PHOTON STIMULATED DESORPTION PHENOMENA AT THE TAIWAN LIGHT SOURCE VACUUM SYSTEM

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Abstract

The photon stimulated desorption (PSD) by the synchrotron radiation irradiated from the Taiwan Light Source (TLS) vacuum chambers were analyzed. The desorption behavior of the various gas species were compared by either adjusting the electron beam orbit and hitting the photons on the fresh chamber walls or turning off the pumps. The dominated gases during the earlier years' operation are the H_2, in concentration of > 90%, followed by other gases, e.g. CO, H_2O, CH_4, etc.. However, some of the massive gas species, e.g. CxHy, CxFy, were observed after replacing the new vacuum parts or unsuitable baking the O-ring gate valves in higher temperature. The contaminated gases are to be reduced by beam-self cleaning treatment. Planning in upgrading the storage ring vacuum system is also described.

1 INTRODUCTION

In the Taiwan Light Source (TLS) of the Synchrotron Radiation Research Center (SRRC), three insertion devices, W20 wiggler (1.8 Tesla, 25 poles), U10P undulator (1.04 Tesla, 37 poles), and U5 undulator (0.675 Tesla, 75 poles), have been built and installed in the 1.3 GeV electron storage ring since the spring of 1995 to the spring of 1997[1]. The long straight section vacuum chambers were replaced by the new vacuum chambers for the insertion devices[2,3]. The photon stimulated desorption (PSD) phenomenon is continuously monitored by the residual gas analyzers located near the new chambers, and the performance of the vacuum system after installing the new chambers were also compared[4,5]. Several upgrading works to improving the performance of the TLS vacuum system are planned during the periods of the installation. The PSD phenomenon and the upgrading programs will be reported in this article.

2 PHOTON STIMULATED DESORPTION

The photon stimulated desorption (PSD) by the synchrotron radiation were measured by the quadrupole mass spectrometers located near the bending chambers. The dominated gases desorbed from the vacuum chamber

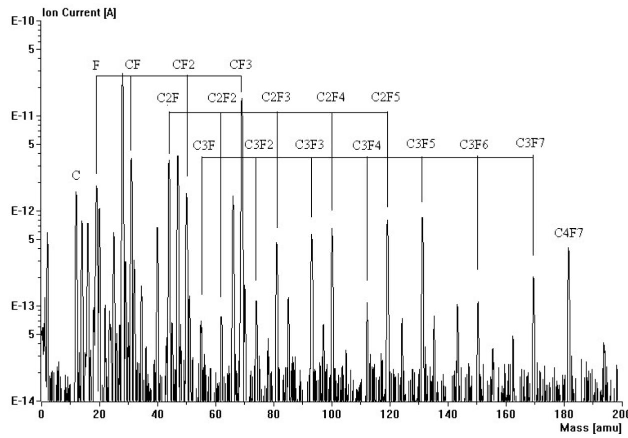

Figure 1:Mass spectrum near the bending chamber closed to the O-ring gate valve at a stored beam.

during the currently routine operation are the H_2, in concentration of > 90%, followed by other gases, e.g. CO, H_2O, CH_4, etc.[6]. However, an unsuitable baking an O-ring sealed gate valve to a temperature of 300 ℃ was occurred at once of baking a bending chamber in the storage ring by the end of 1996. Unlike other sections of the storage ring, some of the massive gas species, e.g. CxFy, were clearly observed at the bending chamber closed to the over-baked gate valve after baking as well as during a stored electron beam. Figure 1 shows the mass spectrum near the bending chamber at a stored beam which reveals the families of the cracked molecular ions decomposed from the CxFy molecules. The CF_3^+ ion, with mass number of 69, was selected as a better role to represent the behavior of the families of $CxFy^+$ cracking ions for easier illustrating the PSD phenomenon in various conditions in this article. Figure 2 shows the intensity of CF_3^+ ion observed near the contaminated area in three different conditions, the electron beam was injected and stored (region a), the nearby sputtered ion pump (IP) and the distributed ion pump (DIP) were switched off (region b), and the nearby non-evaporable getter (NEG) pumps were activated (region c). The increase of the intensity of CF_3^+ ion at a stored beam (region a) shows the observed outgas species of CxFy molecules were stimulated by the synchrotron photons and desorbed from the bending chamber wall near the contaminated area. The dramatic peaks appeared in

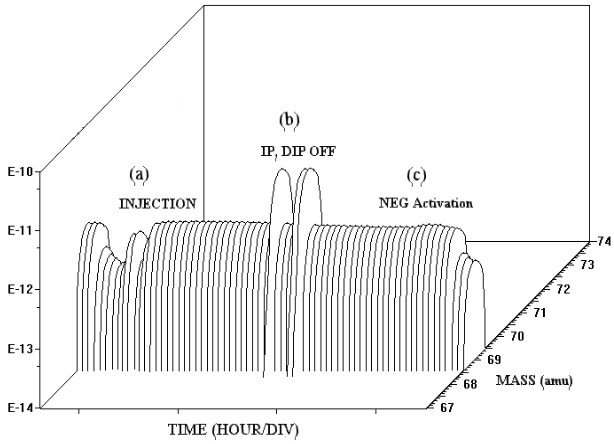

Figure 2:Intensity of CF_3^+ ion, mass [69], observed near the contaminated area at a stored beam.

region (b), when switching the IP and DIP off, reveal the pumping effect to the CxFy molecules is so efficient with the sputter ion pumps be operated. In region (c), no severe pumping effect to the CF_3^+ ions was observed during activating the NEG pump.

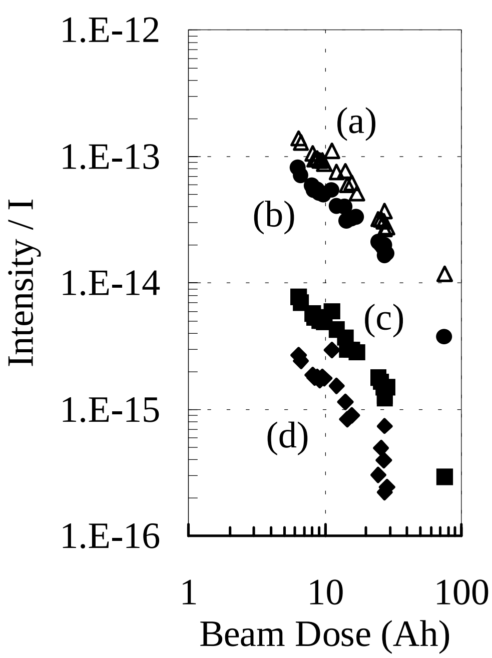

Figure 3:Curves of intensity of various gases, (a)[28], (b) [69], (c)[12], and (d)[2], per electron beam current as functions of the accumulated beam dose.

Figure 3 shows the curves (a) to (d) which represent the intensity of various gases with mass-over-charge ratio of [28], [69], [12], and [2], respectively, per electron beam current as functions of the accumulated beam dose. The behavior of the curve (b), [69], is similar to other curves which decay during the continuous beam running that reveals a fact that the contaminated gases could be effectively reduced by continuous exposure to the synchrotron radiation, which is so called beam-self cleaning treatment.

3 PLANNING IN UPGRADING THE TLS VACUUM SYSTEM

The planning to upgrade the vacuum system of the TLS electron storage ring, started from 1996, is to reduce the vacuum pressure, to reduce the impedance of the vacuum chambers, to remove the vibration source, etc.

3.1 Reduction of the Vacuum Pressure

The nuclear scattering between the electron beam and the gas molecules in the beam chamber will shorten the life time and induce the instability of the circulated electron beam. To maintain a vacuum pressure under 10^{-10} Torr in the beam chamber is necessary. The sources of the gas species contained in the vacuum chamber include (1) surface desorption from the vacuum chamber by the PSD process, (2) leakage, (3) outgas from the contaminated parts, etc. The observed outgas species in the TLS vacuum system can be classified as (1) H_2, (2) carbonate gas, e.g. CO, CO_2, CxHy, CxFy, etc., (3) leakage gas, e.g. N_2, O_2, Ar, etc., and (4) H_2O. Since the installed vacuum chambers in the storage ring had pre-cleaned by the oil-less machining, chemical cleaning, and the vacuum baking processes. Although the surface desorption induced by the synchrotron radiation can be effectively reduced by continuous exposure to the synchrotron light. However, it takes long time to reach the goal. It is necessary to improve the machining and the pre-cleaning processes if we want to reduce the carbonate gases.

The current undergoing works are reported as following mentioned processes. The gate valves sealed with viton or kalrez O-ring which have potential problems to produce the massive molecules, e.g. CxFy, come from the O-ring materials will be replaced by the all metal sealed gate valves. Increase the effective pumping to the H_2 and CO gases by adding the quantity of the non-evaporable getter (NEG) pumps into the vacuum chambers. Most of the leakages come from the sealing gasket between the stainless steel flange and the aluminum alloy flange after the baking process. The reason to induce the leakage is not so clear. However, the leak parts will be replaced during the shutdown periods.

3.2 Reduction the RF impedance of the Chamber

The chambers for the screen monitors will be replaced by the new designed chambers. The calculated rf impedance of the new chamber is 1% less than the original chamber for the screen monitor.

3.3 Remove the vibration source from the Chamber

Since the turbo-molecular pumps (TMP) and the dry pumps (DP) are the potential vibration sources to the vacuum chambers. On the other hand, it takes much effort to prevent the vacuum chambers from the back streaming contaminated outgas from the TMP and DP. Thus all the TMP and DP will be removed from the vacuum system after completing the roughing process and the vacuum baking by these pumps.

4 SUMMARY

The photon stimulated desorption phenomena and the future planning to improve the vacuum system of the TLS synchrotron light source is reported in this article. The contamination of the massive gas species, CxFy, was observed after an unsuitable baking an O-ring gate valve to 300 ℃ near a bending chamber. The families of the CxFy molecular ions clearly appeared when the electron beam was stored, which reveals a fact of the outgas species coming from the kalrez O-ring material. The outgas molecules were stimulated by the synchrotron photons out of the vacuum chamber wall near the O-ring gate valve. The contaminated gas molecules can be reduced by beam self-cleaning treatment during a long period beam operation. Due to the poor conductance of the vacuum beam pipes and the effective evacuation to the CxFy gas by the sputter ion pumps, no evidence was shown that the CxFy molecules had propagated to another sections of the storage ring. Future planning to upgrade the TLS vacuum system will improve the machining and the cleaning processes for the vacuum chambers, replace the new vacuum chambers with lower rf impedance, remove the vacuum parts contained the O-ring material, remove the vibration sources, e.g. TMP, DP, etc., increase the NEG pumps, and replace the leakage vacuum parts.

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