Vacuum Technology

Room: 618a - Session VT2-ThA

Large Vacuum Systems

Moderator: N. Peacock, MKS Instruments, Inc.

3:40pm **VT2-ThA6 Recent Advances to Enhance Space Simulation**, ***F.G. Collins***, The University of Tennessee Space Institute **INVITED**

Accurate ground-based simulation of low earth orbit (LEO) conditions experienced by a satellite has proven to be a challenge. The continuous progress that has been made toward this goal will be reviewed. A satellite in LEO has a speed relative to the atmosphere of approximately 8 km/s. The neutral atmospheric molecules exchange momentum upon collision with the surfaces of the satellite, leading to drag, lift, and moments, but ground facilities still have trouble simulating pure beams of this speed for the relevant atmospheric gases in their ground state. A facility that is making progress toward this goal will be described. The most important atmospheric molecule, atomic oxygen, collides with ram-direction satellite surfaces with a relative energy of 5 eV. Energetic atomic oxygen atoms plus solar UV radiation produce synergistic effects that result in many chemical reactions on or in the vicinity of the outer satellite surfaces. These can lead to structural or operational damage and the spacecraft glow phenomena. It is desirable to generate large beams of atomic oxygen in the ground state, with the atoms possessing energy of 5 eV. Several techniques for attempting this will be reviewed. Solar radiation has a wide spectrum. The UV spectrum is a composite of many emission lines and continuum, which must be simulated using special lamp systems. Satellite surfaces are exposed to high energy protons, electrons, and other particles. These are simulated in combined effects space simulation chambers for materials degradation studies. Thruster plumes, surface outgassing, and liquid dumps lead to surface contamination. Contamination can reduce the effectiveness of thermal control paints, the output of solar cells, and the effectiveness of optical lenses. Some electric thrusters exit directly to the vacuum of space, which must be simulated if the thruster plume is to be accurately simulated. Specially designed cryogenic pumps designed to simulate the conditions that these electric thrusters will experience in orbit will be described. All of the facilities to be reviewed require special diagnostic instrumentation, much of a specialized type. Some of this instrumentation will be described and the limitations of older techniques will be noted. Satellites in LEO also are immersed in a plasma but the effects of plasma charging, which has been well reviewed elsewhere, will not be covered. Links to inventories of space simulation chambers will be given.

4:20pm **VT2-ThA8 Performance of a Unique Cryogenic Pumping System for Spacecraft-Thruster Interaction Studies**, *C.G. Ngalande*, University of Southern California, ***A.D. Ketsdever***, Air Force Research Laboratory, Edwards AFB, *S.F. Gimelshein*, University of Southern California

With the advent of advanced propulsion systems, the interactions of spacecraft thruster plumes and spacecraft materials is receiving renewed attention. Chamber IV of the Collaborative High Altitude Flow Facility (CHAFF-IV) was designed to obtain high fidelity spacecraft-thruster interaction data. CHAFF-IV uses a total chamber pumping concept by lining the entire interior of the chamber with an array of cryogenically cooled surfaces. The main pumping surface consists of a unique radial fin array which allows for the pumping of both neutral and ion effluents. A Monte Carlo numerical simulation has been performed to investigate the pumping efficiency of the radial fin array. In general, it has been found that longer fin widths and smaller fin thicknesses result in higher pumping efficiency. For a particular geometry, there is an optimum fin-separation distance at which the radial fin array pumping efficiency is maximum. A comparison of the pumping efficiency of the radial fin array with a flat pumping surface has shown that particles with high sticking coefficient such as neutrals will be pumped better with flat panel whereas particles with low sticking coefficients such as ions will be efficiently pumped with the radial fin array. CHAFF-IV is expected to pump, not only plume, but also sputtered material. Since ions are highly energetic, they will cause sputtering of both the array material and the pumped molecules. If not properly accounted for, these two populations can substantially increase the overall magnitude of pressure in the chamber making highly accurate tests impossible[1]. The Monte Carlo simulation has also been used to investigate CHAFF-IV's ability to pump these sputtered particles. A set of experiments has been performed to investigate the pumping efficiency of the radial fin array as manufactured. These experiments compared the radial fin results to a more traditional flat plate pumping surface with a neutral plume. These results indicate that there are flow regimes in which the radial fins are more efficient at pumping neutral molecules than a flat surface.

[1] Ketsdever, A.D., "Design Considerations for Cryogenic Pumping Arrays in Spacecraft-Thruster Interaction Facility", Journal of Spacecraft and Rockets, Vol 30, number 3, 400-410, 2001 .

4:40pm **VT2-ThA9 Outstanding Problems in Vacuum Gas Dynamics from an Industrial Point of View**, ***M. Wüest***, INFICON Ltd, Balzers, Liechtenstein

Many industrial vacuum processes in the semiconductor, coating, tribology, lighting or food packaging industry occur in the transitional flow regime in the pressure range between 10^{-3} - 1 mbar. Industry wants high throughput in its vacuum processes, which requires fast pumping and venting. To achieve an optimum equipment design, the conductance of the vacuum flow path needs to be calculated. This is not an easy endeavour, as many assumptions in the derivation of the analytical conductance formulas are violated in the complicated non-symmetrical process equipment geometries and non-stationary process conditions. Modelling can also become quite difficult, especially if many different flow regimes need to be considered. Water outgassing is a critical process as it heavily influences the pumpdown time. However, our present understanding of the process is incomplete. There are two physically different models, namely the isothermal reversible adsorption and the diffusion-controlled outgassing models, to explain water outgassing. We also do not know the sticking coefficient of water on stainless steel very well. In this talk I will highlight a few outstanding vacuum gas dynamics problems from an industry perspective.

5:00pm **VT2-ThA10 Minimizing Contamination to Multilayer-Dielectric-Diffraction Gratings within a Large Vacuum System**, ***B. Ashe***, *K.L. Marshall, D. Mastrosimone, C. McAtee*, University of Rochester

The University of Rochester's Laboratory for Laser Energetics is in the final stages of constructing the OMEGA EP short-pulse, petawatt laser system. A critical component for OMEGA EP is the grating compressor chamber (GCC). This large (12,375-ft^3) vacuum chamber contains critical optics where laser-pulse compression is performed at the output of the system on two 40-cm-square-aperture, IR (1054-nm) laser beams. Critical to this compression, within the GCC, are four sets of tiled multilayer-dielectric (MLD) diffraction gratings that provide the capability for producing 2.6-kJ output IR energy per beam at 10 ps. The primary requirements for these large-aperture (43-cm x 47-cm) gratings are high diffraction efficiency greater than 95%, peak-to-valley wavefront quality of less than @lamda@/10 waves, and high laser-induced-damage threshold greater than 2.7 J/cm^2 at 10-ps measured beam normal. Degradation of the grating laser-damage threshold due to adsorption of contaminants must be prevented to maintain system performance. The presence of extrinsic contaminants (either particulate or molecular) in the vacuum system puts the MLD gratings at risk with respect to lowered damage threshold. A number of protocols have been developed and implemented at LLE to minimize MLD grating contamination and characterize the performance of the GCC vacuum chamber. In this paper, we describe the GCC vacuum chamber and component cleaning procedures, the qualification, testing methods, and studies undertaken for materials intended for use within the chamber, the use of absorptive getters to protect the gratings from molecular contamination, and the protocols necessary for the integration and operation of the MLD gratings. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article. Key words: laser-pulse compression, vacuum chamber, cleaning, particulate contamination, molecular contamination.

Authors Index

Bold page numbers indicate the presenter