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THE SEARCH FOR LOW PHOTODESORPTION COATINGS*

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ABSTRACT

Low photo desorption (PSD) from surfaces of vacuum chambers increases the beam lifetime and reduces the cost of the pumping system of any storage ring. In compact rings where all radiated power (~10 kW) is incident on a few meters only, low PSD and good thermal conductivity of photon absorbers are of particular importance. An experimental chamber in which one meter long bars can be exposed to white photon beam with 500 eV critical energy has been built and installed on the U10B beamline in the VUV ring at the NSLS. Several reference bars made of high purity copper and a TiN coating on copper have been measured. Subsequent runs will include gold coating on copper, aluminum (200°C baked), diamond coating on copper and uncoated beryllium bars. In this paper the desorption coefficients will be measured and compared.

I. INTRODUCTION

Vacuum surfaces having low Photo Stimulated Desorption (PSD) yields are necessary for good beam lifetimes and for reasonable construction cost of storage rings where synchrotron radiation will exist. PSD is the dominant gas load during operations and increases with beam current. To date, stainless steel and aluminum have been acceptable materials for beam chamber fabrication. Copper due to its good thermal and electical properties has been successfully utilized as photon absorbers. As is well known, the preparation of the material and surface treatments is a primary consideration.

New applications of electron storage rings such as compact rings and B factories place severe demands on vacuum system design due to limited space for pumping and extremely high currents. Much more careful and extensive studies of new materials and surfaces will be required to resolve both the photodesorption and heat dissipation. In addition the effect of angle of incidence, difuse and speecular reflection as well as photoelectron generation will have to be better understood to optimize the choice of materials.

We have therefore built an experimental apparatus that can rapidly change the angle of incidence and measure all the above effects. At present it is operational on the U10B beam line haveing critical energy of 500 eV. Plans are being made to adapt it to the X28C, X-ray beam line with variable photon energy of 120 to 5000 eV.

Since a substantial amount of data exists on aluminum and stainless steel we will concentrate our efforts on copper, berillium and thin films of TiN, diamond and gold on copper.

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Stainless and aluminum will also be investigated for comparisson. Preliminary results on 1.21m long Cu and TiN coated Cu bars will be presented in this paper. Two test set ups were used for the measurements.

II. DESCRIPTION

A. Experimental Set Up

The details of most of our previous experimental set ups have been described [1,2,3] when aluminum, stainless steel, and copper coated chambers were tested. In present experiments, see Fig. 1 schematics, one meter long samples were exposed to white light with critical energy of 500 eV. The vertical collimator (C_v) was adjusted to 3.5 mrad and the horizontal collimator (C_h) was initially set to 10 mrad. The horizontal, C_H, collimator must be adjusted smaller when the sample is rotated for incident angles less than 50 mrad to keep the primary photons within the length of the sample. The samples receive photons directly from the source since there are neither mirrors nor monochromaters in this beam line.

The total incident photon flux per beam current I, per horizontal opening angle θ, and per second t is given by [4]

$$N/I\ \theta t = 1.28 \times 10^{14}\ E\ photons\ mA^{-1}\ mrad^{-1}\ s^{-1}, \tag{1}$$

where E is the machine energy of 0.75 GeV. Since the main gases desorbed are H_2, CH_4, CO and CO_2, the residual gas analyzer (RGA) was calibrated to yield their relative sensitivities. The absolute partial pressures have always been calculated from the calibrated BA gauge readings. The relative abundance of desorbed gases is obtained from RGA data. The RGA was recalibrated for each test run on each sample.

The specific molecular desorption yield [4] η_i is given by

$$\eta_i = \frac{GS_i \Delta P_i / I}{(N/I\theta\ t)\ \theta_1}\ molecules\ photon^{-1}, \tag{2}$$

where $\Delta P_i/I$ is the specific pressure rise of each gas in Torr mA^{-1}, θ_1 is the horizontal opening angle in the experiment, $G = 3.2 \times 10^{19}$ molecules $Torr^{-1}\ l^{-1}$, S_i is the pumping speed in $l s^{-1}$ for each gas species at orifice 01.

The beam line between the ring and valve, V3 in Fig. 1a was vacuum baked to 200°C for forty-eight hours and conditioned with V3 closed. The nitrogen conductance of orifice 01 is 47.5 l/s and can be considered the speed Si in Eq 2 when V3 is open. Orifice 01 is a rectangular duct and its calculated conductance was verified by

in situ nitrogen speed measurements using the pressure drop across a known conductance.

In test set up #1, in Fig. 1b, the sample is mounted length wise across the chamber in the horizontal plane, making the photon incidence angle, 100 mrad. Three parallel pick up wires spaced 10mm apart are located opposite the sample bar to measure photo electrons and to sample diffusely reflected photons. The chamber was constructed of 304 stainless steel, vacuum baked to 300°C for forty-eight hours and argon-oxygen glow discharge conditioned just prior to measurements with installed samples. The window on the end was used for alignment prior to installation of the sample. The sample to be tested is secured in the test chamber to stainless steel plates welded inside each end of the chamber.

In test set up #2 the sample was mounted horizontally length wise on the chamber wall (see Fig. 1c). This chamber was also fabricated with 304 stainless steel and was vacuum baked at 200°C for 72 hours. It has a horizontal pick up wire opposite the sample, and a pick up wire along the top of the chamber. At the down stream end of the test chamber is a water cooled, electrically insulated, photon stop. As with chamber #1 the ends of the sample are mounted to plates welded on the chamber wall. The chamber is mounted to a rotatable X-Y table with its center of rotation located relative to the horizontal center the exposed sample face.

B. Oxygen free Copper (OF-Cu)

A forty eight inch long by two inches wide and one half inch thick OF-CU sample was exposed to photons at 100 mrad incidence angle. The sample was etched and solvent cleaned following standard NSLS procedures prior to installation in test set up #1.

The test set up #1 with sample was vacuum baked 175°C for 48 hours and pressure was less than 1 x 10^{-9} torr after cool down. The desorption yields versus dose are shown in Fig. 3. The sample was removed from test set up#1 and later installed in test set up #2 with the unexposed side away from the wall for measurements. Test set up #2 was vacuum baked with sample to 175°C for 72 hours.

C. Titanium Nitride Coated Copper (TiN-Cu)

A copper sample (48 x 2 x 1/2) was cleaned and sent out to a vendor for titanium nitride coating. The sample was first mounted in test set up #1, baked to 175°C for forty eight hours. After cool down pressure was less than 1 x 10^{-9} Torr. The desorption yields versus dose are shown in Fig. 2. After run #1 the sample was removed from test chamber one and conditioned at 200°C including an Argon glow discharge dose of 2 x 10^{-18} ions/cm^2. It was then re-installed in test chamber #1 for measurement of its unexposed face. It was baked to 175°C for forty eight hours in situ. Cool down pressure was again less than 1 x 10^{-9} torr. The desorption yields versus dose are shown in Fig. 4.

III. DISCUSSION

A. Oxygen Free Copper

OF-Copper is commonly used in storage rings and beam lines to

absorb unwanted power. It is normally used internally and usually water cooled. Our results are comparable to our previously run copper absorber[6], plated copper[2] and recent work[5] of Ueda et al. We did not see traces of high mass containments we have experienced with plated copper. Our NSLS copper cleaning procedure includes an etch.

The photon stop in test set up #2 is constructed of OF Cu and was conditioned after bake using direct photon from the source normal to its surface. The photo electron current was the same as the OF-Cu sample in test set up #1. The desorption yield was almost the same as Fig. 2.

B. Titanium Nitride Coated OF-Copper

An OF-Cu sample was coated in vacuum by a vendor using his propriority process. This is the type coating that has been used in storage ring RF cavities to improve vacuum operations. The yield η from titanium nitride coated OF-Cu was almost the same as uncoated Of-Copper. (See Fig. 2 and 3) The coated sample is very slightly higher with clean up rates for H_2, CO, and CO^2 the same as uncoated.

Argon glow discharge conditioning of the TiN-Cu sample as expected, resulted in a large reduction of η yield. Initially, reduction of half an order of magnitude for H_2, an order of magnitude for CO, and one and a half order of magnitude for CO_2. The yield was seen to decrease significantly after an exposure of 10^{23} photons per meter.

CONCLUSION

Vacuum baked OF-Copper and TiN coated copper have approximately the same desorption characteristics. Our previous work and that of other has found vacuum baked copper and stainless to be almost the same. Therefore, copper, TiN coated copper and stainless steel have almost the same desorption coefficients after the same vacuum bake procedure.

Glow discharge conditioning of TiN coated copper results in reduced photo desorption. This was previously experienced to a greater degree with stainless steel. An Argon oxygen glow had been used for stainless.

Additional measurements of other materials are either planned or in process awaiting their turn. Among those in line are Gold plated copper, Berrillium bars, aluminum bar (200°C baked), and hard carbon coated copper. We have not yet developed a good homogeneous hard carbon process for our large sample.

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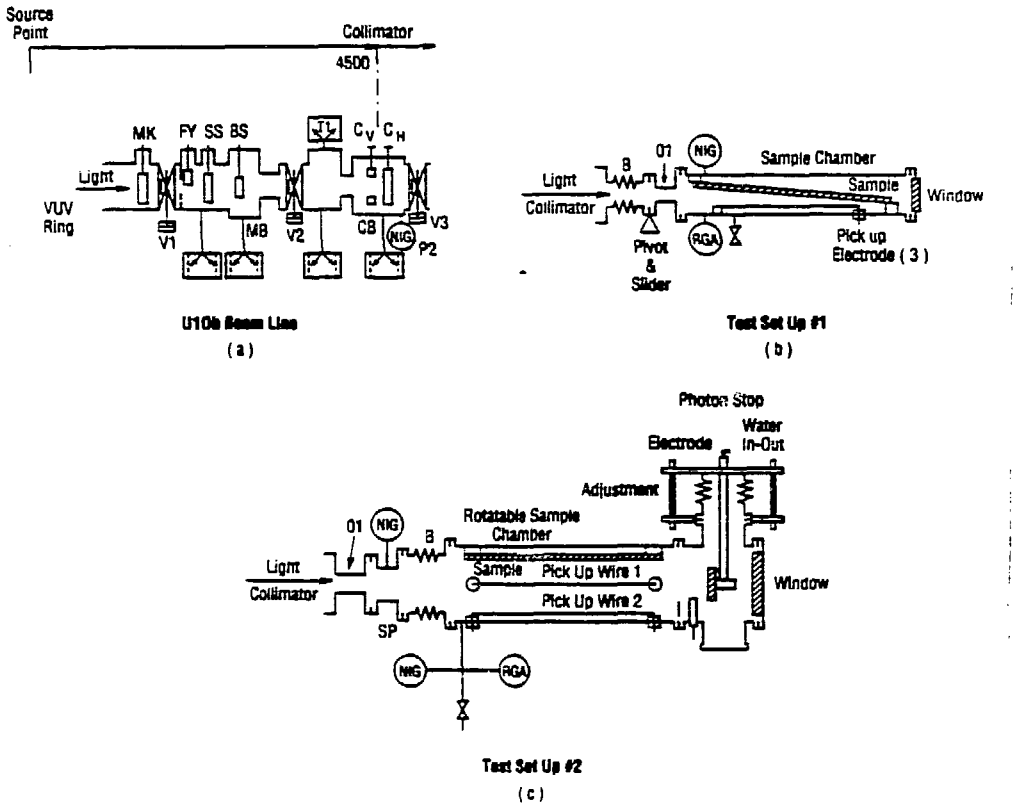

Fig. 1 Schematic diagram of the beamline and test set ups. (a) Components: MK-mast for front end valve-VI; FV fast valve; SS-safety shutter; BS-beam stop; MB-mirror box; V2-U10B isolation valve; CB-collimator box with adjustable vertical-CV and horizontal collimators-CH; V3-isolation valve. (b) components; B-Bellows; 01-rectangular conductance. (c) 01-rectangular conductance; SP-spool, piece; set up #2.

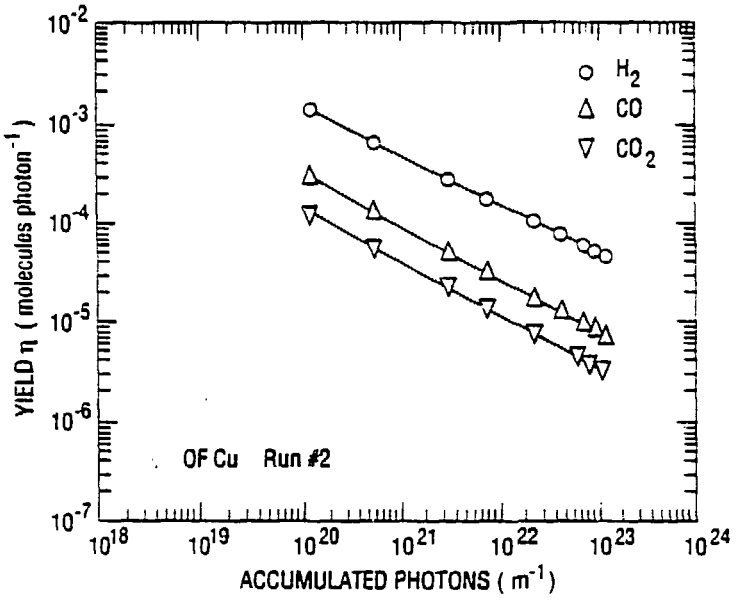

Fig. 2 Molecular Desorption Yields for oxygen free copper after vacuum bake

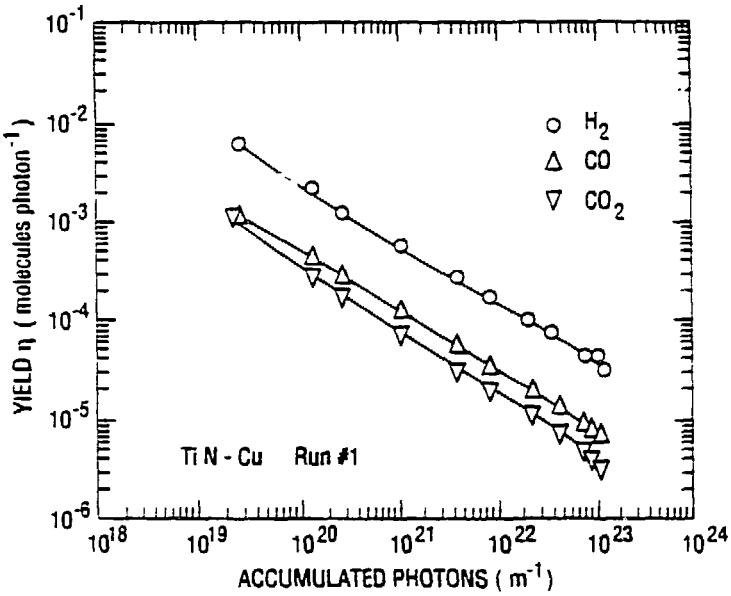

Fig. 3 Molecular desorption yields for Titanium nitride coated copper after vacuum bake

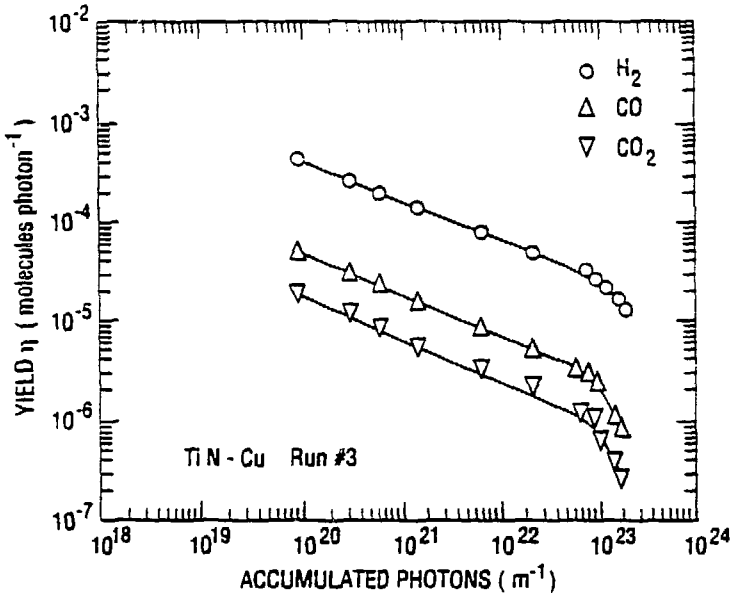

Fig. 4 Molecular desorption yields for glow discharge conditioned Titanium Nitride coated copper

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