

## VACUUM SYSTEM OF THE STORAGE RING OF HLS-II

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### Abstract

HLS storage-ring has been operated for more than twenty-five years. In 2014 we began to upgrade the machine, which is called HLS-II. The emittance is reduced to 40 nmrad, five insertion devices are added and the injection energy increases to 800MeV. Now the machine commissioning has already been completed. The typical life time is 300 mins at 300mA, 800MeV. The average pressure of static and dynamic vacuum are below  $2 \times 10^{-8}$  Pa and  $1.2 \times 10^{-7}$  Pa respectively. The design, installation and commissioning of the vacuum system of the storage ring are detailedly stated in this paper.

### INTRODUCTION

The 800MeV electron storage ring of the National Synchrotron Radiation Laboratory (NSRL) is a dedicated VUV and soft X-ray synchrotron radiation light source. The construction of NSRL facility began on November, 1983 and was completed in 1989. HLS comprises of 200 MeV injector, 800 MeV storage ring, 12 beamlines and 15 experimental stations by 2010. In order to supply synchrotron light with higher brightness and stability to the users, the upgrading project of HLS has been carried out during 2010-2014. The main changes of the new HLS (HLS-II) include: The energy of the injector increases to 800 MeV, so the electrons can be injected to the storage ring with full energy. The lattice of the storage ring was changed from TBA to DBA. The beam emittance decreased to 40 nmrad. A group of multifunctional sextupole magnets are employed and thus the long and short straight section are both lengthened. Five insertion devices were installed in the storage ring.

### A VACUUM SYSTEM OF STORAGE

The storage ring's circumference is 63.66 meters. The main vacuum pipes are made of 316LN stainless steel by welding. The section is octagonal as shown in Fig. 1. To reduce surface degassing and magnetic permeability induced by welding, the chambers are baked at 900 °C in the vacuum furnace. After this treatment, vacuum chambers of the total leak rate, outgassing rate and magnetic permeability are below  $2 \times 10^{-8}$  Pa L/s,  $2 \times 10^{-11}$  Pa L/s cm<sup>2</sup> and 1.02 respectively, which meet the design requirements. Considering the convenience of installing, commissioning and maintenance, 3 RF-shielded all-metal gate valves are used to separate the storage ring into three cells. 20 UHV gauges are distributed in the storage ring to

monitor the vacuum and also for interlock protection system.

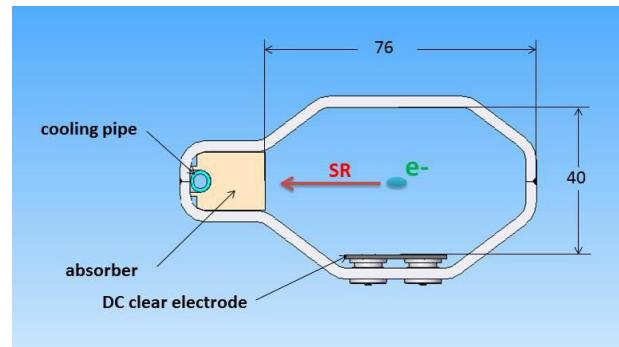


Figure 1: The section of the main vacuum pipe.

Because of the low electron energy, the deflection angle of the dipole magnet is relatively large, so the synchrotron light can hardly be absorbed by a lumped photon absorber. To ensure thermal stability of the vacuum pipes and reduce photon stimulated desorption, water-cooled absorbers made of oxygen-free copper which can protect the inner surface of the dipole magnet pipe from being hit by the synchrotron light, are arranged in the pipes along the beam direction and near the light outlet, as shown in Fig. 2. The absorbers in the pipes also act as supports and simplify the design of vacuum pipes.

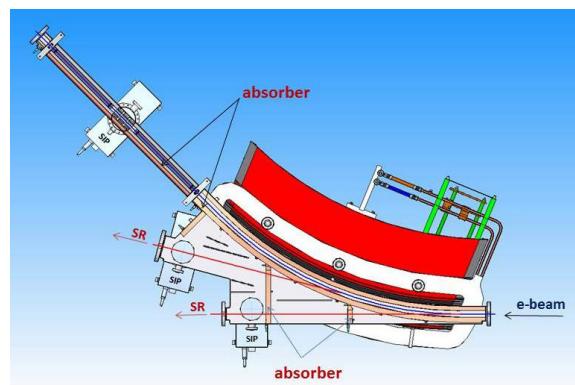


Figure 2: A standard segment of the storage ring.

18 RF-Shielded bellows are adopted to eliminate the machining and installing errors, deformation induced by temperature difference, and for the smooth transition of chambers with different sections. The bellows are machined by welding with high stability. Considering the smooth transition of chambers and high frequency contact resistance, the RF shield is achieved by using shield fingers. Shield fingers (Cu-Be) which bridge the gap between neighbouring flanges inside the welding bellows.

The permissible longitudinal and transverse error are  $\pm 10$  and  $1.5$  mm respectively. The design value of the contact stress of shield finger is larger than  $25\text{Kg}/\text{cm}^2$ .

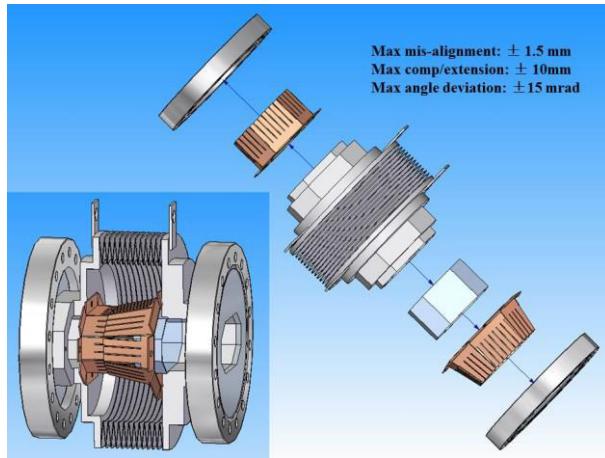


Figure 3: RF shielded bellow.

The pumping system comprises 38 SIPs with the pumping speed of  $200\text{ L/s}$  and 3 SIPs of  $400\text{ L/s}$ . NEG strips WP1250 supplied by SAES are added into the SIPs and the pumping speeds are increased by 2-3 times[1]. According to the calculation, the overall degassing of the storage ring after beam scrubbing with  $100\text{ Ah}$  dose is approximate  $2 \times 10^{-3}\text{ Pa L/s}$ . The pumping system can evacuate the amount of gas load and even higher gas load while the storage is operated at  $500\text{ mA}$ .

## INSTALLING AND COMMISSIONING

The storage ring of vacuum pipes can't be in situ baked due to the limitation of small aperture of the magnets. Therefore, before the installing of pipes, the entire ring was divided into 17 subsystem for assembling and vacuum pre-commissioning and each subsystem was baked so that the ultimate vacuum could be better than  $5 \times 10^{-8}\text{ Pa}$ . After the subsystem was hoisted in place, installed and aligned accurately on the support, high purity nitrogen was introduced and then all the subsystems are connected together. The installing of a subsystem is shown in Fig. 4. Only the pipes outside of the magnets and SIPs were baked on  $200^\circ\text{C}$  for 48 hours. Two days after the activation of NEG and then starting the SIPs, the average pressure was  $5 \times 10^{-8}\text{ Pa}$  and one week later this value was  $2 \times 10^{-8}\text{ Pa}$ .

Now the HLS-II has been commissioned and operated for more than one year and the total accumulated beam dose is over  $1200\text{A}\cdot\text{hr}$ . The process of beam scrubbing is shown in Fig. 5.

The lifetime with the beam of  $300\text{ mA}$  and  $800\text{ MeV}$  is more than 300 minutes just after  $80\text{ A}\cdot\text{hr}$ . In November 2014, the storage ring was exposed to air for replacing the ceramic chambers. After the replacement and baking, the vacuum and beam lifetime restored quickly to the values before exposure to the air, as shown in Fig. 5.



Figure 4: Installation of a subsystem.

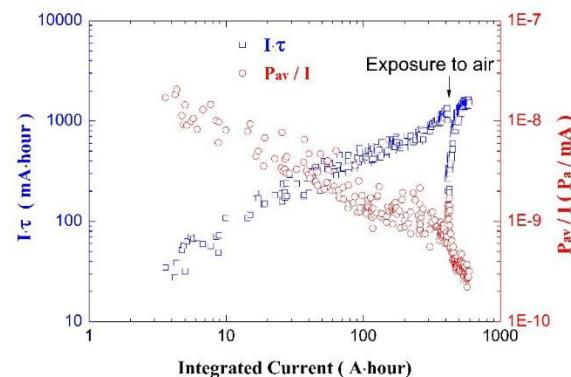


Figure 5: Progress of beam cleaning and growth of beam lifetime.

## CONCLUSION

After one year commissioning and operation of HLS-II storage ring vacuum system, the average pressure of static and dynamic vacuum are below  $2 \times 10^{-8}\text{ Pa}$  and  $1.2 \times 10^{-7}\text{ Pa}$  respectively and the beam life is more than the design value of 5 hours. All this indicates that the design, installing and commissioning are successful.

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## REFERENCES

[1] Integration of Commercial Sputtering Ion Pumps with Non-Evaporative Getter, VACUUM SCIENCE AND TECHNOLOGY (CHINA), 2004, 24(3): 222-224.