THE IMPROVEMENTS OF VACUUM PERFORMANCE AT TAIWAN LIGHT SOURCE

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Abstract

The vacuum system of TLS storage ring has been upgraded recently. The upgrade plan includes the installation of NEG pumps, reducing the outgassing rate from the chamber and the gas leakage. The vacuum pressure was improved from 1×10^{-9} torr to 1.5×10^{-10} torr without electron beam stored in the chamber. During an 1.5 GeV, 200 mA electron beam operation, the pressure was also improved from 2×10^{-9} torr to 3×10^{-10} torr. For decreasing the outgassing rate, the ozonized water rinsing was developed. The surface characterization was characterized by the secondary ion mass spectrometry (SIMS) and photon stimulated desorption (PSD).

1 INTRODUCTION

The storage ring in the Taiwan Light Source (TLS) has been upgraded by installing the U5, EPU undulator chambers and replacing new bending chambers during the shutdown periods[1]. Several tasks have been done to increase the gas scattering related beam lifetime. For decreasing the outgassing rate of vacuum chambers, the ozone cleaning process has been investigated recently[2]. It indicated that the hydrocarbon on the surface was reduced by the reaction of ozone molecules with hydrocarbon to produce evaporable gas products (CO, CO_2, etc.) and evacuated away. We have developed a process of ozonized water rinsing followed by chemical cleaning in the laboratory. The result of surface cleaning was characterized by surface analytic tools, such as the secondary ion mass spectrometry (SIMS) and photon stimulated ion desorption (PSID). The photon stimulated ion desorption was measured by varying the photon energy. Owing to the good results on surface characterization, this method has been applied to the cleaning of U9 undulator chamber.

2 VACUUM IMPROVEMENTS

The improvements of SRRC vacuum from the end of 1996 to 1998 is shown in figure 1. These improvements have been done during each shutdown period. The accomplished tasks were : (1) The reduction of leakage rate - The junction of Al and the stainless steel was found to be the most probable leakage location. This was attributed to the difference of thermal expansion of these two different materials during the baking process. (2) The increase of pumping speed by installing more NEGs (non-evaporable getters) - Owing to the main residual gases in storage ring are H_2, CO, H_2O, CO_2, etc., more NEGs have been installed on most of the bending sections and cavity section to evacuate these gases. (3) The replacement of the outgassing components - This included replacing most of the O-ring gate valves by all metal gate valves. (4) The improvement on the sealing reliability of isolation valves - Another bellow valve was utilized to keep the atmosphere side of the isolation valve in the lower vacuum pressure to make sealing more reliable. Up to now, we have improved the vacuum pressure of this 120 m long storage ring to 1.5×10^{-10} torr. The dynamic pressure when an 1.5 GeV, 200 mA electron beam stored was reduced to 3×10^{-10} torr. After the vacuum improvement, the beam lifetime and stability related to the gases scattering were increased. No more holiday effect appeared on the first injection after the weekend shutdown[3].

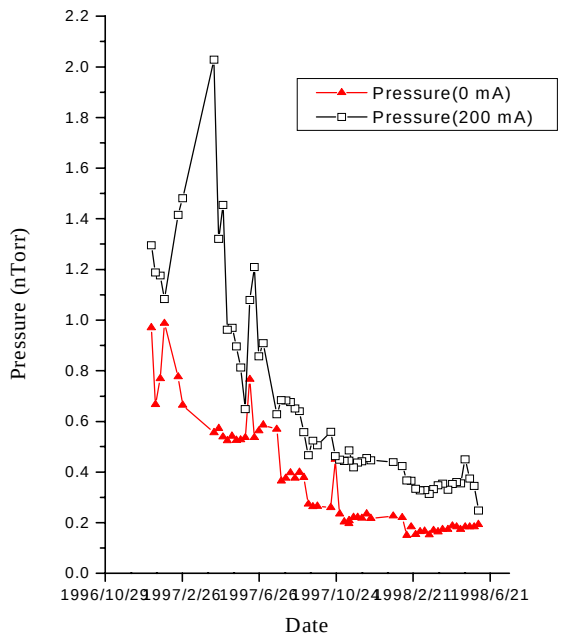

Figure 1. The average pressure of static vacuum and dynamic vacuum at 1.5 GeV, 200 mA in storage ring from the end of 1996 to 1998.

3 PHOTON STIMULATED ION DESORPTION

3.1 ozonized water rinsing

In addition to improve the vacuum for storage ring in the shutdown period, we developed a new cleaning process for vacuum chamber in the laboratory. This process is the chemical cleaning followed by an ozonized water rinsing. The ozonized water was generated by the mixture of ozone and deionized water. The concentrations in the water and the surrounding were simultaneously monitored by individual detectors. The maximum ozone concentration in the water achieved was about 8 ppm. The result of surface cleaning of Al sample through chemical cleaning and followed by ozonized water rising was characterized by the secondary ion mass spectrometry.

The comparisons of secondary ion intensities with and without this method were shown in the figure 2 and figure 3 for negative ions and positive ions, respectively. The results for negative ions in the figure 2 showed that the hydrocarbon contamination on the Al surface through ozonized water rising was much lower than using the chemical cleaning only (e.g. C^-, C_2^-, C_2H^-, etc.), whereas the signals of aluminum oxides (e.g. O^-, AlO^-, AlO_2^-, etc.) were not in the diminished trend. This resulted from the oxidation of hydrocarbons by ozone molecules and carried away by flowing the deionized water. The new oxide layers on surface were then formed after the contamination removed.

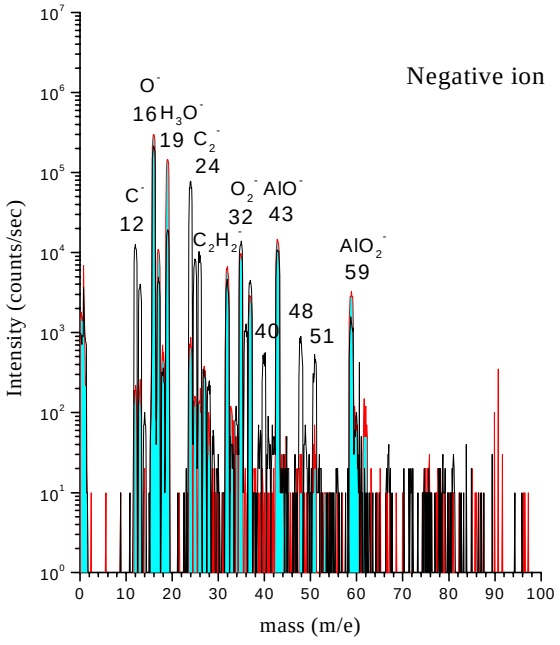

Figure 2. The negative secondary ion mass spectrum of Al alloy with (a) chemical cleaning only, (b) chemical cleaning followed by ozonized water rinsing (shadowed area).

The positive ions in the figure 3 showed that some alkali metals (e.g. Na^+, K^+) and alkaline-earth metals (e.g. Mg^+, Ca^+) were also reduced besides the hydrocarbons and oxides mentioned above. Apparently, these metals were not the compositions of aluminum alloy, we thought the surface might be contaminated in the chemical cleaning process. By the ozonized water rinsing method, these metal contamination were decreased. Owing to the good results of surface characterization, this method has been applied to the cleaning of U9 undulator chamber. It also showed a lower partial pressures of hydrocarbon in the residual gas analysis of the U9 chamber .

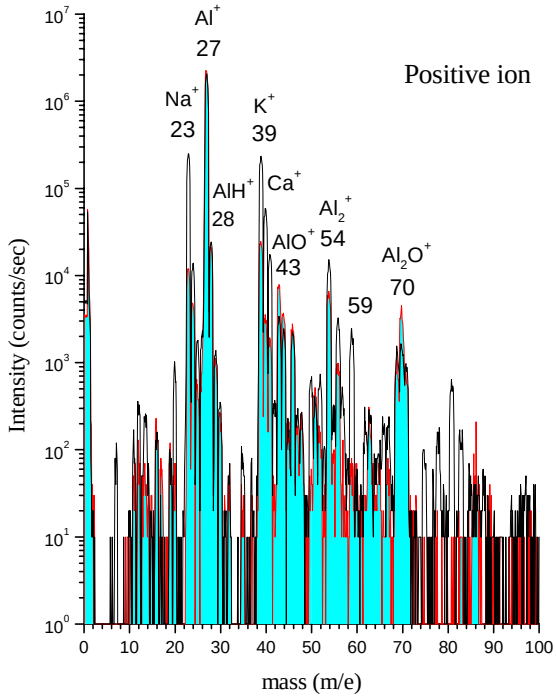

Figure 3. The positive secondary ion mass spectrum of Al alloy with (a) chemical cleaning only, (b) chemical cleaning followed by ozonized water rinsing (shadowed area).

3.2 Photon Stimulated Ion Desorption

Most of the experiments have focused on the neutral particles desorption from surface by photon irradiation. Only few experiments were done with the ion desorption. Furthermore, for avoiding the background interference from residual gases we worked on the ion desorption measurements from Al sample (13 mm × 11 mm) with ozonized water rinsing. The experiments were carried out by monochromic light and white light on 1 m LSGM beam line at SRRC.

When the ion desorption was measured, the sample was biased with +30 volts for positive ions and -30 volts for negative ions. The current produced on the sample by irradiation of photons was measured as the target current. All of the data were also normalized by photon flux. The

results by irradiation of white light showed that the most intense ions released from the Al sample were H_3O^+ (mass=19) and H^+ (mass=1). The observation of H_3O^+ might be from the combination of H^+ and H_2O or H and H_2O^+, because the PSID spectrum of H^+ and H_3O^+ had the similar behavior. By varying the photon energy from 50 eV to 150 eV, the PSID spectra of H^+ and the target current measurement were shown in the figure 4 and figure 5, respectively.

The direct excitations of Al (2P) for aluminum metal and oxide were evident at photon energy of 77 eV and 80 eV. It is proved by the energy difference of these components are the same as the energy separation of their binding energy. It was clear that the desorption peaks of PSID spectrum corresponds to the excitation of these states. We believed that the ions desorption at these energy was stimulated by the photoelectrons which were generated in the excitation process. In addition to the excitations of Al(2p), the PSID spectrum showed that a higher ion desorption yield at higher photon energy from 85 eV to 150 eV. The corresponding target current spectrum appeared to have a similar behavior. By reviewing the energy states of the other compositions of Al 6063 (e.g. Si, Mn, Fe, Cu, Ti, etc.), we found that the ion desorption could not be attributed to the excitations of these states, because the contribution was low by the product of their concentration and cross section of electron yield. Obviously, most of the ion desorption were assigned to the multi-hole and multi-electron excitations of aluminum which were generated in the relaxation process. However, we found that the ion desorption at photon energy from 50 eV to 150 eV was dedicated to the stimulation of electrons which were generated in the process of photon excitation.

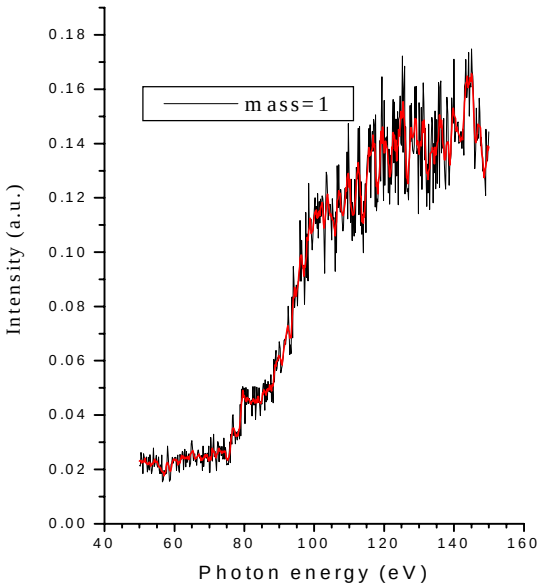

Figure 4. The photon stimulated ion desorption (PSID) spectra of mass=1 with variation of photon energy 50 ~150 eV.

4 SUMMARY

The vacuum system of TLS storage ring has been successfully improved. The beam lifetime and stability related to the gases scattering were increased. For the outgassing study, we found that the surface contamination of aluminum was further reduced by the extra ozonized water rinsing. The ion desorption from the excitation with white light revealed few hydrocarbon but more H^+ and H_3O^+. By variation of photon energy from 50 eV to 150 eV, we found that the ion desorption spectrum was coincidence with the target current measurement. It indicated that the ion desorption was dedicated to the indirect excitation of electrons which were generated in the relaxation process.

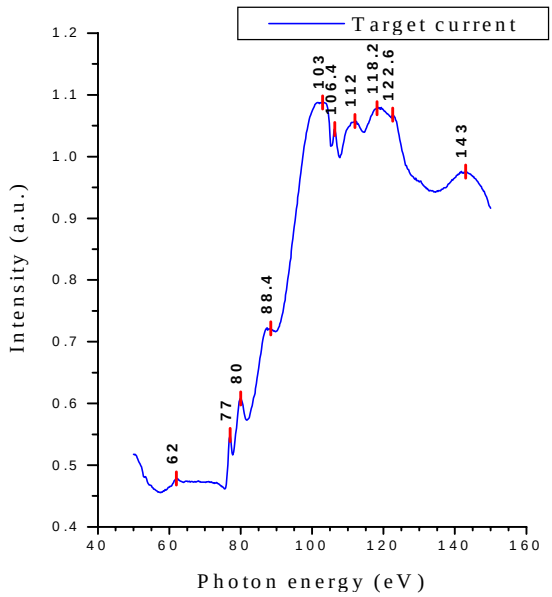

Figure 5. The target current measurement of Al alloy with variation of photon energy 50 ~150 eV.

5 ACKNOWLEDGMENTS

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