Additive Manufacturing at LNGS: Facilities, Metals Testing and Future Capabilities

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Gran Sasso National Laboratory
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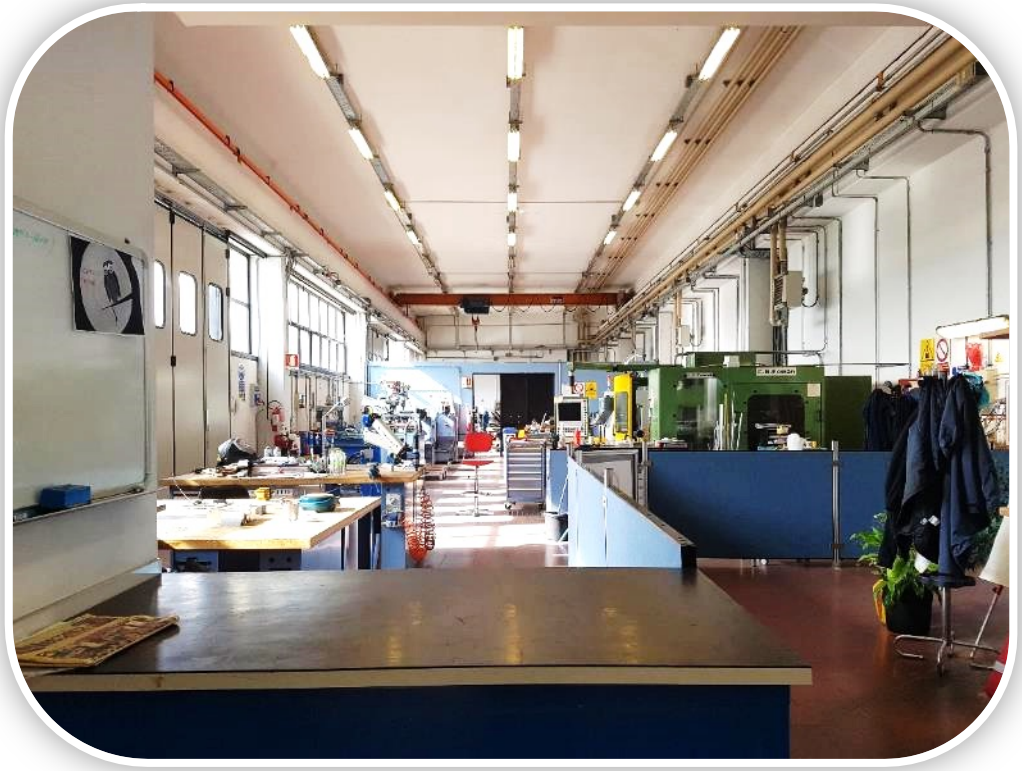
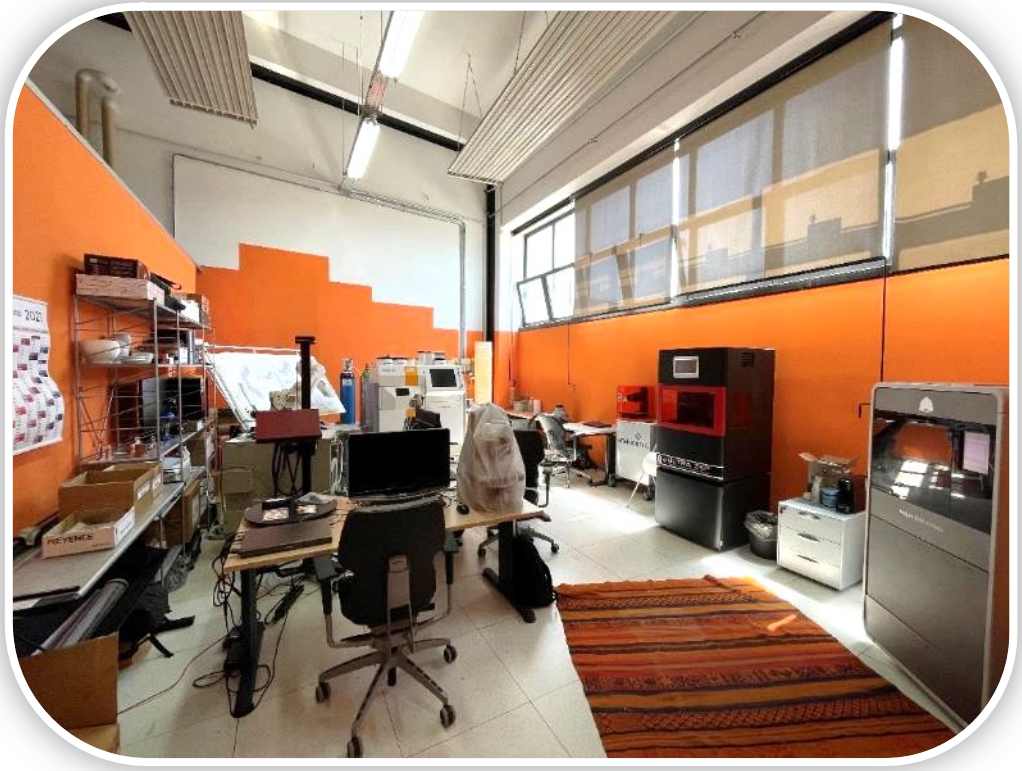
Mechanics Service

Gran Sasso National Laboratory – LNGS



Workshop Department



Design and Additive Manufacturing Department

The Mechanics Service

Gran Sasso National Laboratory – LNGS

LNGS MECHANICS SERVICE

Responsible: *Donato Orlandi*

Workshop Department

Responsible: *Angelo Corsi*

Main activities

Traditional machining, CNC, quality control



Design and Additive Manufacturing Department

Responsabile: *Daniele Cortis*

Main activities

Design, multiphysics simulations (FEA / CFD), additive manufacturing with plastic and metal materials, reverse engineering, technology transfer, research and analysis on materials.



INFN

The Mechanics Service

Gran Sasso National Laboratory – LNGS

Client
(Experiment, Working Group, etc..)

Ticket System
INFN National Management System
Unique request code:
LNGSMECC-XXX

Reporting
Technical and administrative (performance, productivity)

Production
CNC Machining
Additive Manufacturing

Input data
Extrapolation of technical data from requests

3DExperience (PLM System)
LNGS Local PLM System
Unique code: **PRD000XXXX**
+ reference to the Ticket System code

Output data
Files for storage and interchange (e.g. technical drawings, neutral format CAD, etc.)

Cloud System
Code-based LNGS local backup system
LNGSMECC-XXX

Technologies and equipment

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Realization of the components is realized by means of classic subtractive technologies (CNC) and by means of machines for additive manufacturing for plastic and metal materials (Additive Manufacturing).

SISMA
L-PBF (SLM)

3DSystem
PoliJet

ENVISIONTEC
SLA

ENVISIONTEC
DPL

Technologies and equipment

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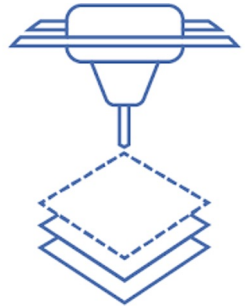
Metal Additive Manufacturing

Similar to all other processes, metal additive manufacturing machines produce objects by adding material one layer at a time.

In this way it is possible to build objects with geometries that are impossible to produce with "traditional" subtractive (CNC) or training (Metal Casting) technologies, without the need for specialized equipment (for example a mold).

Technology available at LNGS:

- **Laser Powder Bed Fusion (L-PBF): Selective Laser Melting (SLM)**



Technologies and equipment

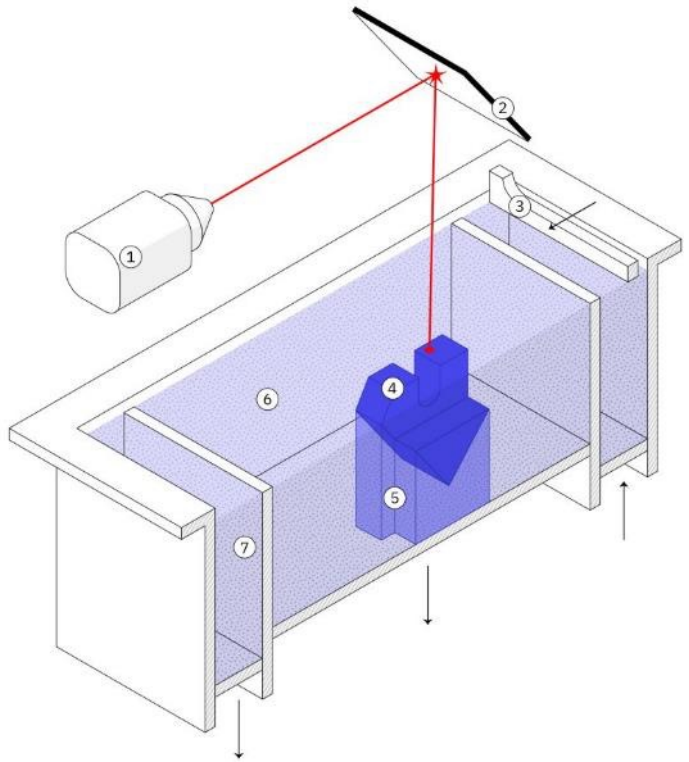
Gran Sasso National Laboratory – LNGS

SLM (Selective Laser Melting)

SLM technology uses a laser beam to selectively melt a powder bed in order to produce a layer-by-layer component as schematically represented in the figure.

A layer of metal powder is deposited on a construction platform through the use of a recoater characterized by a ceramic, steel or rubber blade according to the type of metal powder used.

The melting of the powders is carried out with a high-power laser beam guided in the construction plan through appropriate galvanometric mirrors and the entire process takes place in a controlled atmosphere of inert gases such as Ar or N.



Technologies and equipment

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SISMA MySint 100 (PM/RM)

Version developed specifically for R&D.

Main Features:

Building volume	Ø 100 mm x 90 mm
Laser source	175 W (single laser)
Laser spot	30 μm
Layer thickness	20-40 μm (regolabile)
O2 sensor	100 ppm

Other:

- Patented Coater tilting offers reduced re-routing times
- Each processing parameter is customizable

Processed materials

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The materials that can be used by the machine are Steel, Titanium alloys, Nickel alloys, Aluminum alloys, Copper alloys, precious metal alloys and Cobalt Chrome alloys.

Materials currently processed at LNGS:

Steel	Aluminium alloys	Copper Alloys	Copper
AISI 316 L	SCALMALLOY®	CuCrZr	Cu > 99.8 %
	AlSi10Mg		Cu OFE




Quality analysis

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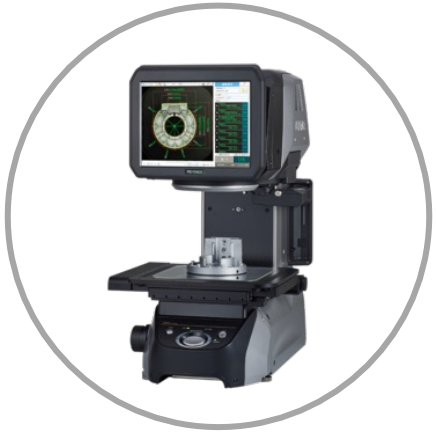
In addition, tools are available for the quality analysis of the components produced and reverse engineering (e.g. 4K **high-resolution optical microscope**, GOM **3D scanner**, **high-resolution optical profile meter**).

GOM
Atos Core

KEYENCE
VHX-7000



KEYENCE
IM series

Future investments

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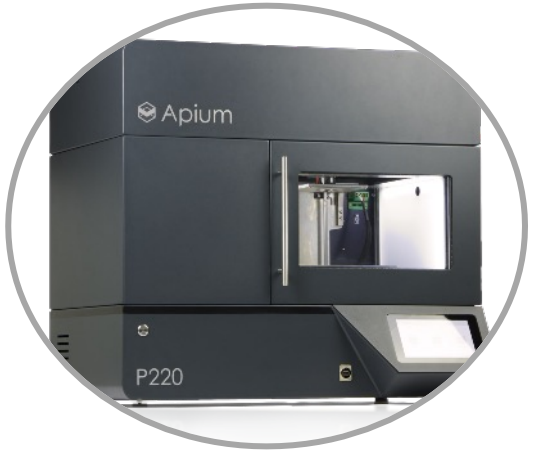
The service is also constantly evolving and technological renewal of its machine park.

Atomizer of metal powders for L-PBF

Traction machine with climatic chamber (-150 / +600 °C)



PEEK/Carbon Filled PEEK Printer FDM

HAMMER

Gran Sasso National Laboratory – LNGS

HAMMER - Hub for Additive Manufacturing, Materials Engineering and Research

The Hub focuses on the design and production of complex components for both nuclear/astroparticular physics research and technology transfer.

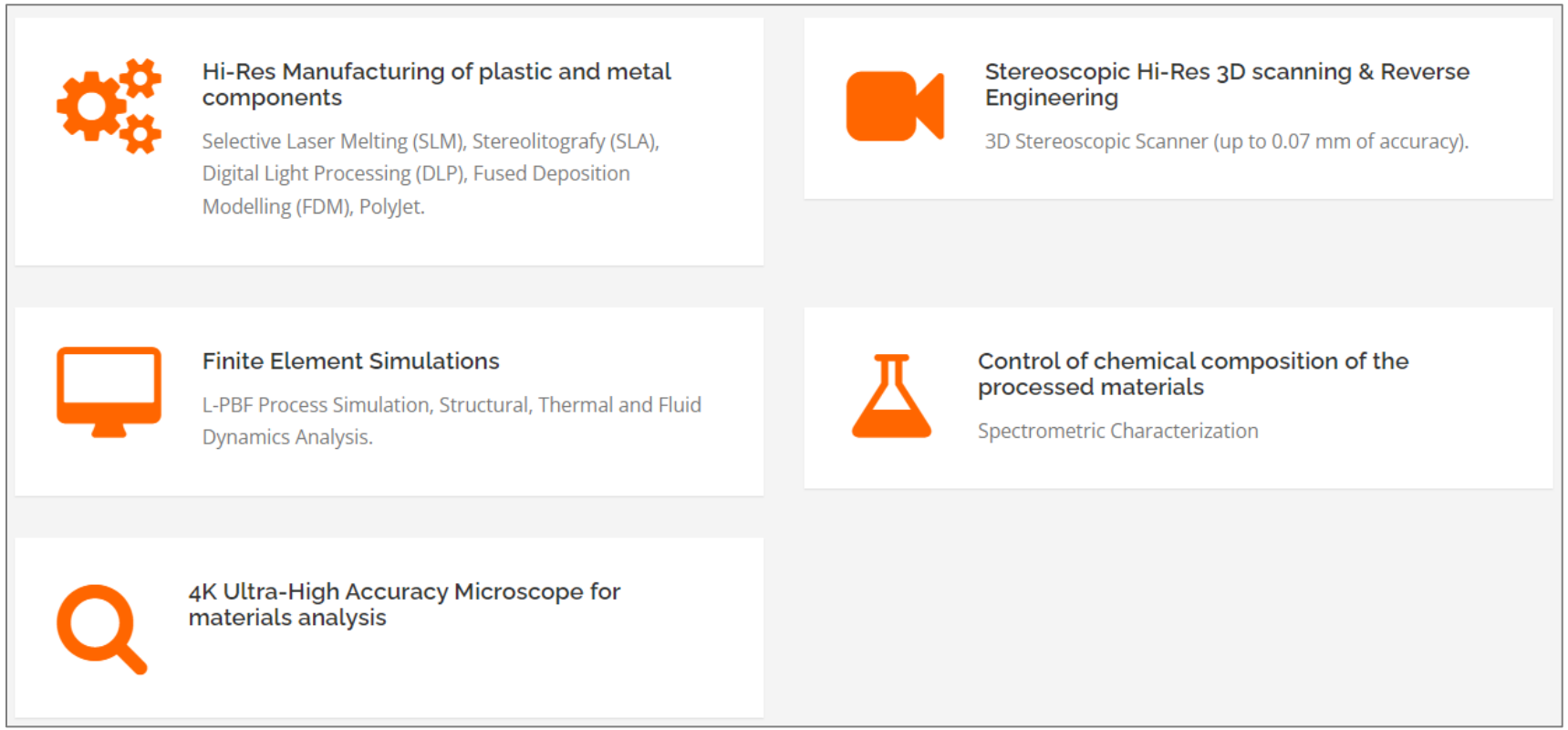
HAMMER

https://hammer.lngs.infn.it/

HAMMER

Gran Sasso National Laboratory – LNGS

HAMMER - Hub for Additive Manufacturing, Materials Engineering and Research



Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of heat exchanger

Design requirements:

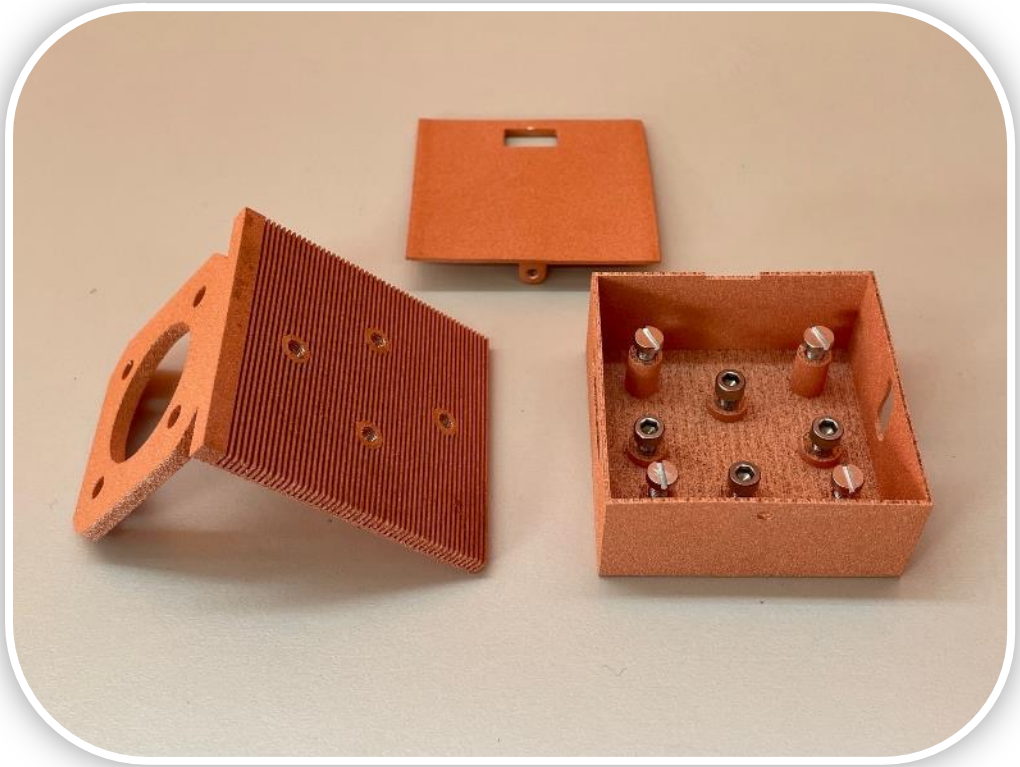
- Vacuum component
- Cryogenic conditions
- High thermal conductivity
- Coupling with electric motor
- Highly customized geometry (electronic components)

Material:

- Cu OFE

Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of heat exchanger



Components made:

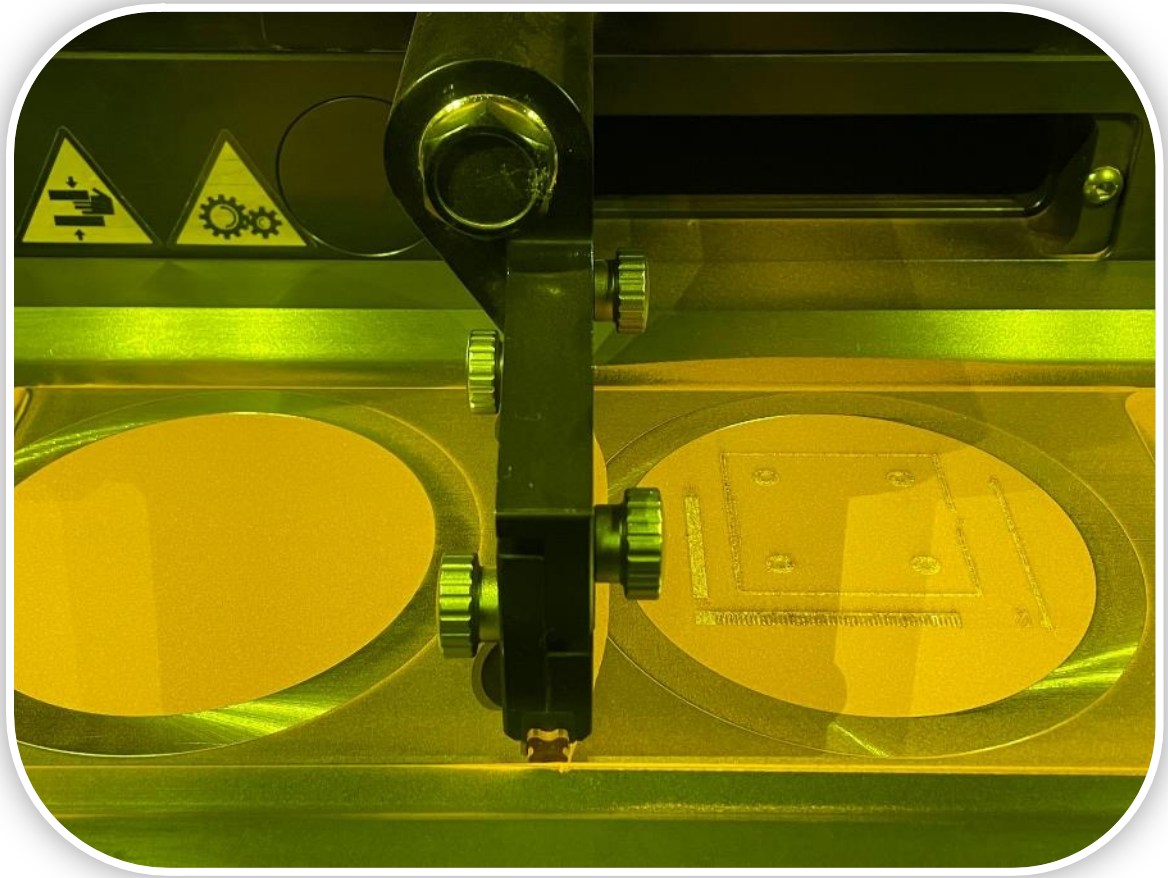
- Heat exchanger
- Electronics case
- Case cover

Post-operations:

- Sandblasting
- Threaded holes

Research Activities & Case Studies

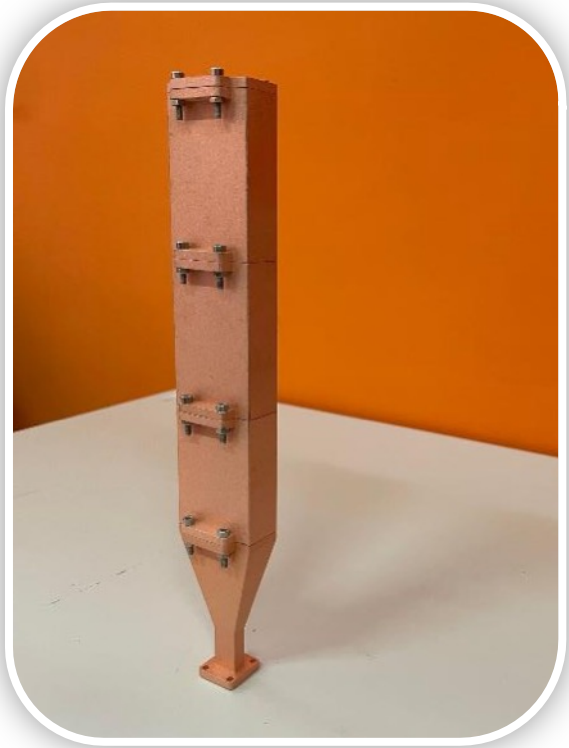
[LNGS: PTOLEMY] Design and production of heat exchanger



Construction phase

Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of waveguides



Design requirements:

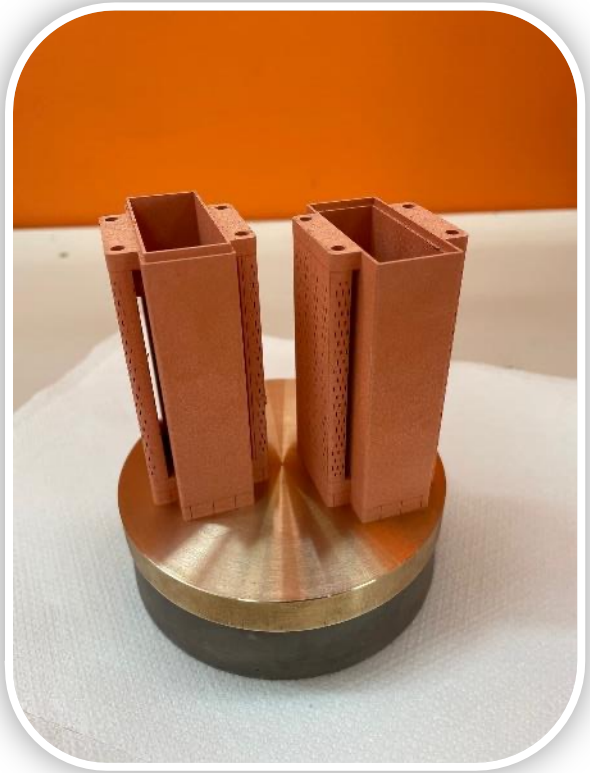
- Vacuum component
- Cryogenic conditions
- High precision mechanical coupling

Material:

- Cu OFE

Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of waveguides



Components made:

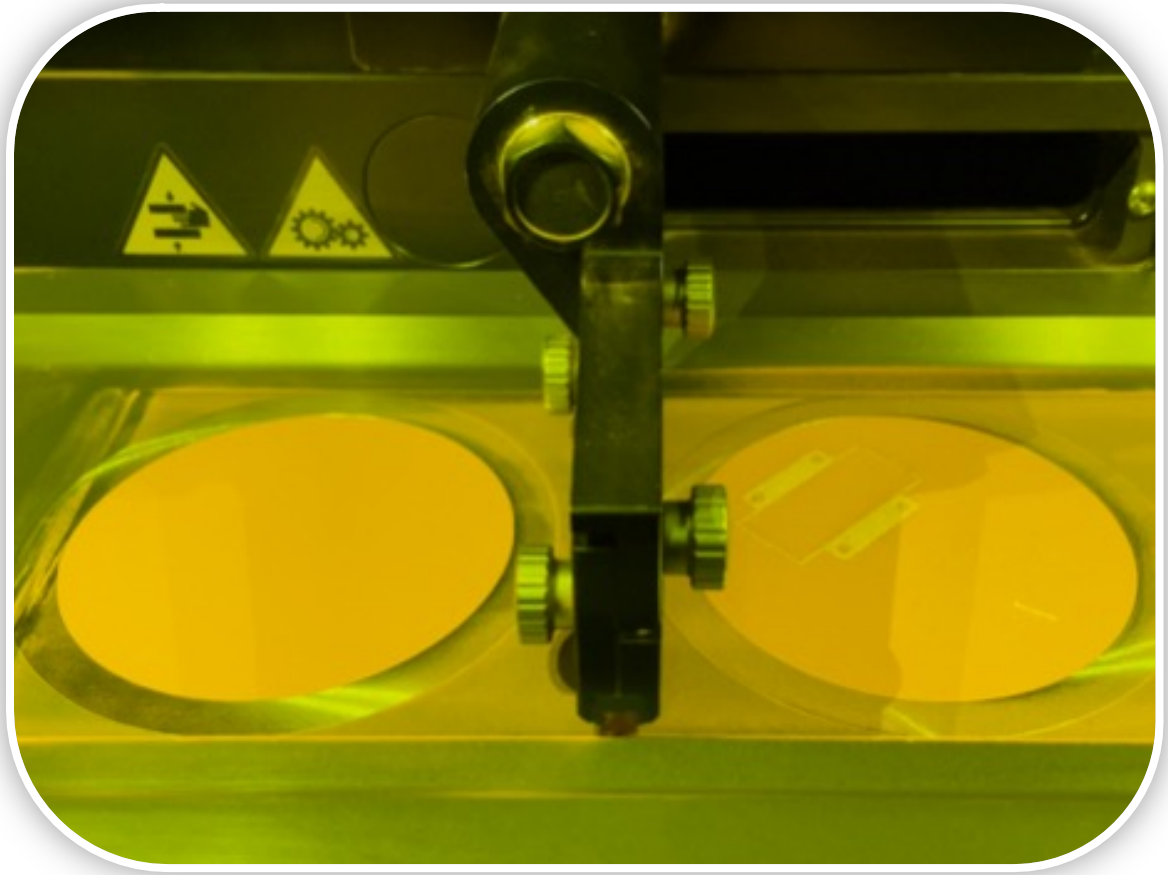
- N.4 waveguide sections
- N.2 caps with different geometry

Post-operations:

- Sandblasting
- Threaded holes

Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of waveguides



Construction phase

Research Activities & Case Studies

[HAMMER: LNGS - ROMA1] Sandwich frame production

Design requirements:

- Vacuum component
- Cryogenic conditions
- High precision mechanical coupling

Material:

- Cu OFE

Research Activities & Case Studies

[HAMMER: LNGS - ROMA1] Sandwich frame production

Components made:

- N.2 frames (prototypes)

Post-operations:

- Sandblasting
- Threaded holes

Research Activities & Case Studies

[LNGS: ADM2021 Conference] Design of Ar – N Condenser

Design requirements:

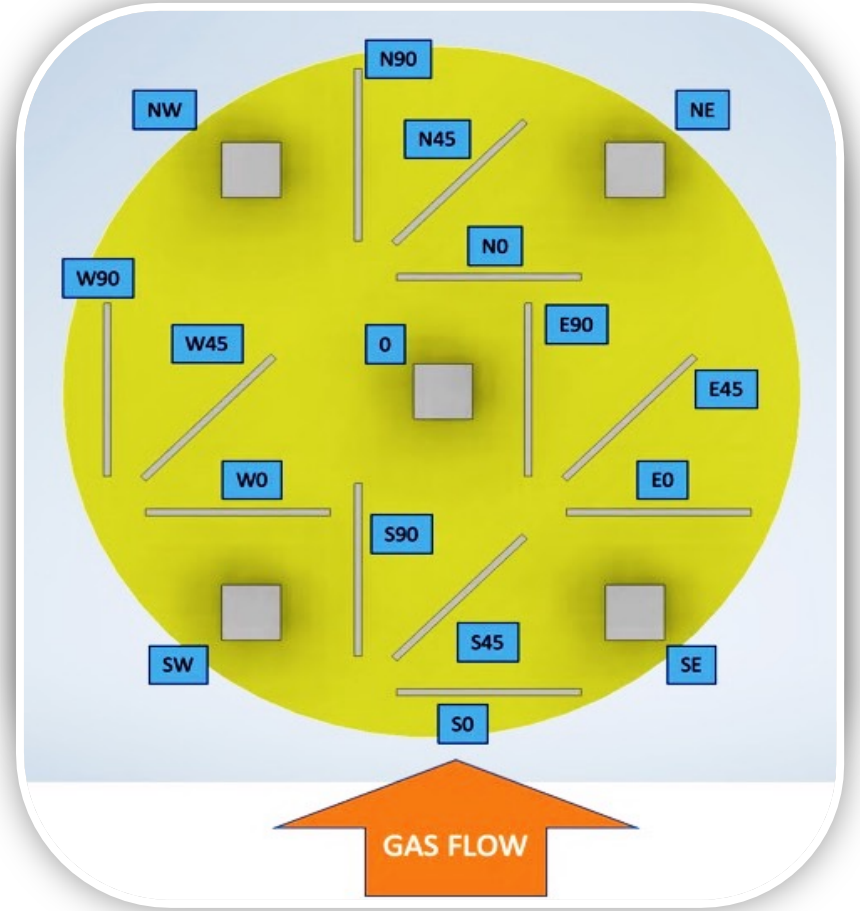
- Vacuum component
- Cryogenic conditions

Material:

- Cu > 99.8%

Research Activities & Case Studies

[HAMMER: LNGS - ROMA1] Collaborative research SIAD-SEAMTHESIS



Objectives:

- Evaluate the effects of inert gas flow
- Evaluate the effects of the type of inert gas (N, Ar, He)

Material:

- Cu > 99.8%

Research Activities & Case Studies

[HAMMER: LNGS - ROMA1] Development of new materials

Objectives:

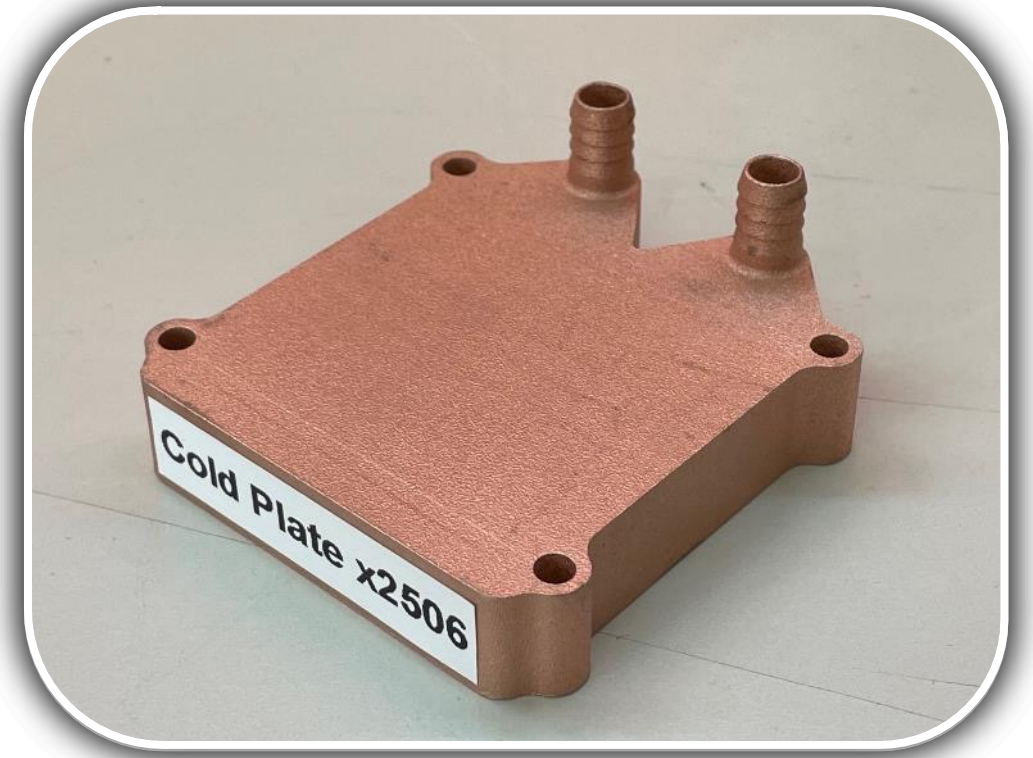
Development of new copper metal matrix materials

Material:

- Cu > 99.8%

Research Activities & Case Studies

[LNGS: Koral Technologies] Collaborative research of lattice structures



Objectives:

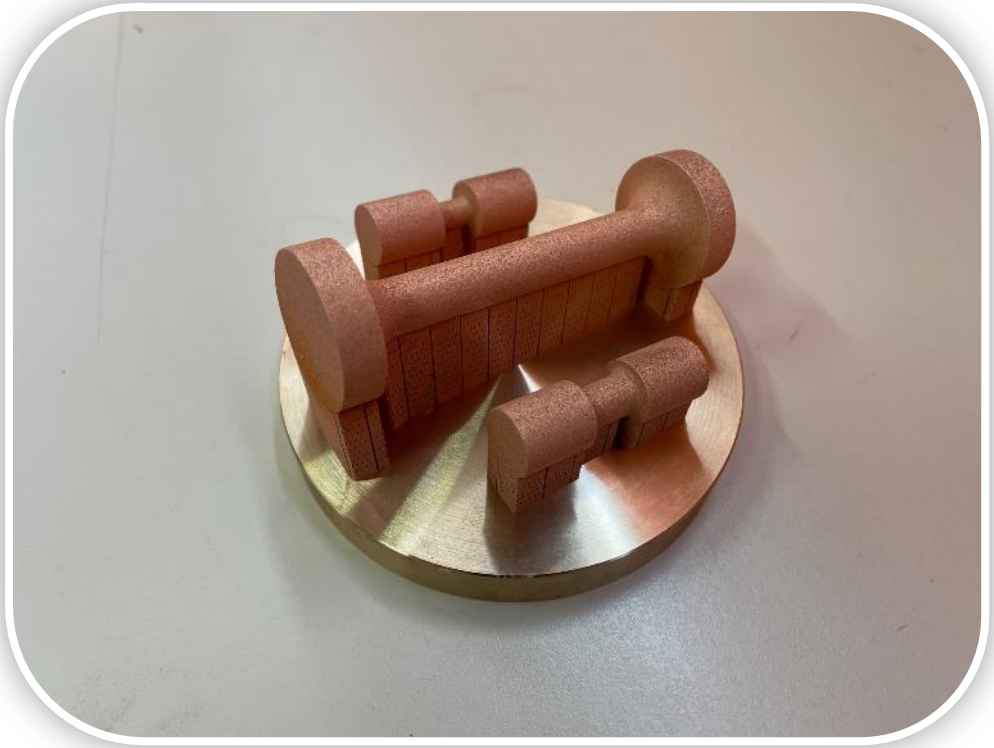
- Development of innovative heat exchangers with lattice structures for electronics

Material:

- CuCrZr

Research Activities & Case Studies

[LNGS: UNIVAQ] Characterization of mechanical property CuCrZr



Objectives:

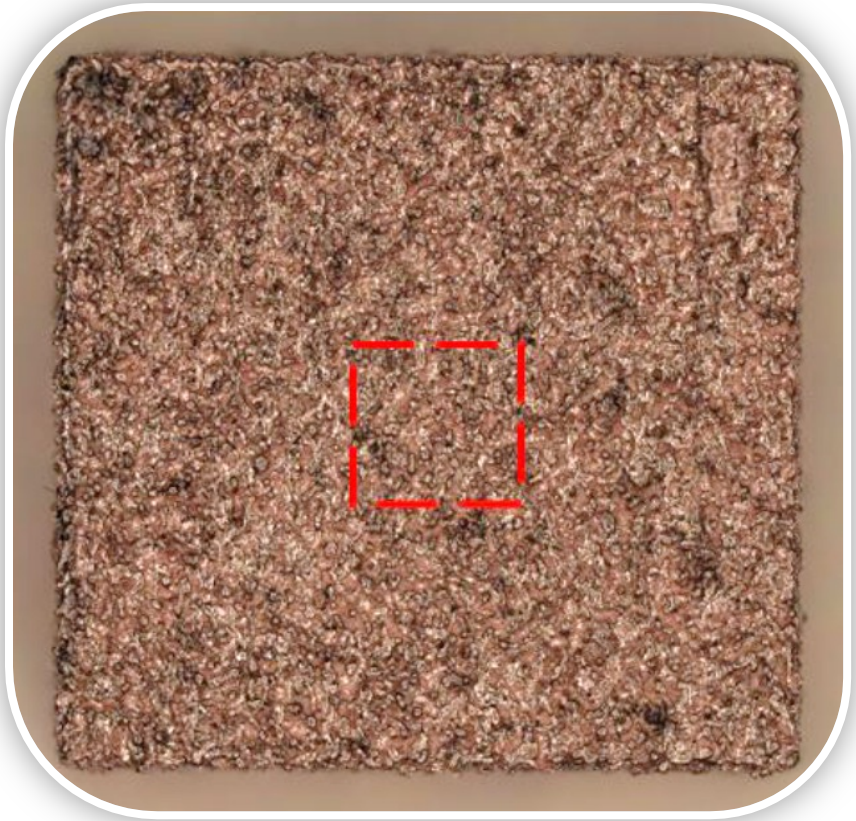
- Study and characterization of the mechanical, static and dynamic properties (strain-rate), of the CuCrZr copper alloy produced by SLM, with and without heat treatment

Materials:

- CuCrZr

Research Activities & Case Studies

[LNGS: UNIVAQ] Study of surface quality



Objectives:

- Study and analysis of the surface quality of parts made of CuCrZr copper alloy by SLM

Material:

- CuCrZr

Research Activities & Case Studies

[LNGS: OMA-FaVRIA] Commissioned research

Objectives:

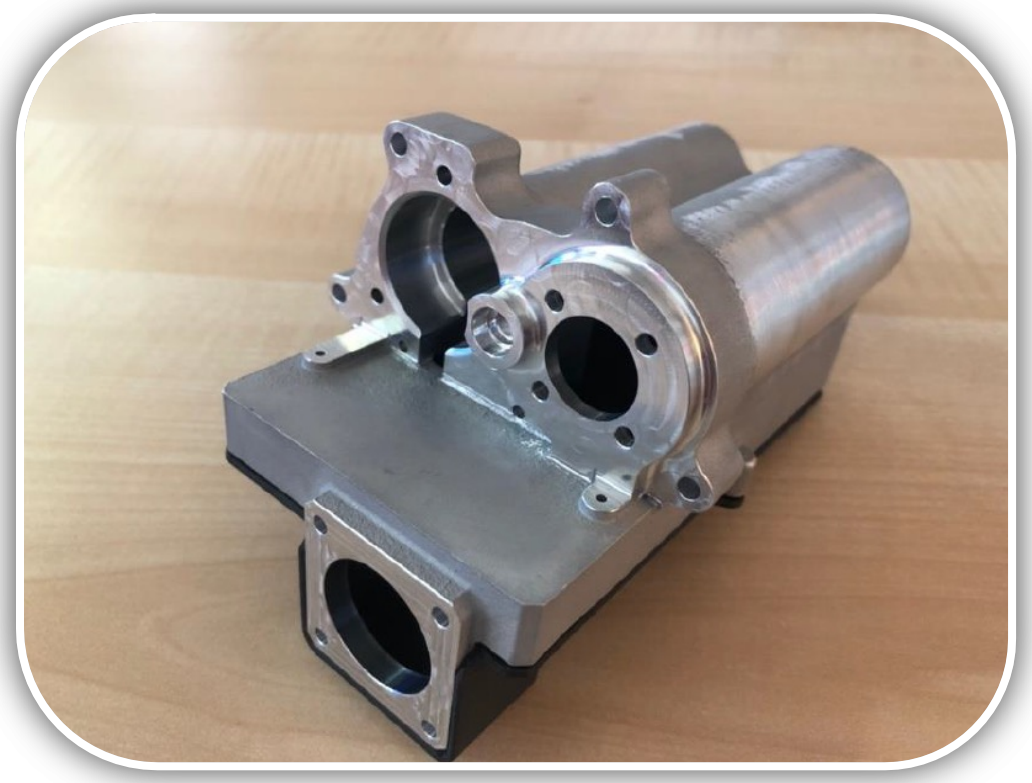
- Design for Additive Manufacturing (optimization) of aeronautical components and their realization

Material:

- Aluminum Alloy (SCALMALLOY®)

Research Activities & Case Studies

[LNGS: OMA-FaVRIA] Commissioned research



Components made:

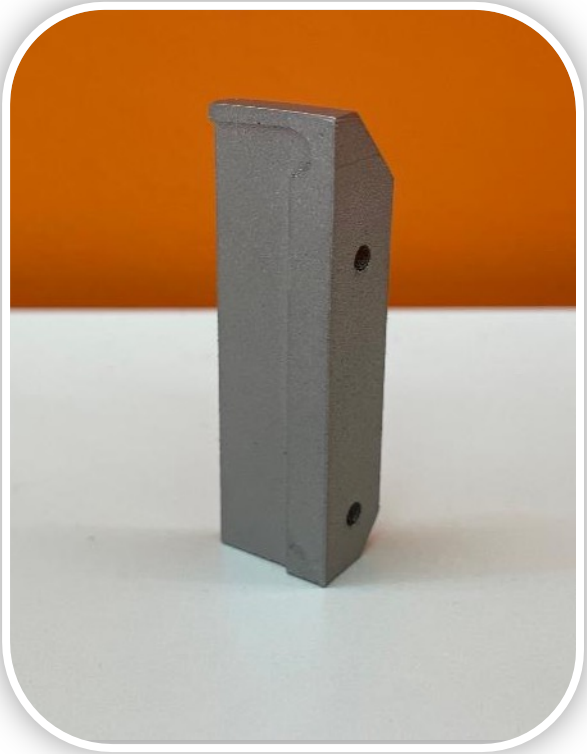
- N.3 **hydraulic valves** with optimized channels via CFD analysis
- N.3 **electromechanical actuators** optimized by topological optimization

Complementary activities:

- Static and fatigue characterization tests
- Spectrometric characterization
- Dimensional checks
- Cryogenic tests

Research Activities & Case Studies

[LNGS: PLANETA] Design and production of crystal holders



Objectives:

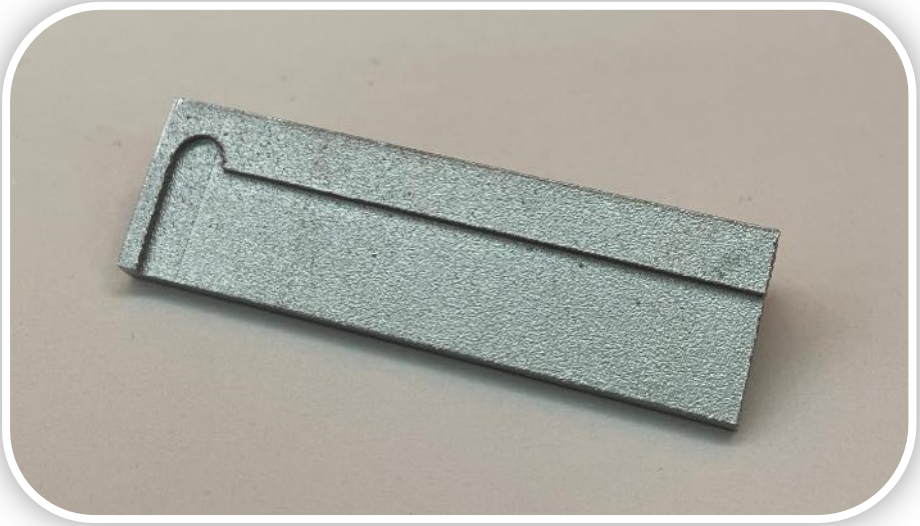
- Vacuum component
- High precision mechanical coupling

Material:

- Steel AISI 316L

Research Activities & Case Studies

[LNGS: PLANETA] Design and production of crystal holders



Components made:

- N.4 holders

Post-operations:

- Sandblasting
- Threaded holes

Research Activities & Case Studies

[LNGS: UNIROMA1] Study of the realization of multimaterial components

Objectives:

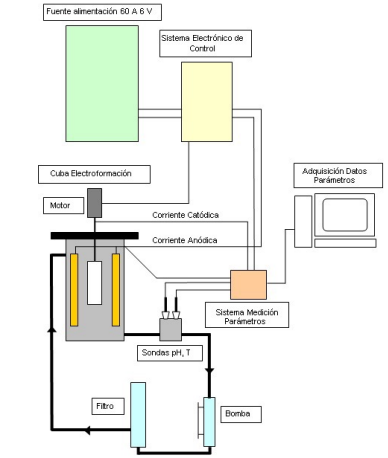
- Study of the realization of multi-material components using SLM technology

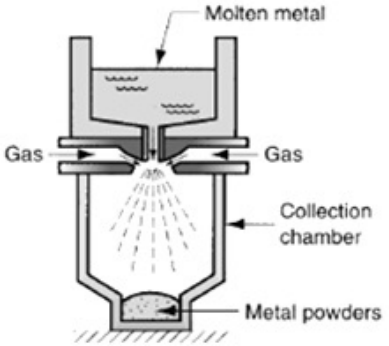
Material:

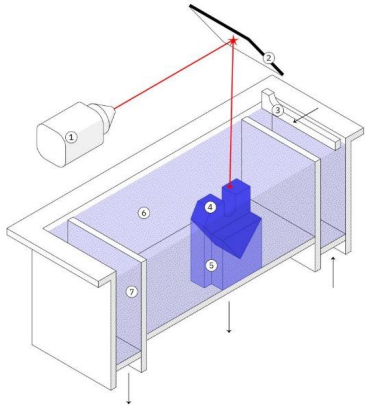
- Steel AISI 316L / CuCrZr

Research Activities & Case Studies

[LNGS & LSC] Innovative hybrid process based on EF/Atomization/SLM







Objectives:

- Realization of complex components using SLM technology
- By atomizing Electroformed Copper

Material:

- EF Copper from LSC (see Eric's talk)

Laboratorio Subterráneo Canfranc

Thanks for your attention

(and you're welcome at LNGS Mechanics Service)