PHOTODESORPTION AND POWER TESTING OF THE SR CROTCH-ABSORBER FOR BESSY-II

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Abstract

Some elements of BESSY-II vacuum system [1] as Crotch-Absorbers were produced at Budker Institute of Nuclear Physics (BINP). One of that OFHC copper crotch-absorber was tested both for photodesorption yield and with power. The special SR beamline and installation were designed, build and installed with aim to measure gas photodesorption from the crotch-absorber. The crotch-absorber have been exposed to 2.66 keV critical energy synchrotron radiation from the wiggler on VEPP-3 storage ring at BINP. The photodesorption yield dependence as a function of accumulated photons is presented. This measurements allow to predict the dynamic pressure in BESSY-2. An electron beam welding machine was used for power testing of the crotch-absorber. It was shown that the power up to 600 W per cm of the crotch-absorber length and the total power of 5 kW could be accepted for the tested SR crotch-absorber.

1. PHOTODESORPTION TESTING

1.1 SR beamline and setup

The SR beamline shown on Fig. 1 loads synchrotron radiation from the VEPP-3 wiggler to experimental installation located in VEPP-3 hall.

The critical energy of synchrotron radiation from the VEPP-3 wiggler at electron energy of 2 GeV is 2.66 keV and the photon intensity is $2.3 \cdot 10^{15}$ photons/(sec·mrad·mA).

The experimental setup made of stainless steel consist of two parts: an absorber's volume (AV) with tested crotch-absorber and a pumping volume (PV) with known conductance between them. The pumping volume is pumped out with combined pump contained an Ion Pump (IP) and Titanium Sublimation Pump (TSP) with total pumping speed of about 1000 lt/s.

The synchrotron radiation from the wiggler was first collimated horizontally to about 3.5 mrad in front of the pumping volume, then it goes through the pumping volume and the conductance (10mm × 35mm) to the tested crotch-absorber. Correspondingly, the total flux of photons entering to the testing absorber at electron current of 150 mA is about $1.1 \cdot 10^{18}$ photons/sec.

The calibrated conductance provides a pumping speed of 19 lt/s for N_2. Calibrated cold cathode gauges are located as at the absorber's volume as at the pumping volume and a calibrated quadrupole residual mass analyser (RGA) is installed at the absorber's volume.

The crotch-absorber position with respect to the photon beam are checked by two methods: with help of movable luminophor detector in the pumping volume and trough the window in the absorber's volume.

The temperature of the tested absorber are measured with thermocouple held in special hall located very close to irradiated surface.

Before measurements the experimental setup was baked at 200°C for 24 hrs.

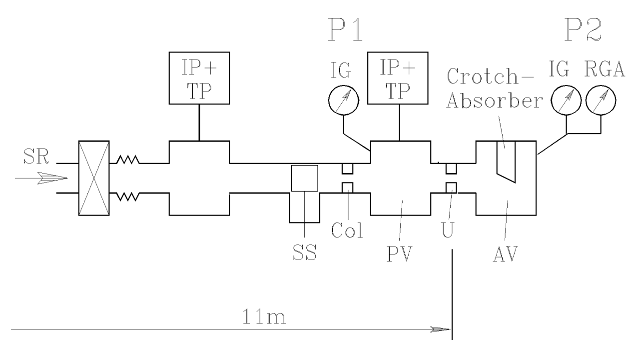

Figure A. Experimental installation for photodesorption test.

1.2 Calculation of the photodesorption yield

For a quantity measurement of the photodesorption yield was be used the conductance *U* between the absorber's volume and the pumping volume and pressures P2 and P1 in these volumes.

The gas flux through the conductance could be estimated by:

$$Q\left[\frac{Torr \cdot lt}{\sec}\right] = \frac{\eta\left[mol / ph\right] \cdot \dot{\Gamma}\left[ph / \sec\right]}{3.3 \cdot 10^{19}},$$

here $\dot{\Gamma}$ is the photon flux, is η the total photodesorption yield.

For another side the pressure difference $\Delta P = P2 - P1$ depends of the gas flux Q through the conductance U:

$$\Delta P = \frac{Q}{U}.$$

Thus

$$\eta = 3.3 \cdot 10^{19} \cdot \frac{\Delta P \cdot U}{\dot{\Gamma}}$$

As soon as the pressure in the absorber's volume was much higher then in the pumping volume: $P2 >> P1$, the photodesorption yields of different gases could be calculated with use of RGA recorded data:

$$\eta_i = 3.3 \cdot 10^{19} \cdot \frac{P_i^{RGA} \cdot U_i}{\dot{\Gamma}},$$

here η_i is a photodesorption yield for *i*-th gas, P_i^{RGA} is a partial pressure of *i*-th gas and U_i is a conductance for *i*-th gas.

1.3 Measuring of the photodesorption yield

The testing measurements have been started at beginning of April 1997. The data of pressures measured by RGA and gauges, the electron beam current (to be converted to photon flux) and dose were recorded. The dependence of photodesorption yield on photon dose was obtained following the data treatment procedure described in previous paragraph.

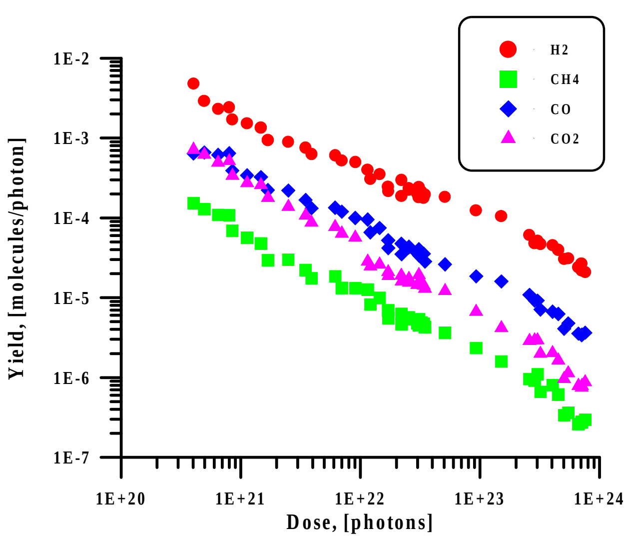

Figure B. The photodesorption yield dependence on photon dose.

The photodesorption yield dependence on photon dose (the number of photons accumulated by the absorber on the irradiated area of 10mm × 35mm) is presented on Fig. 2. This data will allow to predict the dynamic pressure in BESSY-2 as a function of machine operating time.

2. POWER TESTING

2.1 Setup

An electron beam welding machine which was used for power testing of the BESSY crotch-absorber has been built at the Budker Institute of Nuclear Physics [2]. Electron beam energy is 60 keV, electron current is up to 250 mA, beam power is up to 15 kW. Operating pressure is about 10^{-6} Pa.

For testing the BESSY crotch-absorber was installed inside the vacuum chamber of electron beam welding machine in front of electron gun. An electron beam could be focused to about 0.5 to 1 mm size and deviated ±7° with a frequency of 750 Hz. It gets a possibility to irradiate the strip on the crotch-absorber with sizes 1mm × 35mm by electron beam at normal incident angle.

The crotch-absorber was cooled by water with flow of 2 lt/min and inlet temperature of 9°C.

The temperature profile of the tested absorber was measured with tree thermocouples held in special halls located 8.5 mm, 16 mm and 22 mm under irradiated surface. As well the temperatures of inlet and outlet water were measured.

2.2 Experiment

The testing measurements have been performed at beginning of November 1997. There was made the temperature profile test and the surface condition test at different electron beam power.

Temperature test

The temperature measurement was performed for the crotch-absorber. The electron beam current raised up step by step from 0 to 83 mA, corresponding power raised up from 0 to 5 kW. For each step of 5 mA the measurement of temperature have been made after about 3 min (when temperature becomes stable). The dependence of the measured temperatures on power is present in Fig. 3. The maximal measured temperature was 287°C which was measured by thermocouple located 8.5 mm under the irradiated surface. Maximal temperature of outlet water was 34.5°C at total power of 5 kW.

There was no reason to continue the test at more high power as soon as it was clear seen what the crotch-absorber surface has been melted at that power.

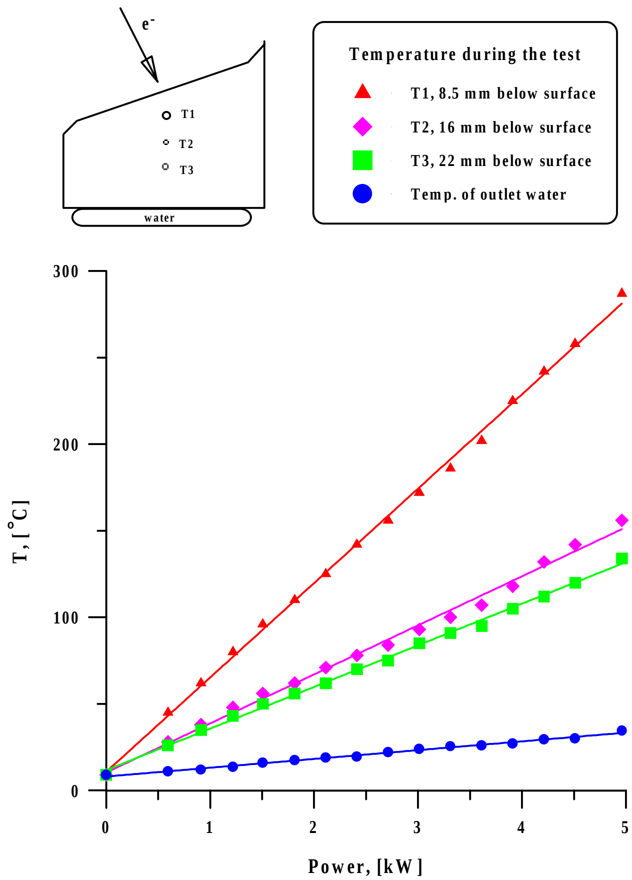

Figure C. The dependence of the measured temperatures on electron beam power.

Surface test

With aim to have possibility to study the condition of the crotch-absorber surface after irradiating with different powers the crotch-absorber was irradiated by eight different powers for 4–5 minutes (to keep some time at stable temperature). For each step the electron beam was moved such way to have possibility to see the result of each test power independently of others. The result of the test is shown on photographs of surface after the test and described in the Table 1.

Table A Effect of power on the absorber surface condition

Power		Surface condition
kW	W/cm	of the crotch-absorber
0.9	260	No effect
1.5	430	No effect
2.1	605	No effect
2.7	775	Thin (<0.05 mm) melted line
3.3	945	0.5-mm melted line
3.9	1120	0.8-mm melted line
4.2	1205	1.5-mm melted line
5.0	1420	2.5-mm melted line

3. CONCLUSION

1. The photodesorption yield dependence on photon dose for the crotch-absorber should help to estimate pressure in BESSY-II vacuum chamber in presents of beam depending of machine operating time.

2. The power up to 600 W per cm of the crotch-absorber length could be accepted for the tested SR crotch-absorber.

3. The total power of 5 kW could be absorbed by the tested SR crotch-absorber.

REFERENCES

[1] BESSY-II. Eine optimierte Undulator/Wiggler-Speichrring Linchtguelle fur den VUV- und XUV-Spectralbereich, BESSY, Berlin, 1986.

[2] N.S. Bibko, V.G. Veshcherevich, V.N. Volkov, M.M. Karliner, I.K. Sedlyarov, S.R. Singatulin. Computerized Electron Beam Welding Machine. Preprint INP 93-63, BINP, Novosibirsk, 1993.