IEEE Transactions on Nuclear Science, Vol. NS-26, No. 3, June 1979

NEUTRAL MOLECULE DESORPTION FROM SS(304) AND Al(6061) DUE TO PARTICLE BOMBARDMENTS*

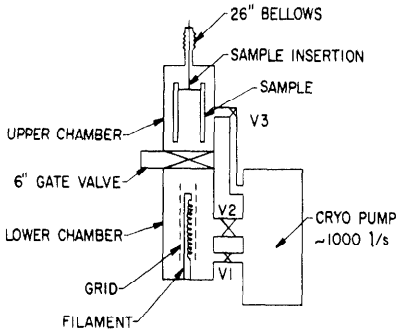
D. Edwards, Jr.[a]

Abstract

The pressure in both electron and proton storage rings is dependent on the particle wall bombardment molecular desorption rates due in one case (proton storage rings) to ~ keV ions while in the other to ~ 100 eV electrons. Also in order to minimize secondary electron amplification effects in both types of machines the secondary electron emission coefficient should be as low as possible. The above quantities have been measured on Al(6061) and SS(304) materials having had various treatments including a sputter deposition of Ti and TiN in the case of Al. The results indicate for both electron and proton storage rings that SS(304) materials properly prepared have particular advantages over Al considering both molecular desorption yields and secondary electron emission effects.

INTRODUCTION

The desorption of neutral molecules from the walls of vacuum chambers due to the bombardment of the wall by energetic particles is a source of outgassing in electron storage rings[1] and may lead to pressure instabilities in proton storage rings. In order to ascertain the effect of material and treatment on the vacuum performance of the ISABELLE storage ring, a desorption test facility was constructed (Figure 1)



DESORPTION TEST FACILITY

allowing a sample with appropriate in lab treatment to be inserted into the instrument and the entire system plus sample baked to ~ 200°C. After this preparation both the ion and electron desorption yields and the unit yield energy (E_o) are measured.[2]

Results

Both stainless steel (304) and aluminum materials were studied with various treatments and are listed below.

I. s.s., vacuum fired (typ. 900°C, 4 hrs.), glow discharged (an Ar^+ dose typ. of 1E18/cm^2), 200 C bake.
II. As 1, but unbaked.
III. s.s., electropolished, then treated as 1.
IV. Al(6061) with a degrease only treatment, ~ 200 C bake (see ref. 2).
V. Al(6061) with a sputter deposited Ti coating using N_2^+ or N^+ as the ion projectile. A coating typ. of 100-1000 A was deposited.
VI. As 5 using Ar^+ as the projectile.
VII. As 5 using O_2^+ or O^+ as the projectile.

The results are reported in Tables I and II.

Table I Stainless Steel Desorption Yields For Various Preparations

	I		II		III	
	Ar^+	e^-	Ar^+	e^-	Ar^+	e^-
H_2	<.3	2E-3	2.4	3E-2	<.3	3E-3
CO	1.1	6E-4	3.9	1E-2	1.0	8E-4
CO_2	1.0	2E-3	3.3	4E-2	4.7	
CH_4	1E-2	3E-5	0.2	8E-4	1E-2	6E-5
E_o(eV)	>400	>400	>400		>400 eV	

TABLE II Aluminum Desorption Yields For Various Coatings

	IV		V		VI		VII	
	Ar^+	e^-	Ar^+	e^-	Ar^+	e^-	Ar^+	e^-
H_2	1.5	0.3	0.16	0.001	0.18	0.004	0.08	0.005
CO	1.4	0.1	1.6	8E-4	1.0	0.02	1.2	0.07
CO_2	0.4	0.3	4.8	0.04	3.0	0.5	15	6
CH_4	0.06	0.007	0.008	7E-5	0.01	6E-4	0.01	6E-4
E_o(eV)	50		>400		>400		175	

The Ar^+ yields are for a 1000 eV Ar projectile where as the e^- yields are for a 500 eV indident electron.

Discussion

Stainless Steel Results. One of the unexpected results of this study is that the hydrogen desorption yields on s.s. after a vacuum firing are considerably less than on nonfired samples, indicating that the dissolved hydrogen influences the surface hydrogen concentration. Also seen from Table I, is that the electropolishing treatment has a small effect on the desorption yields.

It is interesting to note that the unbaked s.s. tube had desorption yields ~ 10 times larger than the sample baked at 200°C likely due in part to the ~ 1 monolayer of the H_2O weakly adsorbed on the unbaked sample. This measurement is useful in that it does imply that for low desorption yields, a baked chamber is required.

Aluminum Results

There are two observable effects on the measurements for the various coatings on the aluminum samples. One is the distinct increase of E_o from 50 eV for untreated aluminum to a value greater than 400 eV for the Ti-N_2 coating. The possible significance of the unit yield energy on machine performance has been discussed elsewhere.[3] The other effect is the dependence of the CO_2 yield on the particular coating. Among the various coatings studied, the Ti-N_2 or Ti alone has provided the lowest desorption yields together with high values

*Work performed under the auspices of the U.S. Department of Energy.

[a]Brookhaven National Laboratory, Upton, NY 11973

0018-9499/79/0600-4089$00.75 © 1979 IEEE

of the unit yield energy. It is interesting to note that the Ti-O_2 coating produced very high ($\sim$ 15) CO_2 yields with correspondingly low unit yield energies (175 eV), which makes it particularly unsuitable as an aluminum coating.

Discussion

The results obtained to date indicate both from the point of view of pressure instabilities and secondary electron amplification that suitably prepared stainless steel should present no particular vacuum difficulties in the presence of a proton beam. It has also been found that the stainless steel material results in electron desorption yields an order of magnitude lower than untreated aluminum and a unit yield energy of 400 eV compared to 50 eV for untreated aluminum. Thus, for electron storage rings, vacuum problems should be significantly reduced by the use of properly prepared stainless steel beam tubes as opposed to untreated aluminum chambers.

References

1. E. Fischer, J. Vac. Sci. Technol. 9, 1203 (1972).
2. For further experimental details see: D. Edwards, Jr., J. Vac. Sci. Technol. 15, 1586 (1978).
3. D. Edwards, Jr., Nuclear Instrum. Methods 150, 339 (1978).