Surface Conditioning of Accelerator Components: Secondary Electron Yield and Chemical Analysis

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Acknowledgements

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Outline

1. Background
2. APS Experiments
3. XPS and SEY Measurements
4. Future Work

What is Conditioning?

•Experience at numerous facilities has shown that over time, the performance of many accelerator structures (RF cavities, vacuum chambers, etc.) improves.

•The accepted reason for this is that photon and/or electron interaction with surfaces causes desorption of gases and reduction of the surface metal-oxide layer.

•The resulting surface has less gaseous species which could be desorbed and a lower secondary electron yield (SEY) coefficient (more metallic).

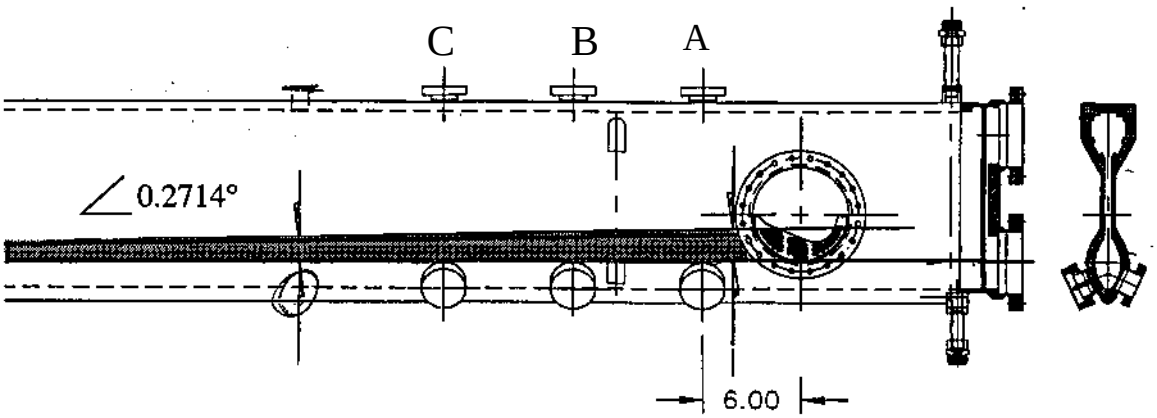
Literature on Surface Oxide Reduction

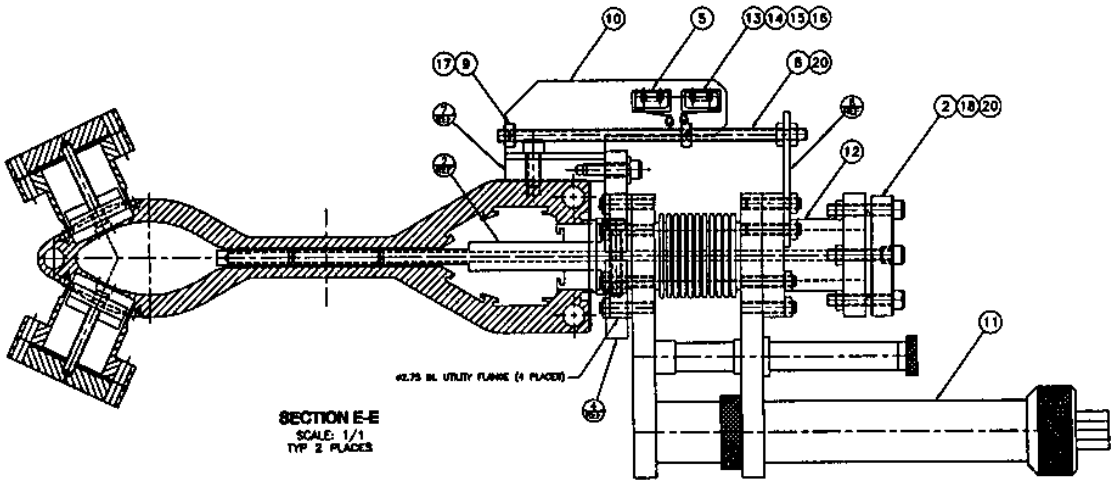
- Saphire reduction using 1-3 keV electrons: J.-W. Park, A.J. Pedraza, and W.R. Allen, J. Vac. Sci. Technol. A **14**, 286 (1996); A. Hoffman and P.J.K. Paterson, Surf. Sci. **352-354**, 993 (1996). Observe production of metallic Al as the result of electron bombardment.
- SR photon modification of 6063 Al oxide: T. S. Chou, NSLS Activity Report, U7B (1991). Using XPS observe loss of oxygen from surface oxide layer as the result of broadband SR.
- 2 keV Electron bombardment of 6063 Al alloy oxide layer: M. Andritschky, Vacuum **39**, 649 (1989). Observe loss of oxygen, but, also, growth of carbon on alloy oxide surface. See no growth of carbon on clean surface.
- 1067 eV bombardment of metal-nitride and metal-carbide films: E.L Garwin, F.K. King, R.E. Kirby, and O. Aita, J. Appl. Phys. **61**, 1145 (1987). Saw a reduction in surface oxides and SEY coefficient.

Experimental

- Three targets with different surface coatings (Cu, oxidized Al, TiN) were installed in the APS storage ring in October, 1998, and removed in October, 1999. XPS and SEY measurements were performed before installation and after removal.
- Typical pressure in the vacuum chamber containing the targets was 1-2 x 10^{-10} torr. RGA spectrum was dominated by mass 2 (H_2) and mass 28 (CO, N_2).
- Targets were exposed to SR at an angle of 5ˆ for between 1-4 hours each. Measured target current was ~100 µA with 20 mA in the storage ring.
- When retracted the target current was ~100 nA when positrons were used(90 Amp-hours) and ~20 nA when electrons were used (270 Amp-hours) at a storage ring current of 100 mA.

Modified Chamber





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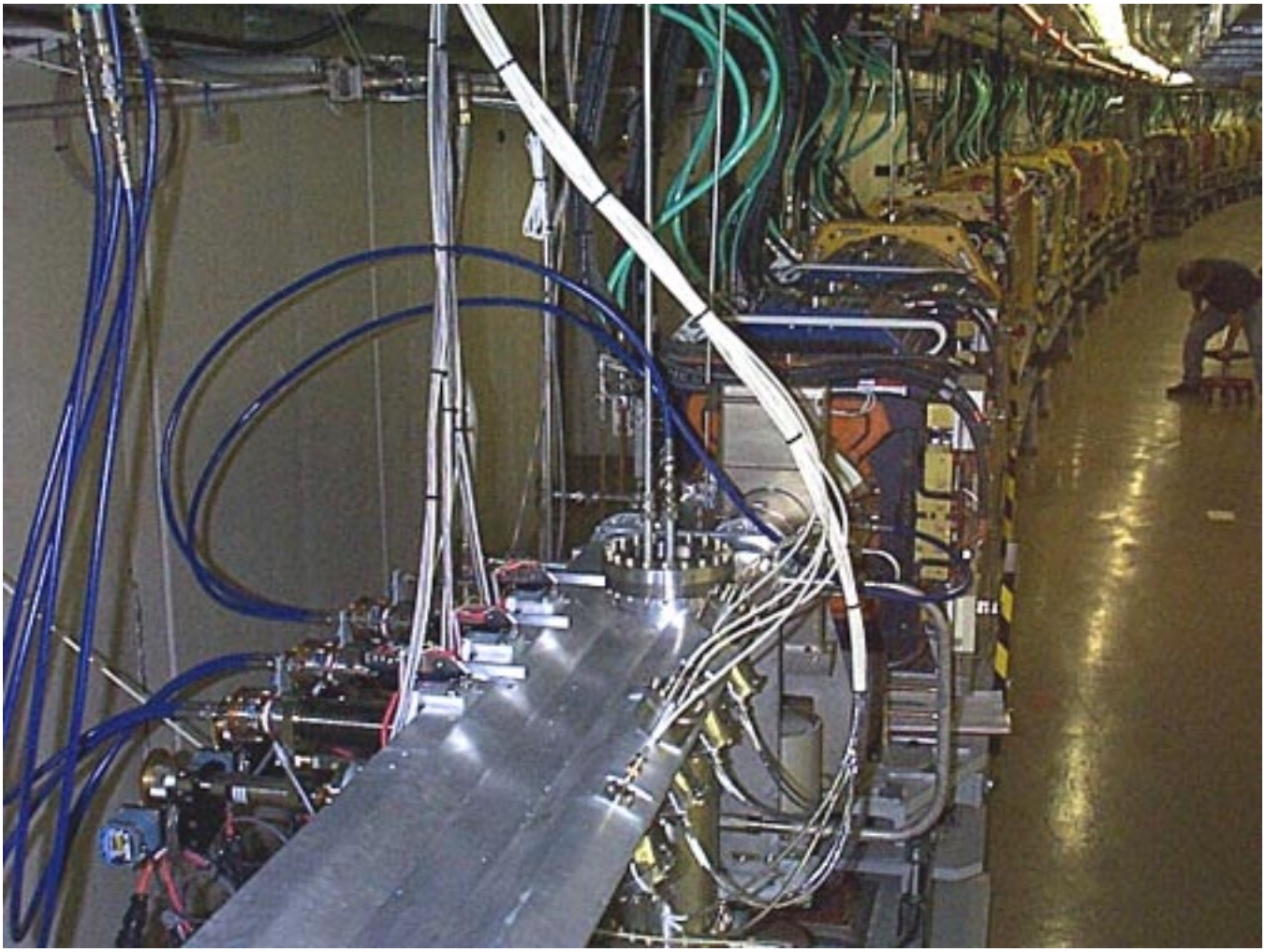
Pictures of Al-coated target



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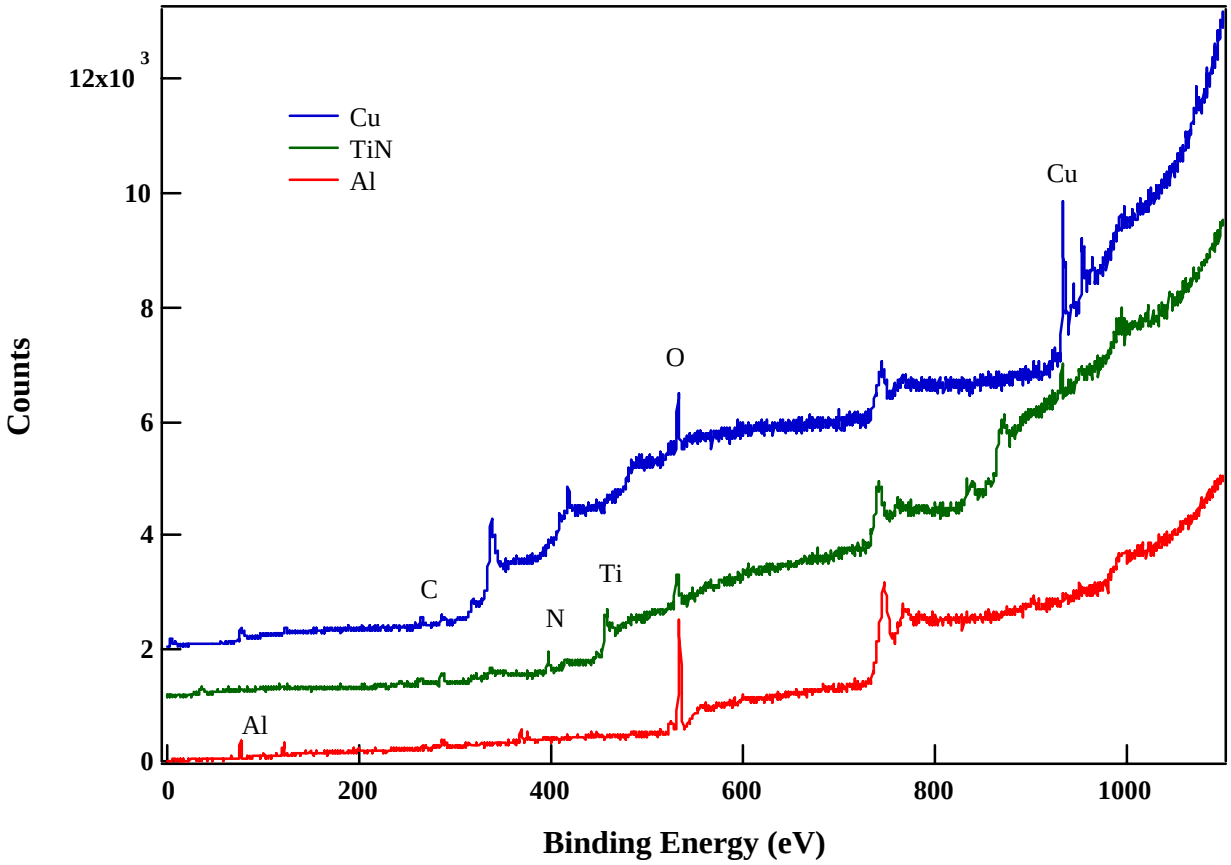
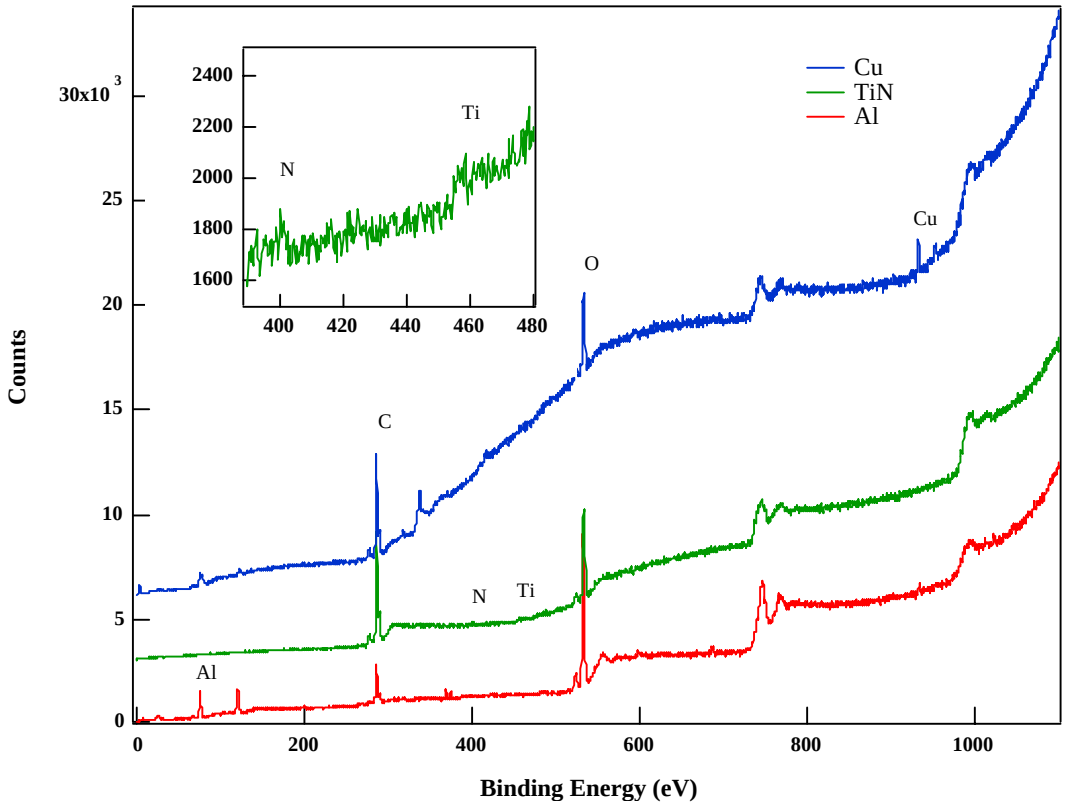
XPS Results From Targets Before Exposure



XPS Results From Targets After Exposure



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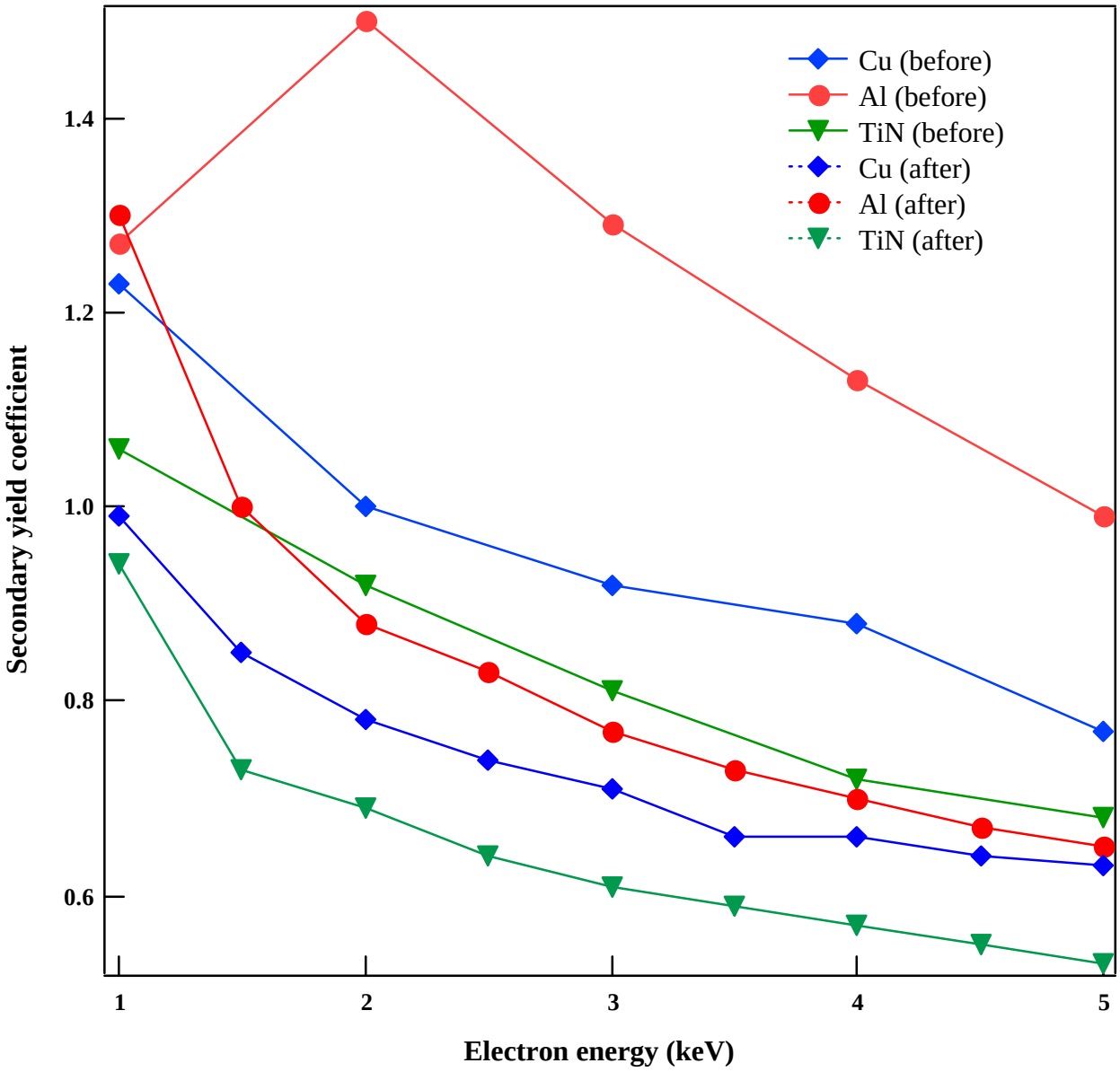
Effects of exposure to accelerator environment on carbon/metal (C/M) and oxygen/metal (O/M) intensity ratios

	C/M	O/M
Al	0.3 1.4	6.5 5.6
Cu	0.1 2.5	0.3 2.1
TiN	0.2 36	0.7 30

Before exposure
After exposure

Secondary Yield Coefficients of Targets



Literature on Surface Carbon Growth

- Carbon contamination in an electron microscope: J. Hillier, J. Appl. Phys. **19**, 226 (1948).
- Carbon contamination on mirror surfaces exposed to synchrotron radiation, K. Boller, R.-P. Haelbich, H. Hogrefe, W. Jark, and C. Kunz, Nucl. Instr. Meth. **208**, 273 (1983). Examined the growth rate of carbon films on different substrates and under various conditions. Developed model.
- Deposition of carbon on gold using synchrotron radiation, R.A. Rosenberg and D.C. Mancini, Nucl. Instr. Meth. **A291**, 101 (1990). Investigation of the deposition of carbon on gold using broadband SR while varying gas composition, pressure, and substrate temperature.

Future Work

- In April we are planning to install well-characterized (XPS, SEY) samples in several locations in the APS storage ring. Four samples will mounted at each location: two facing the beam and two shielded from the beam. We will measure the sample current at each location.
- In 6-12 months we will remove the samples and characterize them again.
- We hope the results will allow us to more definitely answer the question “What is conditioning?”