	>50nm
Lens	f-Theta
Beam delivery	Galvanometer
Scan speed	up to 3m/s
Minimum layer Z	> 20micron
Inert gas	Nitrogen / argon
Gas consumption	~4 l/min
Object format	Gcode

Special features

Open parameters

Test mode for a fast parameters search

Laser paths in open and editable format

** Sharebot reserves the right to change equipment specifications without notice.*

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Unique characteristics

- Start a job in less than 15 minutes
- Test your alloy starting with just 1kg powder
- Open parameters
- Clean and change the powder in hours not days
- Easy to clean
- Open platform
- Focus modifiable
- Remote control
- Gcode object format
- Slicer: Simplify3d / Cura



Materials printed up to date

316L	Steel
Ti64	Titanium
CrCo	Cobalt chrome steel
CuCrZr	Copper alloy
Cu	Pure copper
AlSi	Aluminum
BRZ	Bronze

Special development

We consider our metalONE a development platform as we have complete control on both hardware and software, so we are open to discuss special solutions to fulfill the needs of our users.

Accessories

The typical set of accessories for a metal 3D printer is:

Powder sieve

Vacuum cleaner

Die grinder

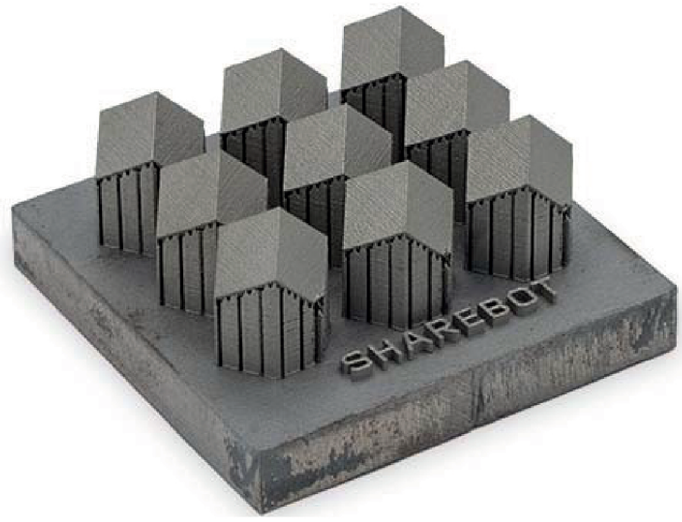
Sand blaster

If a heat treatment is required to achieve the right proprieties a furnace is required.

Note: accessories can be very different depending on powders or alloy you are using.

Software

All the basic required software is included with the machine. You can slice your own .stl objects and start printing the just after finishing the training program.



Guidelines

The design of parts for metal printing is different from other additive technologies so some design guidelines needs to be followed.

One of the main problems is the creation of the supports as for this technology they have different functions:

1- keep the molten material in place

2- anchor the object to the construction plate

3- dissipate the heat generated by the process

Support generation

We had good results using Fusion 360 using the functions dedicated to generate support for laser metal printing and exporting the resulting supported structures as a single stl file.
Other programs like Netfabb, Magix and Materialize can be used to generate the support structures, they may require a tool to convert the resulting file in a format suitable for MetalONE.

General design guidelines

Note: The powder (type and granulometry) can modify the values, these are the ones that we suggest for 316L stainless steel.

Precision in XY axes is usually +/- 0.2mm

Precision along the Z axis is the layer height

Features

Minimum wall thickness: 0.3mm

Minimum hole size: 0.5mm

Minimum pin diameter: 1mm

Overhanging surfaces without supports: 45° minimum

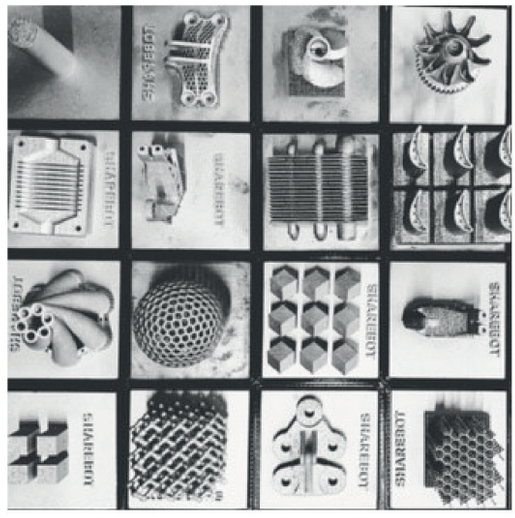
Surface quality

Usually upward facing surfaces are better than downward ones.

A visible stepped effect can be visible on angled surfaces depending on the layer thickness.

Mechanical properties

Tensile value, elongation, modulus of elasticity and hardness properties comparable to forged or cast properties.



MetalONE resources

https://www.sharebot.it/stampanti/metalone/

Club

Sharebot following his philosophy of sharing experiences and solutions has created an area on his own website where users and interested people can share what has been achieved and discovered.

Here is the link for the metalONE CLUB

https://www.sharebot.it/en/sharebot-metalone-club/

Contact us to get access

Youtube channel

Sharebot makes available on its youtube channel a series of time lapse and videos of the objects build.

https://bit.ly/3ijO4a5

LinkedIn metalONE club

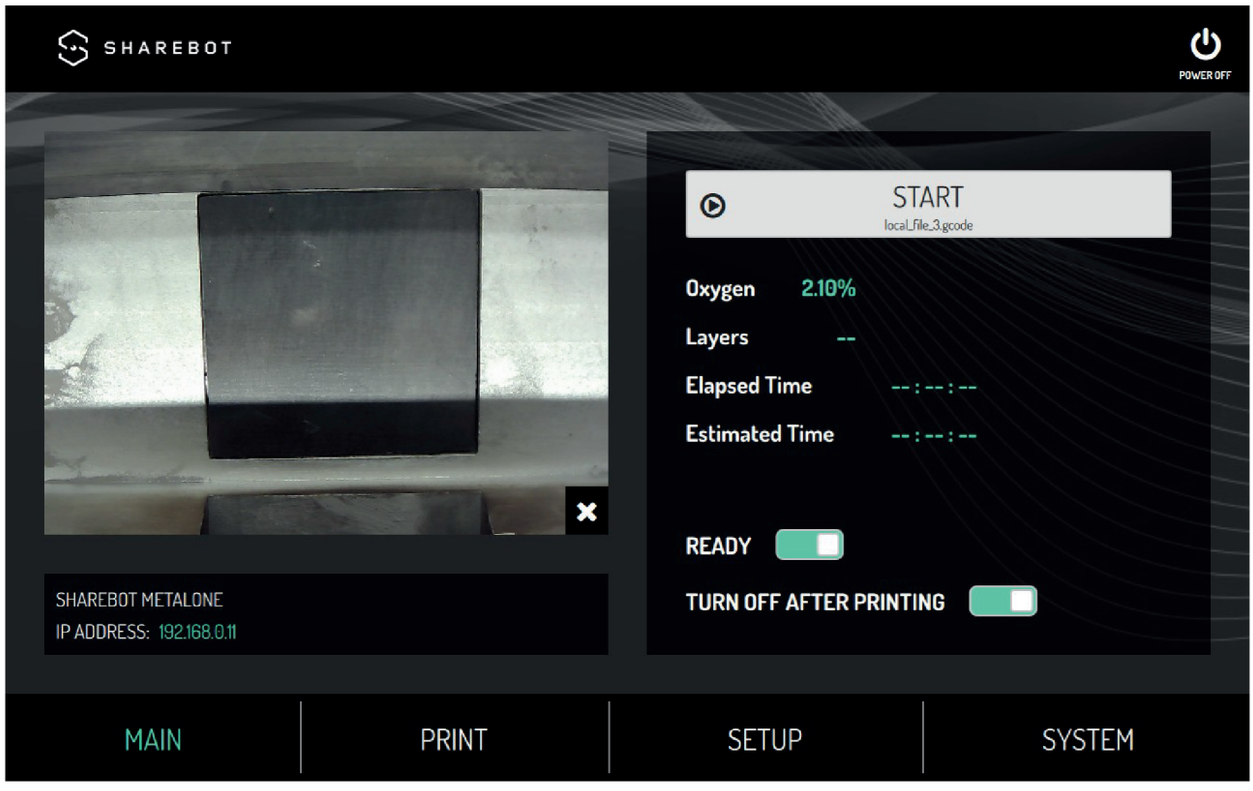
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User interface

metalONE is equipped with a touch screen that allows you to view the main parameters during printing and manage the files.

Furthermore, through an intuitive interface, it is possible to insert and/or modify all the parameters of the printing process.

In the main menu you can see the build area trough a webcam and all the relevant build information.

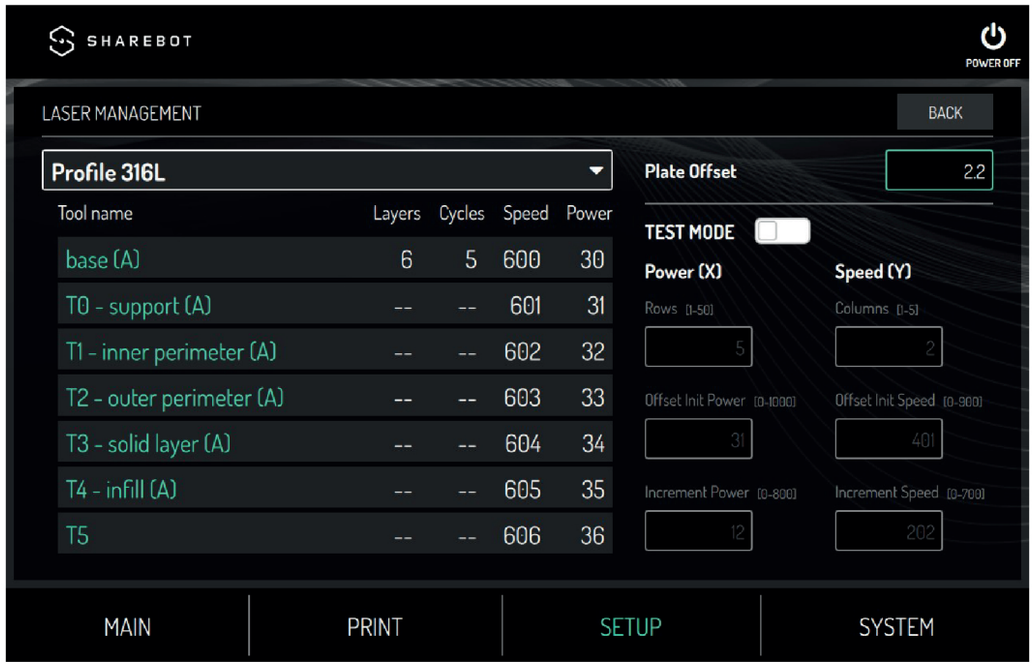


Log files

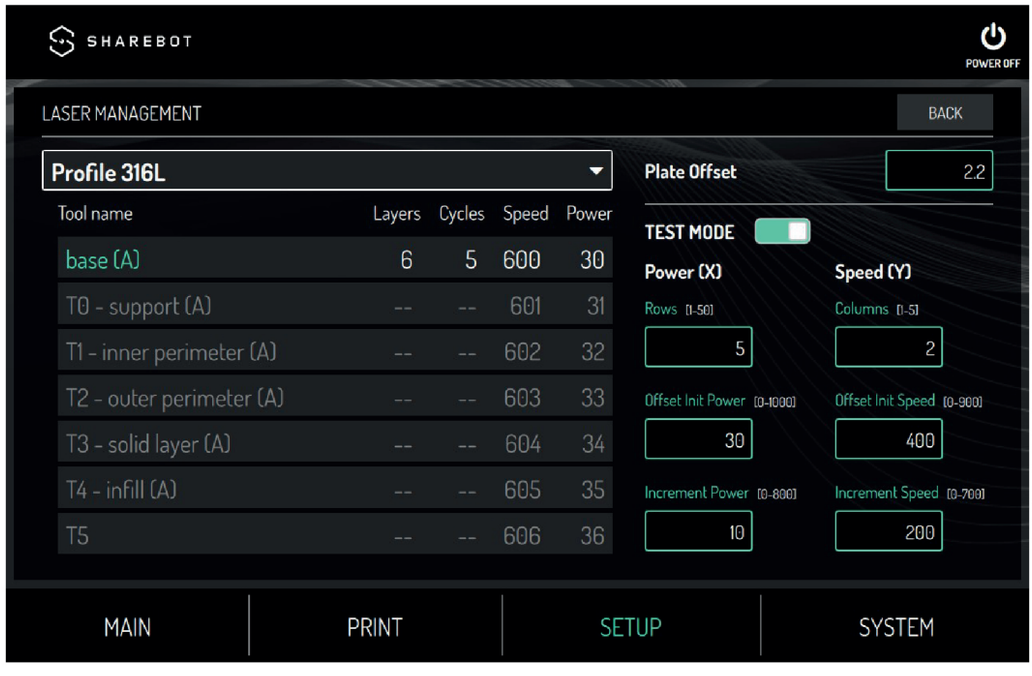
MetalONE records in a file every data recorded during the build and these data are downloadable.

In particular the internal camera archives an image just after the powder is spread (before the passage of the laser) and one after the passage of the laser. Plus you can download all the sensor’s relevant data in csv (comma separated values) files.

All the laser parameters are accessible:



and when “Test mode” is enabled you can define a range of values to be used to produce a matrix of identical objects:



Typical user

The typical metalONE user whats to:

- study new materials and alloys, starting with little quantities to verify his characteristics and proprieties before approaching an industrial machine

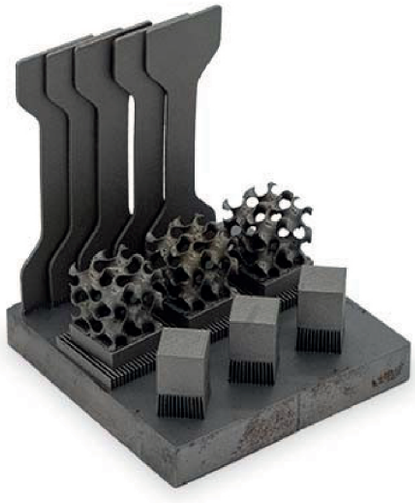
- personalize a DMLS machine with different sensors or process implementation

- teach how 3D metal printing affects the design of pieces

- allow students to experiment with a machine that’s affordable and easy to use

- prototype or build small pieces

- a research team, universities or powder manufacturers who study new materials or new alloys.





SCIENTIFIC PUBLICATIONS


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Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

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Selective Laser Melting of high purity copper on a low cost, low power (250W) machine

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This work explores the feasibility of selective laser melting (SLM) of high purity copper on a low power, low cost SLM printer, namely, the Sharebot MetalOne. Due to the high reflectivity and high thermal conductivity of copper, stable melting of copper powder can be difficult with low power machines.

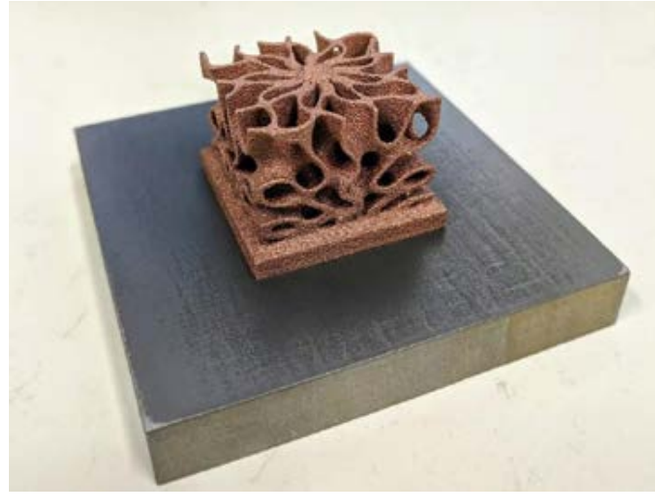
Copper's thermal properties make it desirable for heat exchanger applications. Additionally, the advanced geometry feasible with additive manufacturing (AM) enables optimisation of the heat exchanger performance.

10mm cube specimens have been printed using different process parameters (scanning speed, laser power, scanning strategy). The structure of each specimen has been analysed by means of scanning electron microscopy and the density measured using the Archimedes method. Marketable density of copper has been achieved with a laser power of 250W. The small scale, rapid iteration with the MetalOne has proved itself financially effective for experimentation.

SLM printers are typically costly and complex to maintain, hence, limited as experimental platforms. Proving the feasibility of copper with a low cost printer opens the door to more open-ended research on a financially viable platform.



Polished cross section of specimen



Advanced geometry demonstrator

Tim Gordon is an undergrad Mechanical Engineering (Hons) student at the University of Auckland. He is researching metal Additive Manufacturing processes in the Creative Design and Additive Manufacturing Lab and has international experience marketing applications of Polymer SLS AM.



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This work is done under: RegioneLombardia Innovative Solutions 4.0

In collaboration with: IC MATE Institute of Condensed Matter Chemistry and Technologies for Energy LECCO

MetalONE update 6/2021

Dear supporter,
We are thrilled to inform you that our R&D team **modified a metalONE** and we are now testing almost **pure copper.**

We began increasing the **laser source power** to 1 KW and changed all the **optical systems** accordingly. We have now entered the testing phase to **find the right combination** of **printing parameters** (laser power, speed and focus). We know that there's a long road ahead, but we're sure that the work we're doing will bring **continuous improvements** to the metalONE system.
The following images show the results obtained from the **first print jobs** with this material.

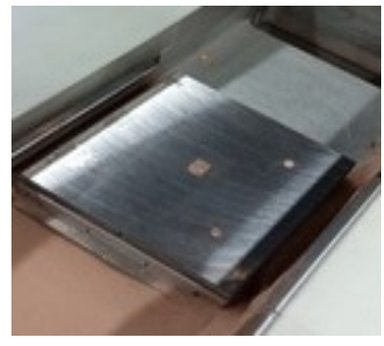
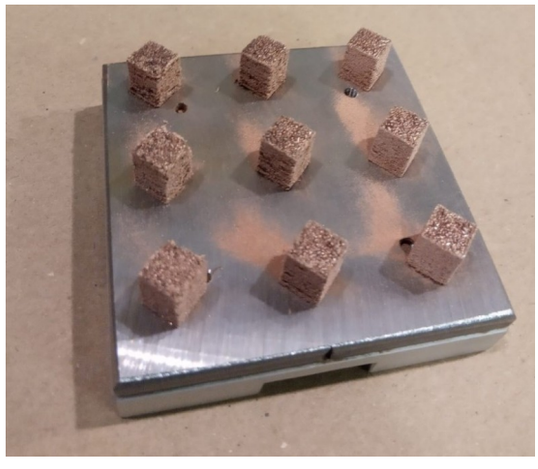


Fig. 1 First test to understand the copper adhesion to the iron buildplate.



Fig. 2 A failed print, the fused material did not attach to the plate and moved around.

As shown in Fig. 2 it's not an easy task to maintain the prints stuck to the print platform. **Preheating** techniques have been implemented to ensure bed adhesion and **regulate the heat dissipation** during the first layers of the prints.
Laser source **power** and printing **speeds** were also **tweaked accordingly** to find the working window that enabled us to **print the first test cubes**.



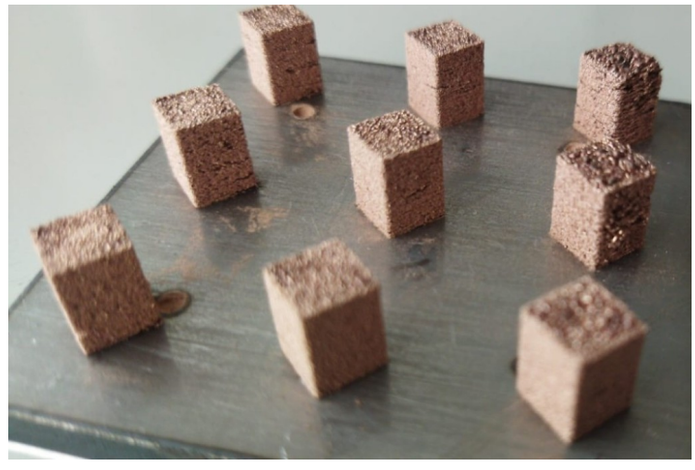


Fig. 3 and Fig. 4 Two build plates with test cubes sintered with different laser power and speed parameters

Sharebot srl via Montello 18 23895 Nibionno (LC) Italia Capitale sociale 25.600 euro

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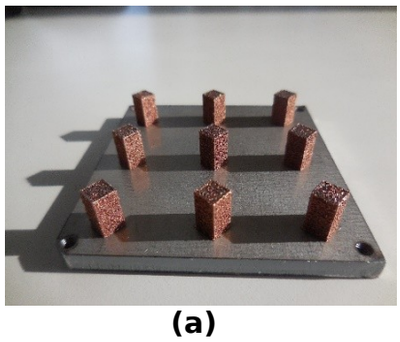
LPBF of CuCrZr parts: processability, microstructure, mechanical and thermal performances

Carlo Alberto Biffi[1], Jacopo Fiocchi[1], Stefano Boldrini[2], Ausonio Tuissi[1]

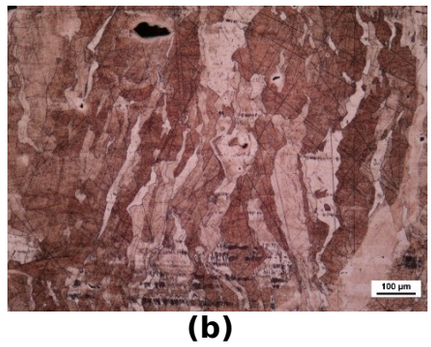
[1] CNR ICMATE, Lecco, Italy. [2] CNR ICMATE, Padova, Italy.

CuCrZr is a copper alloy designed to be strengthened through precipitation hardening: therefore, it is able to couple a relatively good thermal and electrical conductivity with high mechanical resistance. Therefore the possibility of producing this alloy by laser powder bed fusion (LPBF) appears extremely promising and opens interesting possibilities in several demanding fields, such as the aeronautical and space ones.

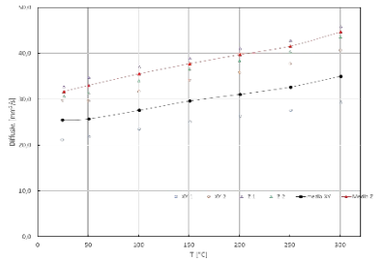
In the present work CuCrZr powder was processed by means of a modified Sharebot MetalOne LPBF system, equipped with a 1 KW fiber laser. Full dense parts (up to 99.3 %), characterized by columnar graing growing along the building direction, were obtained. The dependence of thermal diffusivity on building direction and temperature was evaluated. Mechanical behaviour was found to be fully satisfactory with a good strength (230 MPa) and interesting ductility (elongation to failure was higher than 30 %).



(a)



(b)



(c)

Figure 1: (a) CuCrZr samples produced by MetalOne, (b) as-built microstructure parallel to the building direction, (c) evolution of thermal conductivity at varying temperature.

This work is done under

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Journal of Materials Research and Technology
Volume 26, September–October 2023, Pages 9127-9138

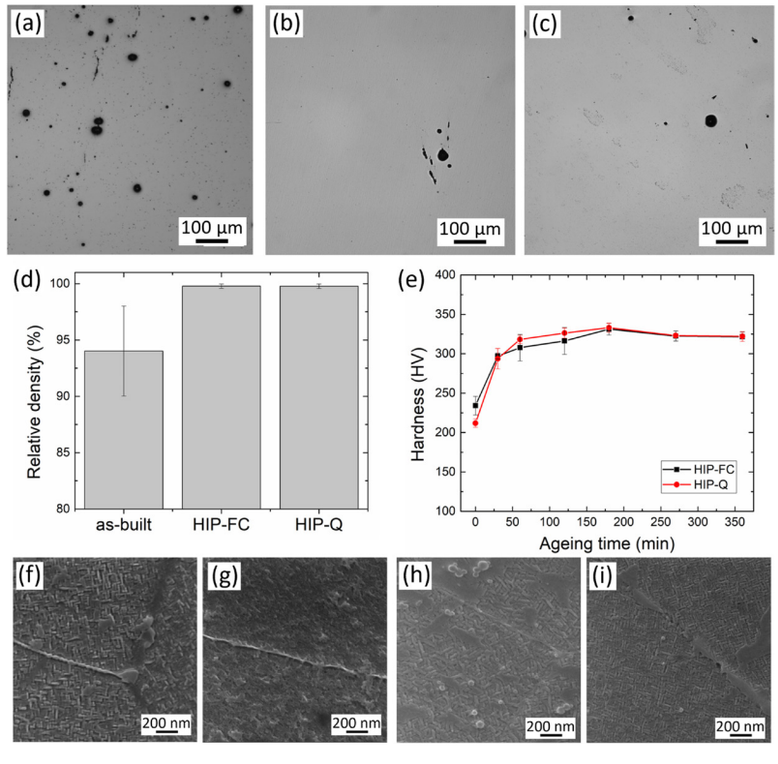
Hot isostatic pressing and heat treatments of LPBFed CoCuFeMnNiTi0.13 high-entropy alloy: microstructure and mechanical properties

J. Fiocchi, C.A. Biffi, M. Elnemr, J. Shipley, A. Tuissi ,R .Casati

https://doi.org/10.1016/j.jmrt.2023.09.223

Abstract

The present work explores the possibility of processing a CoCuFeMnNiTi0.13 high-entropy alloy by laser powder bed fusion (LPBF). The alloy, produced under optimised processing conditions, presents good densification but also hot cracks, caused by the liquation of an inter-dendritic Cu-rich phase. Microstructure of the as-built alloy is characterised by face centred cubic (FCC) columnar grains, containing Cu-poor dendrites and Cu-rich inter-dendritic areas. The alloy, which was designed to be strengthened by spinodal decomposition and precipitation, was subjected to different thermo-mechanical treatments to try and improve its properties. Direct ageing and solution treatment and ageing produced a strong but brittle material (tensile strength of 683 MPa and elongation to failure of 1.3%), whereas hot isostatic pressing followed by controlled cooling was able to heal pores and cracks while triggering the desired microstructural transformations (spinodal decomposition and precipitation). This resulted into a balanced set of mechanical properties (tensile strength of 473 MPa and elongation to failure of 7.6%). This work shows that proper post-processing can mitigate the issues typically affecting LPBF fabricated HEAs, producing tailored microstructures with satisfactory mechanical performances.



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Lasers in Manufacturing and Materials Processing.

CuCrZr alloy manufactured by LPBF process: correlation between microstructure, mechanical and thermal properties

Carlo Alberto Biffi, Jacopo Fiocchi, Stefano Boldrini, Ausonio Tuissi

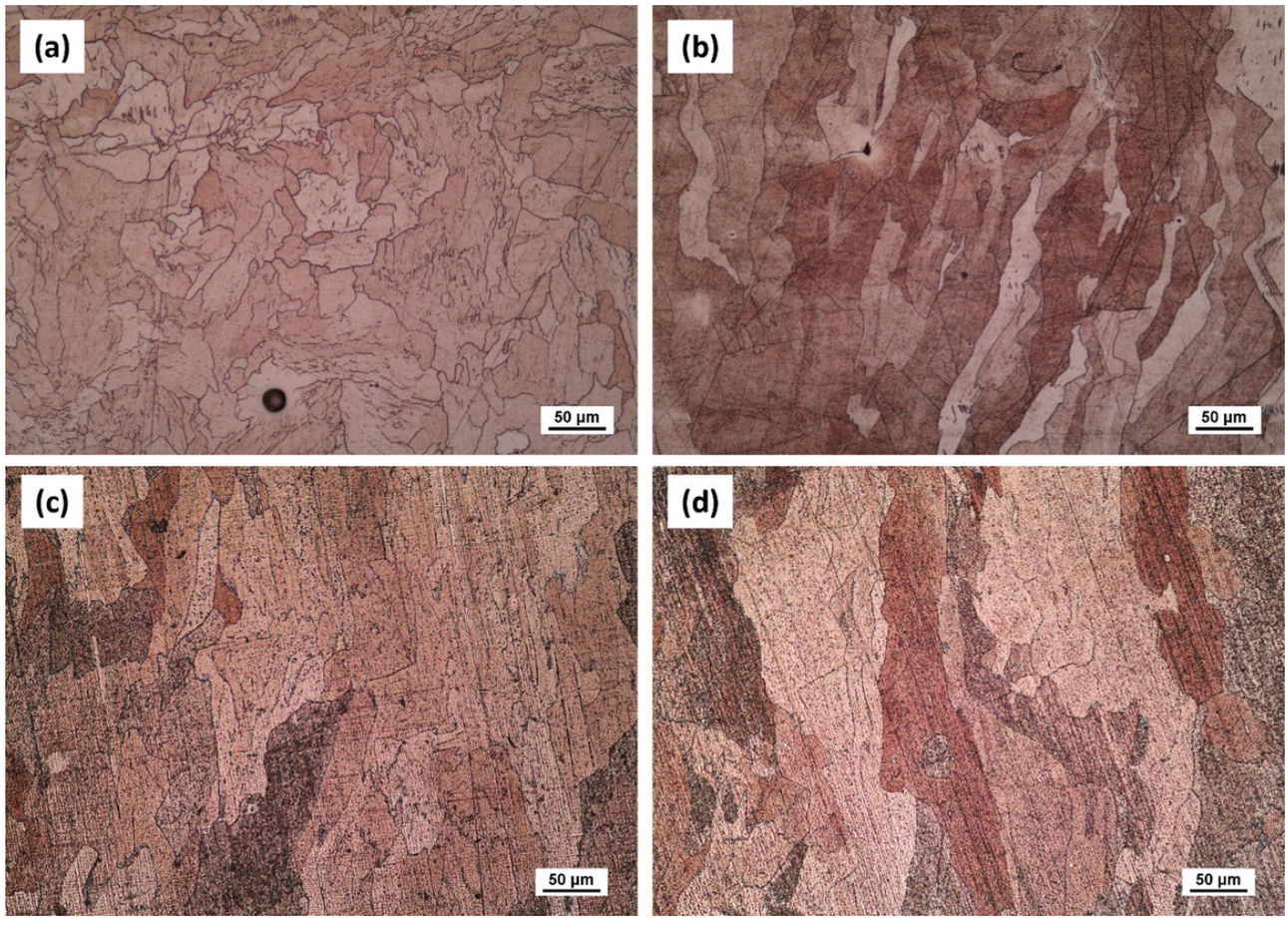
https://doi.org/10.21203/rs.3.rs-3171022/v1

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Abstract

Copper based alloys are promising materials for electrical and thermal devices. In this respect, the use of laser powder bed fusion (LPBF) allows the realization of 3D complex structures, possibly enhancing the functional performances of such devices. LPBF also induces refined microstructures and build-up of residual stresses, due to the rapid solidifications and high cooling rate.

In this work a CuCrZr alloy was manufactured by LPBF and a process feasibility window was defined. The effect of a heat treatment, consisting of solution annealing and artificial aging, and of the building direction on the microstructure, tensile, and thermal properties was evaluated. It was found that thermal conductivity is improved by the heat treatment and that thermal conductivity resulted anisotropic, being higher in the growth direction.



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MECHANICAL CHARACTERIZATION OF 316L SPECIMENS

The tensile tests were carried out with an MTS Criterion Model 43 testing machine, using a 5 KN load cell, and a 25 mm resistive contact strain gauge.

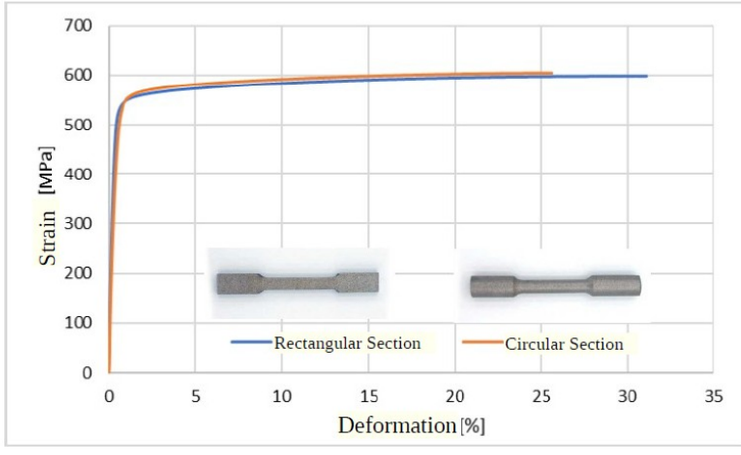




Fig 1. Stress-deformation curves of rectangular and circular section specimens

Table I shows the values of tensile strength, deformation at maximum load and the elastic modulus. Is determined by drawing a straight line passing through the points of the curve in correspondence with a deformation equal to 0.05% and 0.25%.

	Properties		
Specimen	Elastic module [GPa]	Resistance to traction [MPa]	Deformation [%]
Square Section	190,8	598,8	31,4
Cicular Section	189,8	604,4	25,6

Table I. Mechanical properties of 316L specimens

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Materials Science and Engineering: A

Volume 828, 2 November 2021, 142109

On the effect of rapid annealing on the microstructure and mechanical behavior of additively manufactured stainless steel by Laser Powder Bed Fusion

Mohammad Reza Jandaghia[a], Abdollah Saboorib[b], Luca Iuliano[b], Matteo Pavese[a]

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b) Department of Management and Production Engineering, Politecnico di Torino, Corso Duca Degli Abruzzi 24, 10129, Torino, Italy

https://doi.org/10.1016/j.msea.2021.142109

Abstract

This work presents an investigation on the effect of rapid annealing on the microstructure evolution and mechanical performance of stainless steel 316L (SS316L) fabricated by Laser Powder Bed Fusion. In this process, it is well documented that the intensive thermal gradient in the heat flux direction leaves remarkable residual stress and promotes strong texture along the building direction (BD). In the current research, to swiftly reduce residual stresses, a short-term heat treatment at 1300°C for different holding times of 10–120s was designed and studied. Microstructural observation through the optical microscopy and scanning electron microscopy, as well as the X-ray diffraction analysis, revealed that rapid annealing longer than 30s resulted in the gradual annihilation of the cell walls which are indeed the sub-grain boundaries (SGBs). In addition, electron backscatter diffraction outputs demonstrated that rapid annealing significantly reduced the low angle grain boundaries and attenuated the texture developed along the BD. Moreover, the analysis of grains size and shape illustrated that annealing up to 30s recovered the structure. In contrast, longer annealing resulted in increasing the aspect ratio of grains along the direction with maximum residual strain (i.e. BD) due to activation of the strain induced grain boundary migration (SIGBM) mechanism. After the rapid annealing, the mechanical performance of the samples also indicated that annealing up to 30s would not reduce the compressive and tensile strength more than 6%. In comparison, longer annealing resulted in 24% reduction in mechanical properties along with coarsening of dimples in the fracture surface of the samples.

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Materials Science and Engineering: A

Volume 857, 1 November 2022, 144114

In-situ alloying of stainless steel 316L by co-inoculation of Ti and Mn using LPBF additive manufacturing: Microstructural evolution and mechanical properties

Mohammad Reza Jandaghia, Hesam Pouraliakbarb, Sang Hun Shimc, Vahid Fallah, Sun Ig Hong, Matteo Pavese

https://doi.org/10.1016/j.msea.2022.144114

Abstract

The grain refining impact of Ti in additively manufactured steels as well as the outstanding formability of high-Mn steels owing to their low stacking fault energy (SFE) has been confirmed in the literature. In the current work, Ti and Mn were inoculated simultaneously to the stainless steel 316L by laser powder bed fusion (LPBF) in-situ alloying. The local accumulation of the additions developed complexes of Ti-rich brittle phases that improved strength. Microstructural observations revealed the formation of intermetallic chunks of FeTi (bcc), σ (tetragonal), and C14 Laves phase (hcp) surrounded by emerged ferrite grains within the austenite. The rapid solidification of the molten tracks induced significant thermal stresses, which were responded by the generation of geometrically necessary dislocations (GNDs) at the austenite/ferrite interfaces, and activation of synchroshear mechanism within the Laves phase along with thermally activated slip systems in FeTi phase. Mn addition contributed to higher interface cohesion by facilitating dissociation of dislocations.

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Politecnico di Torino

Laser Powder Bed Fusion of Pure Titanium: Optimization of Processing Parameters by Means of Efficient Volumetric Energy Density Approach

Claudio F. Badini, Tommaso Santero, Michele Rosito, Elisa Padovano.

Department of Applied Science and Technology, Politecnico di Torino

ABSTRACT:

This paper focuses on optimizing the process parameters for manufacturing commercially pure titanium grade 2 using Laser Powder Bed Fusion (L-PBF) technology. The most common approach involves trial-and-error builds with varying parameter combinations, followed by characterizing the bulk samples for defects and the microstructure. This method, typically based on Volumetric Energy Density (VED), is time-consuming and overlooks key powder properties. An alternative approach involves the use of efficient Volumetric Energy Density (VEDeff), which represents the energy density effectively available for the L-PBF process, considering both the process parameters and powder properties such as absorptivity and thermal diffusivity. In this study, VEDeff was applied and compared to a work window defined by thermodynamic data, with limits corresponding to the energy needed for titanium melting and evaporation. Forty-two tests were performed with different combinations of laser powers and scanning speeds; the samples were then characterized in terms of porosity, microstructure, and hardness. The findings showed no correlation between VED and the work window while VEDeff aligned with the work window, although the highest relative densities (>99%) and hardness values were achieved in a narrower range. Despite this, the VEDeff approach proved to be a useful starting point for optimizing the process parameters.

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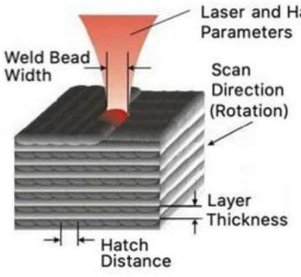
3D micro-lattices produced by L-PBF

Introduction

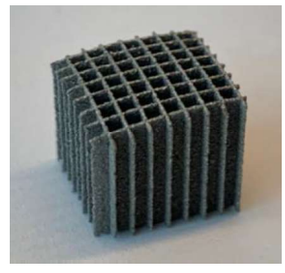


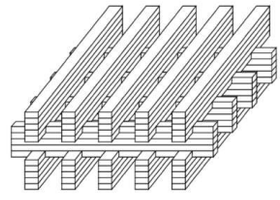
- ✓ 3D lattices represent an attractive option for lightweight design of structures
- ✓ Metal Additive Manufacturing offers full freedom of fabrication for complex shapes, from the macro- to the micro-scale
- ✓ Large and complex shapes require demanding design of the model, wich must contain full details of the lattice geometry

Experimental approach



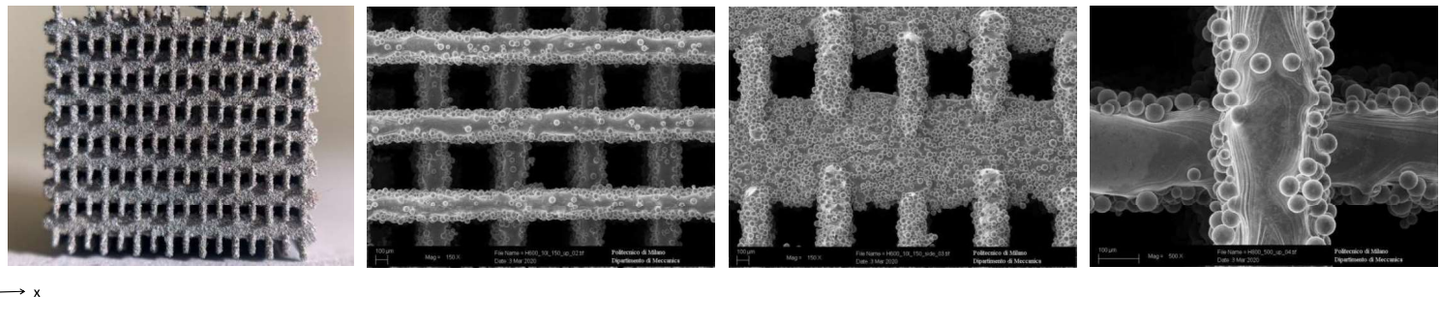
- ✓ An alternative option here investigated is the generation of micro-lattice structures by adjusting the Laser processing parameters upon L_PBF manufacturing of solid shapes
- ✓ Widening of the hatch distance and proper desing of the rotation sequence of batches of layers allows creating different micro-lattice geometries using simplified models



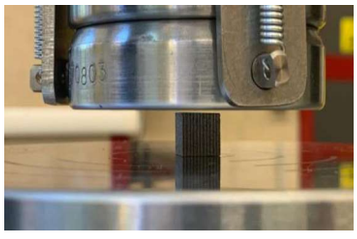


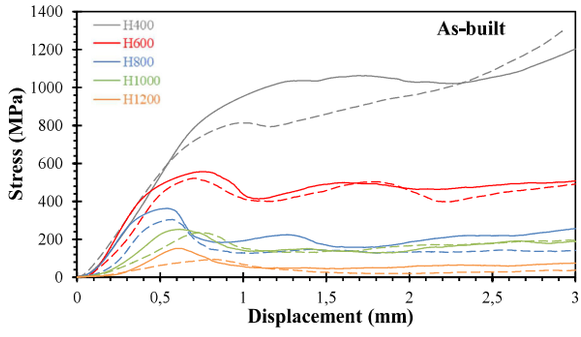
Tests have been carried out using both 316L stainless steel and Ti-6Al-4V alloy

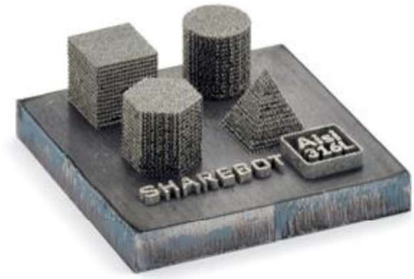
Results & Conclusions



- ✓ Flexibility of the L-PBF system and accurate process parameter setting allowed designing and producing sound 3D lattices showing good geometrical control of the strut even at the microscale (beam size 100um, beam spacing 200 um)
- ✓ Many variables can potentially be tuned to design new micro-lattices, such as: stacking sequence of layer batches, their rotation, struts width and height, degree of overlapping at intersection points, …
- ✓ Mechanical properties (here shown in compression) are promising as well and show the expected dependance on unit cell geometry)







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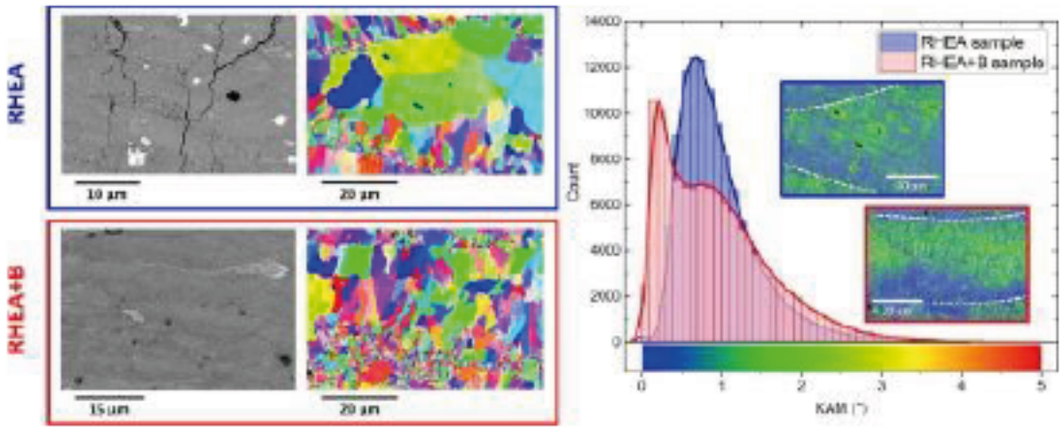
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Improvement of LPBF processability of equiatomic MoNbTaTiZr RHEA powder by in-situ precipitation of boride particles

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ABSTRACT:
The equiatomic MoNbTaTiZr biocompatible and refractory high-entropy alloy (RHEA) was additively manufactured by laser powder bed fusion (LPBF). The possibility to reduce the cracking susceptibility of the RHEA during LPBF was investigated. By the addition of pure B to the RHEA powder feedstock, the in-situ precipitation of boride particles was promoted. These precipitates limited the grain growth, thus avoiding the formation of cracks.



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