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SURFACE CONDITIONING OF SYNCHROTRON RADIATION SOURCE TO IMPROVE BEAM LIFETIME

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Introduction

Surface cleanliness is of prime importance to achieve the desirable vacuum condition for long beam lifetime in all synchrotron radiation sources. The Photon Factory at KEK resolved the severe gas load from synchrotron radiation by in-situ Ar glow discharging the whole storage ring.[1] Sufficient experience had been gained in the past two years operation on the synchrotron radiation source, especially on the VUV ring of the National Synchrotron Light Source (NSLS), to allow us to decide to glow discharge the VUV ring. In hoping to obtain higher circulating current and to reveal the cause of lifetime limitation, a better understanding of the beam loss mechanism is needed. Photo desorption is the major gas load in all existing electron (positron) storage rings. It is generally believed that these photodesorbed species (neutral and charged) provide the major loss mechanism to lessen the beam lifetime. The interaction of these species to the beam give rise to the various loss mechanisms[2,3] such as multiple Coulomb scattering, single scattering, bremsstrahlung and ion trapping. All these mechanisms has been under intense study at NSLS. This report only describes the result of surface condition and beam lifetime.

Experiment and Results

The experimental set-up is shown in Fig. 1. The goal of the glow discharge cleaning is to condition the beam tube surface to smooth the initial commission phase. The effeuence of the glow discharge is Argon with 10% oxygen mixture. The discharge voltage is about 400 volts, the gas pressure at 30 m Torr. The mass spectrometer at the pumping station (TMP) is used as a monitor during glow discharge cleaning. The mass spectrometers at various locations of the ring are used to monitor the effectiveness of the glow discharge at the end of cleaning procedure. Eight of the bending magnets are glow discharged through the anode of the distributed ion pumps in pairs. The opportunity to study the adverse effect of Fomblin oil on the beam lifetime was offered to us via an unfortunate accident which resulted in Fomblin oil diffusing into the beam tube. Immediately following the accident, additional glow discharge cleaning along with 100°C bakeout was initiated. The effect of the Fomblin oil on the beam lifetime is shown in Fig. 2 through Fig. 5. Comparing the spectra from Fig. 3 to Fig. 2 one can see clearly that the Fomblin oil which has a major peak at M/e = 69 is evaporated by the photoflux of a very weak beam of 25 mA. At the same time the M/e = 19, believed to be F, have increased many fold. The beam lifetime at this point is unacceptably short, τ = 18 minutes. Figure 4 snows the different behavior of M/e = 19 peak than M/e = 69 Fomblin oil peak. Mass 69 peak decreases progressively as beam dosage increases while mass 19 peak increases as beam dosage. But at a given dosage both mass peaks increase as the beam current increases until either the beam exhausts its source such as Fomblin oil case, as shown in Fig. 5, or the source has saturated the mass spectrometer such as F peak case. After 10 ampere-hours of beam conditioning, the Fomblin oil is essentially removed from the beam tube and the beam lifetime vs. the beam current has been measured. Table 1 lists the results of this study.

Table 1. VUV Lifetime Studies After Fomblin Oil Spread

I(ma)	P(Torr)	τ(minutes)	Mode	τ^*(minutes)
47	2.2×10^{-9}	61	Storage	130
100	3.6×10^{-9}		Injection	
150	4.9×10^{-9}		Injection	
135	4.7×10^{-9}	30	Storage	
180	5.6×10^{-9}		Injection	
177	5.7×10^{-9}	27	Storage	
214	6.5×10^{-9}		Injection	
200	---	23	Storage	70
0	1.3×10^{-9}	--	No beam	

τ^* is based on 1 bunch, 0.22 mm < σ_y < 0.24 mm dated on 8/30/84 before VUV shutdown for maintenance.

The inability to achieve an acceptable beam lifetime as shown in Table 1 has been attributed to a high Z component in the outgassing spectrum from the RGA.

Based on this strong evidence, we opted for an unconventional cleaning method of the VUV. 10^{-8} Torr of H_2 was introduced into the beam line via the hot titanium filaments from titanium sublimation pumps. The H_2-F reaction product, HF, was observed (in small quantities) on subsequent RGA scans during beam current treatment. The fresh Ti provided sufficient pumping of the HF. The significant lifetime improvement shown in Table II clearly indicates the effectiveness of this treatment.

Table II. After Beam Conditioning at H_2 Atmosphere of 10^{-8} Torr

I(ma)	P(torr)	τ(minutes)
30	0.1×10^{-9}	240
60	0.2×10^{-9}	160
100	0.3×10^{-9}	136
205	0.8×10^{-9}	76

The increase in mass 20, which we believe to be HF, is shown in the RGA spectra before and during beam injection (as shown in Fig. 6).

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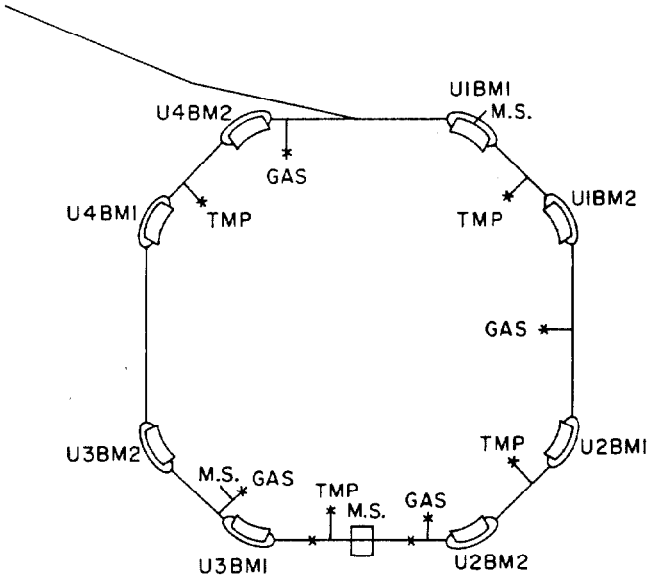

VUV RING: GLOW DISCHARGE CLEANING FACILITIES
Fig. 1

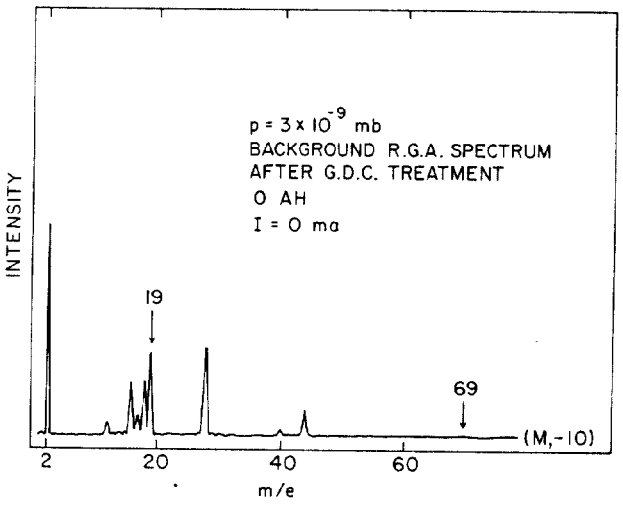

Fig. 2

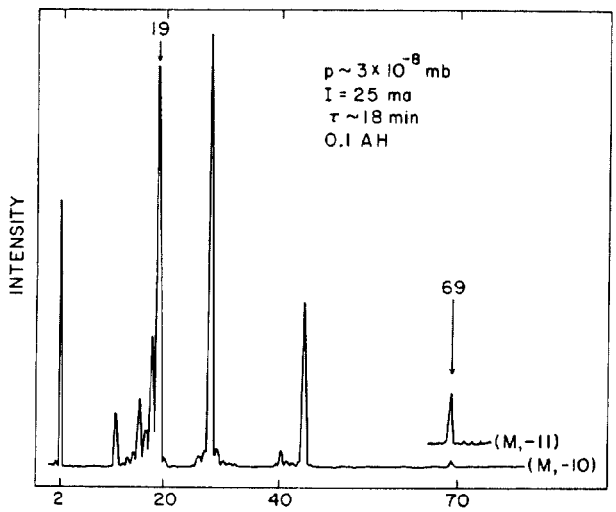

Fig. 3

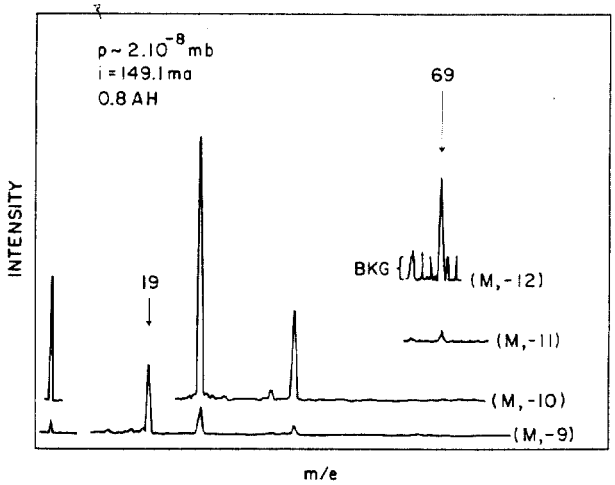

Fig. 4

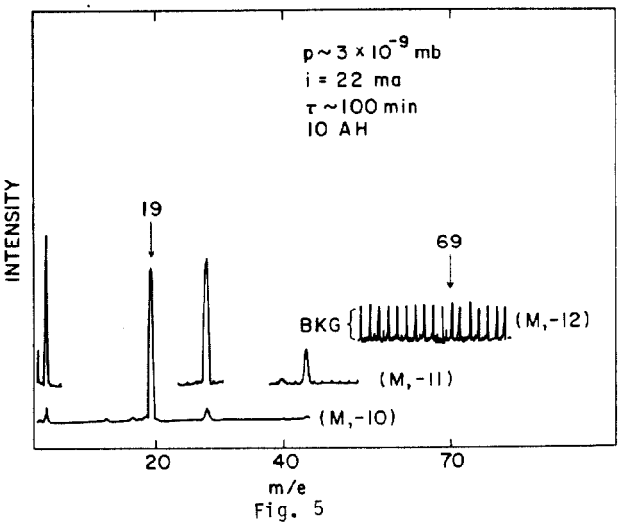

Fig. 5

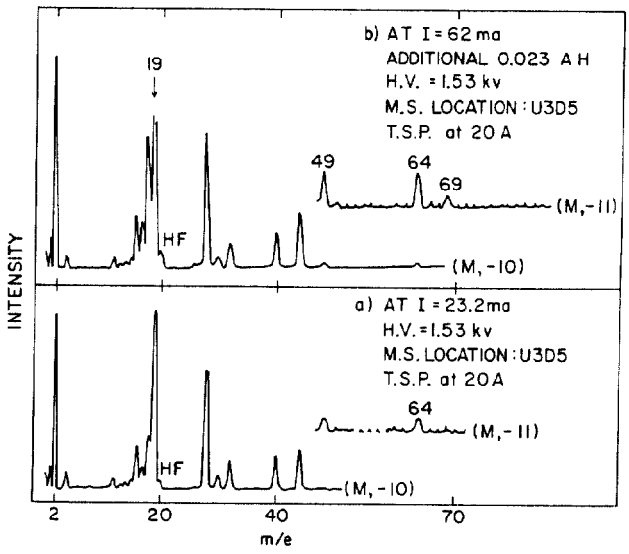

Fig. 6