Monday Afternoon, October 22, 2018

Vacuum Technology Division
Room 203B - Session VT-MoA

Pumping and Outgassing

Moderators: James Fedchak, NIST, Giulia Lanza, SLAC National Accelerator Laboratory

1:20pm **VT-MoA1 Gas Adsorption and Desorption Properties of 3D Printed Objects***, **Matt Hartings,*** American University*; J. Scherschligt, J.A. Fedchak, Z. Ahmed,* National Institute of Standards and Technology **INVITED**

Additive manufacturing processes are enabling technologies, supporting advances in a number of applications where either controlled gas uptake and release or the maintenance of a good vacuum environment are critical. In each of these scenarios, a detailed understanding of how a 3D printed object interacts with gas molecules is necessary to advancing how these objects can be used in a technical setting. I will describe two 3D printed systems and their outgassing properties. In the first system, we have compared traditionally machined vacuum chambers, made of either steal or titanium, with their 3D printed counterparts. We have evaluated hydrogen outgassing at low pressures for each of these systems and analyze how the surface micro- and nano-scale structure affects these measurements. In doing so, we assess how different printing parameters can affect outgassing of the object of interest. In the second system, we have studied the gas uptake, retention, and controlled gas adsorption of polymer composites that contain metal organic framework (MOF) particles. MOFs are a relatively new class of materials that have been implicated in a number of gas storage and delivery applications. We have 3D printed objects with our polymer-MOF composite materials and have evaluated the dynamics with which they adsorb and desorb hydrogen and nitrogen. We have found that chemical interactions between the MOF and the polymer can help to support or diminish the capacity to effectively store gas. Our work in both of these areas has shown how additive manufacturing processes can help to further technological goals while delineating the work that remains to successfully incorporate 3D printing objects into commercial devices.

2:00pm **VT-MoA3 Outgassing, Desorption, and Gas Uptake of 3D-Printed Materials***, **James Fedchak,*** NIST*; J. Scherschligt, Z. Ahmed,* National Institute of Standards and Technology*; M. Hartings,* American University

We are investigating the outgassing, gas uptake, and gas desorption properties of novel 3D-printed composite materials, 3D-printed metals, and heat-treated metals. Materials we have investigated include 3D-printed titanium, stainless-steel, and composites of acrylonitrile butadiene styrene (ABS) melt-blended with metal-organic framework (MOF) materials. We have performed measurements of the outgassing into vacuum, the gas absorption of atmospheric gases such as H_2, N_2 and water at pressures greater than 50 kPa, and the desorption of the gases into vacuum. There are three motivations behind these investigations: first, we are interested in producing ultra-high vacuum (UHV) and extreme-high vacuum (XHV) pressures in small devices for quantum sensor and quantum science applications, such as our cold-atom vacuum sensor (CAVS). Second, we are interested in using novel new materials for gas sensing and, third, we are interested in using these composite materials for gas storage and separation. We will present our most interesting and recent results from these studies. For example, the ability of MOFs to store gas is now well-known, but our studies show that the MOFs retain their gas-absorption properties within the 3D-printed MOF-ABS composites.

2:20pm **VT-MoA4 Performance Prediction Approaches for Liquid Ring Vacuum Pumps with Mercury as Working Fluid***, **Santiago Ochoa Guaman,** T. Giegerich,* Karlsruhe Institute of Technology, Germany*; C. Dahlke,* HERMETIC-Pumpen GmbH, Germany*; C. Day,* Karlsruhe Institut of Technology (KIT), Germany

In the European fusion reactor (DEMO) development program, continuous working vacuum pumps are foreseen to pump the reactor. The pumps have to process large amounts of tritium, a radioactive and chemically very active gas. In a systems engineering approach, a pumping solution based on liquid ring pumps (LRPs) and diffusion pumps has been identified. Mercury is the only fluid perfectly tritium compatible and will be applied as working fluid.

LRPs exist for around 130 years and several mathematical approaches have been developed for its 1D modelling. Diagrams and tables also have been produce from experiments for fluid densities between 800 kg/m^3 to 1200 kg/m^3 but mostly for water as working fluid and with air as pumped gas. Modern 3D simulation tools have not been applied so far for analyzing these pumps. Thus, in order to design and analyze the operating behavior of LRPs with mercury as working fluid, it is necessary to design a special code for the prediction of the thermodynamic and operational behavior of LRPs operating with high density working fluids.

This great challenge is presented in this work, starting with the development of a simulation code based on three already existing methods. For its benchmarking against literature data, water as working fluid and air as pumped gas will be used. In a follow-up step, the code will be run considering mercury as working fluid. These results will be discussed against experimental results produced at the THESEUS vacuum pump test facility at KIT.

In the second part of this work, a two-phase three-dimensional CFD model will be performed using a more detailed pump geometry. Goal of this activity is to achieve a more accurate description of the pump performance without the use of empirical parameters. This requires extensive modelling and high computational effort. The status of this task will be presented in this paper and first results will be shown and benchmarked against experiments and the code.

2:40pm **VT-MoA5 Particle Emission from Ion Pumps: Optimized Shielding without Severe Conductance Limitation***, **Mauro Audi,** C. Paolini,* Agilent Technologies, Italy*; P. Manassero,* Agilent Technologies

Charged particle emission from ion pumps is a potential major concern in sensitive applications such as Electron Microscopes , Particle Accelerators and Synchrotron Light Sources .

In fact , emitted positive ions and electrons can affect the performance of the machine or the resolution of the instrument.

Optical shield can be used to limit the number of emitted particles , but standard existing solutions have major conductance limitations as an unwanted side effect .

A test campaign on various shielding designs was carried out with a Faraday Cup powered at different bias voltage at the inlet of the ion pump , and the tests were repeated at different operating pressures and voltages .

Test results demonstrate that it is possible to reduce the number of charged particles by three orders of magnitude with minor conductance limitation and consequently maintaining a high fraction of the original ion pump pumping speed .

3:40pm **VT-MoA8 VTD Early Career Award Invited Talk: The Development of the Spacecraft Atmosphere Monitor***, **Steven Schowalter**[1],* Jet Propulsion Laboratory **INVITED**

In this talk I will focus on our team's recent development of the Spacecraft Atmosphere Monitor (SAM), a miniaturized Gas Chromatograph Mass Spectrometer slated to be commissioned as a Technology Demonstration Unit on the International Space Station in early 2019. The sensor system for this instrument consists of a quadrupole ion trap mass spectrometer coupled with a MEMS preconcentrator, gas chromatograph, and valve system. The SAM has been designed to monitor major constituents as well as trace organic contaminants in the atmospheres of crewed spacecraft. The requirements of spaceflight have placed stringent constraints on the instrument design which have led to a highly-intentionally designed vacuum system. The vacuum chamber is manufactured by a custom additive process and is equipped with novel differential pumping and gas inlet architecture. The design of this vacuum system will be detailed and preliminary data will be presented.

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[1] **VTD Early Career Award**

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