A Characteristic of Photon Stimulated Gas Desorption from Aluminum

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Abstract

The photon stimulated gas desorption (PSD) from aluminum is investigated experimentally in relation to the number of carbon on surface. The photodesorption yield (η) during the first stage of irradiation reduced by three orders of magnitude by removing the carbon on surface using argon ion etching. The amount of desorbed CH_4, CO and CO_2 decreases almost linearly as increasing the quantity of carbon removed. The results indicate that desorbed gas comes from the surface layer of aluminum in the initial stage of irradiation at least.

I. INTRODUCTION

The gas desorption from beam chambers irradiated by synchrotron radiation (SR) emitted from electron or positron beams is called the photon stimulated gas desorption (PSD). The PSD is very important on accelerator operation, since it reduces beam lifetime or increases the beam emittance. Lots of studies on the PSD have been reported and some characteristics have been made clear. Gas components desorbed from common beam chamber materials, such as stainless steel, aluminum and copper, are mainly hydrogen (H_2), methane (CH_4), carbon monoxide (CO) and carbon dioxide (CO_2). However, the quantitative relation between the condition of the irradiated surface and the amount of PSD, which is essential to understand the mechanism of PSD, has not been made clear.

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In this paper, we removed carbon on the surface of several aluminum samples by argon (Ar) ion etching and measured the photodesorption yield (η) of carbonate gases from these samples. Quantitative relation between the η and the carbon on the surface was obtained and the source of desorbed gas was suggested. The results are detailed in the following.

II. EXPERIMENTS

The experiment was performed at NE9 beam line of TRISTAN Accumulation Ring. The beam energy was 6.5 GeV and the critical energy of SR was 26.3 keV. The SR was collimated to 10 mm x 10 mm at 15 m from the source point. Incident photon number per beam current per second was 5.3×10^{18} photons/sec/mA. The collimated photons entered a sample chamber through an orifice with an aperture of 20 mm x 20 mm (conductance of 46 l/s for N_2 at room temperature) and hit normally aluminum samples. Total pressure of both side of orifice were measured using extractor gauges (LEYBOLD) calibrated previously by a spinning rotor gauge. Partial pressure in the sample chamber was measured using a quadrupole mass spectrometer (Balzers). The η is calculated by

$$\eta = \frac{K \times C \times \left\{ \left(P_1^{SR} - P_2^{SR} \right) - \left(P_1^{b} - P_2^{b} \right) \right\}}{N_p}, \quad \text{.....(1)}$$

where K is a constant = 3.3×10^{19} [molecules/Torr/l], C [l/s] is the conductance of orifice for each gas species and N_p [photons/s] is the number of photons. P_1 and P_2 [Torr] are the

pressures in the sample chamber and beam line, respectively. The superscript *SR* and *b* above P_1 and P_2 means the pressures during and before photon irradiation, respectively.

The sample chamber has an ion gun to remove carbon on aluminum samples. The surface analysis chamber with an Auger electron spectrometer (AES) is connected through a gate valve to the sample chamber. The surface analysis of irradiated sample pieces, therefore, can be done without exposing them to air and at any time.

Sample pieces were cut from EX-extruded aluminum alloy (A6063-EX) [1] by oil-free machining. They received an ultrasonic cleaning in an acetone bath. The area of sample piece has 27 mm x 30 mm with a thickness of 3 mm. These pieces were etched by argon ion in different ion dose and analyzed by AES. The amount of carbon removed was calculated using depth profile.

III. RESULTS AND DISCUSSIONS

Four sample pieces, SP1 - SP4, with different quantity of carbon were prepared. Argon ion dose and total number of removed carbon for each sample were presented in Table 1. Figure 1 shows the total η in N_2 equivalent for each sample as a function of photon dose. The η at the photon dose of $2\text{x}10^{17}$ photons/cm^2 of SP3 and SP4 were lower by one order of magnitude than that of SP1 (untreated). The η of SP2 was further lower by about two orders than SP3 and SP4 at the same photon dose. The η for CO and CO_2 are

Table 1 Ar ion dose and total number of removed carbon

	Ar ion dose ions/cm^2	Removed carbon atoms/cm^2
SP1	0	0
SP2	$2.2\text{x}10^{18}$	$3.7\text{x}10^{16}$
SP3	$2.2\text{x}10^{17}$	$1.1\text{x}10^{16}$
SP4	$5.7\text{x}10^{17}$	$1.8\text{x}10^{16}$

shown in Figures 2 and 3, respectively. The η decreased in the order of the number of carbon removed. The results indicated the strong correlation between η and the number of carbon remaining on the surface.

The η of CH_4, CO and CO_2 at the photon dose of $1\text{x}10^{20}$ photons/cm^2 became almost equal for all samples as

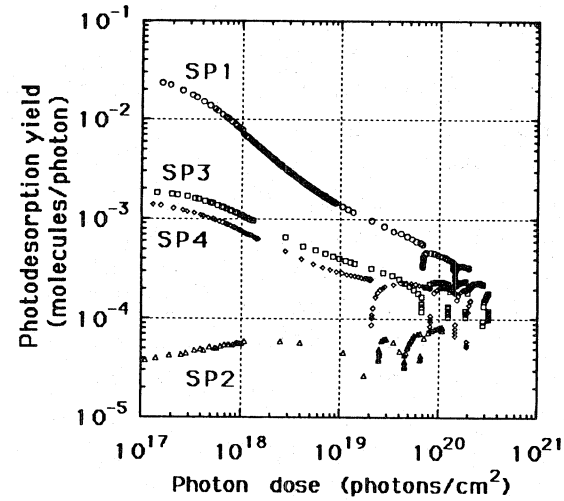

Figure 1. Total photodesorption yield.

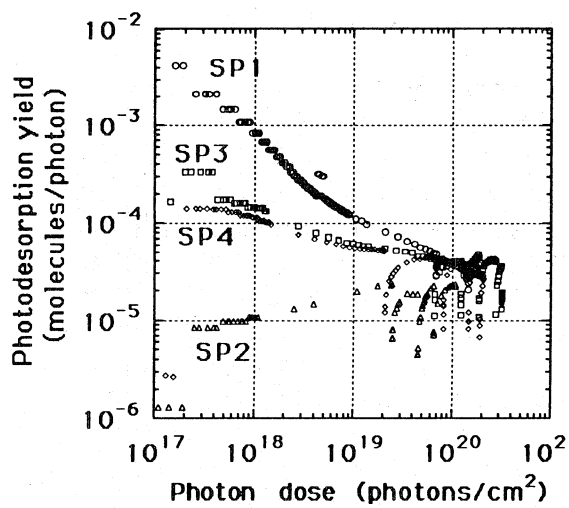

Figure 2. Photodesorption yield for CO.

shown in Figures 2 and 3. Total amounts of these gas species integrated up to $1\text{x}10^{20}$ photons/cm^2 for each sample are shown in Figure 4 as a function of the amount of carbon removed. The reduction of the total amount of main carbonate gas species is apparently proportional to the amount of carbon removed. A dashed line in Figure 4 was obtained by a least square

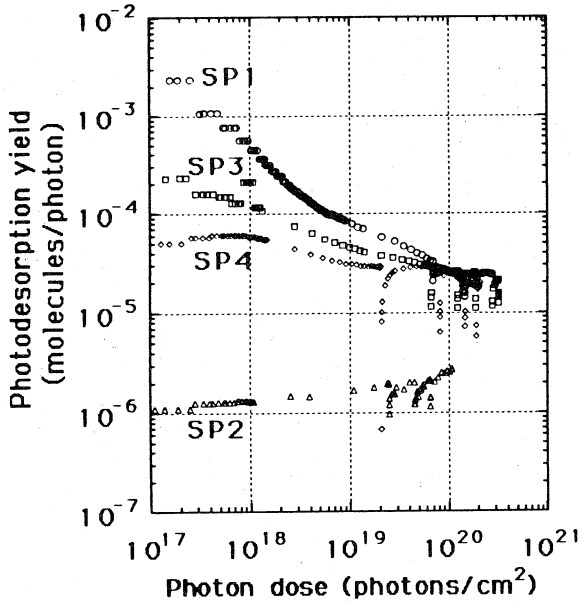

Figure 3. Phtodesorption yield for CO_2.

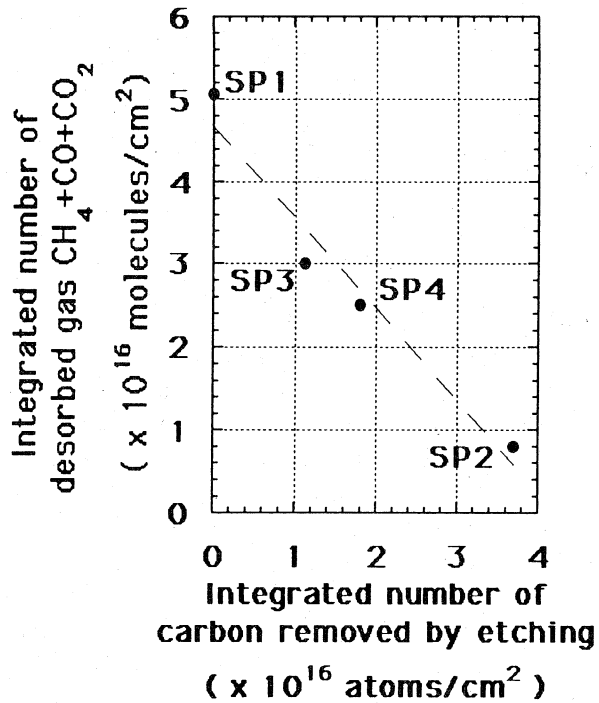

Figure 4. Total amounts of carbonate gas species integrated as a function of the amount of carbon removed. A dashed line in figure is obtained by a least square method and its slope is about -1.

method and its slope was about -1. This suggests that the gas desorbed comes from the surface layer of aluminum in the initial stage of irradiation at least.

IV. SUMMARY AND CONCLUSIONS

The relation between the η of carbonate gases from aluminum and the number of carbon on the surface layer was studied. The η at the initial photon dose reduced drastically by removing carbon on aluminum surface by ion etching. The amount of desorbed CH_4, CO and CO_2 decreased almost linearly as increasing the number of carbon removed. It was suggested that the source of desorbed gas in the initial stage was the surface layer of aluminum.

V. REFERENCE

[1] H. Ishimaru, J. Vac. Sci. Technol. A9, 1984, pp. 1170.