PHOTON-STIMULATED DESORPTION EXPERIMENT FOR A TPS CROTCH ABSORBER

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Abstract

National Synchrotron Radiation Research Center (NSRRC) is constructing a large third-generation synchrotron accelerator in Taiwan, the so-called Taiwan Photon Source (TPS). This 3-GeV, 500-mA machine will generate high-density bending-magnet radiation, of which 90 % of the power is absorbed by the crotch absorber in the storage ring. To understand better the beam-cleaning and photon-desorption phenomena of a copper crotch absorber, we have performed a PSD (photon-stimulated desorption) test in Taiwan Light Source (TLS) at Beam line 19 (BL19). Some mathematical modelling, experimental designs and results are also presented here.

INTRODUCTION

Taiwan Photon Source (TPS) is a third-generation synchrotron accelerator with a storage ring of circumference 518 m, beam energy 3 GeV, beam current 500 mA and bend radius 8.4 m. A crotch absorber located downstream from the bending chamber intercepts most synchrotron radiation emitted by the bending magnets; the yield of photon-stimulated desorption (PSD) will limit the lifetime of the stored electron beam. Because of the outgassing caused by the PSD yield, it will also extend the pumping time during commissioning. It is thus feasible to investigate to try to improve this pumping time. Oxygen-free high-conductivity copper (OFHC) is chosen as an absorber material because of its properties: large thermal conductivity, small rate of thermal outgassing and small photoemission yield.

DESIGN AND ANALYSIS

Figure 1 shows a drawing of the TPS crotch absorber, comprising an OFHC cooling body, stainless-steel 100CF flange and two pairs of OFHC cooling tube. All parts to assemble are subject to vacuum brazing.

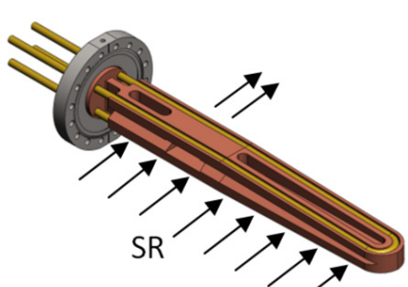

Figure 1: TPS crotch absorber.

Of bending chambers of three types, each corresponds to a crotch absorber, B1 (for ID), B2 (for BM) and B3 (for IR). The design of the crotch absorbers is nearly the same, except their corresponding lengths and apertures. Table 1 shows the dimensions of each crotch absorber.

Table 1: Dimensions of the Crotch Absorbers.

	Length/mm	Aperture/mm*mm
B1 crotch absorber	501.5	50x20
B2 crotch absorber	528	50x14
B3 crotch absorber	378	40x14

The heated surface facing the synchrotron light has a 60^0 V-shaped groove that minimizes back scattering and diminishes the maximum temperature[1]. A thermal analysis was performed via finite-element simulation using SolidWorks. Table 2 lists the simulation parameters.

Table 2: Simulation Parameters of Crotch Absorbers.

Beam Energy	3 GeV
Beam Current	500 mA
Distance from the source(B1)	2.282 m
Bending radius of dipole	8.403 m
Bending magnet field	1.19 T
Beam height	0.59 m
Peak power density	50.2 W/mm^2

Figure 2 shows the temperature distribution; the maximum temperature, 132 ^{0}C, occurs in the V-shaped groove, whereas the cooling tube is about 83 ^{0}C. Because of the heat, the maximum thermal expansion, 1.54 mm, occurs at the end. The thermal-expansion simulation is presented in Figure 3.

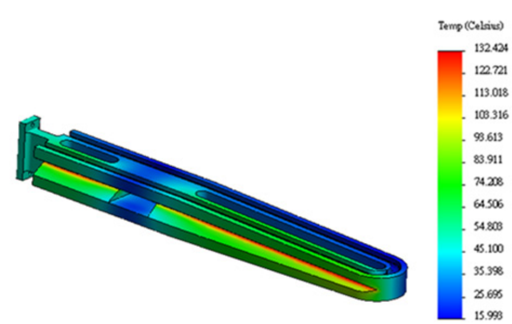

Figure 2: Temperature distribution of the crotch absorber.

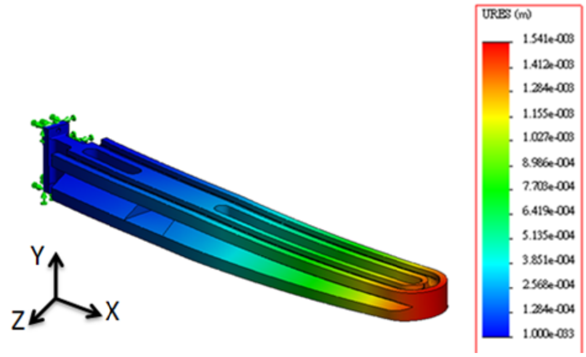

Figure 3: Thermal distribution of the crotch absorber.

PSD EXPERIMENTS

Figure 4 illustrates the vacuum system for the PSD experiment. Because of space constraints at TLS 19BL, the crotch absorber must be installed inverted, and synchrotron light illuminates only about 1/4 of the length of groove surface. The system was evacuated with a 70 L/s turbo molecular pump and a residual-gas analyzer recorded the mass spectrum. Synchrotron light was emitted from the 1.5-GeV electron beam of current 360 mA. Three electro-feed through bias voltages were applied to the absorber; in this way the photoemission current from the absorber was measured. The absorber was cooled with DI water to decrease the thermal effect.

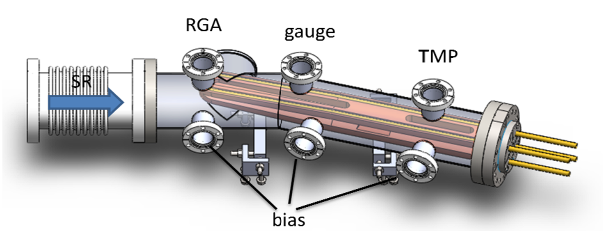

Figure 4: PSD system of the crotch absorber

Before performing PSD experiment, we baked the crotch absorber at 200 ^{0}C for 24 hours to eliminate most gas, especially water and hydrocarbons, adsorbed on copper surfaces. Figure 5 shows the pumping curve vs. time; the ultimate pressure after pumping for 72 hours was 6.2 10^{-10} Torr.

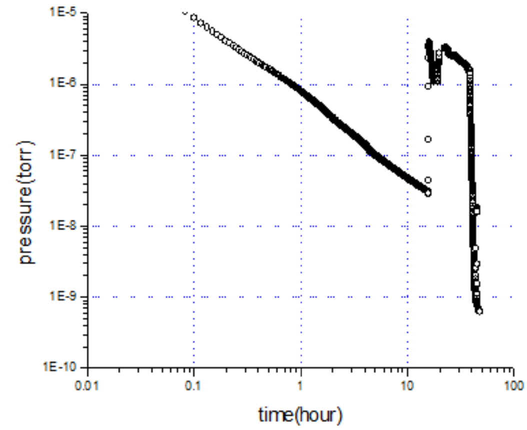

Figure 5: Pumping curve for the OFHC absorber.

Figure 6 shows the relation between the dynamic pressure rise per mA beam current and the accumulated beam dose. An aluminium absorber was also measured in this test. At beam dose 120 mA hours (20th min.) and 3080 mA h (3rd hour), the bias applied +300 V producing electron-stimulated desorption (ESD). The result shows that the PSD yield of OFHC is superior to that of aluminium, consistent with preceding work[2].

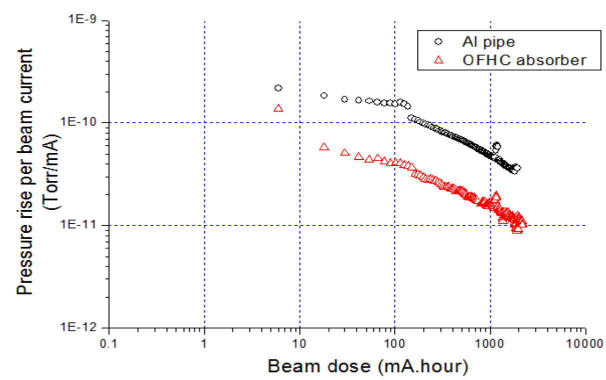

Figure 6: Total pressure rise per beam current as a function of beam dose for OFHC and Al absorbers

A real-time mass spectrum is shown in figure 7. The partial pressure of all gases except water (mass 18 u) increased sharply while the OFHC absorber was being irradiated with synchrotron light. Water vapour rose slowly and was affected slightly by the +300-V bias; this result is similar to that for aluminium[3,4]. During the experiments, the pressure intensity of all gases recovered when the synchrotron light was suspended for 10 min. on inserting a photon absorber (PAB).

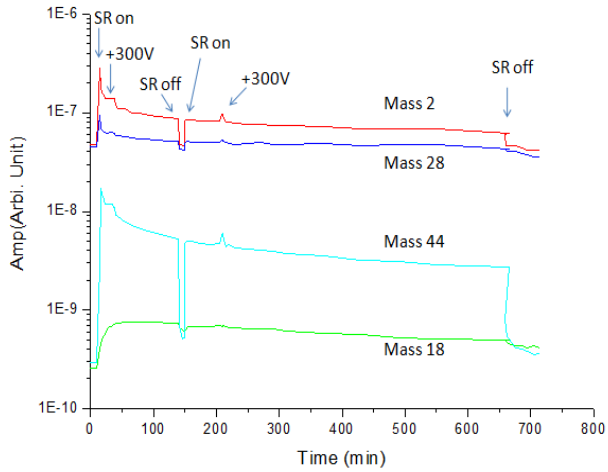

Figure 7: Real-time mass spectrum for an OFHC absorber

SUMMARY AND CONCLUSIONS

The TPS crotch absorber is intended to intercept most synchrotrons light. The OFHC cooling body has a 60^0 V-shaped groove to minimize backscattering and to decrease the maximum temperature. Analysis shows that the maximum temperature 132 ^{0}C occurs in the V-shaped groove; the thermal expansion is 1.54 mm at the body end. In PSD experiments, the PSD yield of OFHC absorber is smaller than that of an aluminium absorber. The mass spectrum shows that the behaviour of water vapour differs from that of other gases.

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