Wednesday Morning, October 21, 2015

Vacuum Technology
Room: 230B - Session VT-WeM

Accelerator and Large Vacuum Systems
Moderator: Yulin Li, Cornell University, Lily Wang, Los Alamos National Laboratory

8:00am **VT-WeM1 MAXIV Vacuum System: From Design to Operation**, ***Eshraq Al-Dmour***, *M. Grabski, J. Ahlbäck, P. Fernandes Tavares, C. Pasquino*, Max IV Laboratory **INVITED**

MAXIV facility is under commissioning in Lund-Sweden. The facility consists of full energy Linac, two electron storage rings operating at 1.5 GeV and 3 GeV and a short pulse facility. The 3 GeV storage ring is 528 m in circumference, and has compact magnets design with small magnet apertures, as a result, the chambers inside diameter is also small (22 mm), so the conductance of the vacuum chambers is low and lumped pumps are ineffective. In order to provide the desired vacuum level (less than 1e-9 mbar) distributed pumping which has been realized by the use of non-evaporable getter (NEG) coating of the chamber walls was implemented. In addition, the vacuum chambers should absorb the heat from synchrotron radiation (SR) as an antechamber is difficult to realize, to solve this, the chambers are made from Silver bearing oxygen free (OFS) copper and the walls work as distributed absorbers where distributed cooling is used at the location where the SR hits the wall. The design, production, installation and conditioning of the vacuum system were a challenge, and therefore they are presented here.

8:40am **VT-WeM3 Construction Status of the SuperKEKB Vacuum System**, ***Yusuke Suetsugu***, *K. Kanazawa, K. Shibata, T. Ishibashi, H. Hisamatsu, M. Shirai, S. Terui*, KEK-High Energy Accelerator Research Organization

The SuperKEKB, the upgrade project of KEKB, is an electron-positron collider with asymmetric energies, that is, 7 GeV electrons and 4 GeV positrons. The goal luminosity is $8x10^{35}$ $cm^{-2}s^{-1}$, approximately 40 times higher than that achieved in the KEKB. The construction of the new vacuum system for the SuperKEKB has been in progress since 2010, as a key item of the upgrade. Most of the vacuum components, especially in the positron ring, are newly fabricated to manage the electron cloud effect (ECE), and to reduce beam impedance, which are essential to keep the low-emittance beams stable even for high beam currents. The design and the manufacturing of the major vacuum components, including beam pipes, bellows chambers, gate valves, vacuum pumps and so on, have been completed. Approximately 1240 new beam pipes were made of aluminum-alloy or pure copper depending on the intensity of the irradiated synchrotron radiation. They basically have two antechambers at both sides of a central beam channel. The main pump at arc sections of the ring is a strip-type NEG installed in one of the antechambers. Approximately 1130 NEG modules were prepared with various lengths of from 0.7 to 3 m consisting of three NEG strips. New bellows chambers and gate valves have basically a comb-type RF-shield and have the same cross sections to the connecting beam pipes. Countermeasures against the ECE, such as the coating of TiN film, the grooved surface, the clearing electrode and so on, were prepared for the beam pipes of the positron ring. All of aluminum-alloy beam pipe have TiN coating inside to reduce the secondary electron yield. Approximately 150 beam pipes for dipole-type magnets have grooved structure at top and bottom of the inner surface. Beam pipes for wiggler magnets have 116 clearing electrodes inside in total. The installation of these components into the KEKB tunnel has almost finished. The MO-type flanges, which have structurally little step inside, were adopted to the connection flanges between the beam pipes and the bellows chambers. The air-leak rate at the first fastening was less than 5 % out of more than 5000 times fastening in total during the pre-baking, the TiN coating and the connection in the tunnel. The final activation of NEG pumps in the tunnel has finished approximately 70 % of the ring until October. After the NEG activation, the average pressures decreased to on the order of 10^{-8} Pa, where the beam pipes were not baked in situ. The vacuum system will be ready in next January, 2016. The construction status SuperKEKB vacuum system, including various experiences during the construction stage, will be reported.

9:00am **VT-WeM4 Commissioning of the 3 GeV TPS Accelerator Vacuum System**, ***Gao-Yu Hsiung***, *Y.C. Yang, H.P. Hsueh, L.H. Wu, C.M. Cheng, C.K. Chan, J.R. Chen*, National Synchrotron Radiation Research Center, Taiwan, Republic of China

The Taiwan Photon Source (TPS), a 3 GeV synchrotron light source composed of a booster synchrotron and the electron storage ring concentrically installed in the same tunnel, has been completed the construction and the installation in July 2014. Then the commissioning of the booster has been started and reached to the goal of 3 GeV full-energy-injections on Dec.17. After tuning the beam parameters, the electron beam was stored at 1 mA beam current, extracting the first synchrotron light, and raised to 4.5 mA stored with few minutes beam life time on Dec. 31 2014. The beam-cleaning process for mitigating the significant photon-stimulated-desorption (PSD) outgas inside the storage ring is one of the major purposes of the commissioning. The pressure in the beam duct was kept under 1E-6 Pa that limited the increase of beam current and the consequent upper bound of the Bremsstrahlung radiation level through the beam-cleaning. After three-months commissioning that has achieved the accumulated beam dose of 30 Ampere-hours, the average pressure was reduced to ~ 1.2E-7 Pa at 100 mA of stored beam current with life time of ~ 6 hour. Besides the vacuum conditioning, the beam emittance of 1.6 nm-rad approached to the goal has been demonstrated. In this paper, the concept about the high efficient beam-cleaning process and the progress of the commissioning for the TPS will be described.

9:20am **VT-WeM5 Construction, Installation, and Commissioning of TPS Booster Vacuum System**, ***Hsin-Pai Hsueh***, *C.M. Cheng, S.N. Hsu, G.Y. Hsiung, J.R. Chen*, National Synchrotron Radiation Research Center, Taiwan, Republic of China

For better performance and more efficient operation of today's storage ring of electron synchrotron radiation facilities, it is essential to have a good booster vacuum system to start with. The ultrahigh vacuum system for the electron booster ring of the 3GeV Taiwan Photon Source accelerator has been constructed since 2010, and then installed and commissioned since 2014. TPS booster is a 496.8m long stainless steel vacuum system and currently the largest of its kind in the world. Although low impedance consideration is not critical in a booster vacuum system, the tight dimension and other demanding engineering tolerances do show their criticalness in the construction, installation, and commissioning phases. During construction, some of the original ideas have been modified due to these given tight tolerances. It is even more demanding as we found in the commissioning phase and a lot of actions have been taken to make commissioning process possible. The original design, the modifications in both the construction and commissioning phases will be described in this paper.

9:40am **VT-WeM6 Design of a 250 KV DC Electron Gun Operating at Cryogenic Temperature**, ***Xianghong Liu***, *I. Bazarov, B.M. Dunham, V.O. Kostroun, H. Lee*, Cornell University

A photocathode DC electron gun is being built in our laboratory for ultrafast electron diffraction experiments. It is designed to operate at voltages up to 250 KV, with a maximum electric field of 12 MV/m in the cathode – anode gap. An inverted ceramic insulator is used for the high voltage insulation, making the gun relatively compact. In order to reduce the mean transverse energy of the electrons emitted from the photocathode, and hence increase the coherent length of the electron beam at diffraction, the photocathode is operated at 20 K instead of room temperature. A stainless steel thin wall tube connects the cathode holder to the insulator; it minimizes the heat load through conduction while providing a rigid support for the cathode holder. The cathode holder is cooled by a cold head through a sapphire rod of 225 mm length. The sapphire rod provides both sufficient electrical insulation and excellent thermal conduction at the temperature of interest. A load-lock system is attached to the back of the gun chamber for loading the photocathode to the gun. Photocathodes are transported into and out of the system through a vacuum suitcase. The load-lock system also provides storage for multiple photocathodes. The decay of the quantum efficiency of the photocathode is dominated by the existence of residual gases in the gun chamber, and thus vacuum level of 1x10-11 Torr or better is required to prolong the lifetime of the photocathode. The chamber is pumped by NEG pumps and ion pumps. We'll describe details of the design and report initial test results.

11:00am **VT-WeM10 Introduction to Tri Alpha Energy's Fusion Concept, Vacuum Requirements and Performance of Our Current C2U Machine**, ***Alan Van Drie***, Tri Alpha Energy

Tri Alpha Energy (TAE) is researching a novel fusion concept of energetic ions magnetically trapped as large orbits in a Field Reverse Configuration plasma (FRC). C2 and C2U are the previous and current generation machines that have pushed and continue to push our understanding of FRC plasmas, energy levels, durations, control, and engineering required toward an energy generating machine. C2 was operated between 2008 and 2014, followed by its completed upgrade to C2U in early 2015. C2 and C2U are both linear vessels (~20m long, ~17m^3 volume, low 10^{-9} Torr pressures) with many attached sub systems such as 1.8 MW neutral beam sources (10 MW total injected power into the plasma) and a plethora of diagnostics. The talk will first give an overview to TAE's concepts and C2U, followed by a discussion of the physics that drive the vacuum requirements, such as wall recycling, ion-neutral losses, divertor gas loads and how we solved many of the technical vacuum challenges in order to meet our performance goals.

11:20am **VT-WeM11 Vacuum Architecture of an Extreme Ultra-Violet Exposure System**, ***Freek Molkenboer***, *N.B. Koster, A.F. Deutz, D.J. Naron*, TNO Technical Sciences, Netherlands

TNO is designing and building an Extreme Ultra-Violet (EUV) exposure system capable of exposing samples and 6" EUV masks with high EUV power and intensity. This system will be named EBL2.

EBL2 will be suited for characterizing and analysing phenomena such as carbon growth on EUV masks, oxidation of multilayer optics, as well as investigating the physics and effects of EUV-induced plasmas.

EBL2 contains an EUV Beam Line, in which samples/EUV masks can be exposed to EUV radiation in a flexible gas environment, with UHV background vacuum quality. Gases such as H_2, XCDA and H_2O can be added in a controlled fashion to create a customized environment for the exposure at hand.

Attached to this Beam Line is an XPS system, which can be reached from the Beam Line via an in-vacuum transfer system. This enables surface analysis of exposed samples/masks without breaking vacuum. Automatic mask handling with dual pods is foreseen so that exposed EUV mask will still be usable in EUV lithography tools to assess the imaging impact of the exposure.

Qualification of the setup is expected to start Q1 2016. After completion, this unique facility will be open for external customers and other research groups.

This presentation will focus on the vacuum architecture and design implementations of the EBL2 system to meet all the stringent vacuum requirements.

Authors Index

Bold page numbers indicate the presenter