Wednesday Afternoon, November 5, 2003

Vacuum Technology
Room 323 - Session VT-WeA

Outgassing and Large Vacuum Systems

Moderator: L. Westerberg, Uppsala University, Sweden

2:00pm **VT-WeA1 How to Control Hydrogen Outgassing from Gauges and Materials**, ***F. Watanabe***, Vaclab Inc., Japan **INVITED**

The most important point for XHV technology is control of hydrogen emitted from the bulk. If we generate XHV, which is denoted by a hydrogen equivalent pressure below P=10@super -10@(H@sub 2@)Pa in a vacuum chamber, from the equation P=Q/S at the ultimate pressure, the limiting level of total outgassing should be below Q=PS=~10@super -11@Pa(H@sub 2@)m@super 3@/s when the pumping speed is e.g. S=~0.1m@super 3@/s. Here, we need three technologies for XHV, a minimum amount of a chamber, a pump and a gauge, in order to check the generated vacuum. However, if there is a large hydrogen outgassing from any component, the ultimate pressure is limited by that total value. That is, Q@sub total@(material)= Q@sub c@(chamber)+Q@sub g@(gauge)+Q@sub p@(pump) In the case of the chamber, a surface area of A=~0.5m@super 2@ is typical for a laboratory, therefore, the hydrogen outgassing rate from the material should be below q=Q/A=~2×10@super -11@Pa(H@sub 2@)m/s. To meet this situation, we have obtained an outgassing of Q=~10@super -12@Pa(H@sub 2@)m@super 3@/s for a hot-cathode ionization gauge and the extremely low outgassing rate of q=~10@super -14@Pa(H@sub 2@)m/s in the material of a 0.2% beryllium copper alloy. Therefore, we can easily obtain XHV in a laboratory using a pump of only a few liters/second. At the session, the process of development up to the present will be reviewed with the following program: (1) the importance of low emissivity material, (2) the unavailability of cold emitters for a gauge, (3) the concept of the heated-grid gauge/RGA, (4) the importance of copper alloy materials, (5) a comparison of recently-published ultra-low hydrogen outgassing materials, and (6) my conclusion for hydrogen outgassing reduction.

2:40pm **VT-WeA3 Outgassing Characteristics of a TiN-coated SUS-316 Vacuum Chamber Developed for XHV**, ***M. Hirata***, *H. Akimichi, A. Kurokawa, S. Ichimura,* National Institute of Advanced Industrial Science and Technology (AIST), Japan*; H. Yamakawa,* ULVAC Technologies, Inc.

The control of outgas from a vacuum chamber is the key issue to achieve XHV condition, since any pump has a limited pumping speed usually determined by effective connection area of the pump to the chamber. We have developed a new chamber accordingly, aiming at reducing outgas from the chamber wall as low as possible, and studied outgassing characteristic of the chamber. The chamber is made of vacuum melted stainless steel (SUS 316L) to minimize hydrogen outgassing, and treated by electrolytical polishing followed by pre-baking in vacuum and TiN coating. The outgassing rate of the chamber was measured by a throughput method after each treatment. The results are 4x10@super -9@Pa m/s, 3x10@super -12@Pa m/s and 1x10@super -13@Pa m/s, respectively.@footnote 1@ However, the ultimate pressure of the chamber (1x10@super -9@Pa) evacuated by a pump (1000 L/s) was quite higher than the pressure of 2x10@super -13@Pa estimated from the lowest value of the rate and the chamber inner area. In order to clarify the difference, the rate of the TiN coated chamber was measured by pressure rise method using an ionization (extractor) gauge and a spinning rotor gauge for several months. The results were 3x10@super -10@Pa m/s by the ionization gauge and 2x10@super -13@ to 3x10@super -12@Pa m/s by the spinning rotor gauge, respectively. The lowest value measured by the spinning rotor gauge was roughly equal to the value obtained by throughput method. These results suggest that outgas from the ionization gauge could not be ignored, and that the measured pressure of 1x10@super -9@Pa could be mainly attributed to outgas from the ionization gauge. A new method for XHV pressure measurement is inevitable. @FootnoteText@@footnote 1@S.Ichimura et. al.: Vacuum 53 (1999) 291.

3:00pm **VT-WeA4 Residual Gas in the LIGO Beam Tubes: Science, Arts and Recipes**, ***R. Weiss***, Massachusetts Institute of Technology **INVITED**

The LIGO (Laser Interferometer Gravitational-wave Observatory) has remote sites at Hanford, Washington and Livingston Louisiana. At these sites laser beams traverse 4km long 1.2 meter diameter beamtubes in vacuum to make the gravitational wave detection. The vacuum requirements are pressures less than 10^-8 torr of hydrogen and smaller pressures for heavier and more polarizable gases. The talk will describe the science and techniques developed, including: outgassing models, outgassing measurements, optical properties, material preparation, surface cleaning, bakeout and leak detection.

3:40pm **VT-WeA6 RHIC Pressure Rise with High Intensity Beam***, *P. He,* ***H.C. Hseuh***, *L.A. Smart, D. Weiss, S.Y. Zhang,* Brookhaven National Laboratory

RHIC is a superconducting heavy ion collider with two rings of 3.8 km circumference designed for nuclear physics research. With increasing ion beam intensity during recent RHIC operations, pressure rises of several decades within a few seconds were observed at a few room temperature vacuum sections. There are two distinct types of pressure rises, one occurs at injection and the other during acceleration. The first type has been associated with electron multi-pacting, electron stimulated desorption and ion desorption. The second type is coupled with beam halo scraping and desorption, with desorption rates of up to 10e+7 molecules per incident ion. Improvements to the RHIC vacuum systems have been evaluated, and some implemented, including extensive in-situ bakes, additional UHV pumping with lumped pumps and NEG coating, electron detectors and beam tube solenoids. The effectiveness of these measures in reducing the beam induced pressure bumps and increasing the vacuum system reliability are discussed and summarized. *Work performed under Contract Number DE-AC02-98CH10886 with the auspicious of the U.S. Department of Energy.

4:00pm **VT-WeA7 The Effect of Purge Pressure on Desorbing Water Removal Rate**, ***L.D. Hinkle***, Falmouth Public Schools

The need for high purity gas supply for vacuum systems and related processing equipment has driven the requirements for the design and operation of components in gas delivery subsystems. Water has been widely regarded as a major contaminant species in such subsystems. For designs that follow generally accepted practices for construction, sealing, and layout, the primary cause of water contamination is associated with ambient atmospheric exposure during maintenance or repair. The subsequent removal of this adsorbed water, and in particular, how this process can be accelerated has been the subject of much interest. While the enhancement of molecular desorption through various methods has received considerable attention, the effective removal of water vapor after desorption is also worthy of attention. This is especially true when considering the typical geometry of gas distribution and delivery subsystems. It is shown that at typical purge pressures a water molecule desorbing from a surface is likely to be adsorbed again. Thus, desorption may be required multiple times for the molecule to be removed from the subsystem. However, if the purge flow is operated at modest vacuum, a desorbing molecule remains in the purge stream considerably longer and travels farther downstream before being re-adsorbed, thus improving the removal rate. The primary focus of this investigation is to understand the dependence of the rate of water removal on the pressure of an inert gas purge. In most cases, the implementation of lower pressure purge may be accomplished with little or no change to existing equipment. In addition to the obvious savings and convenience resulting from a time reduction, considerably less purge gas is consumed.

4:20pm **VT-WeA8 Vacuum Analysis and Improvement for the Jefferson Lab Photo-Electron Guns**, ***M.L. Stutzman***, *P.A. Adderley, G.R. Myneni, B.M. Poelker,* Thomas Jefferson National Accelerator Facility

The 100 keV photo-electron guns at Jefferson Lab have demanding vacuum requirements since the photo-cathode lifetime is decreased by residual gas ionization and photocathode ion back-bombardment. The gun vacuum in the vicinity of the cathode/anode gap is ~ 1x10@super -11@ Torr. Improved vacuum would enhance the operating lifetime of the photo-electron guns. Measurements on vacuum test stands have been undertaken to better understand the vacuum limitations of the Jefferson Lab photo-electron guns. The measurements include a comparison of vacuum chamber material outgassing rates, preliminary investigations into coatings to reduce outgassing rates, and NEG pump speed measurements under various activation conditions. The results of these studies will be presented together with recommendations for improving photo-electron gun vacuum. @FootnoteText@ This work was supported by U.S. Department of Energy Contract No. DE-AC05-84-ER40150.

4:40pm **VT-WeA9 Status of the SNS Accumulator Ring Vacuum Systems***, *P. He,* ***H.C. Hseuh***, *M. Mapes, L.A. Smart, R. Todd, D. Weiss,* Brookhaven National Laboratory

The 2 MW US Spallation Neutron Source (SNS) consists of a 1 GeV linac, a 248m accumulator ring, two beam transport lines, and a mercury target. Brookhaven is undertaking the design, construction and commissioning of

the accumulator ring and the beam transport lines for SNS. To this date, over 80% of the ring and transport line vacuum components have been fabricated and assembled. More than 50% of the ring vacuum chambers have been coated with TiN. The physics objective and the design of SNS will be briefly described. The status of the vacuum systems will be presented. Technical developments and challenges encountered, such as remote flange assemblies and conductive coating of large ceramic chambers, will be summarized. *Work performed under Contract Number DE-AC05-00OR22725 with the auspicious of the U.S. Department of Energy.

5:00pm **VT-WeA10 High Vacuum Applications of Silicon-Based Depositions on Stainless Steel**, ***D.A. Smith***, Restek Corporation; *B.R.F. Kendall,* Elvac Associates

Continuing tests of stainless steel components with a silicon-based deposition have shown progressively lower outgassing rates. Evolution of the coating process has led to significantly lower outgassing rates over a wide range of operating conditions when compared with untreated stainless steel and stainless steel surfaces cleaned via a combination of ultrasonic, heat and vacuum techniques. Experimentation was developed for comparing otherwise identical samples having various surface treatments and/or coating types. The samples are heated and cooled in turn while the outgassing rates are recorded at temperatures up to 250 degrees C. Base pressures ranged from 10@super -7@ Torr to 1.2 x 10@super -10@ Torr. The coatings are resilient, inert and capable of withstanding temperatures above 400 degrees C. Other surface aspects have been evaluated, including electronic characteristics and anti-galling traits. As well as the obvious potential for reducing outgassing rates in vacuum chambers thereby allowing shorter pump-down times with smaller vacuum pump systems, these coatings have proved useful in minimizing errors due to thermal desorption in experimental metal-envelope ionization gauges operating down to the low 10@super -10@ Torr range.

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