Vacuum Technology Division
Room: East Exhibit Hall - Session VT-TuP

Vacuum Technology Poster Session & Student Poster Competition

VT-TuP1 Measurement of Molar Mass and Viscosity of a Viscous Flowing Gas with a Resonant Vibrating Sensor, ***A. Kurokawa***, National Institute of Advanced Industrial Science and Technology (AIST), Japan, *H. Hojo, T. Kobayashi*, VPI Co., Japan

We would show that a quartz tuning-folk type resonator can measure the viscosity and the molar mass of the gas in which the resonator is vibrating. The vibrating resonator has two kind of outputs which are frequency change (Δf) and impedance change (ΔZ). The Δf and ΔZ are defined as the shift from their origin measured at high vacuum. We reported that the Δf and ΔZ given as a function of pressure are independent, and then the measurement of Δf and ΔZ will give the gaseous viscosity with no need to measure the gaseous pressure [1, 2]. In this report we will show that the molar mass of the measurement gas can be given by measurement of Δf, ΔZ and pressure.

In this experiment the temperature controlled measurements were essential because Δf and ΔZ are sensitive to the temperature variation. The measurement apparatus, such as the vibrating sensor, driving circuit for oscillation, mass flow controllers, gas accumulator and the pressure gauges, are in a temperature controlled chamber by 29±0.02ºC. The impedance of the resonator was evaluated by the current passing through the sensor under constant driving AC voltage. The frequency of the resonator was 32kHz. The measured gas was Ne, Ar, N2, O2. The Δf and ΔZ were measured for the pressure between 120 kPa and vacuum. The absolute pressure was measured with a capacitance manometer.

The results showed that the $\Delta Z(P)$ and $\Delta f(P)$, give as a function of pressure, are larger for higher pressure. The $\Delta Z(P)$ and $\Delta f(P)$ for Ar, N2, O2 gases do not have the intersection. However Ne gas, having smaller molar mass but larger viscosity, crossed the other curves. So we cannot distinguish the gas species simply by $\Delta Z(P)$ or $\Delta f(P)$ measurements. To discriminate the gas species with their viscosity the ΔZ-Δf plot is useful. We found that the characteristic curves of ΔZ-Δf lied in the descending order of the viscosity, i.e., Ne, Ar, O2, and N2. These curves do not across each above 1 kPa.

We found the molar mass can be derived with the vibrating sensor. The product of molar mass and pressure can be evaluated without pressure measurement. The molar mass can be given with additional pressure measurement. The results showed that above 10kPa of the gas pressure the deviation of measured molar mass is less than a few percent.

[1] A. Kurokawa, H. Hojo, T. Kobayashi, AVS 57th Int. Sympo. Exhibi. (2010, Albuquerque).

[2] A. Kurokawa, H. Hojo, T. Kobayashi, Appl. Phys. Express **4** (2011) 037201.

VT-TuP3 Pumping Performance of Scroll Pump, ***F.C. Hsieh***, *P.H. Lin, J.C. Lu, F.Z. Chen*, National Applied Research Laboratories, Taiwan, Republic of China

Scroll pumps are widely used in solar-optic and semiconductor industry for backing purpose. The performance of scroll pump could affect significantly the performance of pumping station. The performance of a scroll pump was predicted by using VacTran commercial software and the experiment were conducted to verify the prediction in this study. Specifically, the delivered pumping speed, conductance and delivered throughput of the pump were investigated. The experimental delivered pumping speed increased as the inlet pressure increased and reached to 291.05 L/min at 11.62 mbar. As the inlet pressure increased, the conductance increased to $4.58\text{x}10^{3}$ L/min at $1.18\text{x}10^{2}$ mbar. The analysis delivered throughput increased obvious from $3.77\text{x}10^{-2}$ mbar and reached its maximum value at $1.2\text{x}10^{2}$ mbar. The standard deviation between analysis and experimental delivered pumping speed was less than 15% in the pressure ranges from $1.9\text{x}10^{-1}$ mbar to 45.3 mbar.

VT-TuP4 A System for Vacuum Gauge Calibration in the Pressure Range of 10^{-5} to 10^{5} Pa, ***Y.W. Lin***, *C.P. Lin, C.N. Hsiao*, National Applied Research Laboratories, Taiwan, Republic of China

A vacuum gauges calibration system for wide-range pressure was developed, and the measurement uncertainty associated with the system. The design of the system took into consideration of influencing factors that include uniformity of gas distribution and the geometric location of the gauge to be calibrated. The system operates following the procedure stipulated in the comparison vacuum gauge calibration method. The calibration may range from 10^{5} to 10^{-5} Pa. The system makes use of capacitor vacuum gauge, SRG and hot cathode thermion vacuum gauge to estimate the degree of uncertainty associated with the system. The data collected from the gauge calibration tests indicated that if the background pressure of the system had reached 10^{-7} Pa, the uncertainty associated with the system were as follows: less than 4 % in the pressure range of 10^{-5} to 10^{-2} Pa, less than 2 % in the pressure range of 10^{-2} to 10^{5} Pa. The present research has demonstrated the high stability of the vacuum calibration system, and its capabilities of conducting calibration for vacuum gauge with great efficacy.

VT-TuP5 Application of AutoResonant Ion Trap Mass Spectrometry (ART MS) to Vacuum Quality Measurement, ***P.D. Acomb***, *G.A. Brucker, J. Rathbone, B.J. Horvath*, Brooks Automation, Inc., Granville-Phillips Products

Autoresonant Ion Trap Mass Spectrometers (ART MS) have demonstrated significant benefits when applied to vacuum quality measurement at ultra-high vacuum (UHV) levels. Vacuum quality monitors based on ART MS technology are known to deliver more accurate gas analysis at UHV levels than any other competitive mass spectrometry technology presently used for residual gas analysis. The speed, accuracy and remote-sensing capabilities of ART MS technology for vacuum quality measurement at UHV levels will be explained and several application examples will be presented. The low outgassing rates associated to ART MS sensors will be justified and explained in terms of surface area and power dissipation considerations. Gas analysis results, data-acquisition rates and detection limit values will be listed and compared against similar results obtained with legacy instrumentation including quadrupole-based residual gas analyzers. Instrument optimization strategies for UHV applications will be disclosed.

VT-TuP6 Combination of NEG and Sputter-Ion Pumps for Particle Accelerator Vacuum Systems, *P. Chiggiato, J.M. Jimenez, S. Meunier, I. Wevers*, CERN, Switzerland, *A. Bonucci, A. Conte,* ***P. Manini***, SAES Getters

NEG and sputter-ion pumps are usually combined in particle accelerators to attain UHV pressure specifications. NEG pumps provide very high pumping speed at a reasonable cost for most of the residual gases except CH4 and rare gases, which amount to less than an hundredth of the total outgassing rate. Sputter-ion pumps remove all gases, though with a lower pumping speed. As a consequence, an optimized design should be based on NEG assisted by sputter-ion pumps for the gases that are not adsorbed chemically. Two examples of such configuration are here described. In the first, a commercial NEG lump pump is installed on a dedicated set-up together with sputter-ion pumps of different nominal pumping speeds. We show that the ultimate pressure achieved in the system does not depend on the applied sputter-ion pump nominal pumping speed in the range 30 to 400 ls-1, and that values in the XHV range can be reached. In the second, we consider the vacuum system of the long straight section of the Large Hadron Collider (LHC) where most of the vacuum pipes were coated by magnetron sputtering with thin Ti-Zr-V films using Kr as discharge gas; the guidelines for the choice of the location and quantity of the sputter-ion pumps are reviewed in term of sectorization criteria and CH4 and Kr outgassing rates.

VT-TuP7 Cryogenic Viscous Compressor Design and Development for the ITER Vacuum System, ***S.J. Meitner***, *L.R. Baylor, C.N. Barbier, S.K. Combs, R.C. Duckworth, T.D. Edgemon, M.P. Hechler, D.A. Rasmussen*, Oak Ridge National Laboratory, *R. Kersevan, M. Dremel, R.J.H. Pearce*, ITER International Organization, France

A specialized cryopump known as a cryogenic viscous compressor (CVC) is being developed for the ITER vacuum system to pump the regenerated, hydrogenic, fusion reaction gases from the torus cryopumps and neutral beam cryopumps, to the tritium exhaust processing facility. Several of these pumps will operate in parallel and are staged to maintain continuous pumping during plasma operation. The CVC's regenerate at a higher pressure (500 mbar) than the torus and neutral beam cryopumps, which allows the regenerated gas to be pumped by a tritium compatible scroll pump train, with sufficient speed to maintain the regeneration duty cycle. The CVC's are cooled to operating temperatures by precooling the inlet gas with a 80K helium cooled chevron heat exchanger, followed by a tube bank heat exchanger cooled with supercritical helium at 4.5K. Hydrogenic gas is frozen on the inner tube bank walls while helium impurity gas, a byproduct of the fusion reactions, passes through the CVC and is pumped by conventional vacuum pumps.

A conceptual design of the CVC has been developed and a representative prototype has been designed, fabricated, and is undergoing testing to verify the concept of a full scale CVC before detailed design is completed. While cooling is provided by either cold helium gas or supercritical helium, hydrogen with trace amounts of helium gas is introduced into the central column of the cryopump at 100 Pa and 80 K at flow rates of 8 mg/s. Heat transfer between the laminar flowing gas and the cold pump tube is being enhanced with the use of internal petal fins. Temperature and pressure measurements are made along the pump gas stream in order to benchmark with design heat transfer characteristics. Comparison with a fluid dynamics code is under way. Modeling of the gas flowing into the pump and through the precooler heat exchanger and freezing zones is accomplished with the CFX computational fluid dynamics code [1]. The flows into the pump are at low pressure (~ 1mbar) and are in a laminar, low Reynolds number regime, (Re < 300) that is handled well with the CFX code. As the gas begins to desublimate in the cold zone of the pump, it reaches a rarified gas regime where the CFX model for flow and heat transfer breaks down. The modeling results are being compared with the prototype testing and will be used to further optimize and ensure reliable operation of the full CVC in the ITER application.

[1] ANSYS CFX, ANSYS, Inc., Canonsburg, PA 15317, USA

* This work was supported by the Oak Ridge National Laboratory managed by UT-Battelle, LLC for the U.S. Department of Energy under Contract No. DE-AC05-00OR22725.

VT-TuP9 Development of Niobium Thin Films Tailored for SRF Applications, ***J.S. Spradlin***, *A.-M. Valente-Feliciano*, Jefferson Lab

Over the years, Nb/Cu technology, despite its shortcomings due to the commonly used magnetron sputtering, has positioned itself as an alternative route for the future of superconducting structures used in accelerators. Recently, significant progress has been made in the development of energetic vacuum deposition techniques, showing promise for the production of thin films tailored for SRF applications. JLab is pursuing energetic condensation deposition via techniques such as Electron Cyclotron Resonance and High Power Impulse Magnetron Sputtering (HiPIMS). As part of this project, the influence of the deposition energy on the material and RF properties of the Nb thin film is investigated with the characterization of their surface, structure, superconducting properties and RF response. It has been shown that the film RRR can be tuned from single digits to values greater than 400. This paper presents results on surface impedance measurements correlated with surface and material characterization for Nb films produced on various substrates, monocrystalline and polycrystalline as well as amorphous.

VT-TuP10 Bulk-like Nb Films might be Possible with Coaxial Energetic Deposition for Superconducting RF Cavities, ***T. Tajima***, High Energy Accelerator Research Organization (KEK), Japan and LANL, *N.F. Haberkorn, L. Civale*, Los Alamos National Laboratory, *E. Valderrama, M. Krishnan*, Alameda Applied Sciences Corporation

B_{pen}, the magnetic field at which magnetic vortices start to penetrate into Nb films prepared by coaxial energetic deposition (CED) technique was measured with a SQUID magnetometer. Unlike the films prepared by conventional sputtering technique that showed B_{pen} ~ 94 mT at 2.5 K, the CED films showed B_{pen} of 180-190 mT at 2.5 K, a value that is very close to the number for bulk Nb used for SRF cavities. This corresponds to an accelerating gradient (E_{acc}) of approximately 45-48 MV/m for the SRF cavities with B_{peak}/E_{acc} ~ 4 mT/(MV/m) such as those for the European XFEL or the ILC projects. These samples were coated on MgO, Sapphire and Borosilicate with RRR ranging between 21(Borosilicate) and 540 (MgO). The next step will be to coat on copper. If it is possible to fabricate Nb coated copper cavities that have similar performance to bulk Nb high-gradient cavities, this will lead to a significant cost saving since the cost of copper is about 2 orders of magnitude less than Nb. It will also have other benefits such as better thermal stability due to high thermal conductivity of copper and less susceptibility to ambient magnetic field than bulk Nb cavities as has already been shown by LEP Nb/Cu cavities at CERN.

Authors Index

Bold page numbers indicate the presenter

— A —

Acomb, P.D.: VT-TuP5, **1**

— B —

Barbier, C.N.: VT-TuP7, 1
Baylor, L.R.: VT-TuP7, 1
Bonucci, A.: VT-TuP6, 1
Brucker, G.A.: VT-TuP5, 1

— C —

Chen, F.Z.: VT-TuP3, 1
Chiggiato, P.: VT-TuP6, 1
Civale, L.: VT-TuP10, 2
Combs, S.K.: VT-TuP7, 1
Conte, A.: VT-TuP6, 1

— D —

Dremel, M.: VT-TuP7, 1
Duckworth, R.C.: VT-TuP7, 1

— E —

Edgemon, T.D.: VT-TuP7, 1

— H —

Haberkorn, N.F.: VT-TuP10, 2
Hechler, M.P.: VT-TuP7, 1
Hojo, H.: VT-TuP1, 1
Horvath, B.J.: VT-TuP5, 1
Hsiao, C.N.: VT-TuP4, 1
Hsieh, F.C.: VT-TuP3, **1**

— J —

Jimenez, J.M.: VT-TuP6, 1

— K —

Kersevan, R.: VT-TuP7, 1
Kobayashi, T.: VT-TuP1, 1
Krishnan, M.: VT-TuP10, 2
Kurokawa, A.: VT-TuP1, **1**

— L —

Lin, C.P.: VT-TuP4, 1
Lin, P.H.: VT-TuP3, 1
Lin, Y.W.: VT-TuP4, **1**
Lu, J.C.: VT-TuP3, 1

— M —

Manini, P.: VT-TuP6, **1**
Meitner, S.J.: VT-TuP7, **1**
Meunier, S.: VT-TuP6, 1

— P —

Pearce, R.J.H.: VT-TuP7, 1

— R —

Rasmussen, D.A.: VT-TuP7, 1
Rathbone, J.: VT-TuP5, 1

— S —

Spradlin, J.S.: VT-TuP9, **2**

— T —

Tajima, T.: VT-TuP10, **2**

— V —

Valderrama, E.: VT-TuP10, 2
Valente-Feliciano, A.-M.: VT-TuP9, 2

— W —

Wevers, I.: VT-TuP6, 1