Vacuum Technology
Room: Hall D - Session VT-TuP

Poster Session, Including Student Poster Competition

VT-TuP1 Construction of a Laboratory Based Resistance Thermal Evaporator and/or Sputtering Module and the Associated Safety Systems, ***V. Lambe***, *A. Pender*, Institute of Technology Tallaght, Ireland

Construction of a laboratory based resistance thermal evaporator and/or sputtering module and the associated safety systems. This student project involves building both the vacuum system consisting of bell jar, turbo and rotary vein pump and associated ducting and valves. The high voltage system consists of a 30A dc power supply and associated circuitry. The aim of the project was to evaporate and characterise aluminium deposition on silicon (thickness versus time, power versus thickness etc). An addition aim was to characterise the equipment and provide documentation for the user. A simple film thickness monitor is to be built and installed into the system. In particular the student has concentrated on the safety aspects of the design. These includes, 1. Half atmosphere switch to protect the turbopump 2. EMO and breaker circuitry for the high voltage power supply 3. Interlocks for the power supply 4. Air driven vacuum interlock to protect against high voltage.

VT-TuP2 A Study of a Method to Evaluate the Corrosion Resistance of Al_2O_3 Coated Vacuum Components for Semiconductor Equipment, ***J.Y. Yun***, *S.W. Kang*, KRISS, Korea, *S.M. You, J.S. Shin*, Daejeon University, Korea

This study is concerned with the evaluation of the corrosion resistance of coated semiconductor equipment parts with various processes. To select the appropriate basis for evaluation, replacement parts were observed during the semiconductor manufacturing process. This study also ran a dry corrosion test using Al2O3, which is mostly used as a coating material. This test quantitatively measured the efficiency of coated parts. Surface morphology, leakage current and breakdown voltage were also evaluated. This study showed that the leakage current increased and the dielectric strength largely decreased after a dry corrosion process that led to the drop of electrical properties. The surface morphology test produced found that surface impairment can be severe depending on exposure to corrosive environments. By using the values that changed during the corrosion process, it may be possible to contrive a method to evaluate the efficiency of coated parts with various processes.

VT-TuP4 The PM-IRRAS Study of Water Thin Film on Aluminum Alloy Surface with Vacuum Pumping Down Process Condition, ***H.P. Hsueh***, NSRRC, Taiwan, *W.F. Liu*, NTHU, Taiwan, *C.K. Chan, G.Y. Hsiung*, NSRRC, Taiwan, *J.R. Chen*, NSRRC and NTHU, Taiwan

Baking is always a necessary step for achieving ultra high vacuum (UHV). For a previously baked system to have the vacuum parts replaced and to achieve the same level of vacuum without repeated baking is a challenge to today's large vacuum system like synchrotron radiation facility. With ongoing study on ultra-dry parts replacement system, the need to understand how dry is enough becomes essential for both scientific aspect and cost of ownership aspect. Previous studies have shown a phase change for water on crystal Al_2O_3 (0001) near 10 torr. In our study, polarization modulation-infrared reflection-adsorption spectroscopy (PM-IRRAS) results have shown a clear spectrum change at 8 torr on ozone water cleaned A6061-T6 aluminum alloy surface. We also measured the temperature change during pumping down process and found out the temperature can go as low as -30^{o}C for this adiabatic expansion process. This pumping down process could cause the water molecules on the surface to be frozen and then to be melted during the whole pumping down process. The PM-IRRAS study has shown the phase change result. A more detailed PM-IRRAS study corresponding to the pressure and temperature during pumping process will be shown in this presentation for both A6061-T6 aluminum alloy and crystal Al_2O_3 (0001).

VT-TuP5 A Novel, UHV Analysis System for Detecting Electron Stimulated Reaction Products Generated during Field Emission Studies, ***M. Bagge-Hansen***, *R.A. Outlaw, M.Y. Zhu, H. Chen, D.M. Manos*, The College of William and Mary

Carbon nanosheets (CNS) are a promising carbon allotrope for high current field emission cathodes and are grown by plasma-enhanced chemical vapor deposition (PE-CVD) from a C_2H_2/H_2 gas blend at substrate temperatures of ~ 600 °C. The resulting film consists of sp^2, vertically oriented, honeycomb carbon arrays terminating in a single graphene sheet that serve as field emission cathodes. A novel ultrahigh vacuum (UHV) system has been assembled for the study of gas products generated by etching of the CNS during field emission testing. A residual gas analyzer (RGA) located in direct line-of-sight of the field emission gap (254 µm) of the Cu diode geometry is used for measurement of reaction products generated during field emission tests. Electron bombardment of the Cu anode (up to 2 mA/mm^2) generates atomic hydrogen (1-5 eV) by electron stimulated desorption (ESD) which, in turn, reactively etches the CNS cathode and produces predominantly CH_4 as a reaction product. The Cu anode assembly is actively water-cooled by an external chiller to 0 °C to minimize thermal effects. The typical operating pressure is $<2x10^{-10}$ Torr. Mass spectral and I-V data are collected simultaneously by an integrated LabView program. Carbon monoxide and carbon dioxide were also observed during field emission and are also correlated with the emission current. Scanning electron microscopy of the CNS topography and cross section was used to confirm the etching rate (~2 nm/hr). These results are consistent with the density functional predictions reported by Kanai et al. of CH_4 generated by atomic hydrogen incident on graphene.[1]

[1] C. Kanai, K. Watanabe, and Takakuwa, Phys. Rev B 63, 235311 (2001).

VT-TuP6 A Compact Deposition Chamber Design for Low Temperature Growth of Ultra-Thin Crystalline Films on Metal-Insulator-Semiconductor Devices, ***R.E. Lake***, *J.R. Puls, M.P. Ray, C.E. Sosolik*, Clemson University

Fabricating ultra-thin crystalline metal films is especially important in new studies of ballistic electron transport at interfaces and energetic processes of atoms on surfaces. In order to probe physics at the atomic level without contamination these studies require that homogeneous, atomically ordered, and defect free thin films be deposited in the same ultra-high vacuum (UHV) system where they will be studied. With this constraint in mind, we have designed and built a compact deposition chamber that allows for in situ growth and analysis of atomically ordered epitaxial metal layers which are only a few monolayers thick. This UHV deposition chamber is attached to a port on the fast exchange load lock (FELL) of our Omicron variable temperature STM (VT-STM) and has an internal volume of 476 cm^3. It contains an evaporation gun slot that can be equipped with either an electron beam evaporator or a simple thermal evaporator. The target substrates used for deposition are compatible with the VT-STM design and are held in place at the center of the deposition chamber in a specially-designed clamping slot fabricated into an oxygen-free high-conductivity copper stage. The copper sample stage facilitates rapid cooling of the substrates to the temperatures required for crystalline film growth. This is done using a continuous flow of liquid nitrogen through the hollowed out interior of the sample stage. Following film growth, samples can be kept under vacuum and transferred into the FELL via a rotary-linear manipulator and then directly into the VT-STM chamber for analysis. Our compact chamber design has made the VT-STM system more effective for measurements of as-grown surfaces and interfaces, and its low cost and ease of use should be of special interest to other physicists, chemists, and engineers with similar research goals.

VT-TuP7 HORST - A New Device for Digital In-Line X-ray Holography, ***F. Staier***, *A. Rosenhahn, M. Grunze*, University of Heidelberg, Germany

The holographic x-ray scattering chamber (Holographische Röntgenstreukammer HORST) is a new experimental station for coherent x-ray sources such as synchrotrons and free electron lasers. It is designed for digital in line holography but also flexible to have add ons like magnets or beamstops for diffraction imaging. HORST consists of a large vacuum chamber with three stage systems for pinhole, sample and camera positioning and a differential pumping stage to achieve a very good vacuum pressure at the beamline. All this is mounted on a mobile and height adjustable framework. The three motorized stage systems has 13 axes of motion: pinholes can be moved and tilted perpendicular to the beam axis, samples can be moved in all three dimensions as well as rotated for tomography and the CCD camera can be positioned. We present first images acquired at UE52SGM at BESSY which characterizes the imaging properties of the system. The applicability to handle biological samples and first holotomography results will be presented.

VT-TuP8 The Titan Blimp, ***J.T. Hagen***, Cedarville University

The purpose of this project was to test the feasibility of an exploratory blimp in the harsh conditions present on Saturn's largest moon, Titan. A blimp would possess significant advantages over satellites due to Titan's enormously thick atmosphere, as well as over rovers due to the extremely cold temperatures that exist on the surface. These facts establish that a blimp with the flexibility to ascend and descend through the atmosphere and land on the surface would be the most practical exploration vehicle. An insulated pressure/vacuum chamber was constructed to house a simulated atmosphere of Titan. This vacuum chamber was constructed from a steel dollar-coin changer measuring 26” x 19” x 13”. The lid was sealed with an inch thick acrylic lid to allow for visible inspection as experimentation was run. Liquid nitrogen was poured into the chamber, and its evaporation created the -180ºC temperature of Titan’s surface, the 95% nitrogen gas composition of Titan’s atmosphere, as well as the 147kPa surface pressure. A 12-liter mylar balloon was placed inside the chamber and filled with cryogenic helium gas to generate buoyancy. RTD temperature probes were used in the chamber to measure the chamber temperature as well as the balloon temperature. Two pressure transmitters were also installed to measure the pressure of both the chamber and the balloon. These pressure transmitters as well as electric solenoid valves were connected to pressure controllers, which could then regulate the pressure of both the chamber and balloon simultaneously. A pressure control program was used in conjunction with a vacuum pump to simulate an ascent and descent through the Titan atmosphere, reaching simulated altitudes of 16km. A feasible balloon was successfully kept fully inflated through various pressure changes without exploding.

VT-TuP9 Scaling of Low-Pressure Transport Coefficients for Gas Mixture Flow in a Tube, ***M. Vukovic***, Tokyo Electron, US Holdings

Low pressure gas mixture flow in a tube can be analyzed with the linearized Boltzmann equation or the DSMC method. Alternatively, one can use the linearized Boltzmann equation to calculate gas transport coefficients that depend on the local concentration and density. These coefficients are then used in the gas flow analysis. This procedure requires repeated solution of the linearized Boltzmann equation, or preparation of coefficient tables for the whole range of expected gas concentrations and densities. Using the numerical results of Sharipov and Kalempa (J. Vac. Sci. Technol. A 20, 814 2002), we show how to rescale each transport coefficient for a gas mixture, collapsing the curves for various gas mixtures to a single curve. Once this re-scaling is done, to calculate the transport coefficients one needs the free-molecular value of the coefficient, the slip flow value, and interpolation of the dimensionless curve. This reduces the computational cost of the coefficient calculation to that of calculating the slip flow coefficients (for which relatively inexpensive methods are available) and interpolation of the dimensionless curves.

VT-TuP10 Vacuum Pressure Simulation for the Upgrade of Front-End at NSLS Insertion Device Beamline, ***J.-P. Hu***, Brookhaven National Laboratory

The beamline 9 at X-ray storage ring of the Brookhaven Lab’s National Synchrotron Light Source (NSLS) is being upgraded from a conventional bending magnet beamline to an insertion device beamline, with installation of a mini-gap undulator (MGU) at upstream of the dipole magnet. The new undulator, which is made of neodymium-iron-boron magnet and vanadium-permandur poles, will generate a high-brightness photon beam through the X-9 front-end to the experimental end-station enclosure, where sampling of nano materials will be conducted by small-angle X-ray scattering (SAXS). For the beam focusing and radiation shielding, most of the optical apparatus and vacuum systems at front-end of the beamline will be modified or replaced. To determine limit of conductance for gas pumping between the proposed aperture and collimator where the beam size is defined, vacuum pressure along the straight chamber from beam port of the undulator down to the differential pump (replacing beryllium window as vacuum barrier) is calculated, using two validated computer codes. In the statistical Molflow code which is a Monte-Carlo based software package, chamber conductance through different sections at front-end is estimated for pump arrangement. In the analytical Vaccalc code which is a finite-difference formulated Fortran program, pressure distribution along the beam axis is calculated based on balanced diffusion-and-pumping of gas species in consecutive segments of the vacuum chamber. The result is verified by the output from code runs previously performed to optimize the beamline vacuum. Details of pressure profile versus component setup at X-9 front-end will be presented. (Work performed under auspices of the United States Department of Energy, under contract DE-AC02-98CH10886).

VT-TuP11 Thermistor Vacuum Gauge; High Sensitivity Shows Direction and Acceleration Which Enables Vacuum Leak Detection, ***D. Casilio***, *R. Kromer*, Myers Vacuum

Thermistor gauge sensors are rugged sensors that have been used to measure vacuum indirectly for many decades. The single resistor element is employed in a bridge-type detector. A constant source to the heating element of the sensor is maintained to a fixed resistance. The amount of drive needed to maintain this value is measured. A decrease in pressure reduces the number of gas molecules available to transfer heat away from the heating element. This results in a temperature and resistance output change from the sensor. This signal is filtered and amplified, and then sent to an analog to digital converter. The microprocessor reads this signal, does further filtering and uses the result as an index into a lookup table for pressure. This value is written to the display and to a digital to analog converter that generates the analog voltage output. High sensitivity over most of its range allows for direction indication as well as how fast pressure is accelerating in which direction. Due to its quick response, a solvent can be used to trigger the response near a chamber vacuum leak.

Authors Index

Bold page numbers indicate the presenter