Wednesday Afternoon, October 21, 2015

Vacuum Technology
Room: 230B - Session VT-WeA

Vacuum Quality and Partial Pressure Analysis
Moderator: Steve Borichevsky, AMAT VSE, Ted Martinez, SLAC National Accelerator Laboratory

2:20pm **VT-WeA1 Plasma Cleaning of SEMs and Large Vacuum Systems**, ***Ronald Vane***, XEI Scientific Inc. **INVITED**

Vacuum-based processes can suffer harmful effects from the presence of adventitious hydrocarbons that result from various sources such as oils and solvents as well as work-pieces. The problem of carbon and hydrocarbon contamination in vacuum chambers of scanning electron microscopes (EM) and other ion beam instruments is well known. An effective tool at removing hydrocarbon contamination from electron microscope chambers is remote, or downstream, plasma cleaning. Electrically neutral radicals flow from the plasma source into the chamber so that carbon compounds are removed by chemical reactions.

Plasma cleaning of hydrocarbons for electron microscopes and vacuum chambers is a simple version of the more complex plasma etch and ashing technologies used in semiconductor production and other plasma processing. Its premise is straight forward: remove carbon compounds and do no damage to the instrument. Doing this requires a small plasma source that can be mounted on an instrument port. Desirable properties are 1) Use air as an oxygen source for oxygen chemical etch, 2) Avoid ion sputtering . 3) operate at low power to avoid heat and high sheath energy potential 4) Produce a narrow electron energy distribution. 5) operate over wide pressure range.

The Evactron® De-Contaminater from XEI Scientific is a hollow cathode RF plasma device that meets these criteria. First developed to operate at low vacuums produced by roughing pumps, it has been now been modified to work with high vacuum produced by turbo molecular pumps (TMP). Now Evactron cleaning can be initiated with a TMP at full speed and vacuum of < 10-7 Torr. The flow of gas through plasma raises the chamber pressure during cleaning but the TMP retains full speed. If the chamber pressure drops below 15mTorr (2 Pa) the mean free path becomes long enough that a pink flowing afterglow fills the chamber. The afterglow is the result of reduced recombination rates of radicals and metastables at the lower pressures. The flowing afterglow is a marker for the presence of the oxygen radicals that do the plasma cleaning. The cleaning volume and rates are greatly increased with flow afterglow cleaning.

The pink flowing afterglow from air plasma is caused by nitrogen metastables and contains many UV emission lines that can desorb water vapor and hydrocarbon vapors from surfaces in the chamber which speeds pump down after plasma cleaning. RGA mass spectrometry results have shown remarkable decreases of the partial pressures of all gasses in UHV chambers if flowing afterglow cleaning is done during pump down. If this effect can be used to avoid bake out of UHV systems, considerable time savings may be achieved.

3:00pm **VT-WeA3 Double Deflection and Enhanced Detection - The Use of a Novel Ion Optics for Metastable Rejection and Improved Detection in the Low ppb Range**, ***Jonathan Leslie***, MKS Instruments Spectra Products, UK **INVITED**

During electron ionisation in a Quadrupole Mass Spectrometer (QMS), metastable neutrals are produced in addition to positive ions. The ion source in current QMS Residual Gas Analysers (RGA) is coupled with “line of sight” into the mass analyser and detector. Conversion of the metastable neutral into an ion and electron can cause increased noise, especially at lower masses. The higher noise level can determine the limit of detection in the RGA. The baseline signal can vary with changes of bulk gas and/or pressure.

The use of ion optics with novel cylindrical geometries between the ion source and mass analyser, enables a focused beam of ions to be displaced onto a second parallel axis, then back to the original axis. The cylindrical geometry provides good focusing resulting in no loss of signal, combined with a simple and robust mechanical design. The tuning is robust with a single low voltage lens setting.

The theory and performance of this elegant and innovative deflection system will be discussed, highlighting applications in which it offers a competitive advantage over current RGA designs.

4:20pm **VT-WeA7 The Deployment of a Commercial RGA to the International Space Station**, ***Matthew S. Kowitt***, Stanford Research Systems, *D. Hawk*, Orbital-ATK, *D.J. Rossetti*, Conceptual Analytics, *M.S. Woronowicz*, SGT Inc. **INVITED**

The International Space Station (ISS) uses ammonia as a medium for heat transport in its Active Thermal Control System. Over time, there have been intermittent component failures and leaks in the ammonia cooling loop. One specific challenge in dealing with an ammonia leak on the exterior of the ISS is determining the exact location from which ammonia is escaping before addressing the problem.

Together, researchers and engineers from SRS and NASA's Johnson Space Center and Goddard Space Flight Center, have adapted a commercial off-the-shelf (COTS) residual gas analyzer (RGA) for repackaging and operation outside the ISS as a core component in the ISS Robotic External Leak Locator, a technology demonstration payload currently scheduled for launch during 2015. The packaging and adaptation of the COTS RGA to the Leak Locator will be discussed. The collaborative process of adapting a commercial instrument for spaceflight will also be reviewed, including the build-up of the flight units. Measurements from a full-scale thermal vacuum test will also be presented demonstrating the absolute and directional sensitivity of the RGA.

5:00pm **VT-WeA9 Temperature-stable Quartz Oscillator Applicable to Pressure Gauges, Gas Sensing, Partial Pressure Measurement, and Plasma Diagnostics**, ***Atsushi Suzuki***, AIST, Japan

A quartz friction pressure gauge (Q-gauge) is advantageous because it can measure pressures in the range of 0.01 kPa to 100 kPa and because the size of a quartz oscillator is less than 1x1 cm^2. The underlying principle of Q-gauge use in pressure measurement is that the electric impedance (Z) of the quartz oscillator depends on the viscosity and gas density of the measured gas. When the total absolute pressure is known, then properties related to viscosity and molecular weight can be obtained from Z.

This is important because it enables changes in viscosity and molecular weight of the measured gas to be detected in addition to changes in pressure. Thus, many types of methods are made possible, such as hydrogen gas sensing, hydrogen concentration measurement, partial pressure measurements of binary gas mixtures such as ozone-oxygen and silane-hydrogen, and measurements of gas decomposition efficiency and composition changes induced by plasma.

However, the disadvantage of these measurements using a quartz oscillator is that the output Z from the quartz oscillator is affected by temperature. This temperature dependence must be corrected in particular for uses of hydrogen sensing outdoors and in other applications in which temperature changes.

In this presentation, a novel temperature-stable quartz oscillator (TSQO) will be introduced. The output from the TSQO used in this study was the electric-impedance converted voltage, which represents Z. First of all, it was shown that this output depended on the total pressure from 0.01 kPa to 100 kPa, indicating that this TSQO works well as a Q-gauge device. Fluctuation of the reading output at constant temperature was 0.06% of the total output.

Temperature stability was confirmed at atmospheric pressure and for temperatures varying from 15 °C to 50 °C. With this temperature change, the change of the TSQO output was less than 0.2% of the reading output. Because the output fluctuation of a conventional quartz oscillator across the temperature range above is normally about 2.0% of the reading output, it was shown that temperature stability was attained by the TSQO. The measured degree of output fluctuation for this TSQO is acceptable for hydrogen sensing because it is smaller than the 0.2% change induced by contamination of hydrogen concentration and less than one-fourth of the fluctuation introduced by low-level explosions of hydrogen in air (4%), which is the necessary minimum detection level. Therefore, it can be concluded that this TSQO is practically useful for various measurements that involve hydrogen sensing anywhere that temperature fluctuates.

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5:20pm **VT-WeA10 An Ultra-high Vacuum Processing System for Constructing Small Format Photodetectors**, *D.R. Walters, R.J. Wagner*, ***John Noonan***, *L. Xia, J. Xie, J. Wang, H. Zhao, M. Virgo*, Argonne National Laboratory

The Large Area Picosecond Photodetector was envisioned to be a frugal design for use in upcoming water-based Cherenkov photodetectors for the detection of neutrinos. This project’s goal is to develop a glass enveloped 20 cm photodetector but to understand the issues of constructing such a detector a smaller 6 cm format was chosen to be the vehicle for parts and process development. An ultra-high vacuum system was designed and constructed for handling the sub-assemblies. This multi-chamber system is integrated so that the scrubbing, photocathode deposition, and hermetic sealing all occur within a single environment. The design of this system has process stations in adjacent chambers so that the sub-assemblies can be easily moved using magnetic linear manipulators. The vacuum performance of the system will be presented along with results on the efficiency of the photocathode, >15%, the clean-up of the scrubbing, and a brief overview of the indium vacuum seal.

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