Wednesday Morning Poster Sessions, October 4, 2000

Vacuum Technology
Room Exhibit Hall C & D - Session VT-WeP

Poster Session

VT-WeP1 Study of Uncertainty of a Constant Volume Flowmeter, ***D. Tian,*** Lanzhou Institute of Physics, P.R. China, P.R.China; *X. Wen,* Lanzhou Institute of Physics, P.R. China

A constant volume flowmeter was built in Lanzhou Institute of Physics (LIP). It can calibrate mass flow meters. In order to find and reduce the systematic errors, its uncertainty is calculated and analyzed at first. The range of the flowmeter is 1.7x10@super-3@-85 Pam@super3@/s (1 sccm-50 slm) with uncertainty (1@sigma@) less than 1.2%. Then, a lot of experiments are accomplished by calibrating the mass flow meters. The measurement data of two mass flow meters prove that the flowmeter has good repeatability and long-term stability. Because the systematic errors are still under discussion, we have to prove our supposition by comparison study at last. The range of constant pressure flowmeter developed in our laboratory formerly is 1x10@super-3@-10@super-8@ Pam@super3@/s, with uncertainty less than 2%. For carrying out the comparison between these two flowmeters, an accurate mass flow meter whose range is 1-10 sccm is used as transfer standard. The mass flowmeter is calibrated by two flowmeters respectively. The result shows that the agreement of these two standards is better than 1.5%. The comparison is mainly dependent on the linearity and stability of spinning rotor gauge, and the uncertainty resulting from these two factors is about 0.5%. The short-term repeatability of the mass flow meter is also an error source of comparison, and the uncertainty resulting from this factor is approximately 0.2%. The big systemic error is not found in the tests and calibration reliability has been ensured through the above discussions.

VT-WeP2 Development of the Quadrupole Mass Spectrometer with the Bessel-Box Type Energy Analyzer : Function of the Energy Analyzer in the Partial Pressure Measurements, ***N. Takahashi,*** *H. Akimichi, T. Hayashi,* ULVAC Japan, Ltd., Japan; *Y. Tuzi,* ULVAC Corporation, Japan

We have obtained several advantages of the newly developed quadrupole mass spectrometer (QMS) with the Bessel-Box type energy analyzer for the accurate measurement of partial pressures in high to extreme high vacuum. The analyzer is placed between the ionizer and the quadrupole assembly of QMS. The gas phase ions and the electron stimulated desorption (ESD) ions generated in the ionizer are separated by the analyzer, because of the difference of kinetic energies between them. As the overlapping of the gas phase ions and ESD ions gives the complex mass spectra, the elimination of ESD ions by the energy analyzer improves the spectra to simpler ones. The accurate measurement of partial pressures was made use of the simple mass spectra of gas phase ions which were given by the new QMS. The sensitivity of new QMS for the very small amount of impurities in the atmosphere of relatively higher pressure was also improved down to 10ppb of the total pressure owing to the reduction of background signal. The background signal is much reduced by the geometrical structure of the energy analyzer which prevents the ion collector with secondary electron multiplier from the irradiations of vacuum ultraviolet rays and soft x-rays generated in the ionizer. The discrimination between the non-dissociative molecular ions and the fragment ions with same mass to charge ratio (m/z) is also the important factor for the accurate measurement of partial pressures. The energy spectra of those ions are determined by the mechanism of ion formation such as ionization process, fragmentation process, etc. Thus, the spectra of each m/z ions are expected to apply for the discrimination mentioned above.

VT-WeP3 A Summary of Quick Disconnect Vacuum Flanges, ***M. Mapes,*** Brookhaven National Laboratory, usa

In accelerator environments especially proton machines, high background radiation necessitates the need for quick disconnect vacuum flanges. The use of quick disconnect flanges significantly reduces the dose of radiation received by workers when installing or removing vacuum chambers in the accelerator. Over the course of many years there have been many different designs used for these flanges at Brookhaven National Laboratory for such machines as the AGS, Booster and RHIC. Several different flanges with apertures as large as 14" diameter were also evaluated for use in the SNS project. A summary of various quick disconnect flanges used at Brookhaven as well as some commercially available flanges and their evaluation results are presented.

VT-WeP4 Continuous Determination of the Gas Composition during Pump-down of Vacuum Chambers, ***N. Mueller,*** Balzers Instruments, Liechtenstein, Principality of Liechtenstein; *P. Schoch,* Balzers Instruments, Liechtenstein

The gas composition during pump-down of vacuum chambers starting at atmospheric pressure is an important information for the evaluation and design of pumping stations. Nevertheless, this composition is rarely determined on-line, as there are no sensors available that directly allow for gas specific analysis over a wide pressure range. To overcome this problem, a differentially pumped quadrupole mass spectrometer with a unique inlet system has been developed. This instrument allows for continuous gas analysis in the pressure range from 1000 mbar down to 1E-3 mbar. Pump-down curves of different pumping stations (e.g. turbo-pumped systems with rotary vane pumps, diaphragm pumps etc.) have been determined. The results of these analysis will be presented and discussed.

VT-WeP5 Hydrogen Outgassing from Titanium Modified Layers with Various Surface Treatments, ***Y. Mizuno,*** Nippon Valqua Industries, Ltd, Japan; *A. Tanaka,* ULVAC-PHI, Inc., Japan; *K. Takahiro,* Tohoku University, Japan; *T. Takano, Y. Yamauchi, T. Okada, S. Yamaguchi, T. Homma,* Chiba Institute of Technology, Japan

In an extreme high vacuum (XHV) system, hydrogen outgassing is the most important factor to obtain vacuum pressure below 1.0x10@super -10@Pa. Titanium is an interesting material for applications in XHV construction. This work aims to be clear about a correlation between hydrogen outgassing and surface structures of pure titanium in vacuum technology. The titanium surfaces were prepared following treatments such as chemical (CP), electrical (EP), buffing (BP) and mechano-chemical polishing (MCP). Characterization of oxide layers has been carried out using Auger electron spectroscopy and angle-resolved x-ray photoelectron spectroscopy, and a cross section of modified layer has been observed with transmission electron microscopy and an optical microscope for metal/scale. The hydrogen distribution in a surface region was measured by using elastic recoil detection analysis. The oxide thicknesses were from 20 to 50 nm, although the finished titanium surfaces were covered with TiO@sub 2@ for CP, EP, BP and MCP, and also TiO was formed under the top layer for MCP. The thick modified layers (about 1μm) on surfaces were made in BP and MCP processing, and the modified layers had extremely high-density distribution of hydrogen (H/Ti about 1-2). Thermal desorption spectroscopy measurements indicated that the desorption behavior of hydrogen was not strongly depending on the thickness of oxide layer, and the hydrogen outgassing rates were less than 4.0x10@super -7@Pa.m.s@super -1@ at room temperature. We will report the results of the relation between the quantities of desorbed hydrogen gas and the structure of modified layers on titanium polished surfaces.

VT-WeP6 Friction Force Measurement of Type 304 Stainless Steel in a High Vacuum, ***A. Kasahara,*** *M. Goto, M. Tosa, K. Yoshihara,* National Research Institute for Metals, Japan

Vacuum friction measurement system based on Bowden-Leben type system was successfully developed. The system can evaluate sliding friction coefficient under changing load from 0.2N to 0.98mN and at changing atmospheric pressure from 1E+5Pa to 1E-8 Pa. The friction measurement was carried out on typical vacuum materials samples as type 304 austenitic stainless steel sheets after such surface treatments as chemical polishing, mechanical polishing or electrochemical buffing. Chemically polished steel shows the lowest friction coefficient as the decrease of the vacuum pressure and as the decrese of the load due to low desorption of adsobate on the surface. The friction measurement especially under the load less than about 10mN in an atomosheric pressure shows that surface adosobate changed by surface roughness of polished steels could have an large effect on friction force. While, the measurement under the pressure less than 1E-5Pa shows little effect by surface absobate on friction force. The measurement results therefore conclude that Amonton-Coulomb's law is valid in measuring friction force under low load in a high vacuum.

VT-WeP7 Surface Cleanness of Substrates Transported with Levitation Transfer System Installed in an Extreme High Vacuum Integrated System, ***M. Tosa,*** *A. Kasahara, M. Goto, K. Yoshihara,* National Research Institute for Metals, Japan; *Y.S.K. Kim, K.S.L. Lee,* Sungkyunkwan University, Korea

The extreme high vacuum (XHV) integrated process with magnetic levitation transports has been developed in order to transfer substrates among vacuum chambers without any contamination on the ultraclean surface. The XHV integrated process has five main lin e chambers, six sidetrack line chambers, connector chambers and six vacuum instrument chambers for surface analyses and film preparation. Levitation transports

using superconducting magnet system and electromagnet system are installed into the line chamb ers because they have no sliding part to generate dust particles as well as outgassing which may damage the ultraclean substrate surfaces and environment. The levitation transports can transfer substrates among connected six chambers in the pressure change of less than 10@super -10@ Pa. Cleanness of transported substrates surfaces was observed by a scanning auger electron microprobe with submicron analysis area. Substrates surfaces of a copper sheet and a stainless steel sheet that were argon ion sputter-cleaned in the auger analysis chamber were kept clean without any adsorption of oxygen nor carbonate during the levitation transportation among the auger analysis chamber and the film preparation chamber. Surfaces of copper film and stainless steel film on steel substrates prepared in the film preparation chamber were also kept clean after the transportation from the film preparation chamber to the auger analysis chamber.

VT-WeP8 Production, Installation and Performance Evaluation of Extruded Aluminium NEG-coated Vacuum Chambers for the European Synchrotron Radiation Facility (ESRF), ***P. Chiggiato,*** *A. Escudeiro Santana, V. Ruzinov,* CERN, Switzerland*; R. Kersevan,* ESRF, France

In order to comply with new European rules concerning the maximum allowable radiation dose for non-exposed workers, the ESRF has started a program for reducing the pressure in the undulator straight sections. This has led to the development of new narrow-gap extruded aluminium vacuum chambers coated with a Ti-Zr-V non-evaporable getter film on the whole inner wall surface. Several aluminium chambers of different dimensions have been coated and their vacuum characteristics have been evaluated. Two of them (5 m long, 74x11 mm elliptical section), have been installed onto the 6 GeV storage ring of the ESRF. Their performances during the vacuum conditioning under an intense synchrotron radiation flux of about 10@super 17@ photons sec@super -1@ m@super -1@ will be reported, together with other details of their operation.

VT-WeP9 Cleaning of Artificial Contamination on Aluminum Surface for Ultra-high Vacuum Treated in Supercritical Fluid and Evaluated with FT-IR, ***T. Momose,*** *H. Mishina,* Miyagi National College of Technology, Japan*; Y. Ikushima,* National Industrial Research Institute of Tohoku, Japan*; K. Tatenuma,* Kaken Corp., Japan*; T. Goto, M. Takahara,* Miyagi National College of Technology, Japan

To decrease outgassing rate of the surface for ultra-high vacuum materials, clean surface is required. We have paid attention on native contamination of the surface.@footnote 1@ Here, cleaning test of the artificial contamination which can be deposited on the surface during treatments is carried out using supercritical fluid(SCF) CO@sub2@ with high solubility for organic materials. Triglyceryde is selected as a contamination because it is the main ingredient of grease of human body. The triglyceryde was deposited on mirror surface of aluminum circular discs(5 mm in diameter) by evaporating ether-triglyseride solutions. The disc was kept in SCF CO@sub2@ for a half hour at 40°C and a fixed pressure. The surface was evaluated from the CH@sub2@- and CH@sub3@- peaks of FTIR spectra. The standard lines of the peaks were obtained from the ones of FT-IR as a function of the density of ether-triglyceride solution. Removing rate was calculated from the ratio, (Lo-Li)/Lo x 100 %, where Lo is the peak height before treatment and Li the one after treatment. The deposited thickness between one μm and 21 μm was proportional to a square root of density of the solution (1%-30%). Precision of removing rate was ±13 %. The removing rate was proportional to pressure, 40 to 100 % in the range from 100 atm to 250 atm, where it was 100 % in the range from 250 atm to 300 atm. The data showed that the cleaning using SCF CO@sub2@ is promising to remove artificial contamination like the ones on the order of μm thick. @footnote 1@ T.Momose et.al, JVST, A17(4), Jul/Aug, 1999, 1391.

VT-WeP10 CESR Phase-III Interaction Region Vacuum Chamber, ***Y. He,*** *Y. Li, N.B. Mistry, S. Greenwald,* Cornell University

Two 115" long copper UHV chambers for the Cornell Electron Storage Ring (CESR) Interaction Region were fabricated. These chambers are a part of the "Phase-III" upgrade project for the CESR storage ring. They incorporate several novel features including a remotely engaging differentially pumped Viton O-ring sealed UHV flange, two RF shielded bellows joints, and inner stepped masking for synchrotron radiation. The fabrication of these chambers incorporates multi-stage electron beam welding to maintain the strict tolerance required for installation through superconducting and permanent quadrupole magnets. Before final welding, a series of EB welding setup tests were done to work out a welding procedure for optimizing welding parameters and avoiding contamination in the weld zone. This paper will describe the design, fabrication, welding, leak checking, and final UHV performance testing of these chambers.

VT-WeP12 Monte Carlo Direct Simulation of Rarefied Flow in the Cylindrical Chamber of an Orifice-flow System, ***Y.W. Chang,*** Precision Instrument Development Center, R. O. C., Taiwan, R. O. C.

The orifice-flow system has been commonly used in the calibration and measurement of the vacuum systems. Such a system usually consists of a vacuum chamber in which two cylindrical or spherical halves separated by a plate with the orifice in the center. For the application of the orifice-flow system, calculating the correct conductance of the orifice is the most important thing to do. However the actual flow condition inside the chamber, such as the gas density distribution and gas flux distribution, also restricts the accuracy of the calibration or measurement. In this paper the flow field inside a cylindrical vacuum chamber of an orifice-flow system is investigated using the direct simulation Monte Carlo (DSMC) method. A known gas flow is introduced to the upper chamber through a port in the center of the top plate. We simulate cases in which the outlet boundary is set to be in vacuum or given a known pressure that represents a vacuum pump. The observation is focused on the pressure distribution in these cases. In each case, baffles are added in the upper and lower chamber after the flow reaches a steady state. Baffles in the orifice calibration system are used to improve the uniformity of the gas density distribution and the gas flux distribution. Therefore the variations of the pressure distribution and the velocity field in the chamber after baffles are added are particularly investigated.

VT-WeP13 The Topology of Molecular Flow in Axial Compressor, ***P.A. Skovorodko,*** Institute of Thermophysics, Russia

An approximate representation of the real geometry of the axial flow compressor by its plane version is widely used in theoretical models of the gas flow in the molecular pump. To analyze the accuracy of such kind of approaches the numerical algorithm for simulation the free molecular flow in the real geometry of the compressor is developed. The algorithm is based on the well known test particle Monte Carlo method. The pumping process in the considered case is completely characterized by two values of direct and back transmission probabilities. The main problem to be solved during the simulation of molecule motion in the tract is to find the point of intersection of their trajectory, which represents a straight line, with stationary or moving surfaces of the compressor units, where the diffuse-specular reflection of molecule with some accommodation coefficient is assumed. Two types of molecular pump are considered: the Holweck pump with spiral grooves placed on the rotor, and the multi-stage turbomolecular compressor with flat-plate blades. The results obtained for real geometry demonstrate higher compression ratio and are in better agreement with available experimental data in comparison with those obtained for plane version of geometry. The difference between two approaches is higher for higher rotor speed. The main reasons for such difference are the topology of axial flow and non-inertial character of rotating system of reference. The developed algorithm may be used to optimize the design of compressor operating in the free molecular conditions.

VT-WeP14 Rapid Cool Dual Slot Load Locks For LCD, ***A. Hosokawa,*** *W. Blonigan, S. Kurita,* Applied Materials Inc.

Rapid cooling of 680mm x 880mm glass substrate was demonstrated in the dual slot load locks @footnote 1@ of Applied Materials AKT 5500 CVD system. It takes 33 sec to cool the substrate from 400°C to 60°C with the uniformity of ±5°C. To accomplish this, two techniques were used. Helium equivalent to partial pressure of 9 torr was injected at the initial stage of venting. Two cooling plates were located above and below the substrate and the distance of the cooling plates was reduced to 8 mm when cooling. Rapid cool dual slot load locks reduced the system cost by eliminating expensive machined components and a more powerful pump. Uniform cooling enabled reliable substrate handling and eliminated undesirable stress on the substrate upon cooling compared with the conventional 12 slot load locks. @FootnoteText@ @footnote 1@ Shinichi Kurita, Wendell Blonigan, Akihiro Hosokawa, US Patent pending #7828.7017, Dec 1999.

VT-WeP15 Experimental and Theoretical Study of a Differentially Pumped Absorption Gas Cell used as a Low Energy-pass Filter in the VUV Photon Energy Range, ***B. Mercier,*** *L. Nahon, O. Dutuit, C. Prevost, R. Thissen, G. Bellec, M. Compin,* LURE, France

In order to separate the fundamental synchrotron radiation from the high harmonics emitted by an undulator, a low photon energy-pass filter has been designed and built, insuring a high spectral purity on the VUV SU5 beamline at Super-ACO. It consists in an absorption cell filled with rare

gases and separated from the ultra-high vacuum of the storage ring and of the beamline by a double differential pumping obtained with thin capillaries, and whose designed has been optimized by numerical computation of pumping speed. Admission pressures in the range of 100 Pa in the central part of the filter have used without any degradation of the upstream or downstream ultra-high vacuum. The measured attenuation factors above the energy cut-off are above 10@super 5@ and 10@super 2@ (and certainly above 10@super 3@ with ultimate pressure of Ne) for respectively argon and neon used as absorbing gas, with no measurable attenuation of fundamental radiation. A sophisticated numerical approach performed in the intermediate regime, taking into account the geometry of the whole absorption cell including the first pair of capillaries, has been developed, allowing reliable predictions of the expected attenuation coefficients for any given configuration of the filter.

VT-WeP16 DSMC Study of Plume Flows in Cryogenic Vacuum Facility, ***M.S. Ivanov***, *G.N. Markelov,* Institute of Theoretical and Applied Mechanics, Russia

The study of plume flows has been an interesting research subject area of rarefied gas dynamics in the past. Experimental techniques and various engineering approaches were mainly employed for such studies. The recent resurgence of interest in the subject is prompted by the design of a new generation of satellites and space stations for which an accurate prediction not only of force and heat loads produced by the plumes, but also of contamination is needed. Therefore, a comprehensive study of plume structure including core flow, periphery flow and backflow is very important. For correct simulation of small thruster plumes in experimental facilities, it is necessary to have reasonable low background pressure levels. Main feature of new high vacuum plume test facilities STG (DLR) and CHAFF-IV (USC) is a novel cryogenic array, where the expanding plume gas hits a complex-structured cryosurface and freezes immediately. Nevertheless, disturbance of the plume is possible due to the penetration of condensate vapor and of plume molecules that do not stick immediately to the condensate. Therefore, it is necessary to supplement experimental modeling of plume flows by numerical simulation of the plume flow inside the facility taking into account the influence of incomplete condensation of plume molecules. It will allow one to determine a region where a plume flow is undisturbed as in space for different thruster and facility operating conditions. The main objective of the paper is a numerical study of thruster plume flows under low-density conditions in a cryogenic vacuum facility with consideration of background pressure caused by incomplete condensation of plume molecules on the cryogenic array.

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