Tuesday Morning, November 14, 2006

Vacuum Technology
Room 2000 - Session VT-TuM

Vacuum Generation and Measurement

Moderator: J.H. Hendricks, NIST

8:00am **VT-TuM1 Turbo Pump Developments for Radioactive Environment in High Energy Physics Applications*, D. Baratto*,** *M. Audi,* Varian Inc. VTT, Italy

This paper presents a novel development of a new 2000 l/s turbo-molecular pump that is resistent to radioactive environments such as those found in High Energy Physics applications including Tokamaks. A previous prototype has been successfully tested on the JET Tokamak UK. In order to withstand the severe application at JET, the new pump is designed with tritium flow compatibility, resistance to radiation, magnetic and high voltage environments. The new pump has several advantages for these applications over standard configured turbo-molecular pumps that cannot withstand radioactive environments. The pump has been designed with radiation resistance up to 10E+8rad, compatibility with high magnetic fields, and a 10E-9mbarl/s range leak specification that restricts the flow of radioactive gas out of the pump. The pump has an active breaking system that stops the pump without an external venting port in a shorter time than natural deceleration. The pump is equipped with a separate control and drive electronics unit that can be rack mounted behind the biological shield, outside of the radioative area in which the pump is mounted. The controller has galvanic isolation that allows it to operate at high potential. Materials selection was a significant challenge during the design phase of the new pump. Ceramic bearings of the pump permanently lubricated with radiation resistant polyphenyl-ester grease are a specific feature of compatibility with a magnetic device operating in a radioactive environment. Further radiation compatibility was achieved by replacing all elastomeric o-rings with full metal sealing. PEEK sheathed cables and glass ceramic connectors have been used: these materials are radiation resistant, non-magnetic and UHV compatible in terms of leak rate. The performances of the pump are presented. The pump proves to be an effective solution for many high-energy experiments and applications as nuclear fusion, particle acceleretors and synchrotron light sources.

8:20am **VT-TuM2 Use of Getter-Catalyst Thin Films for Enhancing Ion Pump Vacuum Performances*, M. Mura*,** *C. Paolini,* Varian Vacuum Technologies, Italy

Extreme High Vacuum can be achieved only by combined pumping systems: on the basis of this scenario, the idea is to reach this pressure range with a unitary system, easy to use and with long lifetime, based on an ion pump specially designed for this purpose and provided with an additional internal NEG-Catalyst thin film coating. The conceived pump is designed with a new anode geometry and a magnetic circuit optimized in order to reduce boundary effects, moreover its shape is tailored for internal NEG+Pd coating produced by means of magnetron sputtering. Since the main drawback in the use of NEG films is their limited lifetime due to the progressive accumulation of contaminants (e.g. nitrogen, oxygen, etc.), with consequent reduction of adsorption performances, the idea is to protect the NEG, depositing on it an overlayer of a noble metal, such as palladium, which acts as a catalyst for the adsorption of hydrogen and allows its diffusion towards the NEG. In this way it is possible to pump large amounts of hydrogen, also in presence of not negligible pressures of other gases, with a very high sticking factor. The consequent loss of pumping for other getterable gases (with the exception of CO) is not an issue in the UHV pressure range, where hydrogen is typically the main residual gas, since the ion pump works fine to pump them all. The sorption of both hydrogen and CO is fully thermally reversible, resulting in a theoretically endless lifetime of the film. The performances of the combined pump, in terms of base pressure and hydrogen pumping speed, will be presented through the evidence of the experimental data collected.

8:40am **VT-TuM3 Strategies for Safe Hydrogen Pumping with Mechanical Vacuum Pumps*, J.P. Luby,*** BOC Edwards

Vacuum pumping hydrogen gas carries significant risk of explosion. This paper examines strategies for minimizing explosion risks when pumping hydrogen gas in the laminar flow range with mechanical vacuum pump systems. Topics addressed include pumping hydrogen concentrations above, below and within explosion limits with various vacuum pump mechanisms and vacuum system configurations. Methodologies are presented to minimize explosion risk which may be applied to a wide variety of flammable applications. Vacuum system performance considerations when pumping low viscosity gases such as hydrogen are also discussed.

9:40am **VT-TuM6 The Effect of Sampling System Surfaces on Gas Species Measured by RGA Analysis*, R.E. Ellefson,*** Consultant

Steady-state flow of gas through a vacuum process after some initial transient time produces a stable composition indicated by gas analysis. But commonly during vacuum processing, rapid changes in gas composition regularly occur; sampling such processes and analyzing the gas with a residual gas analyzer (RGA) can show a long time constant for gas species that have a strong interaction with the walls. A well known case is sampling gases with water vapor as a component of the gas. When onset of the sampling flow occurs, water vapor is adsorbed by the sampling system walls from the flowing gas and the water vapor partial pressure arriving at the RGA is lower than the process value. As flow continues, the wall is saturated and in equilibrium with the flowing gas so that a more accurate value is measured for water vapor. When the process gas is pumped away or water vapor level decreases, an exponential tailing of the water vapor signal occurs as the walls degas. This paper addresses the details of this transient adsorption-desorption process in gas sampling tubes related to changing species concentrations by modeling the gas-surface interaction. Some insights from the model for species equilibration time include the role of species adsorption energy, Î"H, with the surface material, the effect of concentration of the absorbing species in the gas and total pressure of the flowing gas on equilibration time and finally the temperature dependence of the equilibration time. An additional surface effect in RGA usage is the change in surface potential with changing adsorbed or surface reacted gases on ion source and rod surfaces and the filament. Changes in sensitivity can occur when gas is changed from a reducing or neutral gas to an oxidizing gas. This sensitivity change is slowly reversible by returning gas flow to a reducing or neutral gas. Examples of this effect and methods to minimize the effect are presented.

10:40am **VT-TuM9 Limiting Processes in Vacuum Measurement*, P. Looney,*** Brookhaven National Laboratory **INVITED**

The Bayard-Alpert (BA) ionization gauge is the most widely used gauge for vacuum pressure measurement above 10-7 Pa. Its use is ubiquitous, although it does have several significant limitations - even at modest pressures. For pressures below 10-7 Pa, several critical processes which are both physical and chemical in origin, limit pressure measurement using BA gauges. Many variations have been designed to minimize limiting factors, with varying degrees of success. In this talk, I will overview the approaches to vacuum gauging and gauge designs for pressure measurement in the UHV and XHV regimes, with a focus on the limiting mechanisms, gauge interactions with residual gases, and the strategies that have been proposed to overcome them.

11:20am **VT-TuM11 Enhancement of Accuracy and Interchangeability of Multi-Sensor Gauges by Use of Individualized Calibration Parameters Stored on the Sensor Assembly Itself*, P.C. Arnold,*** Brooks Automation, Inc.

Hot cathode ion gauge controllers that make use of gauge calibration information stored in memory in the gauge controller have been available for well over ten years. In recent years, high-temperature bakeout of hot-cathode ionization gauges has greatly diminished in common use, especially in commercial vacuum processing systems. For this reason, there are now many applications in which it is practical to store gauge calibration information in a memory chip attached to the transducer, rather than in a memory located in the controller. The attendant advantage in locating the memory on the transducer is that it permits maintaining a desired level of accuracy in the pressure measurement when one transducer is replaced by another or one electronics package is replaced by another. For those combination gauges containing hot cathode ionization sensors, heat-loss sensors, and piezo-resistive diaphragm sensors, calibration encompasses pressures ranging from high vacuum to atmosphere. A system for performing calibration of a multi-sensor gauge over such a wide pressure range is described, as well as the method of maintaining the reference gauges used in this system. Results are evaluated from testing of a multi-sensor gauge design in which calibration memory resides on the sensor assembly for several situations: (1) repeatability over time of pressure indication for the electronics and multi-sensor assembly as a system, (2) reproducibility of pressure indication when different sensor assemblies were used with the same electronic control unit, and (3) reproducibility of the pressure indication when different electronic control units were used with the same sensor assembly.

12:00pm **VT-TuM13 The Deviation and the Long-Term Variation of the Sensitivity Factor of an Axial Symmetric Transmission Gauge***, N. Takahashi,* ULVAC Inc. Japan, Japan*; Y. Tuzi,* ULVAC Inc. Japan*; I. Arakawa,* Gakushuin University, Japan

We have reported the basic characteristics of two types of axial symmetric transmission gauge (AT gauge). The original AT gauge@footnote 1@ was aimed solely at the measurement in extreme high vacuum (XHV) by the pulse counting of ions using a secondary electron multiplier (SEM). In the commercial type gauge (AxTRAN, Ulvac Inc.),@footnote 2@ which is for practical use in the wider pressure range between 10@super -11@Pa and 10@super -3@Pa, the SEM ion detector was replaced with a Faraday cup type ion collector to extend the upper limit of the operating pressure and to improve the drift of a sensitivity caused by SEM. In both types, the soft x-ray effect and the electron stimulated desorption effect, which disturbs the XHV pressure measurement, are reduced by the Bessel-box type energy analyzer placed between an ionizer and the ion detector. In the present paper, two fundamental characteristics of the commercial type AT gauge are reported: the sensor-head deviation and the long-term variation of the sensitivity factor. The sensitivity factors for nitrogen of 50 sensor-heads of AT gauges were measured by the direct comparison with the spinning rotor gauge. These sensitivity factors were compared with those of 30 sensors of the extractor gauges and the BA gauges. The standard deviations for the three types of gauges are almost the same. The long-term variation of the sensitivity factors of two AT gauges for nitrogen has been examined for several years. The factor of one gauge decreased by 10% gradually in first 1.5 year in the examination. In the following 3 years, the variation of the sensitivity factor was less than 2%. The variation for the other one was relatively small. This different behavior of the sensitivity factor between two gauges is likely caused by the difference of the pre-treatment of the Y@sub 2@O@sub 3@ coated Ir filament before assembly. @FootnoteText@ @footnote 1@ H. Akimichi, et al., JVST A15 (1997) 753.@footnote 2@ N. Takahasi, et al., JVST A23 (2005) 554.

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