Wednesday Afternoon, November 2, 2005

Vacuum Technology
Room 201 - Session VT-WeA
Hydrogen, Outgassing, and Vacuum Systems
Moderator: L. Westerberg, Uppsala University, Sweden

2:00pm **VT-WeA1 System Modeling and Proof of Performance for Large Vacuum Systems**, ***J.P. Luby***, BOC Edwards

Vacuum system modeling is the foundation of vacuum system component selection and provides the user tangible performance prediction. This paper examines vacuum system modeling and vacuum equipment selection for large vacuum systems and introduces the requirements and challenges of proving the performance of a large vacuum system. With rigorous applications engineering, performance modeling and component testing it is possible to provide a detailed performance statement to the user in the early stages of vacuum system design and build.

2:20pm **VT-WeA2 The ISAC Targets Vacuum System**, *I. Sekachev*, TRIUMF, Canadian Research Laboratory, Canada; ***D. Yosifov***, TRIUMF, Canadian Research Laboratory

ISAC (Isotope Separator and ACcelerator) facility at TRIUMF has been in full operation since 1999. The ISAC East and West targets use the proton beam from the cyclotron to produce various radioactive isotope species in the target, which are then ionized and extracted. The ions are then passed through the mass separator and the selected ions are distributed to the low energy experiments or injected into an RFQ accelerator. The accompanying radioactive contamination from the production of radioactive ions requires the vacuum system to be quite complex. The main target vacuum space consists of two semi-separate (primary and secondary) volumes pumped by 1000L/s turbomolecular pumps. The primary volume uses four pumps while the secondary volume uses two pumps. The nominal vacuum in both volumes is about 1.0E-6 Torr. The pressure is monitored by two cold cathode ion gauges and two hot filament ion gauges. Both cold cathode gauges are used to interlock the system during the bake out of the target and beam production. Three exhaust gas storage tanks (decay tanks) are used for handling radioactive gasses and controlled release of the gasses to the atmosphere. The two ALCATEL hermetic rotary vane pumps are used as backing pumps. The gas specie insensitive membrane gauges are used for monitoring the storage tank pressures. This paper describes the details of the ISAC target vacuum system as well as some procedures related to the handling of the radioactive gasses produced by the targets.

2:40pm **VT-WeA3 Pumping Speed Measurement of TiZrV Coated Pipes**, ***A. Bonucci***, *A. Conte*, SAES Getters S.p.A., Italy

In the last few years the interest of the particle accelerators community towards ZrTiV non evaporable getter (NEG) coatings of vacuum chambers has been continuously increasing. With the increase of the interest, also the number of characterizations of this coating from several final users is increasing. One of the key characterizations is the measure of the actual pumping speed of the NEG coating. The typical method used to measure the pumping speed of a getter is described in the ASTM F798-82. Normally, it has been applied onto a discrete sample coated during the process. This approach is not suitable with NEG coated vacuum pipes. An improved experimental configuration for sorption tests is here first described. The method is based on the ratio measurement of pressures at the inlet and the outlet of a coated pipe. A calibration curve permits to evaluate sticking probability of the coated surface from the pressure ratio. A mono-dimensional model is often used in order to obtain the calibration relationship; for high sticking probability this approach is not more suitable. We will show that a three dimensional mathematical model, based on the angular coefficients approach, is needed to calculate the gas distribution inside a vacuum vessel and the relationship between the pressure ratio and the specific pumping speed of the coated surface.

3:00pm **VT-WeA4 Beam Induced Dynamic Pressure Rise in RHIC**, ***H. Hseuh***, *S.Y. Zhang*, Brookhaven National Laboratory

Relativistic Heavy Ion Collider (RHIC) consists of two storage rings of 3.8 km in circumference for high energy and nuclear physics research. With increasing ion beam intensity during recent RHIC operations, rapid pressure rises of several decades were observed at most warm sections and at a few cold (4.5K) sections. The pressure rises are associated with electron multi-pacting, electron stimulated desorption and beam ion induced desorption; and have been one of the major luminosity limiting factors. This dynamic pressure rises will be explained based on the observations at RHIC and the existing understandings. Some remedies to reduce the pressure rises, such as in-situ baking, NEG coating and solenoids, have been implemented over the last few years and their effectiveness will be illustrated. *Work performed under Contract No. DE-AC02-98CH1-886 with the auspices of the US Department of Energy.

3:20pm **VT-WeA5 Hydrogen in Vacuum Systems: An Overview**, ***R.A. Outlaw***, College of William and Mary **INVITED**

Ubiquitous hydrogen plays a dominant role as the primary residual gas in low to ultrahigh vacuum, either in the form of water (unbaked systems) and/or in the form of molecular hydrogen (baked systems). Because of the very small size of the atom, hydrogen resides in interstitial sites, point, line, 2d and 3d defects in the bulk of virtually all materials and is the primary source of outgassing. At the vacuum interface, hydrogen is also located in the form of metal hydroxides. The effective outgassing rate for a given vacuum material is a function of the hydrogen surface concentration which, in turn, is a function of the density of the aforementioned sites and defects. System processing significantly affects the magnitude of the hydrogen concentration and can vary by many orders of magnitude. It is, therefore, quite difficult to analytically characterize the molecular dynamics in UHV systems without accurate knowledge of the existing concentration. In this review, the relevant parameters connected with the location and transport of hydrogen (primarily for stainless steel, but also for aluminum and other selected system materials) is presented. Gas phase variations are correlated with the surface complex chemical composition, thickness and concentration of defects. Surface diagnostics, such as AES, XPS, TDS and TOF-SIMS were employed to determine the sources of hydrogen, desorption mechanisms and the magnitude of outgassing into the vacuum space. Hydrogen solubilities and diffusivities are also presented. System processing, such as, thermal bake, glow discharge cleaning, molecular scrubbing and other outgassing reduction methods are compared. The magnitude of hydrogen outgassing is correlated with the extent of system processing.

4:00pm **VT-WeA7 Hydrogen in Vacuum Systems**, ***B. Hjörvarsson***, Uppsala University, Sweden **INVITED**

Hydrogen is found as an impurity in all materials. The only relevant question in that context is how much there is and which influence it has. In this contribution I will discuss the possibility of influencing the hydrogen content and diffusion rate in materials. Special emphasis will be on what can be learned from modern thin film growth and how thin film techniques can be used to improve materials design and performance. Examples from magnetism, elasticity and outgassing will be highlighted in this context.

4:40pm **VT-WeA9 Explosive Nature of Hydrogen in a Partial Pressure Vacuum**, ***T.M. Jones***, *W.R. Jones*, Solar Atmospheres Inc.

The explosive nature of hydrogen is well reported at atmospheric conditions. However, the explosive properties of hydrogen in a sub-atmospheric pressure are not well known. Hydrogen has desirable characteristics for many processes but using hydrogen in an atmosphere that is primed for an explosion must have several safeguards and an understanding of its explosive limits, vacuum or otherwise. A laboratory vessel was constructed to withstand hydrogen explosions to test these principals. Topics of discussion will include mixtures of hydrogen and air in partial pressure vacuum, and determination of the explosive ranges. Sources of ignition will be discussed and how the ignition source and location can affect the explosive characteristics. Other topics of discussion will be what types of safeguards could be used, more specifically an oxygen probe, and how these safeguards can be employed to prevent a catastrophic explosion.

5:00pm **VT-WeA10 Low Outgassing of Silicon-Based Coatings on Stainless Steel Surfaces for Vacuum Applications**, ***D.A. Smith***, *M.E. Higgins*, Restek Corporation; *B.R.F. Kendall*, Elvac Associates

Comparative tests of stainless steel vacuum chambers and components with and without silicon-based passivation coatings showed exceedingly low rates of gas evolution from the coated surfaces. A variety of approaches have been used to illustrate the low outgassing qualities of vacuum systems and vacuum components modified with an amorphous silicon deposition layer. For example, 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 10-7 Torr to 2.5 x 10-10 Torr. In other experimentation, the outgassing characteristics of systems in the 10-5 to 10-7 Torr vacuum range are compared. The coatings are resilient, inert and capable of withstanding temperatures above 400 degrees C. As well as their obvious potential for reducing outgassing rates in vacuum chambers thereby allowing shorter pump-down times with smaller vacuum pump systems, they have proved useful in minimizing errors due to thermal desorption in experimental metal-envelope ionization gauges operating down to the low 10-10 Torr range.

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