Vacuum Technology Division
Room 7 & 8 - Session VT+MN-TuA

Pumping

Moderators: Tamirisa Apparao, SHI Cryogenics Group, Julia Scherschligt, NIST

2:20pm **VT+MN-TuA-1 Silicon-micromachined Turbomolecular Pump***, **Wei Yang**,* PD Sciences LLC **INVITED**

Deep miniaturization of sensing and analytical instruments, such as mass spectrometers, vacuum electron devices, atomic clocks, and cold atom devices, are pushing the limit of conventional vacuum packaging technologies in micro scales. Ultra-high vacuum (UHV) of 10^{-6} to 10^{-10} torr which are beyond the capability of current passive packaging technologies, have become increasingly necessary for stable operation and high performance. Although 10^{-6} torr and higher vacuum levels are routinely achieved in macro scale systems by passive sealing and getters, maintaining such vacuum at chip-scale has unique challenges arising from scaling laws and practical limitations. Therefore, a micro scale UHV pump is highly desirable as an enabling component for a wide range of mobile or miniature instruments.

Integration of silicon MEMS and precision metal machining offers a viable path to new capabilities unattainable in their own native environments. We will present such an accomplishment in the development of a micro turbomolecular pump that takes advantage of the high-density microstructures from silicon microfabrication, and the range of motion from a precision spindle. Major achievements include compression ratio over 10^6 and maximum stall pressure of 100 Torr at relatively low tip speed of 120 m/s. This is a major milestone in the pursuit of moving UHV systems from laboratories to mobile platforms. Of particular significance, the successful demonstration of the molecular pumping against such a high exhaust pressure, a direct consequence of dimensional downscaling, points to the feasibility of a single-stage system from UHV to atmospheric pressure in miniature scales. We will discuss key technical challenges such as silicon fabrication, high-tolerance bonding, scaling analysis and simulation methodology, and touch on potential applications in small-scale thermal mechanical systems.

3:00pm **VT+MN-TuA-3 A Rigorous Approach to Effluent Gas Management for the Vacuum Processing Industry***, **Paul Dozoretz**,* MKS Instruments, Inc. **INVITED**

Vacuum processing is consistently gaining momentum in the manufacturing of novel materials relying on thin film coating and implantation technologies. The vacuum systems developed for such new applications borrow from many of the standard vacuum processing techniques but consistently push the design limits in terms of the amount of precursor gas consumption and by-product mass generation. In order to handle the large amounts of effluent produced in some of these these processes it has become essential to better understand gas dynamics for the effluent flowing out of the chamber and into the pumping systems. In most cases, effluent gas must be captured or trapped before it can reach and irreversibly damage the pumps and before it can become a danger for the personnel operating the vacuum manufacturing tools. With the aid of gas dynamic modeling software, our engineering team has been able to better understand flow through effluent lines and develop more efficient gas trapping solutions for very novel applications spanning from the semiconductor to the aeronautical industries. In this presentation we describe the rigorous methodology used to guide and validate the design effluent gas handling systems. Detailed understanding of process chemistries and effluent physicochemical properties, combined with gas dynamic flow modeling, has revolutionized the way our team approaches effluent gas management and improved the speed at which customer effluent needs can be addressed.

4:20pm **VT+MN-TuA-7 Compatibility of NEG Pumps with Particle-sensitive Applications: A Review of Recent Experimental Evidences***, P Manini, E Maccallini, **Marco Urbano**, M Mura, T Porcelli, F Siviero,* SAES Getters, Italy

Non Evaporable Getter (NEG) pumps are frequently used when large pumping speeds for H_2 and active gases (i.e., H_2O, O_2, CO, CO_2) are required in conjunction with very small weight and size, reduced magnetic interference and vibration, or negligible power consumption. Thanks to these qualities NEG pumps are widespread in basic and applied research, such as particle accelerators, storage rings, synchrotrons and physics projects to achieve UHV or XHV conditions. Moreover, their use is becoming familiar in UHV analytical instrumentation such as SEM, TEM, surface science as well as portable mass spectrometry and transportation vacuum boxes.

In spite of the excellent results in terms of pressure (10^{-11} mbar are currently achieved in many machines and values lower than 10^{-12} mbar have been measured in various experiments using NEG pumps), application in cryogenic superconductive radio frequency (SRF) cavities and other particle sensitive systems is not common so far. As a matter of fact, the use of NEG pumps is limited as a precaution against potential dust emission, which can be transported inside the vacuum envelope and may interfere with the electromagnetic fields and promote unwanted quenching phenomena.

Nevertheless, these systems could greatly benefit from the high pumping speed and compactness of NEG pumps, so that an assessment of the actual risk of dust release is gradually being undertaken by different players, including potential users in the accelerator community. Here we present and compare experimental data on particle emission collected with several techniques both on compressed and sintered NEG elements, discussing the differences. In particular, a class of sintered getters based on the ZAO® alloy proved to have extremely low particle emission, as shown by tests carried out in actual SRF cavities, where no measurable particle contamination as well as detrimental effect on the cavity efficiency and performances was observed.

4:40pm **VT+MN-TuA-8 NEG Coated Chambers for XHV***, **Marcy Stutzman**, P Adderley, M Poelker,* Thomas Jefferson National Accelerator Facility

Non-evaporable getter (NEG) thin films are typically applied to uniform diameter tubes, such as used for accelerator beamlines. We have been extending the successful application of NEG coating to larger diameter and non-uniform chambers, such as the 36 and 41 cm diameter chambers for the Jefferson Lab polarized electron source, as well as atom trap chambers for MIT and JILA. We show that by combining the NEG coating with a small ion pump to handle the non-reactive gasses, the chamber can reach the low 10^{-12} Torr range, and adding additional NEG pumping yields extreme high vacuum (XHV), with measured pressure below $8x10^{-13}$ Torr. With this demonstration of a reliable and reproducible method to achieve room temperature XHV, we hope to demonstrate the benefits of NEG coated chambers beyond accelerator physics applications to other fields of physics and materials research.

5:00pm **VT+MN-TuA-9 Ion Pump Noble Gas Stability Mechanism of Titanium Cathode Material***, **Anthony Wynohrad**,* Gamma Vacuum

It has long been established that ion pumps with titanium cathodes cannot pump large quantities of noble gases without releasing them back into the vacuum environment. Argon is the typical gas chosen for study of this phenomenon due to its prevalence in atmospheric composition and tendency for use in vacuum depth profiling applications. Traditional resolutions to Ar release is through the addition of denser cathode material (Tantalum) or titanium cathode architecture manipulation (triode). Various reports have shown the long term Ar stability of these methods to be subject to manufacturer claims.

To resolve reported discrepancies of Ar stability in ion pumps with titanium and tantalum cathodes, a detailed study of titanium with various physical attributes was conducted. Five different titanium/titanium alloys were tested for Ar instability at standard depth profiling pressures rather than accelerated high pressure testing. The conclusion was reached that varying the physical properties of the titanium can cause ion pumps to become Ar stable or Ar instable. Additionally, the time to reach instability is directly in correlation to the physical attributes of titanium.

5:20pm **VT+MN-TuA-10 Ricor's MicroStar/Nanostar Compact Water Vapor Cryopump: Applications and Model Overview***, **Rodney Harris**,* Ricor-USA, Inc.*; I Nachman, T Tauber, M Kootzenko, B Barak, E Aminov, D Gover,* RICOR Cryogenic & Vacuum Systems, Israel

Ricor Systems has developed a compact, single stage cryopump that fills the gap where GM and other type cryopumps can't fit in. Stirling cycle technology is highly efficient and is the primary cryogenic technology for use in IR, SWIR, HOT FPA, and other IR detector technology in military, security, and aerospace applications.

Current GM based dual stage cryopumps have been the legacy type water vapor pumping system for more than 50 years. However, the typically large cryopanel head, compressor footprint, and power requirements make them not cost and use effective for small, tabletop evaporation / sputtering systems, portable analysis systems, load locks, and other systems requiring small volume vacuum creation from medium, high, and UHV levels. The compact NanoStar configuration was designed specifically to address this vacuum chamber size area.

This single stage cryopump works well in-line with diffusion and molecular turbopumps. Studies have shown effective cooperation with non-evaporable getter technology as well for UHV levels.

Further testing in this area are ongoing. Temperatures created by Stirling cycle cryogenic coolers develop a useful temperature range of 40 to 150K. Temperatures of approximately 100 K are sufficient to condense water and all hydrocarbons oil vapors. The wide temperature range can freeze out many other gaseous compounds.

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