PhD course of National Interest in Technologies for Fundamental Research in Physics and Astrophysics

Annual report

Name and surname: Alberto Barci
Cycle and a.a.: XL cycle, 2024-2025
Supervisor: Massimo Pellizzari

- **Research activity carried out during the year**

During the first year of my PhD, I studied the additive manufacturing of refractory metals (Ta, Ta10W, Ta-W-based High Entropy Alloy) using LPBF (Laser Powder Bed Fusion) technology, to evaluate their printability and potential for very high-temperature applications. The project is part of the HISOL_NEXT program, dedicated to developing a new generation of high-performance ISOL (Isotope Separator On-Line) sources for the SPES facility at the Legnaro National Laboratories.

In this context, tantalum is already used in ion source components due to its high thermal resistance and chemical stability. My PhD project involves studying the printability of two tantalum-based alloys to which other elements, typically tungsten, are added to enhance their mechanical properties. The two selected alloys were Ta-10W and a high-entropy alloy primarily based on tantalum and tungsten, with the following composition: Ta 35-40 %, W 35-40 %wt.

The goal is to select the best printing parameters starting from simple shapes and then proceeding to complex components.

The first phase was an in-depth literature review on LPBF of tantalum, tungsten, the Ta-10W alloy, and Ta-W-based HEAs. This study outlined the state of the art, highlighted the main technological difficulties (e.g., crack formation in tungsten), and defined an initial range of process parameters for the experimental phase.

Subsequently, the work focused on the 3D printing of pure tantalum, to verify the processability window and understand the main mechanisms influencing material quality. Samples were produced by varying LPBF parameters (laser power and scanning speed), and the quality was assessed through density measurements (Archimedes method) and microstructural observations (optical microscopy and SEM).

The preliminary study on the Ta-10W alloy was then initiated, with the production and evaluation of the first samples. Parameters identified as optimal for pure tantalum were used as a starting point to define a process window. The first samples reached a relatively low relative density (< 97%), indicating that further studies are needed to optimize process parameters.

In parallel, the study of thermal and electrical properties was initiated, essential for assessing suitability in ionization sources operating up to 2000 °C. Starting with tungsten test samples, measurements of

electrical resistivity, emissivity, and thermal conductivity were carried out.

- **List of attended courses and passed exams**

  Analysis and Modelling of the Additive Manufacturing (12 hours)

  Generative Design for Smart Additive Manufacturing (12 hours)

  Coupled electrical-thermal-structural Finite Element Analyses (10 hours)

  Powder Flowability (10Hours)

- **List of attended conferences, workshops and schools, with mention of the presented talks**
  SEAMAC International Summer school: additive manufacturing, from powder to final parts with a smooth surface, 29. 6. – 5. 7. 2025, Ljubljana

- **List of published papers/proceedings**

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- **Thesis title (even temporary)**

  Development and Characterization of Innovative Additively Manufactured Metal Alloys for High and Ultra-High Temperature Applications

Date, 18/09/25 **Signature…** Alberto Bacci

Seen, the supervisor

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