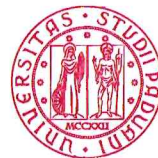




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UNIVERSITÀ
DEGLI STUDI
DI PADOVA

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

Annual report

Name and surname: Tochukwu Emmanuel Ezeaba

Cycle and a.a.: 40th Cycle, 2025/2026

Supervisor: Prof. Cristian Pira

- Research activity carried out during the year

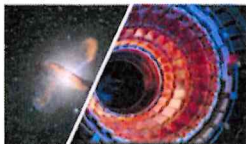
The aim of this project is to optimize the novel plasma electrolytic polishing (PEP) technique for superconducting radio frequency (SRF) cavities and to extend its application to other accelerator components, particularly those produced via additive manufacturing (AM). Since the performance of SRF technology is directly linked to the surface resistance of SRF cavities, achieving surface roughness below 1 μm is essential. While niobium (Nb) has become the standard material for SRF applications, its high cost and material wastage have made thin-film deposition of Nb or Nb₃Sn on copper (Cu) substrates an increasingly attractive alternative. For this reason, our work has focused not only on Nb cavities but also on Cu cavities, preparing their surfaces for Nb coating.

Over the past year, my research has concentrated on refining PEP process parameters to achieve improved results across a range of materials, including stainless steel (SS), Cu, Nb, Ti, and alloys such as steel and CuCrZr. These activities have targeted both SRF cavities and AM accelerator components. Multiple polishing trials were performed on 6 GHz prototypes, serving as a test platform for the widely used 1.3 GHz cavities. Through iterative optimization and careful evaluation after each experiment, we established treatment protocols that can be directly applied to the 1.3 GHz SRF cavities.

Building on these protocols, and in collaboration with KEK and CERN, we successfully treated a single-cell 1.3 GHz Cu SRF cavity using our optimized PEP process. This cavity was subsequently Nb-coated at CERN in August 2025 and sent to KEK, Japan, for RF characterization and testing. This work provides the first validation of PEP from the SRF perspective. The test confirmed that PEP is fully compatible with SRF treatment protocols and, importantly, demonstrated performance improvements over standard surface treatments. In particular, at 1.8 K, we observed enhancements in both accelerating gradient and quality factor at high fields. This is a landmark achievement for INFN-LNL and a significant milestone for the global SRF community. The PEP process and results from this cavity will be presented for the first time at the SRF'25 International Conference on Superconductivity Technology in Tokyo, Japan.

In parallel, we obtained promising results in polishing AM accelerator components. Our findings demonstrate that PEP is indeed applicable to AM components, delivering reliable improvements in surface quality.

Beyond research-related challenges, my main personal difficulty has been adapting to the Italian language. To address this, I have undertaken Italian A2 and B1 language courses, which have significantly improved my ability to communicate and integrate in Italy.



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- List of attended courses and passed exams:
 1. Analysis and Modelling of Additive Manufacturing (2 CFU)
 2. Advanced Scientific Programming (6 CFU)
 3. Science Communication and Knowledge Valorization: Practices & Tools (2 CFU)
 4. Vacuum Technologies (2 CFU)
 5. Italian Language Course – A2
 6. Italian Language Course – B1
- List of attended conferences, workshops and schools, with mention of the presented talks:
 1. PhD Meeting of Gran Sasso
 2. iSAS Conference at INFN, Legnaro
 3. Summer School at the University of Slovenia, Slovenia
 4. International Conference on AM4Linacs at Goethe University, Frankfurt, Germany
(Presented a talk on Recent cases of Plasma Electrolytic Polishing (PEP) of AM parts executed at INFN Legnaro Laboratories)
- List of published papers/proceedings
 1. Plasma Electrolytic Polishing at INFN: A Versatile Surface Treatment Technology for Additively Manufactured Accelerator Components. Author. Proceedings paper submitted to SRF25 – 22nd International Conference on RF Superconductivity.
 2. Plasma Electrolytic Polishing of 1.3 GHz Cavities. Co-author. Proceedings paper submitted to SRF25 – 22nd International Conference on RF Superconductivity.
- Thesis title (even temporary):

Plasma Electrolytic Polishing (PEP) of SRF Cavities and Its Extension to Additively Manufactured Accelerator Components.

Date: 15/09/2025

Signature:

Seen, the supervisor