ISIS@MACH ITALIA

Science and Technology Facilities Council
ISIS Neutron and Muon Source

Experiment Proposal

Experiment number GP2024001

Principal investigator	Dr Luigi Faillace, INFN-LNF - Frascati, Rome, ITALY
Co-investigator	Dr Bruno Spataro, Istituto Nazionale di Fisica Nucleare
Co-investigator (*)	Dr Giovanni Romanelli, University of Rome Tor Vergata, ITALY
Co-investigator	Dr Laura Fazi, University of Rome Tor Vergata, ITALY
Co-investigator	Dr Anna Prioriello, University of Rome Tor Vergata, ITALY
Co-investigator	Professor Roberto Senesi, University of Rome Tor Vergata, ITALY
Co-investigator	
Co-investigator	
Co-investigator	
Experiment title	Material characterization for high-gradient radio-frequency accelerating structure using SEM-EDX
MRF Instrument	**SEM with correlative AFM**
Access Route	Direct Access
Science Areas	Materials, Technique Development
Sponsored Grant	None
Grant Title	-
Start Date	-
Similar Submission?	-
Industrial Links	-

Days requested: 3
Previous GP Number: -
DOI: -
Sponsor: -
Grant Number: -
Finish Date: -

Non-Technical Abstract Performance improvements of next generation of particle accelerators are mostly dependent on the new technological developments of accelerating cavities, i.e., mainly on the field gradients they are capable to withstand. Large electric gradients are required for a variety of new applications, notably including the extreme high brightness electron sources for X-ray free electron lasers (FELs), RF photoinjector, industrial and medical accelerators and linear accelerators for particle physics colliders. In this context, the goal of this proposal is to perform a series of materials characterizations on the Cu-Ag alloy with different Ag concentration, using SEM-EDX and other techniques, in order to improve and optimize breakdown performances, as well as to assess the feasibility of copper (or equivalent metals) coating with a relatively thick film to obtain the same result.

Publications -

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E-platform: No

Instruments	**Days Requested:**
Access Route	**Previous RB Number:**
Science Areas	**DOI:**
Sponsored Grant	**Sponsor:**
Grant Title	**Grant Number:**
Start Date	**Finish Date:**
Similar Submission?	
Industrial Links	

Sample record sheet

Principal contact Dr Giovanni Romanelli, University of Rome Tor Vergata, ITALY
MRF Instrument **SEM with correlative AFM** **Days Requested:** 3
Special requirements:

SAMPLE

Material	Cu-Ag alloy	-	-
Formula	CuAg	-	-
Forms	Solid		
Volume	0.5 cc		
Weight	4 g		
Container or substrate	-	-	-
Storage Requirements	-	-	-

SAMPLE ENVIROMENT

Temperature Range	300 - 300 K	-	-
Pressure Range	0 - 0.1 MPa	-	-
Magnetic field range	0 - 0 T	-	-
Standard equipment	None	-	-
Special equipment	N/A	-	-

SAFETY

Prep lab needed	No	-	-
Sample Prep Hazards	None	-	-
Special equip. reqs	None	-	-
Sensitivity to air	No	-	-
Sensitivity to vapour	No	-	-
Experiment Hazards	None	-	-
Equipment Hazards	-	-	-
Biological hazards	N/A	-	-
Radioactive Hazards	N/A	-	-
Additional Hazards	-	-	-
Additional Details	-	-	-
Sample will be	Disposed by IS	-	-

Material characterization for high-gradient radio-frequency accelerating structure using SEM-EDX

1. Background and Context

Performance improvements of next generation of particle accelerators are mostly dependent on the new technological developments of accelerating cavities, i.e., mainly on the field gradients they are capable to withstand. Large electric gradients are required for a variety of new applications, notably including the extreme high brightness electron sources for X-ray free electron lasers (FELs), RF photoinjector, industrial and medical accelerators and linear accelerators for particle physics colliders.

In the framework of the collaboration amongst Laboratori Nazionali di Frascati (INFN-LNF, IT), Stanford Linear Accelerator Center (SLAC, USA) and University College Los Angeles (UCLA, USA), and the High Energy Accelerator Research Organization (KEK, Japan), INFN-LNF is involved in the modelling, development and test of Radio-Frequency (RF) structures devoted to acceleration with high gradient electric field of particles through metal devices. In order to improve the maximum sustainable gradients in normal conducting RF accelerating structures, we have to minimize the breakdown and the dark current. To this purpose, the study of new materials and manufacturing techniques is mandatory to identify solutions to such extremely demanding applications.

In order to design powerful and more compact accelerators, it is necessary to increase the intensity of the electromagnetic fields at which all accelerating devices operate. Regarding cavity materials, at both the X-band and C-band the cavities based on Cu-Ag alloys have a lower breakdown probability than cavities build on copper alone [1,2]. In detail, recent research on high-gradient RF accelerating structures indicates that the use of Cu-Ag alloy with a concentration of 0.08% provides excellent improvement in high gradient performance over copper.

In this context, the goal of this proposal is to perform a series of materials characterizations on the Cu-Ag alloy with different Ag concentration in order to improve and optimize breakdown performances, as well as to assess the feasibility of copper (or equivalent metals) coating with a relatively thick film to obtain the same result.

2. Proposed experiment

We propose the characterization of a series of Cu-Ag alloy samples (see Figure 1) by using Scanning Electron Microscope (SEM) augmented by Energy Dispersive X-ray Spectroscopy (EDX) using the **SEM with correlative AFM** MRF instrument available at the UTV-Rome Unit of IM@IT. For those regions of the samples with lower roughness, in situ Atomic Force Microscopy (AFM) measurement will be performed as well. This characterization will allow the reconstruction of the elemental (Cu-Ag + impurities) maps of the regions investigated at the SEM/AFM microscope, providing a quality check on the presence of dislocations and the homogeneity of the stoichiometric ratio over several regions of importance across the surface of the sample.

In separate proposals, we also aim to perform a bulk characterization of the dynamic and mechanical properties of the samples using the Dynamic Mechanical Analyzer (DMA) also available at the UTV-Rome IM@IT unit, as well as ancillary characterizations including hardness, elongation, Resistivity and so on.

A second set of measurements, to be requested in an upcoming call for proposals, will be performed after performing an annealing process on the samples. The further characterizations will be used to assess if annealing can reduce the number of dislocations on the surface.

3. Justification of experimental time requested

To perform the proposed experiment, we request 3 days of instrument time of the "SEM with correlative AFM" instrument at the UTV-Rome unit of IM@IT, to be used as follows: 1 day for the 3 samples corresponding to the Cu-0.08 Ag stoichiometry; 1 day for the several samples corresponding to the Cu-0.058 Ag stoichiometry; and 1 day for the 2 remaining samples corresponding to the Cu – 0.028 Ag and Cu – 0.1 Ag stoichiometries.

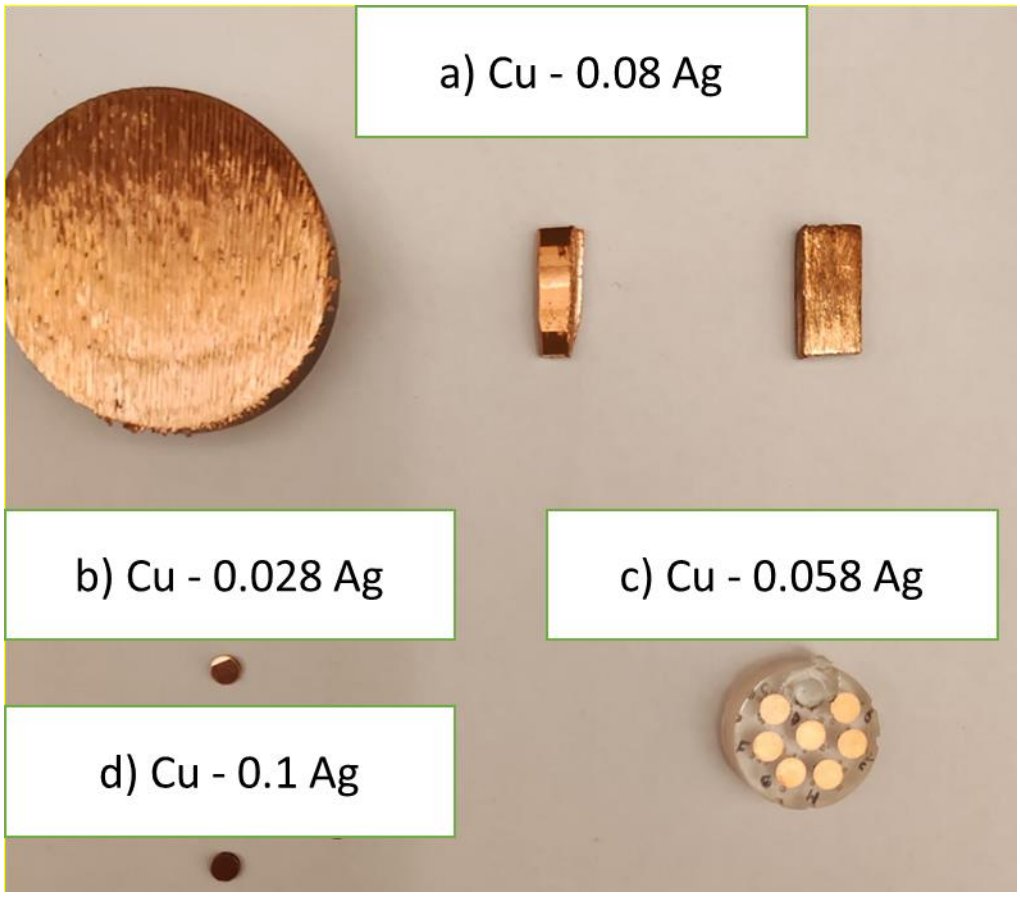

Figure 1. The several samples to be characterized, corresponding to Cu-Ag alloys with different stoichiometric ratios, in particular: a) 1:0.08; b) 1:0.028; c) 1:0.058; d) 1:0.1.

References

[1] Schneider, M.; Dolgashev, V.; Lewellen, J.W.; Tantawi, S.G.; Nanni, E.A.; Zuboraj, M.; Fleming, R.; Gorelov, D.; Middendorf, M.; Simakov, E.I. High gradient off-axis coupled C-band Cu and CuAg accelerating structures. Appl. Phys. Lett. **2022**, 121, 254101

[2] Dolgashev, V.A. Progress on high-gradient structures. In AIP Conference Proceedings; American Institute of Physics: College Park, MD, USA, 2012; Volume 1507.