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Photon Stimulated Desorption Measurement of an Extruded Aluminum Beam Chamber for the Advanced Photon Source*

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The Advanced Photon Source (APS), presently being commisioned, will produce X-ray s of unprecedented brightness. The high energy ring of the APS is a 7 GeV positron storage ring, 1104 meters in circumference designed to operate at less than 10^{-9} Torr with 300 ma of beam and a greater than 10 hour lifetime. The storage ring vacuum chamber is constructed from an extruded 6063 aluminum alloy. During the construction phase, a 2.34 m long section of the APS extruded aluminum chamber was set up on National Synchrotron Light Source (NSLS) X-ray Beamlline X28A and Photon Stimulated Desorption (PSD) was measured. Cleaning and preparation of the chamber was identical to that of the APS construction. In addition to the chamber, small samples of Al, Be, and Cu were also exposed to white light having a critical energy of 5 keV. In addition to PSD, measurements were made of specular and diffuse scattering of photons. The chamber and samples were each exposed to a dose greater than 10^{23} photons per meter. Desorption yields for H_2, CO, CO_2, CH_4 and H_2O are reported as a function of accumulated flux, critical energy, incidence angle, and preparation. These results are compared with previous results for aluminum on NSLS Beamlline U10B and PSD results of other laboratories published for aluminum.

I. INTRODUCTION

The UHV ring beam chambers for the Advanced Photon Source (APS) are fabricated from extruded 6063 aluminum alloy. During the circulating beam operation the walls of the

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copper test chambers run for the PEP-II asymmetric B factory. Some of the pertinent parameters and details are repeated for completeness. A water cooled beryllium filter (0.25 mm thick) can be moved into the beam path to eliminate photons with energies less than 2 keV from the measurement. A water cooled rectangular collimator with an opening measuring 48 mm horizontally and 38 mm vertically is located 12 meters from the source. The vertical cutoff of the aperture is photons of less energy than 6 eV full width at half max (FWHM). Total photon flux is used in the calculations of η(eta), which represents the desorption yield in molecules/photon.

The NSLS X-ray 2.5 GeV ring provides white light with a critical energy of 5 KeV. During the photon exposure measurements the chamber was positioned for a primary photon incident angle of 21 mrad. Calibrated Nude Ion Gauges (NIG) were used to measure the pressure drop across a 51.8 ℓ sec^{-1} conductance, which is used to determine the amount of gases produced during test chamber exposures. A calibrated Residual Gas Analizer (RGA) was used to determine constituents of the total gas pressure measurements. Pressure rises (Δ P/P) are determined for H_2, CH_4, CO, O_2, CO_2 and H_2O from the NIG and RGA readings. The respective yields in molecules per photon are calculated from these results. An electrically insulated water cooled photon stop was located at the end of the beam line which was used to measure specular photons.

A. Test Chamber (see Fig. 1 and Fig 2)

Two electrically insulated probes were located in the middle of the chamber to measure diffusely scattered photons. The chamber and beamline were baked to 150°C prior to the start PSD measurements. One of the center chamber probes was located in the middle of the beam chamber and it consisted of a small block (1 cm x 1 cm x 2 cm) on the end of an insulated shaft. The other center probe was the same size block on an insulated shaft and it was located in the

photon beam at the sample chamber is 57 mm horizontal by 45 mm vertical. The cross section of the holder is 47 mm horizontal by 91 mm vertical and was stepped into the beam for each sample. Steps were in increments of 12.5 mm for each sample exposed. The first step intercepted 20 percent of the beam cross section, the second intercepted 43 percent, the third 67%, the fourth and fifth intercepted 83% of the beam each.

III. MEASUREMENT AND COMMENT

A. Test Chamber

PSD measurements were performed with and without the beryllium filter in the photon beam path. The filter was briefly inserted periodically for measurements such that the majority of exposure was to unfiltered white light. The PSD results are shown in Fig. 3. As was the case with B-factory copper chambers, PSD with the filtered light was larger, most likely due to slight scattering of the photon beam. The PSD results for the Aluminum test chamber were much larger than was found for B-factory copper chambers run on the same beamline. Aluminum has previously been found to exhibit highter PSD yields [6] than other common chamber materials. When compared to a NSLS vacuum chamber run [7] on beamline U10B the desorption yields are less than a factor of three lower. Our results for H_2 and CO are almost the same as those from the DCI [8] storage ring, Orsay, France and our result for CO_2 is within a factor of two compared to DCI, for their baked aluminum chamber. O_2 was always less than CH_4 and is not reported. H_2O is uncalibrated but is given for reference.

The photo electron currents measured on various test probes are given in Table 1. Our lower detection limit was 1×10^{-4} ampere. The specular reflection measured for the test chamber with unfiltered white light was approximately 3.5%, which is almost the same as that previously measured for the B-factory welded copper chamber. With the beryillium filter in the photon beam

new sample. As the holder is stepped into the photon path, a corresponding decrease in photon electron current is measured on the end stop except for the last two samples. The last two samples intercept the same cross section of photon beam. The current on the sample decreased approximately twenty-five percent and the current on the stop stayed the same, when the last sample was moved into the photon path. We have previously [10] calculated similar currents for aluminum, gold and copper which would explain our results. Although we did not have photo electric quantum efficiencies to calculate beryllium, we did measure [10] approximately twenty-five percent less current on the beryllium than on the copper sample.

Very little photon induced current was detected on the sample chamber lower probe located below the sample faces. Currents of 10^{-3} to 10^{-4} $\mu a\ ma^{-1}$ were measured on the ante chamber test probe. Photons not stopped by the sample holder set up would be incident on the previously desorbed test chamber wall. No currents were detected on the beam chamber test probe. End stop currents measured 3×10^{-2} to 5.2×10^{-2} $\mu a\ ma^{-1}$.

Each sample stepped into the beam path exposes twenty perent of new cross sectional area to photon incidence. The rest of the photon beam's primary incident is on previously exposed sample or test chamber surfaces.

CONCLUSIONS

The APS photon stimulated desorption results are similar to previous clean aluminum beam chambers tested at the NSLS and at DCI.

The new environmentally safe Almeco 18 based cleaning procedures developed for the APS storage ring construction are acceptable for storage ring UHV operation.

There were no major differences in the small sample PSD results from sample to sample. They all yielded similar desorption and are most likely moderated by desorption from the sample chamber and the test chamber due to diffusely scattered photons.

References

1. A.G. Mathewson, Vacuum 44, 479 (1993).
2. J. D. Herbert, A.E. Groome and R.J. Reid, J. Vac. Sci. Technol., A12, 1767 (1994).
3. R.A. Rosenberg, M.W. McDowell, and J. R. Noonan, J. Vac. Sci. Technol., A12, 1755 (1994).
4. R.C. Niemann et al, AIP Conf. Proc. No 236, 39, (1991).
5. C.L. Foerster, C. Lanni, C. Perkins, M. Calderon and W. Barletta, J. Vac. Sci, Technol., A13, 581 (1991).
6. H.J. Halama and C. L. Foerster, Vacuum, 42, 185 (1991).
7. T. Kobari and H.J. Halama, J. Vac. Sci. Technol., A5, 2355 (1987).
8. A.G. Mathewson et al, AIP Conf. Proc., No. 236, 313 (1991).
9. X-ray Data Booklet, PUB-490, LBL (1986).
10. C.L. Foerster, H.J. Halama, and G. Korn, J. Vac. Sci. Technol., A10, 2077 (1992).

TABLE 1

Photo Electron Currents in μa/ma at - 40 VDC Measured on Various Test Probes

PRIMARY PHOTON		SAMPLE CHAMBER		TEST CHAMBER		END
TARGET	Be FILTER	HOLDER	LOWER PROBE	ANTE CHAMBER	BEAM CHAMBER	STOP
Test Chamber	YES	5.2×10^{-4}	0.0	3.6×10^{-3}	0.0	0.0
Test Chamber	NO	1.1×10^{-3}	0.0	1.67×10^{-2}	5.3×10^{-4}	8.8×10^{-2}
SAMPLE HOLDER						
Holder Copper	NO	0.62	8.7×10^{-4}	1.3×10^{-3}	0.0	5.2×10^{-2}
GLIDCOP	NO	0.75	0.0	6.4×10^{-4}	0.0	3.0×10^{-2}
Aluminum	NO	0.92	0.0	8.5×10^{-4}	0.0	3.2×10^{-2}
OHFC Copper	NO	1.33	4.8×10^{-4}	9.6×10^{-4}	0.0	3.4×10^{-2}
Beryllium	NO	0.98	0.0	9.1×10^{-4}	0.0	3.4×10^{-2}

X28a Beamline

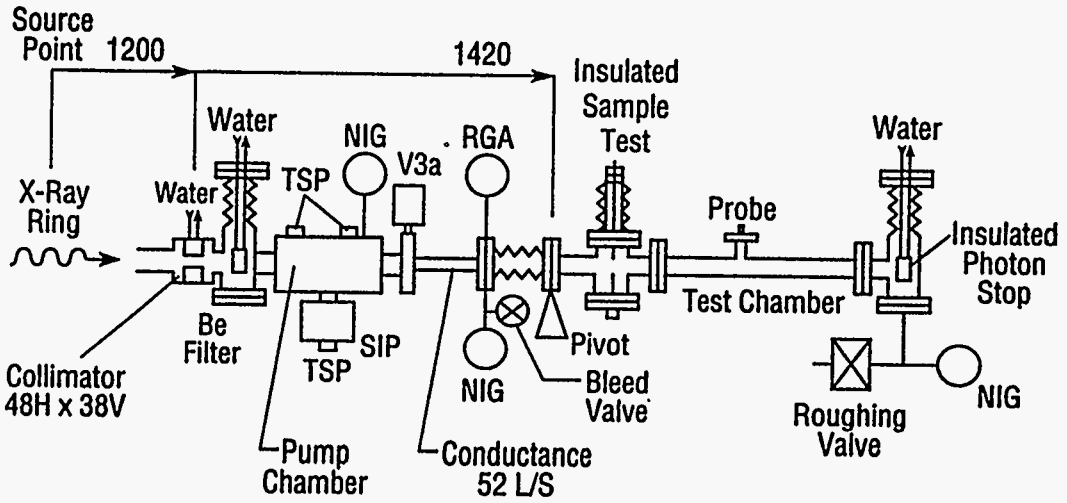

Fig 1

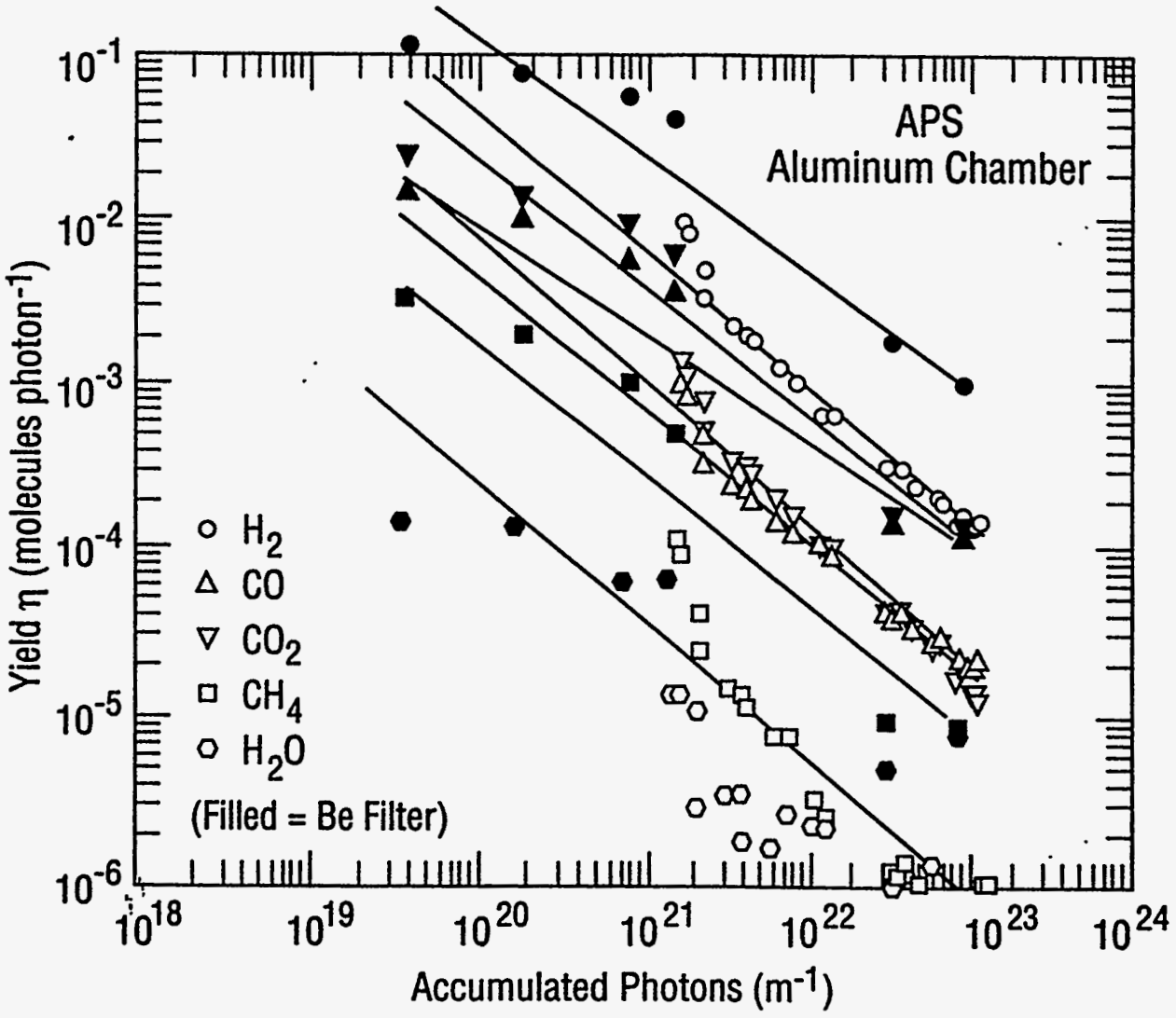
APS
Aluminum Chamber
Yield η (molecules photon^{-1})
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
H_2
CO
CO_2
CH_4
H_2O
(Filled = Be Filter)
10^{18}
10^{19}
10^{20}
10^{21}
10^{22}
10^{23}
10^{24}
Accumulated Photons (m^{-1})

FIG 3