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Modeling, Fabrication, and Optimization of Niobium Cavities Phase III: Quarterly Report

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Modeling, Fabrication, and Optimization of Niobium Cavities –Phase III
Third Quarterly Report

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AAA Research Area: Accelerators / Transmuter

Introduction

This quarterly report provides an update to the last phase of the Modeling, Fabrication, and Optimization of Niobium Cavities. Designing the experimental setup of secondary electron emission was well underway in early summer of 2003 when funding was made available for this portion the study. By March 2004, many of the components of the experimental study reached UNLV with some assembly accomplished. The first secondary electron emission (SEE) measurement was made from the surface of a Faraday cup in September 2004. At a particular beam energy, the current measured with the Faraday cup and electrometer changed sign over a range of energies. Three studies in support of this last phase are being conducted in parallel. The accomplishments and directions in these three areas are presented below.

Material Secondary Electron Emission Studies:

Achievements: The Monte Carlo Back Scattering and Secondary Electron Scattering code developed by Dr. David Joy (ORNL and University of Tennessee Knoxville) is being translated into C++ by a third student and Dr. Kant (volunteer) not associated with this research project but both part of the Electromagnetics and Pulsed Power Laboratories. The code now accepts up to ten layers of varied thickness of material composition in determining the SEE energy and trajectory. The code is fast and agrees with earlier versions.

Direction: Thoughtful code inputs are required. With the use of an RGA and time, we will estimate the formation of gas layers on the sample (partial pressures). After appreciable pumping at around 1e-9 Torr, RGA measurements will be monitored as the sample is brought down to cryogenic temperatures from room temperature. Keeping in mind that cold surfaces act as pumps, the change in the background environment will be noted. Since only the sample and cold heads of the cryostat will be cold, changes in partial pressures will be attributed to these surfaces. This will allow for one to estimate the layers of material deposited on the sample surface and in what order. The sequential layer composition and thickness may be determined and implemented into the SEE code for evaluation.

Experimental Set-up for the SEE from a Niobium Test Piece:

Achievements: We are nearing the completion of the experimental setup for the secondary electron emission (SEE) studies from niobium. Refer to Figs. 1 and 2. The following tasks have been completed:

- The experimental setup with electronics has been assembled.
- The electron gun is functional and appears to work as advertised.
- The detector is assembled and connected to computer. The last check in the sequence of checks for the detector failed. A special source regulation circuit is being designed to correct for the inability of the voltage supplies to reach the required potentials across the MCP stack.
- We have been able to demonstrate about $2x10^{-9}$ Torr pressures with our current system without baking.
- The Faraday cup and tungsten lamp work.

- The cryostat (insides of a cryopump used) is operational. Measured temperatures between 8.5 to 9.5 ^{o}K have been achieved.
- A good thermally conductive grease has been identified and purchased to attach the niobium sample to the cold head. The InGa material used acted as a thermal insulator at cold temperatures. Although In is a good thermal conductor, it appears that separation between the two metals resulted in the Ga to act as a good insulator as far as the test sample is concerned.
- Secondary electron emission has been observed from the Faraday cup detector. A Keithley electrometer was employed to measure the low currents.
- A website has been developed to display some of our efforts regarding this research. Please refer to http://EMandPPLabs.nscee.edu
- LANL and Cornell cleaned niobium samples have been received and are currently stored in a Ni environment in its original packaging awaiting for test.

Direction: Approaching operation mode means that the system will need to be thoroughly tested to know how the beam-target-detector system in the environment developed will be influenced over time. Repeatability and measurement stability will be the main concern during the next phase along with data taking and understanding the results obtained. With this in mind, the following tasks will be examined in the near future:

- It is not clear if the sample will reach the same temperature as the cold head with the grease interface present. A second temperature diode was purchased and will be attached to the cryohead in the same manner as the sample. We will be able to monitor the temperature achieved by the diode and deduce that the niobium sample will be reaching the same temperature.
- The superconductiving temperatures of the niobium occur within the current range of temperature fluctuation. A thermal shield is to be built and attached to the second stage of the cryostat. The thermal shield of the insides of the cryopump will be modified to fit the experimental setup. It is hoped that the shield will allow for temperature stability at the superconducting temperatures of niobium.
- Electron beam presence and its characteristics are important in characterizing SEE from the sample. A phosphor screen (phosphor P43 coated on a glass substrate with charge dissipation properties and an aluminum coating for increase brightness) sensitive to low electron beam currents and energy is being purchased so that one can measure the beam diameter and locate the beam for Faraday cup current measurements. Various types of phosphor like paints have been tested for electron beam location. A faint glow could be observed from only one of the paints tested when the electron beam over a wide range of energies (from less than 50 eV up to 5 keV) bombarded the medium.
- A telescope with reticle is needed to measure the beam diameter with some accuracy.
- The beam width adjustments and detector orientation need to be examined.
- *In situ* sample cleaning techniques will be examined with the present equipment.
- Adjustments to the grid potential and its influence on the secondary electrons are to be studied.
- Some detector-target-gun distance adjustments are needed allowing for a reasonable uniform field region between the grid and target. These distances are crucial in order to capture both low and high energetic secondaries by varying the grid potential.

Theoretical Study for the SEE from a Niobium Test Piece:

In support of the numerical Monte Carlo and experimental studies, a particle tracking numerical/theoretical study is also underway. This study will aid in explaining experimental results. An electrostatic code and a particle tracking code are being used to map all possible secondary electron trajectories with the same termination conditions as obtained from experiment. At this time about three-fourths of the parameter space has been mapped. A database is being kept with a look-up table format. This data will aid in determining what family of secondary electrons with suitable initial conditions will reach the measured position.

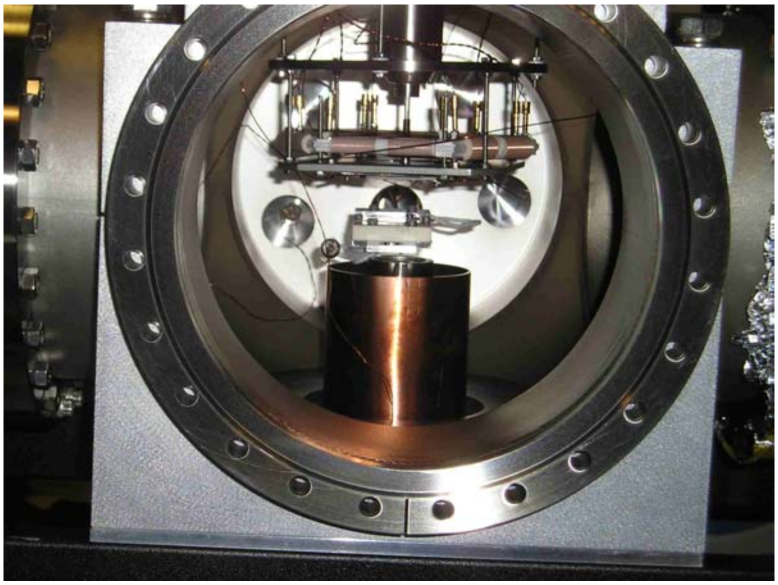

Fig. 1. View of the electron gun, beam tube, detector, manipulator arm, cryostat and thermal shield.

Fig. 2. Anoop George (graduate student) assembling the detector and gun assembly to the vacuum chamber. The electron gun (centered in vertical position on the top flange) and RGA head (offset angle to right of gun) are displayed.