Wednesday Afternoon, November 4, 1998

Vacuum Technology Division
Room 329 - Session VT-WeA

Vacuum Systems and Components

Moderator: J.L. Provo, Sandia National Laboratories

2:00pm **VT-WeA1 Design and Installation of a Low Particulate, Ultra-High Vacuum System for a High Power Free Electron Laser**, ***H.F. Dylla***, *G. Biallas, L.A. Dillon-Townes, E. Feldl, G.R. Myneni, J. Parkinson, J. Preble, S. Williams, M. Wiseman,* Jefferson Lab

A high-average power (kW) infrared free electron laser (FEL) is currently being commissioned for the Jefferson Lab FEL User Facility. The IR FEL is driven by a unique superconducting RF linac which is recirculated to recover electron beam power that is not radiated in the FEL. The design and installation of the vacuum system for the FEL involved particular attention to minimizing particulate contamination which could cause problems with the superconducting acceleration cavities and the high power FEL optics. Particulate contamination levels of all vacuum components were monitored during the cleaning process using laser scattering. Cleaning, transport and installation procedures were developed to minimize the contamination of the complete system. We will summarize a data base we compiled of particulate contamination levels of the various components installed in the FEL vacuum system. This work supported by the U.S. DOE Contract No. DE-AC05-84-40150, the Office of Naval Research, Commonwealth of Virginia and the Laser Processing Consortium.

2:20pm **VT-WeA2 Vacuum Instrumentation and Control System for the Relativistic Heavy Ion Collider**, ***L.A. Smart***, Brookhaven National Laboratory*; R.C. Lee, D. Weiss, D. Zigrosser,* Brookhaven National Laboratory, US

The Relativistic Heavy Ion Collider (RHIC) Project is a nuclear physics research accelerator entering its final year of construction, with beam circulation scheduled for March 1999. To achieve beam emittance growth and lifetime, the vacuum in the two concentric rings must be at specified levels, and the sector valves isolating the cryogenic beam lines from those at room temperature must be open. The RHIC vacuum instrumentation and control (I&C) system performs multiple functions, the first of which is operating the sector valves with input from over one thousand gauges and pumps distributed around the 3.8 km circumference of the accelerator rings. Other vacuum system control functions include operating all gauges, pumps and valves from remote locations, supplying data for beam permits, data logging, and display of vacuum system parameters. Vacuum gauging includes inverted magnetron and convection-Pirani total pressure gauges, and partial pressure analyzers with faraday cup and electron multiplier detectors. Pumps on the high and ultrahigh vacuum chambers include sputter-ion, turbo molecular, and titanium sublimation pumps. Multi-drop serial communication networks are used to transfer pressure readings from gauge and turbo molecular pump controllers 300 m distant to distributed programmable logic controllers, which form the heart of the vacuum system control. This paper describes the architecture and implementation of the RHIC vacuum I&C system from the pumps and gauges to the remote operator interfaces used to control them.

2:40pm **VT-WeA3 An Ultra-High Vacuum System for Hydriding Rare Earth Metal Films**, ***S.J. Black***, *F.J. Steinkruger, C.W. Walthers,* Los Alamos National Laboratory **INVITED**

Los Alamos National Laboratory has designed, fabricated, assembled and tested a state-of-the-art vacuum system for the hydriding of reactive rare earth metal films. The application of this system is dihydriding 5000Å erbium films on molybdenum substrates for neutron tubes. Neutron tubes are a major component of neutron generators, which are used in modern nuclear weapons. The system is capable of achieving pressures in the 10@super -10@ torr range. Such pressures are desirable in order to reduce contaminant gas species (which would otherwise compete with the hydriding reaction), to the parts per billion level. The vacuum is provided by oil-free turbomolecular/molecular drag pumps. Rough pumping is provided by a scroll pump backed by a metal bellows pump. In order to achieve these low pressures, measures were taken in the design and operation of the system. In order to reduce outgassing within the system, we eliminated all organic material within the system through the use of all-metal valves. All fittings are either welded or rely on metal O-rings. Passivation of the vacuum system interior surfaces was performed to reduce condensation of oxygen and water on the stainless steel surfaces. Other materials used within the vacuum system (film substrates, fixtures, and radiation shields) are made of molybdenum which is extensively cleaned prior to use. The loader system is capable of heating the films to 700°C while under vacuum, and continuing to maintain those temperatures after adding several hundred torr of hydrogen isotopes or inert purge gases to the system. Since the vacuum system is opened each time films are either loaded or removed from the vacuum chamber, the apparatus is installed within an inert (nitrogen) glovebox. Remote operation of the system is made possible through the use of pneumatically-actuated valves. The system is heavily instrumented in order to achieve tight process control. Two residual gas analyzers (RGA's) are used to determine the chemical composition of species within the system during evacuation. Details of the hardware design will be presented as well as performance data.

3:20pm **VT-WeA5 Thermal Stability and Sealing Performance of Perfluoroelastomer Seals as a Function of Crosslinking Chemistry**, ***M.J. Heller***, *J.M. Legare, S. Wang, S. Fukuhara,* DuPont Dow Elastomers

Perfluoroelastomer (e.g. Kalrez, Chemraz, etc.), fluoroelastomer (e.g. Viton, etc.) and silicone parts are widely used in sealing applications for semiconductor wafer processing equipment. More specifically, they are often used as O-ring seals in dry chemical process equipment (e.g., Plasma Etchers, Ashers, Diffusion Furnaces, CVD, LPCVD, RTP and Lamp Anneal, etc.). Many of these seals are required to function at process temperatures ranging from 200 - 300°C and in some cases higher. The ability of an elastomer to resist thermal degradation has a significant impact on its ability to function effectively as a seal over time. This paper evaluates and compares the relative long term sealing performance of perfluoroelastomers having different crosslinking chemistries and other typically specified high performance elastomers. Long term compression set and seal force retention data is presented, including a discussion of the different test methods and their relative value in predicting seal performance at elevated temperatures. In addition, air heat aging data for other typically measured physical properties (i.e., Shore A Hardness, 100% Modulus, Tensile Strength at Break, Elongation at Break, % Weight Loss) is also presented and discussed. Results indicate perfluoroelastomers seals have the best long-term compression set characteristics and retain the highest percentage of their original sealing force over time. In addition, data shows perfluoroelastomers having an organo-metallic cross-linking system are the most thermally stable and exhibit the best long term seal performance at elevated temperatures versus those having an organic-peroxide cross-linking system. Finally, because the test conditions best reflect static o-ring seal service conditions, analysis of seal force retention test results provide a more realistic comparison of thermal stability and its relative impact on sealing performance.

3:40pm **VT-WeA6 Vacuum Insulation, 100 years of Cryogenics, and Clean Ultra High Vacuum**, ***G.R. Myneni***, Thomas Jefferson National Accelerator Facility

Sir James Dewar invented vacuum insulation (~ 1872) for improving high temperature calorimetry. He improved the vacuum in his double walled containers with charcoal for cryogenics use. He further enhanced the effectiveness of his dewars by silvering the inner walls. Dewar liquefied hydrogen for the first time on May 10, 1898 and Kammerlingh Onnes won the race of liquefying helium by 1908. Onnes discovered superconductivity in the year 1911. The heat capacity of materials at cryogenic temperatures provided some of the earliest scientific validation of quantum theory. The American space program gave the impetus for developing the multi layer insulation (MLI) to reduce the weight of launch vehicles and spacecraft. Cryopumping is providing clean ultra high vacuum in many high tech systems including semiconductor fabs and accelerators. Jefferson Lab's accelerator (CEBAF) has three independent vacuum systems (vacuum insulation, wave guide vacuum and beam line vacuum) and all of them benefit from cryopumping. The beam line vacuum inside the CEBAF cryomodules is extremely low. Diamond field emitter based extreme high vacuum instrumentation is being developed presently to measure such low pressures. High efficiency dewars are also being used in high tech medical diagnostic systems such as magnetic source imaging (MSI). These historic and present developments will be reviewed in this paper on the occasion of the centenary of the liquefaction of hydrogen by Sir James Dewar. This work supported by the U.S. DOE under contract No. DE-AC05-84ER40510.

4:00pm **VT-WeA7 Method for Measuring Deuterium in Erbium Deuteride Films**, ***J.R. Brangan***, *S.M. Thornberg, M.R. Keenan,* Sandia National Laboratories **INVITED**

Determining the quantity of deuterium in an erbium deuteride (ErD@sub 2@) film is essential for assessing the quality of the hydriding process but is a challenging measurement to make. First, the ideal gas law cannot be

applied directly due to high temperature (950@super o@ C) and low temperature (25@super o@ C) regions in the same manifold. Additionally, the metal hydride does not release all of the deuterium rapidly upon heating and metal evaporation occurs during extended heating periods. Therefore, the method developed must provide a means to compensate for temperature inhomogeneities and the amount of deuterium retained in the metal film while heating for a minimal duration. This paper presents two thermal desorption methods used to evaluate the kinetics and equilibria of the deuterium desorption process at high temperatures (950@super o@ C). Of primary concern is the evaluation of the quantity of deuterium remaining in these films at the high temperature. A multiple volume expansion technique provided insight into the kinetics of the deuterium evolution and metal evaporation from the film. Finally a repeated pump-down approach yielded data that indicated approximately 10% of the deuterium is retained in the metal film at 950@super o@ C and approximately 1 Torr pressure. When the total moles of deuterium determined by this method were divided by the moles of erbium determined by ICP/AES, nearly stochiometric values of 2:1 were obtained for several erbium dideuteride films. Although this work presents data for erbium and deuterium, these methods are applicable to other metal hydrides as well. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DEAC04-94AL85000.

4:40pm **VT-WeA9 Characterization of Aluminum Materials Focusing Electron Stimulated Gas Desorption and Its Surface Analysis in Surface Treatment Techniques*, M. Nishiwaki,*** *S. Kato,* KEK, Japan

In a hot vacuum environment such as a particle accelerator, gas desorption from a vacuum surface during the operation seriously affects the stability, the quality and the lifetime of the electron or ion beam. In order to adopt vacuum materials and surface treatment techniques to hot vacuum, reported data of thermal outgassing from vacuum surface do not always give established indication for outgassing due to particle irradiation. Therefore it is very important to evaluate gas desorption of the materials and the treatment techniques using energetic particle bombardment. We focused on measurement of electron stimulated gas desorption from aluminum materials mainly and its surface analysis in this study. Four different surface treatment techniques for aluminum materials were carried out to make comparison, that is, machining with oil lubricant and subsequent degreasing (OL), machining with a liquid jet of ethyl alcohol (EL), machining in a gas mixture of argon and oxygen (EX) and machining with corona discharges in the same gas mixture (EXP). In order to measure electron stimulated desorption rates from those surfaces quantitatively, a throughput method was used with a pressure calibrated RGA. The base pressure of the sample chamber was in an order of 10@super -7@ Pa. Electrons from an e-gun were irradiated against the samples at a typical condition of a kinetic energy of 1.5 keV, a current density of 10@super -3@ A/cm@super 2@ at a normal incident and a sample temperature of 27 ° C. Surface characterization of those samples was also done by use of Auger electron spectroscopy with sputter etching. This gives information about depth profiles of atomic compositions in an altered surface layer due to the treatment discussing the relation between the electron stimulated desorption rates and the surface atomic compositions.

Author Index

Bold page numbers indicate presenter

— B —
Biallas, G.: VT-WeA1, 1
Black, S.J.: VT-WeA3, **1**
Brangan, J.R.: VT-WeA7, **1**
— D —
Dillon-Townes, L.A.: VT-WeA1, 1
Dylla, H.F.: VT-WeA1, **1**
— F —
Feldl, E.: VT-WeA1, 1
Fukuhara, S.: VT-WeA5, 1
— H —
Heller, M.J.: VT-WeA5, **1**
— K —
Kato, S.: VT-WeA9, 2
Keenan, M.R.: VT-WeA7, 1
— L —
Lee, R.C.: VT-WeA2, 1
Legare, J.M.: VT-WeA5, 1
— M —
Myneni, G.R.: VT-WeA1, 1; VT-WeA6, **1**
— N —
Nishiwaki, M.: VT-WeA9, **2**
— P —
Parkinson, J.: VT-WeA1, 1
Preble, J.: VT-WeA1, 1
— S —
Smart, L.A.: VT-WeA2, **1**
Steinkruger, F.J.: VT-WeA3, 1
— T —
Thornberg, S.M.: VT-WeA7, 1
— W —
Walthers, C.W.: VT-WeA3, 1
Wang, S.: VT-WeA5, 1
Weiss, D.: VT-WeA2, 1
Williams, S.: VT-WeA1, 1
Wiseman, M.: VT-WeA1, 1
— Z —
Zigrosser, D.: VT-WeA2, 1