

## The Electromagnetics Laboratory Adds a Novel Twist to Experimental Studies on Materials with Application to Large Proton Accelerators and Potential Application to the Semiconductor and Space Industries

In the planning for the past five years, the Electromagnetics and Pulse Power Groups in the Electrical and Computer Engineering (ECE) Department at UNLV have been emphasizing material studies in unique environments. A new experiment is to be conducted in the Electromagnetics Laboratory during the summer of 2004 on the study of secondary electron emission from LANL cleaned, superconducting grade, niobium. The Department of Energy, through the Harry Reid Center at UNLV, is funding the project under the Transmutation Research Program (TRP). The TRP program is directed by Dr. Anthony Henchenova (Director, UNLV Transmutation Research Program) and Dr. Gary Cerifice (Deputy Director, UNLV Transmutation Research Program) both residing at the Harry Reid Center. This research is in support of the high-energy proton accelerator at Los Alamos National Laboratory (LANL) in collaboration with Dr. Tsuyoshi Tajima at LANL.

The power handling capability of radio frequency (rf), superconducting niobium cavities used in high-energy proton accelerators is limited by multipacting of electrons. Multipacting is a continuous, periodic impacting of electrons leading to electron avalanche inside the chamber typically initiated by surface contaminants and/or field emission. This current is a substantial energy loss to the system that results in an undesired localized heating of the superconducting wall. Significant numerical efforts have been exploited in designing cavities that inhibit multipacting. Codes require accurate characterization of the secondary electron yields of the specific cavity materials with surface conditioning.

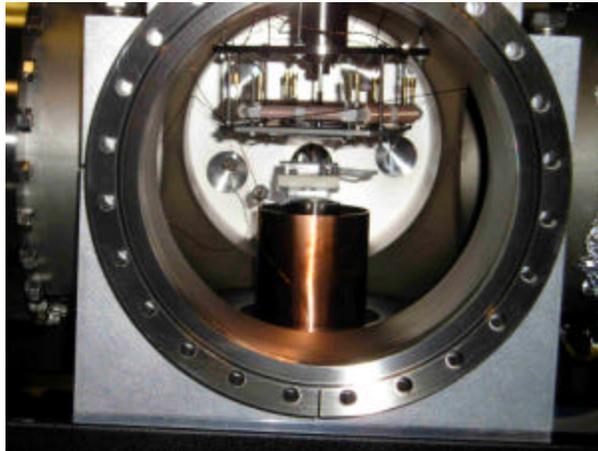


Fig. 1 Close-up view of the gun, detector, cryostat and manipulator arm inside the UHV vacuum chamber.

The experimental research to be conducted in the Electromagnetics (EM) Laboratory will be adding several novel twists to the study of secondary electron emission. First, to our knowledge, secondary electron experiments have not been conducted at the operating temperatures and pressures of the superconductivity cavities. The experiments in the EM laboratory will be conducted with low energy primary electrons obliquely incident on niobium at the superconducting temperature of niobium ( $\sim 8^{\circ}\text{K}$ ) in an ultra high vacuum (between  $10^{-9}$  and  $10^{-10}$  Torr) environment. Currently, the ultra high vacuum pressure milestone has been reached with the vacuum system pictured in Fig. 1 containing the electron gun, particle position detector with multi-channel plate, cryostat, and manipulator arm. Second, a particle position detector is to be used to determine the position and time of collection of the secondary electrons. Over and

above gross secondary electron yield measurements, a family of secondary electron initial states (initial trajectory, energy and momentum) will be determined experimentally and verified with a secondary electron emission Monte Carlo code. Finally, a special manipulator arm (Refer to Fig. 2) loaded with Faraday cup, mechanical manipulation tool, sputter cleaning system, and a thermal heating unit has been designed with the aid of Transfer Engineering Inc.

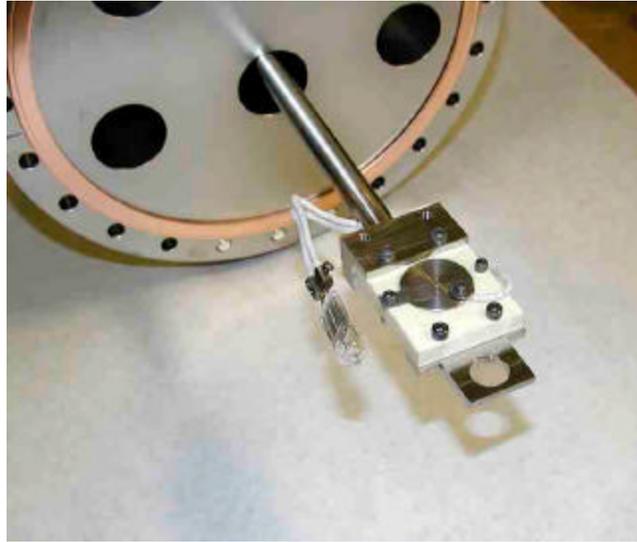


Fig. 2 Working end of the xyz manipulator arm. Thermal unit, Faraday cup, and manipulator tool may be seen. The manipulator arm was partially designed and fully built by Transfer Engineering Inc. in Fremont, California.

Graduate student Anoop George (Refer to Fig. 3) spearheads the secondary electron emission research at UNLV. Not only has he worked in conjunction with Transfer Engineering Inc. to develop the vacuum chamber with manipulator arm and worked independently with electron gun and detector vendors, he also presented a paper at the 2004 American Nuclear Society Student Conference in Madison, Wisconsin on April 1-4, 2004. His paper entitled *Preparation Studies for Secondary Electron Emission Experiments on Superconducting Niobium* received the outstanding student paper award by peer reviewed referees, the highest award offered at the conference. Preprint copies of the publication may be obtained upon request.



Fig. 3 Graduate student Anoop George is (left) cleaning the particle detector grid with nitrogen gas and (right) lowering the detector-electron gun assembly into the UHV vacuum chamber.

The Electromagnetics Laboratory is extremely grateful to a number of individuals and companies that have been instrumental in developing both our laboratory infrastructure and laboratory experience at UNLV. Mr. Stan Goldfarb, Past Chair of the Vacuum Technology Division of the American Vacuum Society and retired vacuum specialist (Refer to Fig. 4), has volunteered many hours of time working with graduate students and staff regarding vacuum equipment and procedures, residual gas analyzers, and vacuum related experiments. His expertise and experience has raised the standards of the laboratory many fold. Dr. Richard Kant, retired physicist (Refer to Fig. 4), has volunteered many hours of time in modifying and developing upon an existing Monte Carlo secondary electron emission source code provided to the lab by Dr. David Joy (ORNL and University of Tennessee, Knoxville). The code will be used to verify experimental measurements. Dr. Michael Benapfl, American Vacuum Society instructor and physicist at Lawrence Livermore National Laboratory, has donated some of his time in teaching students and staff in the Electromagnetics and Pulse Power Laboratories at UNLV some of the vacuum basics. Dr. Benapfl has donated some of the vacuum components that were incorporated in the experiment. Mr. Daniel Jennings of MDC donated various vacuum components used in the experiment. Mr. Les Hughes, Intevac, donated a compressor to UNLV that is being used to drive the cryostat in Anoop's experiment. Mr. Mark Jalbert, Mr. Ted Raabe, Mr. Jim Gentilcore, Mr. Bob Lepofsky and Mr. Bob Willis all from Helix Technology have donated a cryogenic pump and compressor and various forms of support needed for the Electromagnetics Laboratory to reach otherwise unachievable milestones. Mr. Michael Ackeret and his company Transfer Engineering Inc. has been responsible for partially designing and fully building the vacuum system, stand, and manipulator arm. Although purchased, their craftsmanship and care in details after many hours of discussions before, during, and after construction has allowed the EM laboratory reach their design and experimental setup goals. Although this article focuses on the niobium experiment, these men and their companies have provided a number of graduate and undergraduate students with experiences in specialized material experiments otherwise unattainable in the Electromagnetic and Pulse Power Laboratories in the ECE department at UNLV. It is firmly believed that industry and the retired community working with university,

national laboratories, and federal and state governments provides the best educational experience for students who will soon contribute in shaping the future of this world.

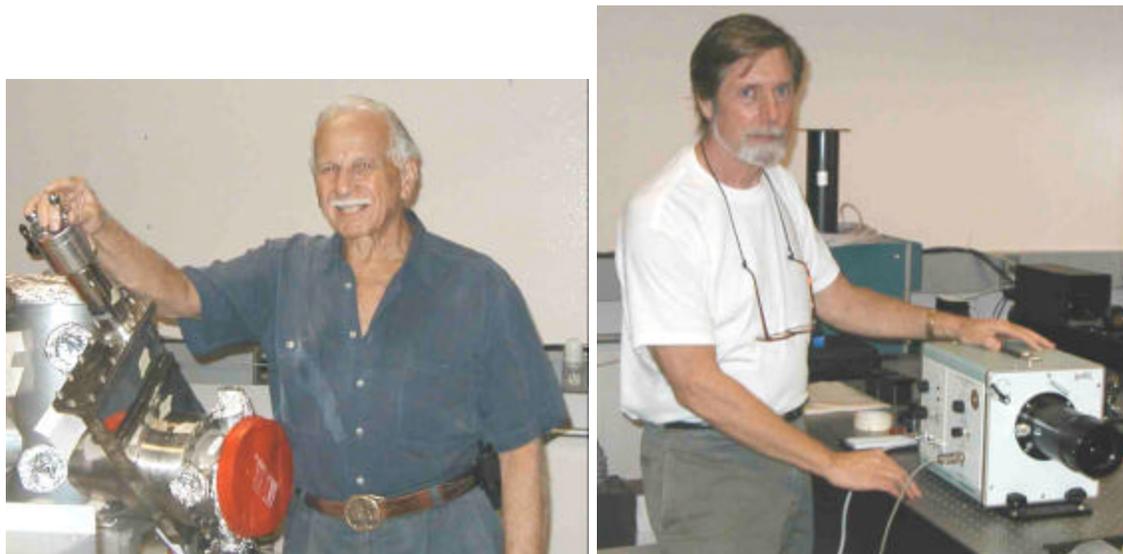


Fig. 4 Mr. Stan Goldfarb (left) standing next to the original vacuum chamber that was attempted to be used in the niobium experiment. Dr. Richard Kant (right) currently developing the Monte Carlo secondary electron emission code also has an experimental experience and background enhanced by his positions at a number of national laboratories.

Where do we go from here? The unique nature of the niobium experiment offers exploration studies of novel semiconductor devices and space materials. For example, solar winds contain high and low energy charged particles that may intercept a space vehicle or satellite. Understanding the interaction process and charge particle damage under extreme temperatures and pressures may offer safer futuristic material designs that are more robust.

### **Other Sponsor Acknowledgements**

The Electromagnetics Laboratory acknowledges alumni Mrs. Angela M. Davison (maiden name Angela Molnar), currently associated with the patent law firm Gifford, Krass, Groh, Sprinkle, Anderson & Citkowski PC in Birmingham, Michigan, for her generous donation. Her donation is being used to upgrade the software used by students in the laboratory.