Vacuum Technology
Room Central Exhibit Hall - Session VT-ThP
Vacuum Technology Poster Session

VT-ThP-1 Surface Characterization and Vacuum Performance of AISI 1020 Low-Carbon Steel for High-Performance Vacuum Systems*, **Aiman Al-Allaq,*** Old Dominion University*; M. Mamun, M. Poelker,* Thomas Jefferson National Accelerator Facility*; A. Elmustafa,* Old Dominion University

The Cosmic Explorer, a next-generation gravitational wave observatory, will be very large with evacuated interferometer arms ten times longer than Advanced LIGO operating today, 40 km each. Consideration is being given to building this extremely large vacuum system using comparatively inexpensive low-carbon steel, commonly used today for natural gas delivery. But besides reduced cost, low-carbon steel offers a vacuum advantage, too. Low-carbon steel has a much lower hydrogen outgassing rate compared to stainless steel. In addition, studies performed worldwide within the gravitational wave observatory community suggest low carbon steel – particularly with a magnetite surface coating – may provide a more rapid pump down, possibly reaching acceptable vacuum conditions with only an 80 °C heat treatment. At Jefferson Lab, we plan to construct a new spin-polarized electron source using low-carbon steel, which we hope operates at a much lower pressure than our photoguns built using stainless steel. In support of this objective, we are performing studies related to water outgassing, pump down times, and ultimate pressure achieved using low-carbon steel. Some of these studies seek to understand if material surface transformations occur following different heating protocols. Small coupons made of AISI 1020 low-carbon steel were characterized using SEM, AFM, XRD, and EDS after various heat treatments. The results showed minimal oxidation up to 150 ˚C, with layered magnetite and hematite developing at higher temperatures. A steam-treated sample exhibited vertical grain orientation, while thermal oxidation favored lateral oxide colony formation. Tests on magnetite-coated and bare low-carbon steel chambers demonstrated that the magnetite-coated chamber consistently achieved lower pump down pressure and lower throughput water outgassing rates, supporting the idea that magnetite coating can improve the vacuum performance of low-carbon steel. Ongoing research at Jefferson Lab focuses on characterizing bare and magnetite-coated low-carbon steel chambers to explore their feasibility in next-generation vacuum systems, such as those required for the Cosmic Explorer project, and for spin-polarized electron guns where improved vacuum will help sustain reliable beam delivery.

VT-ThP-2 Fabrication and Characterization of a Standard Leak Element Based on Capillary Tubings*, **Han Wook Song,*** KRISS, Republic of Korea*; M. Salazar,* ITDI, Philippines*; J. Kim, M. Seo, S. Cho, S. Woo,* KRISS, Republic of Korea

Leak artefacts made of different materials with well-defined geometry are in constant development to improve the knowledge of gas dynamics in narrow channels. In this study, a unique, low-cost material of micro-scale capillary tubing was used to develop a standard leak element (SLE) that will be practical and easily duplicated for industrial use. Two designs of the SLE were fabricated, both designs were developed with variable lengths and throughput were measured through the pressure-rise method. A leak artifact assembly was fabricated with variable lengths and diameters, and throughput rates were measured using the pressure rise method. Throughput rates of up to 10^{-11} Pa m^3 s^{-1} were observed with a relative expanded uncertainty (*k = 2*) of 12%. An established model involving the viscous flow in long pipes was used to verify the results of the actual measurements. This study utilized the ideal gases such as Helium and Nitrogen. Behaviour of the results of actual measurements of throughputs of the first design contradicts the theoretical predictions of the conventional theory while that of the second design is in agreement with the classical theory which indicates that the structure may be an excellent choice for a standard leak artifact that fits the aforementioned purpose and applications.

VT-ThP-3 Commissioning of the New NIST High-vacuum Calibration Standard*, E. Newsome, **Daniel Barker,** J. Fedchak, J. Scherschligt,* National Institute of Standards & Technology

We report our efforts toward commissioning NIST's new ionization gauge calibration system (IGCS). Ionization gauges are critical to applications operating in the high-vacuum and ultra-high vacuum ranges. These gauges determine pressure in a vacuum chamber by first ionizing gas molecules in the vacuum via collisions with electrons emitted from a cathode, then collecting the ions on a wire, and measuring the subsequently generated current. Because the conversion of ion current to pressure depends on gauge geometry, collection efficiency, electrode potential, and other factors, individual gauge sensitivity will vary and, in general, requires calibration to achieve the best measurement accuracy. In the range of 0.1 Pa to 10^{-7} Pa, the IGCS calibrates ion gauges by comparing the gauge reading to a known pressure step using the dynamic expansion technique. We describe the design of the IGCS, focusing on improvements over NIST's previous high-vacuum standard. We also present initial tests of the IGCS and calibration results for NIST gauges.

VT-ThP-4 Developing an Extreme Environment Vacuum System for ITER's Ion Cyclotron Heating Antenna*, **John Michael Clark,*** Oak Ridge National Laboratory

The ITER project is designed with the goal of demonstrating the feasibility of fusion energy, and to advance the technological understanding of fusion for future commercial reactors.In order to achieve a "burning plasma", various heating methods, such as Neutral Beam, Electron Cyclotron Heating, and Ion Cyclotron Heating (ICH) are employed in the ITER fusion device. Each of these technologies require high vacuum environments to ensure safe and efficient operation; however,ICH, in particular, poses unique issues in developing a vacuum system.

The proximity of the ICH antenna, and associated vacuum pumping system of the ICH Removable Vacuum Transmission Line (RVTL) Rear Windows,to the ITER Tokamak necessitates a vacuum system that is able to withstand dynamic magnetic fields in excess of 500 mT and activation of up to 10^4Gy. Vacuum technology and hardware layouts that have become common across ITER vacuum systems are not operablein this extreme environment. To develop a functional vacuum system for the ITER ICH antenna's RVTL Rear Windows, it must be designed with hardware and an arrangement that tolerates the environment and meets pressure requirements without significant increase inevacuation time.

VT-ThP-5 Secondary Electron Yield Measurements of Vacuum Insulators*, **Minh Pham,** R. Goeke,* Sandia National Laboratories

Ceramics are commonly used for high voltage insulation in vacuum systems. The vulnerability of its high voltage standoff is a flashover of the insulator surface. The principal mechanism for this breakdown is a secondary electron emission (SEE) avalanche. In this process, some electrons striking the insulator surface produce more electrons which strike the surface again producing additional electrons. This process continues until a flashover of the insulator surface occurs and the high voltage standoff is lost. We have developed a test stand to measure SEE yields as function of incident electron energy using very small doses of electrons to minimize surface charging of the insulators. This system utilizes a Hemispherical Grid Retarding Field Analyzer to capture all the secondary and backscatter electrons in an Ultra High Vacuum environment, ensuring an accurate measurement of SEE yield. By firing quick small pulses of electrons enables us to analyze insulating samples before the surface becomes charged which will alter the electron emission process. Results from our measurements on ceramic insulators will be

presented.

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