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EFFECT OF OZONATED WATER CLEANING ON PHOTON STIMULATED DESORPTION IN A STAINLESS STEEL CHAMBER *

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Abstract

Aluminium vacuum chambers cleaned with ozonated water show a reduction of residual carbon and lower surface outgassing rate after baking. We would like to investigate if stainless steel chambers show similar effects. A stainless steel test chamber was cleaned by standard chemical cleaning only and then compared with another one after immersion in 30ppm ozonated water for thirty minutes. Both samples were baked, then photon exposed and the photon desorption yields were determined by vacuum gauges and residual gas analysers at the TLS 19B beamline. The test results on photon stimulated desorption yields and partial pressure variations with and without ozonated water cleaning of the stainless steel tubes will be discussed in some detail.

INTRODUCTION

Photon stimulated desorption plays an important role in ultra-high vacuum (UHV) technology. Reducing the PSD outgassing rate can shorten the accelerator commissioning time on beam cleaning process. In an earlier study[1][2], the photon stimulated desorption from aluminium alloy surfaces after ozonated water cleaning was found to be lower compared to chemical cleaning alone. Ozonated water appears also to reduce the amount of residual carbon on the surface.

Many studies have been done to determine photon stimulated desorption from stainless steel surfaces [3][4], but only a few studies covered also ozonated water cleaning. For application in UHV systems it should be shown that stainless steel surfaces can be cleaned in the same way as aluminium alloy and attain lower PSD yields after cleaning with ozonated water.

EXPERIMENTAL OBSERVATIONS

Test chamber preparation

As a test chamber, we used a spare booster vacuum chamber of the Taiwan Photon Source (TPS), which was fabricated from 304 series stainless steel material. The tube was extruded into 35x20 mm ellipse on cross section and with 0.7mm wall thickness. The total length and curvature of test tube is about 1.1 meters and 3.75 degree respectively. The cooling pipe was welded to the outside of the test chamber.

The stainless steel test chamber was cleaned by standard chemical cleaning and then, a part of the test chamber was immersed into 30ppm ozonated water for thirty minutes.

Beamline

The test chamber was installed in the TLS 19B beamline at the NSRRC. The TLS energy was 1.5 GeV and the beam current 360mA (top-up) producing radiation at a critical energy of 2.14 keV. The incidence angle of the photon beam to test chamber is 2.53 mrad.

An aluminium pipe was installed between test chamber and main chamber to provide a conductance of about 10L/s. An extractor gauge and a cold cathode gauge together with residual gas analyser were located upstream and downstream of this conductance tube. An ultra-high vacuum condition was obtained by a sputter ion pump and a NEG cartridge pump before photon exposure. A gate valve prevented exposure of the main chamber to atmospheric exposure during replacement of the test chamber. Figure 1 shows the experimental layout of beamline 19B in the TLS.

After cleaning, the stainless steel chamber was installed at the end of the conductance tube. The vacuum system was roughed down by dry mechanical pumps and turbo molecular pumps and then was baked to 150℃ for 24 hours. After cooling down, the pressure was lower than $2x10^{-10}$ Torr. The photon stimulated desorption yields (η) was determined by vacuum gauges and a residual gas analyser after photon exposure.

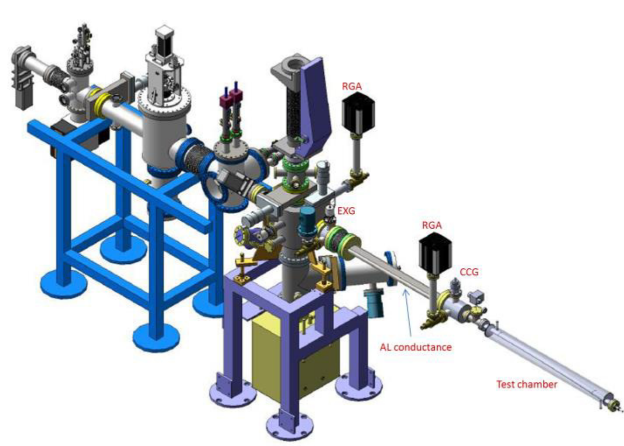

Figure 1: Experimental setup at the TLS beamline 19B.

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RESULTS AND DISCUSSION

The pressure of chemically cleaned test chamber increased to $3x10^{-6}$ Torr at the initial photon exposure, it rose only to $2x10^{-7}$ Torr for the ozonated water cleaned chamber. In the TLS, one ampere-hour (1Ah) of photon exposure is equivalent to about $1.98x10^{20}$ photons per meter.

Figure 2 shows a graph of the pressure difference normalized to one mA of beam current versus total beam dose. The pressure difference is defined by that in the test chamber minus that in the main chamber. At the initial photon exposure, the ozonated water cleaned chamber pressure is about one and a half orders of magnitude lower compared to the chemically cleaned chamber, but this difference decreases with beam dose to about half an order of magnitude (see Fig.3).

The graph in Fig.3 for photon stimulated desorption yields versus total beam dose shows a similar dependence of dP/I with beam dose. The PSD yields are about $5x10^{-3}$ and $2x10^{-4}$ molecules per photon for chemical and ozonated water cleaning at the initial photon exposure. It reduces to below $1x10^{-6}$ molecules per photon in the case of ozonated water cleaning when total beam dose exceeds about 100Ah.

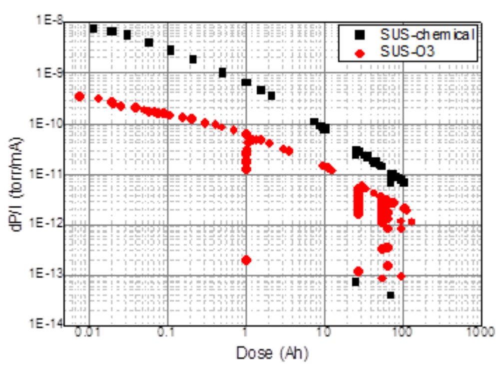

Figure 2: Beam current normalized vacuum pressure rise for different cleaning methods versus total beam dose.

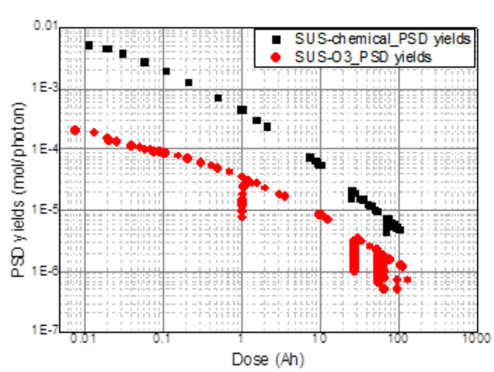

Figure 3: Photon stimulated desorption yields for different cleaning methods versus total beam dose.

Figures 4 and 5 are residual gas analyser spectrum for chemical and ozonated water cleaning for different total beam doses. The main PSD outgases of the chemically cleaned chamber are hydrogen, carbon monoxide, carbon dioxide, methane and hydrocarbons. The partial pressure for hydrocarbons is high at the initial photon exposure and disappeared almost completely when at a beam dose of 100Ah or more.

The main PSD outgases in chambers cleaned by ozonated water are hydrogen, carbon monoxide, carbon dioxide and methane. The partial pressure for hydrocarbons is much lower compared to the chemically cleaned chamber. A residual gas component of mass 69 was found during photon exposure, but to date, we have not yet identified its species and source.

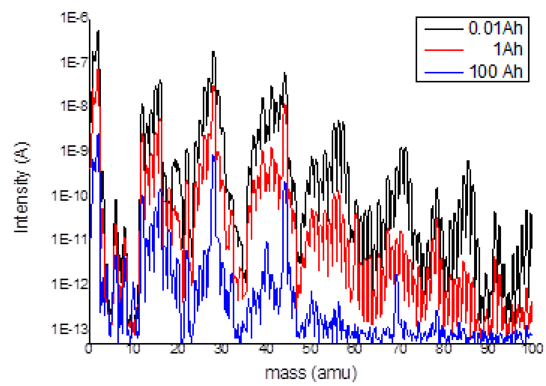

Figure 4: RGA spectrum for a chemically cleaned chamber at different beam doses.

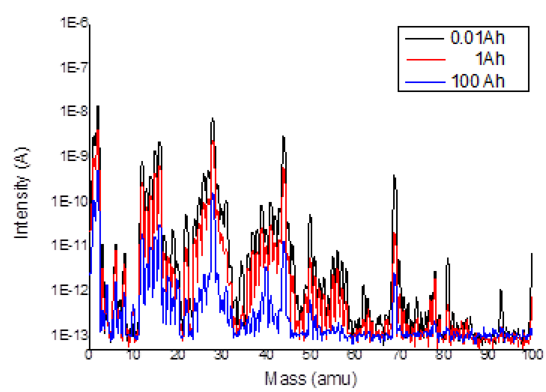

Figure 5: RGA spectrum after ozonated water cleaning of the chamber at different beam doses.

Figure 6 shows photon stimulated desorption yields for different masses of the chemically cleaned chamber. Mass_2, 16, 18, 28 and 44 are related to hydrogen, methane, water vapour, carbon monoxide and carbon dioxide. All residual gases decrease at the same rate except for water vapour, but fortunately the PSD yield of water vapour is low. It stays approximately constant at the ini-

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tial photon exposure and begins decreasing at a beam dose of about 1Ah.

Figure 7 shows photon stimulated desorption yields for different masses in ozonated water cleaned chamber. The PSD yields of methane and carbon dioxide decrease faster than those for hydrogen and carbon monoxide. The PSD yields of water vapour are again very low and decrease little with beam dose.

Stainless steel chamber cleaning with ozonated water after chemical cleaning can reduce photon stimulated desorption yields. All main PSD outgassing yields are lower compared to mere chemical cleaning, especially for hydrocarbons. Photon stimulated desorption yields of high mass hydrocarbons for ozonated water cleaned chambers is much lower than for chemically cleaned chamber. The results are consistent with observations in aluminium alloy chambers. The method of ozonated water cleaning can reduce the carbon content in outgassing from the surface of a chamber.

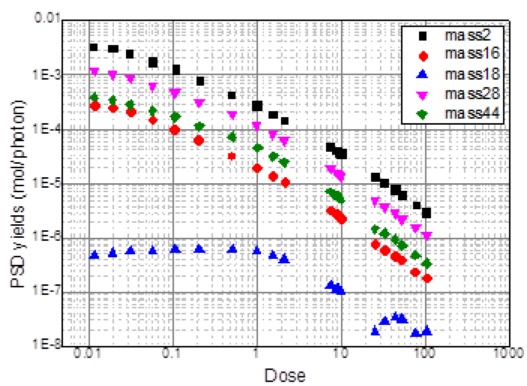

Figure 6: Photon stimulated desorption yields for different masses of chemically cleaned chamber versus total beam doses.

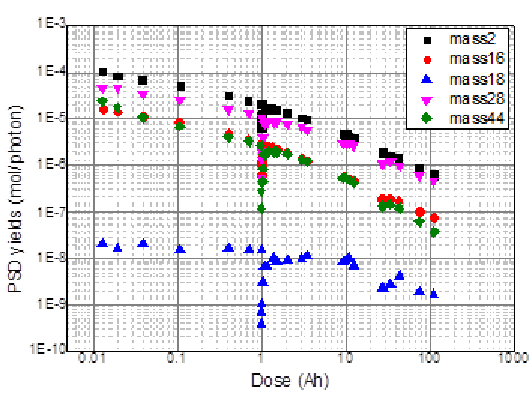

Figure 7: Photon stimulated desorption yields for different masses of ozonated water cleaned chamber versus total beam doses.

CONCLUSION

A stainless steel chamber subjected to different cleaning procedures was installed at the TLS beamline 19B. Photon stimulated desorption yields and partial pressure changes were determined after photon exposure. At the beginning of photon exposure, the photon stimulated desorption yields of the chamber cleaned with ozonated water is about one and a half orders of magnitude lower compared to mere chemically cleaned one. The main photon stimulated desorption outgases are hydrogen, carbon monoxide, carbon dioxide and methane. All major photon stimulated desorption outgases after ozonated water cleaning are lower, especially for hydrocarbons. Ozonated water cleaning can reduce the carbon content of outgassing from the surfaces of the stainless steel chambers.

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