Vacuum Technology Division
Room Central Hall - Session VT-TuP

Vacuum Technology Poster (and Student Poster Competition)

Moderators: James Fedchak, National Institute of Standards and Technology, Yevgeniy Lushtak, SAES Getters USA

VT-TuP-1 Ion-Cathode Bombardment in a DC Deuterium Glow Discharge for High-Density Deuterium Cluster Formation in Metals*, **Erik Ziehm**, G Miley,* University of Illinois at Urbana-Champaign

A deuterium glow discharge is modeled to obtain angular and energy distributions of incident ions on the cathode vs plasma conditions. The model uses a DC Discharge module in COMSOL Multiphysics® [1] coupled to a Particle Tracing module while utilizing Townsend coefficients for prominent reactions derived from a Boltzmann Two-Term Approximation. Care is taken to use appropriate ionization and dissociation reaction cross sections for deuterium as these values present isotopic differences. The model is benchmarked by Langmuir probe measurements of the electron energy distribution along the cathode dark space and negative glow regions. This model is then used to determine the effects of ion incident energies and dose on the creation of the high-density clusters of deuterium atoms beneath the cathode surface layer. Temperature Desorption Spectroscopy (TDS) complimented with X-Ray Diffraction (XRD) is employed to determine the clusters' trapping energies and densities.

VT-TuP-2 Low-cost Device Fabrication and Vacuum Packaging for Energy Efficient Field Emission Lighting*, **Sushma Shrinivasan**, C Hunt,* University of California - Davis

With the growing emphasis on climate change and global warming and the resulting need to cut down energy usage, energy-efficient lighting technologies that resemble day light spectrum and do not present health hazards are extremely attractive. Field emission lamps (FELs) have been presented as a viable alternative to existing lighting technologies with several advantages including (i) spectrum similar to daylight (ii) environment-friendly (iii) no health hazards to name a few. In this regard, the primary goal of this poster is to present a low-cost, simple device fabrication technique for a typical FEL. The FEL device consists of a base plate, face plate and side-wall (all made out of glass). The glass package is built by attaching the various components using ultra high vacuum epoxy. The base plate and face plate comprise of the cathode (reticulated vitreous carbon) and anode (aluminum coating) respectively with the face plate additionally comprising of a phospor coating. The exhaust tube for the device is located on the side-wall. The device is then attached to a turbomolecular pump and pumped down to vacuum levels of 1E-6 Torr. This level of vacuum is shown to activate the barium getter that is attached to the baseplate before the device packaging. The activation of the barium getter is performed using an in-house induction coil and a radio frequency generator operated at a frequency of 300 kHz. The packaged device when combined with a high voltage DC power supply is anticipated to lead to a low-cost energy efficient lighting option that has a spectrum similar to incandescent lamps with an energy consumption comparable to compact fluorescent lamps.

VT-TuP-3 High Precision Measurement Of Tube Conductance From Pressure Decay Curve*, **Tim Verbovšek**, B Šetina Batič, J Šetina,* Institute of Metals and Technology, Slovenia

A unique vacuum system for precise measurement of gas throughput through a tube connecting a vacuum chamber and a pump was constructed. A conductance of a duct between the pump and the vacuum chamber determines the rate of pressure decay $p=p(t)$ when nonadsorbing gas is pumped. If gas back-streaming from the pump through the duct is negligible, and gas temperature in the duct is the same as in the chamber, the conductance C of the duct can be calculated from the time derivative of the logarithm of the pressure decay by $C=V\times d(\ln(p))/dt$, where V is volume of the chamber. The simplicity of this equation is also a basis for a very high precision of such measurement. Uncertainties which have to be considered are related to the volume of the chamber and deviations from isothermal conditions. Since logarithm of the measured $p(t)$ curve is used to calculate conductance, any correction factor of the vacuum gauge cancels out. Moreover, different sensitivity of the vacuum gauge for different gases is totally unimportant, so only random noise of the measured pressure contributes to the uncertainty. Estimated relative uncertainty of measured conductance is less than 0.3%. Reproducibility (with volume V unchanged) is even less than 0.2%.

Very high precision of this method enables studies of the influence of gas-surface interaction on the tube conductance in molecular regime. Any changes of tangential momentum accommodation coefficient reflect in variation of the tube conductance. We will present results of measurements of conductance of a long stainless steel tube with inner diameter of 7.76 mm for initial state and after different treatments (all at 300 °C for 24 h): exposure to O_2 at 0.1 Pa, vacuum bake, and exposure to H_2 at 0.1 Pa. Conductance was measured for gasses He, Ne, Ar, Kr, CH_4 and N_2 in the range of Knudsen numbers from 0.01 to 1000. Variations of molecular scattering on the tube surface resulted in changes of tube conductance of more than 10 % for He, while for N_2 and CH_4 the observed changes were less than 2 %.

VT-TuP-4 Using a High Vacuum Equipment Trainer (HVET) System for Hands-on Learning*, **Del Smith**, N Louwagie,* Normandale Community College

In keeping with the theme of the 2017 Symposium, "Surfaces, Interfaces and Materials: A New Vision," this paper will discuss the experiences of Normandale Community College (Bloomington, Minn.) instructors offering academic courses in vacuum and thin film technology via a telepresence interface. We believe this new model, which brings together on-campus and remote learners in real time, is a positive direction for technical education. Over the past two years, several organizations throughout the U.S. have enrolled their employees and students in courses, which emphasize hands-on learning with a vacuum trainer system.

Normandale staff in the Vacuum and Thin Film Technology Program, with input from senior technicians from several Minnesota-based industries, designed a High Vacuum Equipment Trainer (HVET) system to use in the classroom. The HVET system has 5×10^{-6}Torr base pressure capability and supports demonstrations of vacuum technology operations such as gauging, gas sensitivity, leak testing, RGA analysis, and plasma generation. Students use the HVET system to practice pumpdown sequences, pumpdown curves, rates of rise, and conductance in a lab environment. There are four copies of the HVET, which can be disassembled and shipped to participating sites; students assemble the HVET system as part of their initial learning experience.

The telepresence classroom at Normandale was designed with a combination of high-performance audio and video feeds and multiple monitors to show close-ups of lab experiments and to allow the instructor to respond to nonverbal cues from remote students. Normandale offers an AAS degree in Vacuum and Thin Film Technology. Two courses from this program are available via telepresence: Intro to Vacuum Tech and Vacuum Analysis and Troubleshooting. Eventually, two more courses will be brought online: Thin Film Deposition; and, Foundations in Vacuum Technology, which will teach chemistry and math concepts in the context of vacuum science. Students will be able to complete these courses in a year, via telepresence, earning a Vacuum Technology Certificate and 12 academic credits, which are applicable towards the AAS degree. This paper will discuss how the trainer systems and telepresence provide remote students with access to formal education in vacuum and thin film technology. (This work was made possible in part by a grant from the National Science Foundation: DUE #1400408.)

VT-TuP-5 Advanced Metal Sealing Solutions for Critical Industry Applications*, **Ryan McCall**,* Technetics Group

As operating conditions in many critical industries, such as vacuum and semiconductor, continue to face increasingly extreme temperatures and pressures, sealing technologies are facing challenges that cannot be met with traditional materials and methods. Additionally, there are growing pressures to ensure the protection of the environment remains a top priority for companies and that they are consistently meeting the strict requirements associated with international regulations. More and more manufacturers are turning to metal seals as their solution of choice as today's industry requirements are becoming more and more stringent.

Because of these stringent requirements, metal seals designed for use in modern sealing applications must be resilient to the extreme temperatures and pressures that they are exposed to in a number of harsh environments. Seal designs must also allow for bi-direction flow, be suitable for axial and radial applications, provide a long sealing life, be resistant to corrosion, be able to remain as leak tight as possible under semi-dynamic motions and account for thermal expansions.

This presentation will explain the factors to consider when selecting a metal sealing solution and what types of seal designs (spring-energized, O-rings, C-rings, E-rings, etc) are best suited for each given aspect of a critical industry application. The factors that will be discussed in the presentation will include but are not limited to seating load, seal function, seal material and thickness, required leak rate, coatings, controlled compression and surface finish. Additionally, the specific applications where metal seals are most suited and why will also be discussed.

VT-TuP-6 Development of the Residual Gas Analysis for Large Air Tight Packages*, **Yusuke Nishikawa**,* Advanced Technology R&D Center Mitsubishi Electric Corp., Japan*; M Kinugawa,* Advanced Technology R&D Center Mitsubishi Electric Corp.

A hollow airtight packaging structure is used for electric / electronic parts (e.g. lamps, high frequency devices, etc.) to improve reliability and securing characteristics. It is crucial to know the variety and amount of impurities in the structure's internal gas, which adversely affects said properties. We have developed a gas analysis technique for small parts with an internal volume of 1 cm3 or less [1].

In the case of small package devices, it is possible to break it in a vacuum chamber and analyze the gas inside. However, when analyzing residual gas with a large package, it is very difficult to prepare a larger chamber and break the sample. Furthermore, if the surface area in the package is large, the influence of desorption of adsorbed molecules cannot be ignored. It is difficult to accurately measure the pressure of residual gas.

In this study, we present a new technique for analyzing gas in sealing devices that can be flexibly applied and can minimize the influence on the state of the residual gas composition even for various large samples.

The testing apparatus consists of a gas sampling chamber and an analysis chamber, with both connected to a vacuum valve and an exchangeable orifice. The analysis chamber has a quadrupole mass spectrometer and is exhausted continuously by a turbomolecular pump. The gas sampling chamber has a perforator, a vacuum gauge, and an additional pumping system. The volume of the gas sampling chamber is sufficiently small relative to the volume of the sample. The package sample is connected directly to the connection port of the gas sampling chamber. By using a small gas sampling chamber, an external connection of the sample, and a variable orifice, this technique can be flexibly applied to various large samples.

We measured the temperature of the internal pressure of a certain package sample. As a result, we found that the pressure increase was five times higher than when considering by the ideal gas law and ion intensity of water was increased. We estimated them as the adsorption and desorption levels of gas on the surface of the internal components.

To further advance this technique, we found that it is important to know the influence of gas adsorption and desorption inside the package. We will research the gas adsorption and desorption for the component parts affecting residual gas partial pressure.

[1] M. Kinugawa, et al.: Mitsubishi Denki giho Vol. 81 No. 3 231 (2007).

VT-TuP-7 ARIEL RIB Transport line Vacuum System*, **Geoffrey Hodgson**,* TRIUMF, Canada

The vacuum system of the Radioactive Isotope Beam (RIB) transport line is part of the Advanced Rare IsotopE Laboratory (ARIEL) at TRIUMF. This beam line will accept three simultaneous RIBs and transmit two of them to low energy experimental facilities and one to further accelerators. The RIBs will consist of ions of exotic radioactive species with masses ranging from 6 to 238 amu and energies from 10 to 60 keV. RIBs will be extracted from two new ARIEL target stations and one of two existing ISAC target stations. In ISAC, and one of the ARIEL target stations, targets materials ranging from metals, oxides, carbides to actinide compounds are irradiate by 50kW, 500 MeV protons from TRIUMF's main cyclotron. The second ARIEL target will make use of 100 kW, 35 to 50 MeV electron beam which is converted to high-energy gamma rays in a thin layer of gold. These gamma rays are used for photodisintegration of beryllium oxide or photo photofission of uranium carbide. The beam line will be built on two floors. The lower floor will contain Medium and High Resolution mass Spectrometers (MRS and HRS) having 1:5,000 and 1:20,000 resolution, respectively. The upper floor will contain charge breeding equipment to provide a typical mass to charge ratio of 7 to allow further acceleration of heavier isotopes. The design pressure is $3\cdot 10^{-8}$ Torr for singly charged beams and $1\cdot 10^{-8}$ Torr for highly charged ion beams based on beam loss calculations. The system will use turbo pumps and scroll pumps to achieve the vacuum. Individual components of beam line and beam steering equipment were tested to determine their conductance in molecular flow, and the model of the vacuum profile was created. A 14.5 m prototype section of beam line was built and used to validate the profile model. The beam line is divided into isolable sections, and each section will have a standard vacuum pumping station to facilitate controls and interlocks.

VT-TuP-8 Operational Regime of 2 million L/s Cryobox Pump on Tri Alpha Energy's C2W Machine*, **Ernesto Barraza-Valdez**, A Van Drie,* Tri Alpha Energy, Inc.

Tri Alpha Energy requires a large pumping speed of approximately 2 million L/s for hydrogen and 1.5 million L/s for deuterium in each of the four divertors (22,000 L) on C2W. To accomplish this TAE has developed a liquid nitrogen cooled, titanium getter pump. The experimental pump speed was tested for a variety of parameters including purity of titanium (99.995% and 99.97% Ti), various temperatures, and saturation. Purity of titanium showed no effect on the pump speed but there was a clear correlation with the temperature and saturation. With this, TAE had discovered a regime of operation during plasma shots in C2W.

VT-TuP-9 NEG Coating of 6mm ID Copper Beam Pipes*, **Sol Omolayo**,* Lawrence Berkeley National Lab

Diffraction Limited Sychrotron Light Sources (DLSR) require narrow vacuum chambers due to the small pole gaps of the magnet structures. For the Advanced Light Source Upgrade (ALS-U) project, the magnet pole gaps in the arc and straight sections calls for vacuum chambers that are 6mm to 20mm in internal diameter.

The poor vacuum conductance of such chambers rules out the use of conventional lumped pumping approach for achieving the required pressures (1nTorr for ALS-U). Non-evaporable getter (NEG) coating of these narrow vacuum chambers provides a solution for the vacuum pumping challenge.

NEG coating of vacuum chambers with diameters down to 10mm has been mastered in industry. At the Lawrence Berkeley National Lab (LBNL), we have made substantial progress in NEG coating 6mm diameter vacuum chambers. There are significant challenges to coating a 6mm chambers including electrical shorts, cathode wire size and coating uniformity. We report on the progress we have made overcoming this challenges and the pumping performance achieved.

Author Index

Bold page numbers indicate presenter