Photodesorption Experiments on SSC Collider Beam Tube Configurations*

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Abstract

Experimental measurements of photodesorption coefficients of H_2, CH_4, CO and CO_2 are being done to obtain data necessary to predict the vacuum performance of the Collider. Experiments have been done or are planned for warm tubes (i.e. room temperature), cold tubes (i.e. 4.2 K) and liner configurations (i.e. 4.2 K, 20 K and 80 K). Two synchrotron radiation beamlines have been constructed on the VEPP-2M storage ring at BINP, Russia. The photon critical energy is 284 eV, as in the SSC Collider, angle of incidence is 10 mrad. To date approximately fifteen warm beam tubes have been tested, including electrodeposited Cu, high purity bulk Cu and Nitronic 40 SS, several cleaning procedures, with and without in-situ baking and with and without magnetic field. The maximum integrated photon dose was achieved was $2 \cdot 10^{22}$ photons/m on the high intensity beamline. Several experiments have been done on the VUV ring at BNL to check a subset of the BINP data and to extend the integrated photon flux up to 10^{23} photons/m, or 100 days of SSC operation. The data from the warm experiments will be used to evaluate the best tubes to be used in the more time consuming cold experiments.

I. INTRODUCTION

Density increase in the beam tube due to photon-simulated desorption (PSD) can be a problem for achieving desirable beam current and lifetime in the SSCL 20 TeV proton Collider.[1] This problem may be significantly reduced if appropriate material and proper pretreatment procedures for the beam tube can be found. In order to test the selection of both the appropriate material and proper cleaning technique, we have exposed about fifteen potential candidates for collider beam tubes to synchrotron radiation on the two beamlines assembled in BINP, Russia and on the U10B beamline of the NSLS VUV ring. Each sample is 1 m long and 33 mm inside diameter(ID). Three basic materials for tubes have been tested so far: electrodeposited Cu (Silvex and Fluhmann), bulk Cu (Hitachi 10100) and Nitronic 40 SS (ASTM2169). These tube samples were cleaned following two ultrahigh vacuum cleaning procedures used at BNL and at CERN. Photodesorption measurements were also made for different experimental conditions, such as "in situ" bake of the tested sample and with the presence of 500-1000 G magnetic field.

II. EXPERIMENTAL DETAILS

Basic parameters of the three beamlines used for experiments are given in Table 1, where E - particle energy; I - beam current; γ - relativistic factor; E_{cr} - critical energy of photons; $d\Gamma/dt$ - photon flux; ϕ - angle of incidence; $w_{1/2}$ - FWHM strip height of photons with the median energy $E_{1/2}$ = 23 eV; D - distance from source point.

The BNL experimental setup has been described in detail previously.[2] Here we give some details of the BINP beamlines. The main difference between the two BINP beamlines is the distance from the source point of synchrotron radiation to the beam tube under test. The photon flux on the SSC1 beamline is collimated in both the vertical and horizontal directions in order to expose only the test tube. There is a loss of approximately 25% of low energy photons due to vertical collimation. On SSC2 beamline there is no vertical collimation due to very short distance from the source point. A calorimeter/electrometer is installed on the end of the SSC1 beamline to measure the power and intensity of reflected photons leaving the tube.

The vacuum systems of SSC1 and SSC2 are the same. The main part of these systems is a SS fixture which contains a calibrated RGA and ion gage installed at the center of the fixture. Tubes to be tested are inserted into the fixture from one end. This setup allows using the tube conductance to calculate photodesorption coefficients instead of the conductance of a specially made orifice placed at one end of the tube, as in the experimental setups used at CERN[3] and BNL. At each end of the fixture there is a combination ion and titanium sublimation pump with total pumping speed about 1000 l/s for H_2. Two all-metal gate valves located on the ends of the fixture and small valve installed between the measurement unit and the fixture allow isolation of the beamline, pumps and measuring equipment during mounting of another sample. Each vacuum system was initially baked at 300°C for 24 hours. After a sample is installed it is usually pumped for 48 hours and the base pressure is about $2 \cdot 10^{-9}$ torr in the center

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Table 1
Synchrotron radiation beamline parameters

Beamline	E, MeV	I, mA	γ	E_{cr}, eV	$d\Gamma/dt$, ph/m/s	ϕ, mrad	$w_{1/2}$, mm	D, m
SSC1	534	300	1045	284	$1.1 \cdot 10^{16}$	10	52	11.65
SSC2	534	300	1045	284	$8.4 \cdot 10^{16}$	10	8	1.75
U10B	740	600	1448	490	$1.2 \cdot 10^{17}$	12	16	5.07
SSC	$2 \cdot 10^{7}$	70	21322	284	$1.0 \cdot 10^{16}$	2	4	20

before beginning experiments.

Each tube sample is engraved with a number and chemically treated before experiments. Most of the tubes have been cleaned at the NSLS cleaning facility at BNL by using a standard procedure for this facility. To compare photodesorption results several tubes were cleaned at the CERN cleaning facility. Generally no strong etch treatment was applied to the tubes. The one exception was at CERN where two bulk Cu tubes were treated by a strong acid etch.

Three types of experiments were performed : (a) no bake, no magnetic field; (b) vacuum bake at 150°C or 350°C for 24 hrs, no magnetic field; (c) no bake, with magnetic field.

III. BASIC RESULTS

A. Silvex Electroplated Cu

So far eleven experiments have been done with Silvex electroplated Cu tubes; eight samples at BINP - three on the SSC1 beamline and five on SSC2 - and three samples at BNL.

(a) no bake, no magnetic field

Five tubes have been tested under these experimental conditions, four at BINP and one at BNL. Generally results of all these experiments are almost the same and have a small difference in initial η's. Initial η's differ by ± 50%, integrated desorption yields at 10^{22} photon/m by ± 20%. A typical plot of photodesorption yield versus integrated photon flux is shown in Figure 1.

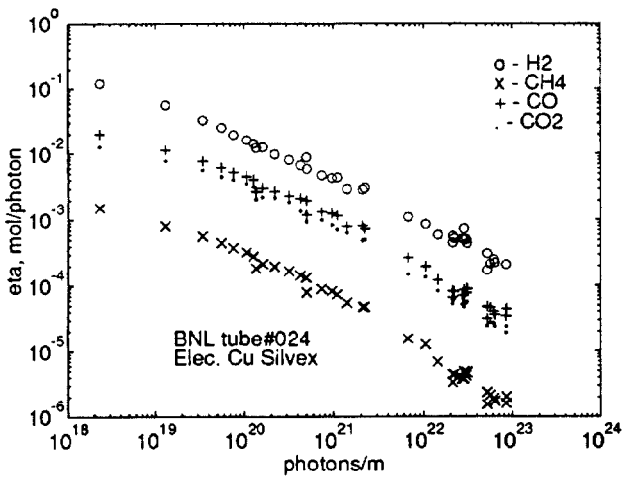

Figure 1. Photodesorption coefficients for unbaked Silvex electroplated Cu.

(b) vacuum bake, no magnetic field

Tube #003 was baked at 150°C for 24 hrs and then was exposed to photons on SSC1 beamline up to 10^{21} photons/m. We did not notice any significant difference in photodesorption coefficients compared with an unbaked sample (tube #002) exposed to the same photon flux in SSC1. For example the integrated amounts of desorbed H2/CO were: $1.0 \cdot 10^{19}$/ $2.6 \cdot 10^{18}$ molecules/m for tube #003 with bake and $7.0 \cdot 10^{18}$/ $1.3 \cdot 10^{18}$ for tube #002 without bake.

Tube #032 was baked at 350°C for 24 hrs and then was exposed to photons on U10B line at BNL. Results of this experiment are shown in Figure 2. The initial η's for main peaks are reduced approximately an order of magnitude compared to the unbaked tube in Figure 1. However due to a smaller rate of cleanup of the baked tube the desorption coefficients are almost the same at ~10^{23} photons/m for the baked and unbaked tubes.

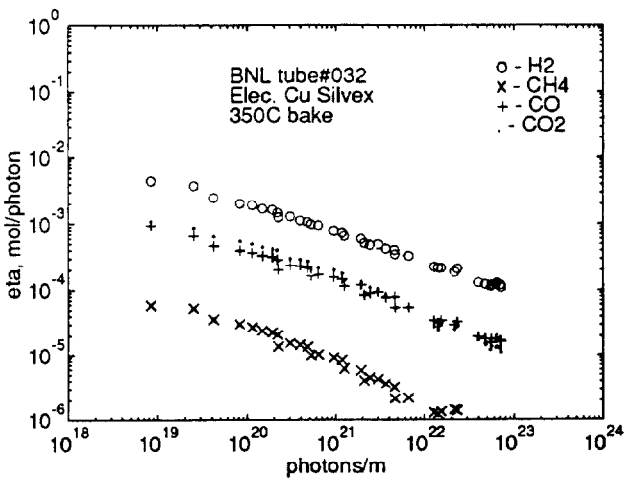

Figure 2. Photodesorption coefficients for *in situ* 350°C baked Silvex electroplated Cu.

(c) no bake, with magnetic field

Two experiments have been done with magnetic field, one on the SSC2 beamline at BINP and one on the U10B beamline at BNL. At BINP we used an electromagnet with ~500 G vertical magnetic field. The experimental data are shown in Figure 3. Most of the time the magnetic field was switched "on" and for short periods it was "off". Only slight differences between "on" and "off" periods were noted and are not visible in Figure 3 (i.e. no initial difference in photodesorption coeffi-

cients and approximately 10% higher photodesorption of H_2 with field "off" compared to field "on" at the conclusion of the experiment). This indicates a rather small role on photodesorption for photoelectrons which leave the surface. A similar experiment at BNL used a permanent magnet with average vertical magnetic field about 1000 G and also showed a very small magnetic field effect.

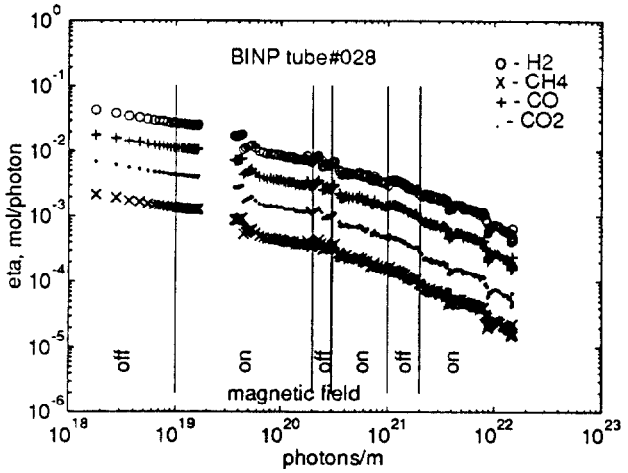

Figure 3. Photodesorption coefficients for Silvex electroplated Cu with magnetic field.

B. Fluhmann Electroplated Cu

One sample of Fluhmann electroplated Cu has been tested at BNL. Comparing with Silvex tubes the only essential difference is in the initial η for H_2 which is about five times less for the Fluhmann tube than the Silvex tube shown in Figure 1. However at 10^{23} photons/m the Fluhmann and Silvex tubes have essentially the same magnitude of photodesorption coefficients for all gases.

C. OFHC bulk Cu

Three OFHC bulk Cu samples have been tested on SSC1 at BINP and one at BNL. Generally the initial photodesorption coefficients obtained from these experiments are approximately 2 to 5 times less then for electroplated samples with the same cleaning procedure. In addition a rather large decrease in initial desorption coefficient was obtained with the CERN strong acid etch procedure compared to the BNL procedure with slight acid etch .

D. Nitronic 40 SS

Experiments on stainless steel tubes have been done at BINP on SSC1 beamline to compare results with earlier data from BNL experiments performed by Halama and Foerster.[4] Good agreement between the new and earlier data give confidence in the experimental procedures.

IV. SUMMARY

In Table 2 we summarize the results of this paper with a comparison of desorption coefficients and amount of desorbed gas at 10^{23} photons/m for H_2 and CO. Leaving the 350°C bake aside, at 10^{23}photons/m Silvex and Fluhmann electrodeposited Cu and bulk Cu have roughly the same magnitude of photodesorption coefficients and of photodesorbed gas (i.e. within a factor of two). The 350°C bake decreased the amount of H_2 desorbed at 10^{23} photons/m by a factor of three and CO by a factor of five. Magnetic field has no effect on initial photodesorption coefficients and there is approximately 10% higher photodesorption of H_2 with field "off" compared to field "on" at 10^{23} photons/m. Differences in cleaning procedures, baking versus no baking and materials are most pronounced in the initial desorption coefficients and tend to decrease to less than a factor of two by the time a photon flux ~10^{23} photons/m has been reached.

Table 2
Photodesorption coefficients and amount of photodesorbed H_2 and CO for different test samples at 10^{23} photons/m

Tube sample	molecules/photon at 10^{23}photons/m		molecules/m	
	H_2	CO	H_2	CO
Elec Cu(S*)	$1.7 \cdot 10^{-4}$	$4.4 \cdot 10^{-5}$	$5.1 \cdot 10^{19}$	$1.3 \cdot 10^{19}$
Elec Cu(S), 350°C bake	$9.3 \cdot 10^{-5}$	$1.4 \cdot 10^{-5}$	$1.7 \cdot 10^{19}$	$2.8 \cdot 10^{18}$
Elec Cu(S) with B	$1.4 \cdot 10^{-4}$	$3.0 \cdot 10^{-5}$	$3.3 \cdot 10^{19}$	$8.1 \cdot 10^{18}$
Elec Cu(F)	$1.3 \cdot 10^{-4}$	$2.8 \cdot 10^{-5}$	$2.8 \cdot 10^{19}$	$5.8 \cdot 10^{18}$
Bulk Cu	$9.2 \cdot 10^{-5}$	$2.0 \cdot 10^{-5}$	$2.4 \cdot 10^{19}$	$7.4 \cdot 10^{18}$

* S - Silvex, F - Fluhmann

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VI. REFERENCES

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