SLS 2.0 Arc Chamber Overview

(Romain Ganter)

The vacuum system for the SLS 2.0 upgrade consist of 12 arcs with an identical chamber layout and four special chambers for the superbends (three of them superconducting and one from permanent magnets). The total length of the SLS 2.0 storage ring vacuum system is 288 m. This includes the 12 straight sections (one injection straight and 11 straights for insertion devices with some of the also for machine components), which still need to be designed. The vacuum chamber material is Cu (OFE) with an octagonal cross section of 18 mm ID (inner diameter), except from the stainless steel BPM / steering magnet chambers with 21 mm ID for shadowing of synchrotron radiation. The chambers have an octagonal cross section of 18 mm (inner diameter) and a 3 mm slit to the antechamber to let synchrotron radiation pass towards crotch absorbers, where ion getter pumps are installed. There are no bellows along the 18 m long arcs and all vacuum chambers will be NEG-coated to reduce the photon stimulated desorption rate. After assembly, the whole arc will pumped, baked and (NEG) activated outside of the tunnel in an 18 m long horizontal furnace. The full arc chamber will be supported during bake out, transport and storage in special frame. No in-situ baking / NEG-activation system is foreseen.

For tendering and manufacturing two LOTs are foreseen. LOT-1 might be produced at PSI (prototype of CBN chamber is presently under fabrication and should be ready by October 2020), LOT-2 in industry.

- LOT-1 consisting of 84 normal bend chambers of four types: CBN (48), CBI (12), CBE (12) and CBO (12)
- LOT-2 consisting of 240 chambers of eight types: CSS (108), CSU (12), CSD (12), CRM (48), CRD (48) CRU (12), CPD, CPS and 84 crotch absorbers

NEG-coating requirements for SLS 2.0 vacuum chambers:

- Adhesion: > 10 MPa, no peel off and delayering
- Thickness: 200 – 400 nm or 300 nm ± 30% over whole e-beam chamber surface
- Composition: Ti. 10-50%; Zr: 15-50%; V: 15-50% to guarantee activation < 200°C
- Morphology: nanocrystals of 5-20 nm to guarantee dense morphology (lower PSD)
- Roughness: Ra < 300 nm to minimize surface geometrical wakes
- PSD Rate: $3 \cdot 10^{-6}$ CO molecules/photon
- Pumping: not expected because of saturation (in reality it will pump due to SR activation: $0 \cdot 1$ $ls^{-1}cm^{-2}$ equivalent N2)

A NEG-coating test set-up for 0.5 m long pipes has been installed at PSI in 2018 to gather first experience and to work on the definition of a NEG-coating procedure for SLS 2.0. For (possible) NEG-coating of the vacuum chamber series at PSI, a “moving solenoid unit” is presently set-up. It provides a 3 m long range of motion at a speed of < 10 mm/s with for solenoid with inner diameter of 340 mm. Different vacuum chambers with a maximum length of 2.5 m and maximum diameter of 250 mm can be installed between two DN250CF crosses (at top and bottom). Centering of the TiZrV wire as well as NEG-coating process observation through a viewport is possible (pumping from the bottom). This new NEG-coating set-up will be commissioned in August 2020 and first coatings of longer (1.5 m), curved tubes and vacuum vessels with antechamber, including the coating of the in-house fabricated prototype vacuum chamber will be done until end of 2020.

It is planned to use VAT seals and VAT valves (VAT series 472 and 482 RF all metal gate valves). As vacuum pumps, the CapaciTorr D 400-2 NEG pump from SEAS and the Agilent VacIon Plus 55 l/s ion getter pump (7 each per arc) are foreseen.

Dipole Chamber Design, Fabrication, Brazing and Assembly Process

(Jonas Buchmann)

The SLS 2.0 dipole chamber is an antechamber design with an 18 mm (ID) octagonal beam channel and a 3 mm (vertical) gap to the antechamber, where crotch absorbers absorb the synchrotron radiation (from the dipole magnet or straight section insertion devices). The whole chamber will be NEG-coated (300 nm ± 30% in the beam channel, possibly thicker coating in the antechamber) and additional NEG and ion getter pumps will be installed at the locations of the absorbers. The Cu-OFE chamber geometry consists of four blocks with upper and lower halves of an upstream and downstream block, which are brazed together at 820°C. First, the upper and lower halves of the upstream and downstream blocks are brazed together before the two blocks are brazed together to a single dipole chamber. After the brazing of the chamber, three cooling channels (Cu-tubes) are brazed to the chamber. In a final step, the stainless steel BPM / corrector chamber and the pumping ports, which are also housing the crotch absorbers, are brazed (at 780°C) to both ends of the dipole chamber. Before installation in the permanent magnet dipoles, the absorber, the (NEG and ion getter) pumps and vacuum gauges are assembled on the pumping port of the chamber.

Distributed and Crotch Absorber Simulation

(Colette Rosenberg)

One complete SLS 2.0 storage ring sector has been modelled with Synrad. The model includes the vacuum tubes for out-coupling of synchrotron radiation from the insertion devices, the (7) antechambers with crotch absorbers and the (water-cooled) chambers acting as "distributed absorbers". The heat load simulations addressed the following (main) issues:

- Which chamber walls are hit by synchrotron radiation and are there specific "hot spots"?
- How much power has to be dissipated on the absorbers and on the chamber walls?
- At which locations is cooling required?
- Are the BPM / corrector (stainless steel) chambers and the (all-metal gate) valves hit by synchrotron radiation?

The Synrad simulations have identified various "hot spots", where the vacuum designs have to be adapted to prevent overheating. For the BPM / corrector chambers made of stainless steel, tapering of the vacuum tube from 18 mm (nominal) to 21 mm has been chosen to avoid direct impact of synchrotron radiation on the chamber wall. There will be a total of 120 such tapers (10 per sector) in the SLS 2.0 storage ring. The impedance of these tapers still has to be analyzed carefully, which is a task for the SLS 2.0 RF group ("impedance task force").

Two different crotch absorber designs for absorbing the synchrotron radiation from the SLS 2.0 normal bending magnets have been studied with Synrad (Colette) and Spectra (Romain) and ANSYS (Xinyu Wang). The first option has two cooling channels and "teeth", while the second option has three cooling channels without "teeth". The absorber material is in both cases CuCrZr. The comparative simulations show that the maximum temperature and the related stress on the material is lower, if the heat load from the synchrotron radiation is distributed over a bigger surface, resulting in a higher heat load capacity of the absorber. For the SLS 2.0 parameters (2.7 GeV and 400 mA), the maximum temperature of absorber option one is 162°C with a maximum stress of 96 MPa, while maximum temperature for absorber option two rises to 230°C with a considerably higher stress of 240 MPa. Similar heat load simulations have been performed for different design options of the SLS 2.0 superbend absorber, varying parameters like "teeth" design (height, angle), absorber angle, material (CuCrZr or Glidcop AL-15), number of cooling channels. First intermediate results indicate that the best performance is obtained, if the cooling channels are closest to the heat load and if a lot of material is around the hottest spots. Better power distribution and more effective cooling could also be achieved with a "double teeth" design at an absorber angle of ± 3.55°.

SLS 2.0 Vacuum System: Issues and Questions Raised

(R. Ganter, C. Rosenberg, J. Buchmann und A. Zandonella)

Impedance budget:	Maximum tolerable NEG thickness (update impedance calculations) Shape of tapers for BPM / corrector chambers (symmetric / asymmetric)
Support concept:	Drafting of support concept for arc chambers. ANSYS / FEM analysis of vacuum chambers with support system, including heat load from synchrotron radiation (chamber cooling concept). Support of vacuum chamber in the magnets (use of capton foil?)
Chamber stability:	Check for deformation of vacuum chambers: static pressure and during transportation. Make detailed (FEM) analysis of chamber stability. Check material: OFE (good impedance) or OFS (stiffer) copper.
Vacuum issues:	refine Molflow simulation including CH_4 (not pumped by NEG but by ion getter pumps) or is CO equivalent pressure ok?
Heat load:	include synchrotron radiation re-emission (10%) and scattering at absorbers in Synrad simulations. Define which effects need to be considered (heat load in unexpected areas, faster conditioning and better average pressure, more out-gassing in the beginning). Check if DLS "inline absorbers" and "local finger absorbers" could be copied. Which other components absorb synchrotron radiation and must be cooled?

Manufacturing:	define Cu-plating (5 µm) of stainless steel BPM / corrector chambers. Check for capacity of potential vacuum chamber manufacturers (if possible, align time schedules of different (European) light source upgrade projects).
Vacuum protection:	define concept for vacuum interlock system (pressure, thermal sensors etc.).
Varia:	check if ion getter pumps (magnetic field) cause problems close to permanent magnet dipoles. Check which valves (CuBe RF fingers…?) VAT has offered