Vacuum Technology Division
Room 329 - Session VT-MoM

Vacuum Gauging, Outgassing and Leak Detection

Moderator: J.P. Looney, National Institute of Standards and Technology

8:40am **VT-MoM2 Data Evaluation of Gas-Analytic Mass Spectra: Special Aspects of Getter-Assisted Helium Analysis*, U. Langer*,** *R. Dobrozemsky,* Vienna University of Technology, Austria

During the last years, a method for the decomposition of complex gas-analytic mass spectra has been developed at Research Center Seibersdorf.@footnote 1@ The method (termed Vector Mass Spectrometry - VMS) is based on the evaluation of data gathered by a quadrupole mass spectrometer (QMS) and a Bayard-Alpert gauge (BAG) during multiple spectrum scans with parameter variation. Although this method allows to analyze even complex mixtures of hydrogen and helium isotopes with accuracies in the percent range, it exhibits severe weakness if small He-amounts have to be measured in a hydrogen background. This particular problem can be overcome by selective pumping, as it has been applied in several labs for similar purposes. In a recent work we have shown that hydrogen reduction factors (i.e. relative He-enrichments) of up to about 50 can be achieved by a simple, orifice controlled SAES getter pump in combination with an additional BAG.@footnote 2@ By a mathematical trick it was possible to evaluate the data by means of the already well-established spectrum decomposition codes, based on a least-squares-fit routine. This method allows quantitative measurements of He-concentrations in the percent range in the presence of hydrogen isotopes. @FootnoteText@ @footnote 1@ R. Dobrozemsky and G.W. Schwarzinger, J. Vac. Sci. Technol. A10(4), 2661 (1992) @footnote 2@ U. Langer and R. Dobrozemsky, contributed paper, submitted to 14@super th@ International Vacuum Congress, Birmingham, UK (1998)

9:20am **VT-MoM4 Long Term Behavior of an Axial-Symmetric Transmission Gauge*, H. Akimichi,*** *K. Takeuchi, Y. Tuzi,* ULVAC Corporation, Japan*; I. Arakawa,* Gakushuin University, Japan

An axial-symmetric transmission gauge (AT gauge) is an ionization gauge developed for the pressure measurements in ultrahigh and extreme high vacua. In the gauge, a Bessel-box type energy filter is placed between the ionizer and the ion collector to eliminate the effects of soft X-ray and electron stimulated desorption ions. The lower limit of the pressure measurement by the AT gauge is estimated to be 10 @super -12@ Pa. The sensitivity factor for hydrogen calibrated by the conductance modulation method was about 2 x 10 @super -3@ Pa @super -1@, and was constant in the pressure range from 10 @super -10@ to 10 @super -6@ Pa. We have examined the characteristics of the AT gauge such as the sensitivity factor, the outgassing rate, etc., over the period of 3200 hours. It was found that the condition of the continuous dynode type electron multiplier, which is used for the ion detection in pulse counting mode, was one of the most important factor that determine the gauge characteristics. The followings were noticed in our study: (1) the outgassing rate of the electron multiplier was higher than that of the ionizer and the energy filter, (2) the outgassing rate of the multiplier as received from the manufacturer was very high but decreased to acceptable level after a few days operation, (3) the outgassing rate of the multiplier increased after exposure to the atmospheric air but restored, (4) the temporal increment of the sensitivity factor was observed after the exposure to the atmospheric air and was assumed due to the change in the secondary electron yield of the electron multiplier, (5) the correlation between the residual current by the X-ray effect and the sensitivity factor of the gauge were observed.

9:40am **VT-MoM5 Ultra-high Vacuum Instrumentation Development Studies*, C. Dong*,** *G.R. Myneni,* Thomas Jefferson National Accelerator Facility and Old Dominion University

Measurements of both total and partial pressure in the ultra high vacuum range are known to be limited by several effects including the x-ray limit, electron stimulated desorption, cathode evaporation and thermal and chemical effects at hot cathodes. In order to understand the contributions of these effects, ultra high vacuum instrumentation development studies are in progress at the Jefferson Lab in collaboration with Teledyne Brown Engineering-Hastings Instruments. These studies include the modification of extractor gauges and RGAs by replacing the hot filaments with Spindt field emitters. The sensitivities of the modified instruments are determined in the Jefferson Lab's vacuum gauge calibration apparatus. In this paper the sensitivities of the UHV instruments for nitrogen, helium and hydrogen with different cathode currents and for various electrode potentials are presented. In addition, the contributions of electron-stimulation desorbed ions are also measured with the help of a Watanabe ion spectroscopy gauge in an ion pump evacuated vacuum system and the results are also included here. This work supported by the U.S. DOE under contract No. DE-AC05-84ER40510

10:00am **VT-MoM6 Effect of Background Neutral Pressure on the m=1 Diocotron Mode Amplitude in a Pure Electron Plasma@footnote 1@***, E.H. Chao, R.C. Davidson,* ***S.F. Paul,*** Princeton University

The word "diocotron" was first used to describe instabilities in hollow electron columns which had shear in the angular flow velocity. These instabilities can occur in propagating nonneutral electron beams and layers and in low-voltage microwave generation devices such as magnetrons, traveling-wave tubes, and ubitrons. We use the word to generally refer to low-frequency electrostatic oscillations perpendicular to the magnetic field and have studied experimentally the mode with azimuthal mode number m=1. The diocotron mode is studied in a pure electron plasma confined in a Malmberg-Penning trap. The frequency of the mode is generally on the order of 100 kHz while the plasma frequency is on the order of 10 MHz and the electron cyclotron frequency is 100 MHz. The frequency of the m=1 diocotron mode in an infinite length column was predicted theoretically by Levy@footnote 2@, however, we find better agreement when the finite column length theories@footnote 3,4@ are used which predict an upward frequency shift from the infinite length case. The mode amplitude is affected by wall resistance as well as by the background neutral pressure. The resistive wall destabilization of the m=1 diocotron mode was predicted and experimentally verified by White@footnote 5@. Our measurements of the growth rate agree reasonably well with theoretical predictions. The m=1 diocotron mode is also predicted to be driven unstable in the presence of collisions with background neutrals@footnote 6@. However, we have found experimentally that increasing the background neutral pressure causes the amplitude of the m=1 diocotron mode to decrease as the column expands. @FootnoteText@ @footnote 1@Research supported by the Office of Naval Research. @footnote 2@R.H. Levy, Phys. Fluids 11, 920 (1968). @footnote 3@S.A. Prasad and T.M. O'Neil, Phys. Fluids 26, 665 (1983). @footnote 4@K.S. Fine and C.F. Driscoll, Phys. Plasmas 5, 601 (1998). @footnote 5@W.D. White, J.H. Malmberg, and C.F. Driscoll, Phys. Rev. Lett. 49, 1822 (1982). @footnote 6@R.C. Davidson and E.H. Chao, Phys. Plasmas 3, 3279 (1996).

10:20am **VT-MoM7 Ionization Gauge Errors at Low Pressures*, B.R.F. Kendall,*** Elvac Laboratories **INVITED**

Factors affecting the accuracy of ionization gauge measurements at low pressures are reviewed. In hot-cathode gauges these include electron-stimulated desorption at the electron collector, forward and reverse X-Ray effects, Auger emission, outgassing, and various controller-related errors. In cold-cathode gauges they include nonlinearities below the "magnetron knee", plasma instabilities, and leakage currents. Case studies are given to illustrate many of these sources of error and their elimination. The case studies were gathered in the course of long-term stability measurements on over 30 ionization gauges at pressures ranging from 10@super-7@ to 10@super-11@ Torr. The investigation included Bayard-Alpert (both conventional and modulated), Extractor, Magnetron, Inverted Magnetron and Double Inverted Magnetron gauges. Recent measurements on Bayard-Alpert gauges with low-temperature (lanthanum boride) and cold (disordered tetrahedral carbon) emitters are also discussed. It is concluded that, with proper precautions, ten percent reproducibility in the 10@super-10@ Torr range is easily achievable with either hot-cathode or cold-cathode gauges. A combination of the two, mounted on a common vacuum flange, is particularly useful at very low pressures.

11:00am **VT-MoM9 Plasma Expansion in a Malmberg-Penning Trap as a Function of Background Pressure@footnote 1@*, E.H. Chao,*** *R.C. Davidson, S.F. Paul,* Princeton University

Single species nonneutral plasmas have very robust confinement properties because the conservation of canonical angular momentum in a system with azimuthal symmetry provides a powerful constraint on the allowed radial positions of the particles. If no external torques act on the plasma, the plasma cannot expand radially to the wall. However, collisions with a background neutral gas will exert a torque on the rotating plasma thus allowing the mean square radius to increase. In the EDG experiment at the Princeton Plasma Physics Laboratory, a pure electron plasma is confined in a Malmberg-Penning trap and the radial density profile is measured as a function of time. The base pressure is 5*10@super -10@ Torr and purified helium is injected to pressures @>=@1*10@super -9@

Torr. The magnetic field is varied between 100 and 600 Gauss. Plasma densities up to 3*10@super 7@ cm@super -3@ are achieved and temperatures are on the order of 1 eV. This leads to a Debye length of about 1 mm while the plasma dimensions are 1-2 cm in radius and 15 cm in length. The expansion rate of the plasma in the presence of a background neutral gas has been studied theoretically by Davidson, et al.@footnote 2,3@ The expansion rates observed experimentally are faster than the theoretical prediction but the magnetic field scaling of the expansion rate is similar. In addition, using the measured radial density profiles along with a numerical code to calculate the axial density distribution, the decrease in electrostatic energy was calculated and compared with the predicted temperature rise in Ref. [3]. Finally, measurements of plasma expansion rates as a function of background gas pressure are in progress. @FootnoteText@ @footnote 1@Research supported by the Office of Naval Research. @footnote 2@R.C. Davidson and D.A. Moore, Phys. Plasmas 3 (1996) 218. @footnote 3@R.C. Davidson and E.H. Chao, Phys. Plasmas 3 (1996) 2615.

11:20am **VT-MoM10 Outgassing Measurements of Vacuum Compatible Stepper Motors***, **J.W. Weed**, R.S. Goeke, J.A. Romero,* Sandia National Laboratories

The $1.2B National Ignition Facility is currently being constructed at Lawrence Livermore National Laboratory in California. This high-power laser inertial confinement fusion device consists of 192 beams with large optical components in the vacuum environment. Over 1000 stepper motors will be used to perform automated alignment of the laser beams prior to shots. Gas load and contaminants from stepper motor outgassing can severely impact the performance and operation of the laser. We have measured the time dependent outgassing rate of "vacuum compatible" stepper motors from four different manufacturers. We have also obtained mass spectra of each motor. The results of these measurements will be presented and the impact on component performance will be discussed. Possible improvements to these commercial-off-the-shelf motors will be described. @FootnoteText@ Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000

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