Comparison of Spacecraft Contamination Models with Well-Defined Flight Experiment

NAS8-40581

Progress Report for May 15, 1997 to August 15, 1997

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1. During this reporting period, ESCA survey measurements were completed on the tray wall sections cut from LDEF tray locations C6-2, A4-9, and E10-8. This concludes the ESCA survey activities on this contract, pending any additional requests by the contract monitor. All results to date from these three surfaces are included in figures 1-3. A first set of depth profiles has been carried out at locations on E10-8. Figures 5 through 13 show the auger sputtering profiles from the locations identified in figure 4. Profiles taken at locations C-1 through -5, and C-8, show thin layers which appear to be essentially silicon dioxide. The ratio of silicon to oxygen is approximately 1 to 2. The carbon profile shows a little surface carbon, as expected from exposure to the atmosphere post-flight, and then extremely low carbon levels in the silicon dioxide layer. At the depths where the silicon intensity begins to decrease, the aluminum peak begins to increase. This indicates the top of the aluminum oxide(anodized) coating. The profile for location C-6, which is quite close to the discolored region, shows a much thicker silicon dioxide layer(almost 1500 angstroms) but otherwise is similar to the previously discussed peaks. The depth profiles from locations C-7 and B-1 are quite complex. The silicon and carbon profiles show periodically varying intensities. The best initial estimate is that these profiles represent very thick deposits from both the silicone based adhesive and hydrocarbon based outgassing sources, such as the polyurethane based paint from the interior of the tray, covered by a silicon dioxide layer. Because the sputtering system is calibrated for SiO2, the sputter rate becomes more difficult to interpret as the carbon content of the material increases. This means the depths shown on the profiles are not very accurate after the first several thousand angstroms of sputtering.

To begin to interpret these profiles it should be kept in mind that the mission time essentially goes from right to left. The first material deposited is the material with the very high carbon content. The periodicity in the intensity levels may be a function of seasonal variation of the sun orientation with respect to the surface, but this is just a guess at present. The oxygen flux rate was much greater toward the end of the LDEF flight relative to the first 3-4 years, so much of the surface oxidation could have occurred over the last few months of the flight. In summary, the contamination deposits directly across from the vents are complex mixtures of materials and the mechanisms by which they may have been changed, once deposited on the surface, are not yet clear. The next surface to be depth profiled will be from tray C6, which saw less than 1% of the atomic oxygen exposure received by tray E10. Tray C6 did see about 60% of the solar exposure level received by tray E10.

Figures 14 and 15 show peak energies and peak shapes for silicon ESCA peaks at different sputtering depths. The peak positions have not yet been corrected for possible charging effects. The position of the Carbon peak has also been measured at each of the nominal depths, but this data is not yet available. The areas under the peaks reflect the relative amounts of silicon at the different depths. Figure 15 shows the peaks normalized to identical areas in order to show the relative shapes of the peaks. The peaks at a nominal depth of 101.5 nm suggest at least two very different materials mixed at this level.

Scanning electron microscope images of fracture specimens from tray E10-9 show a flexible elastomeric contaminant layer covering the anodized aluminum layer on the tray lip. This is essentially material deposited from the silicone gasket post-flight. The contaminant layer along the tray wall has a very brittle structure, suggesting an oxidized material from the on-orbit exposures. The sequence of photos in figure 16 shows a view of a discolored area from an area near position E10-9(a surface at the Earth end of the tray facing space) and locations from which fracture samples were taken. The remaining photos show views of the surface at selected locations and edge-on views to show the structure of the contaminant layers on top of the anodized aluminum.

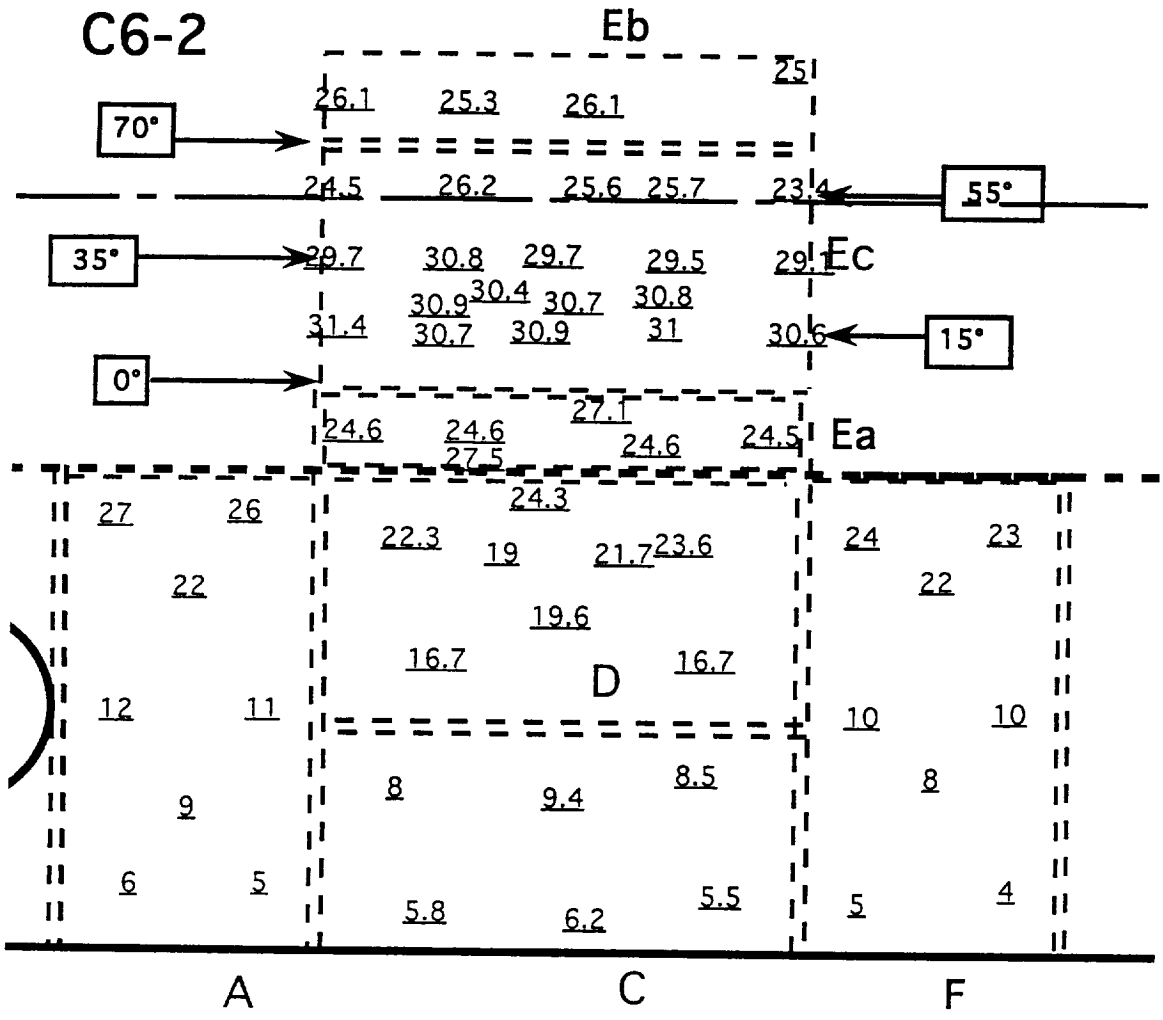
Results of work-to-date on this contract were reported at a Spacecraft Coatings/Contamination workshop July 9-10, 1997. This workshop was sponsored by the Contamination Working Group of the Space Environments & Effects Program.

2. At this time, there are no technical issues impeding the progress of the required contract tasks.

3. During the last phase of this contract, depth profiling will be completed, the model calculations will be carried out, results for all work on this contract will be summarized in presentations given at MSFC, and the final report will be written. Results will be packaged for inclusion on the Space Environments & Effects Program web page.

4. Costs are in line with the percentage of completion of tasks. The expended budget is 81% of the total and the project is approximately 81% complete. Approximately 15% of the overall budget is identified for the subcontractors on this contract.

List of Figures



Percent Silicon

'Unbent' sample pieces

Figure 1. Diagram showing Percent Silicon on the tray surface C6-2 at the measured locations for all individual ESCA measurements.

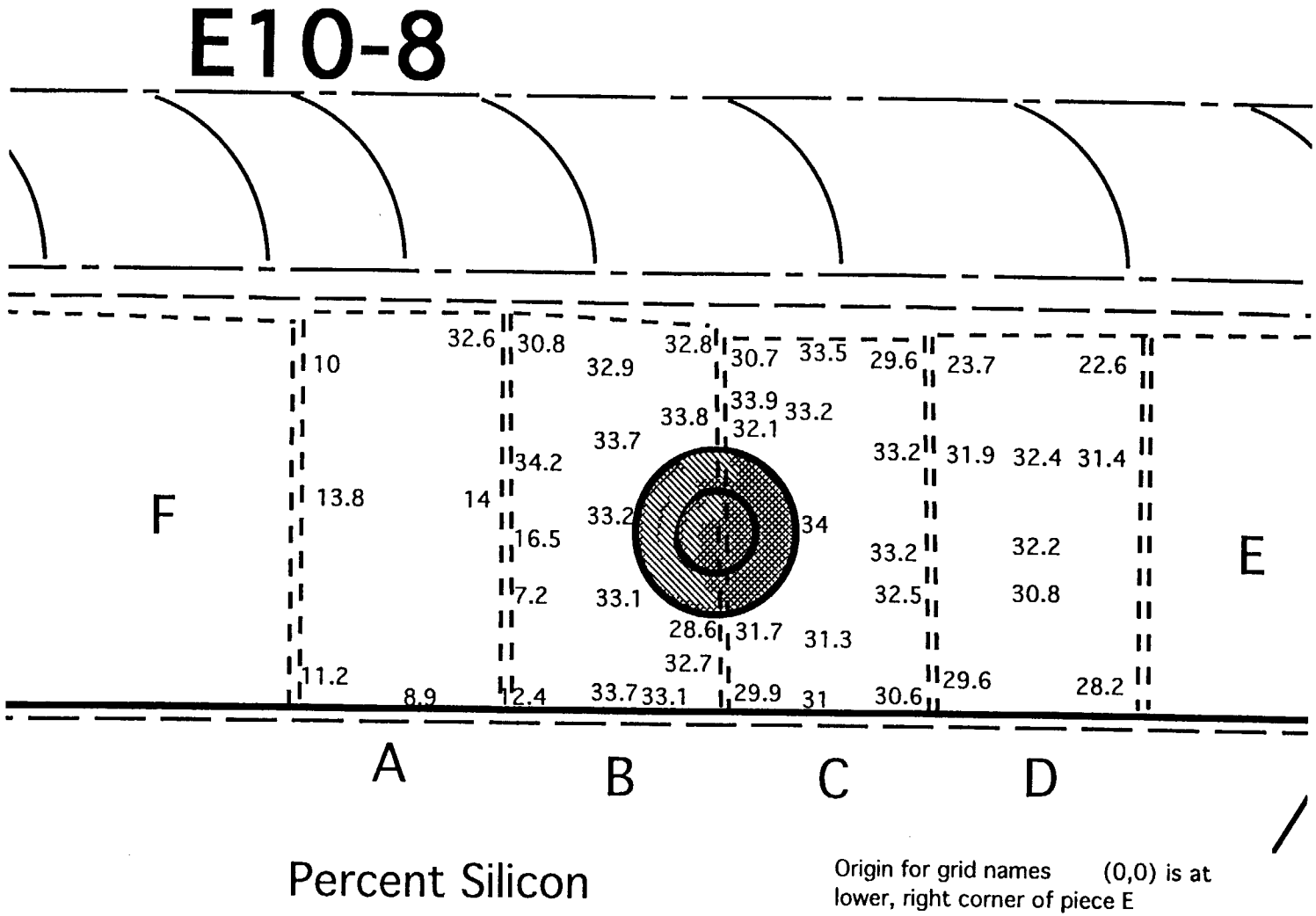


Figure 2. Diagram showing Percent Silicon on the tray surface E10-8 at the measured locations for all individual ESCA measurements.

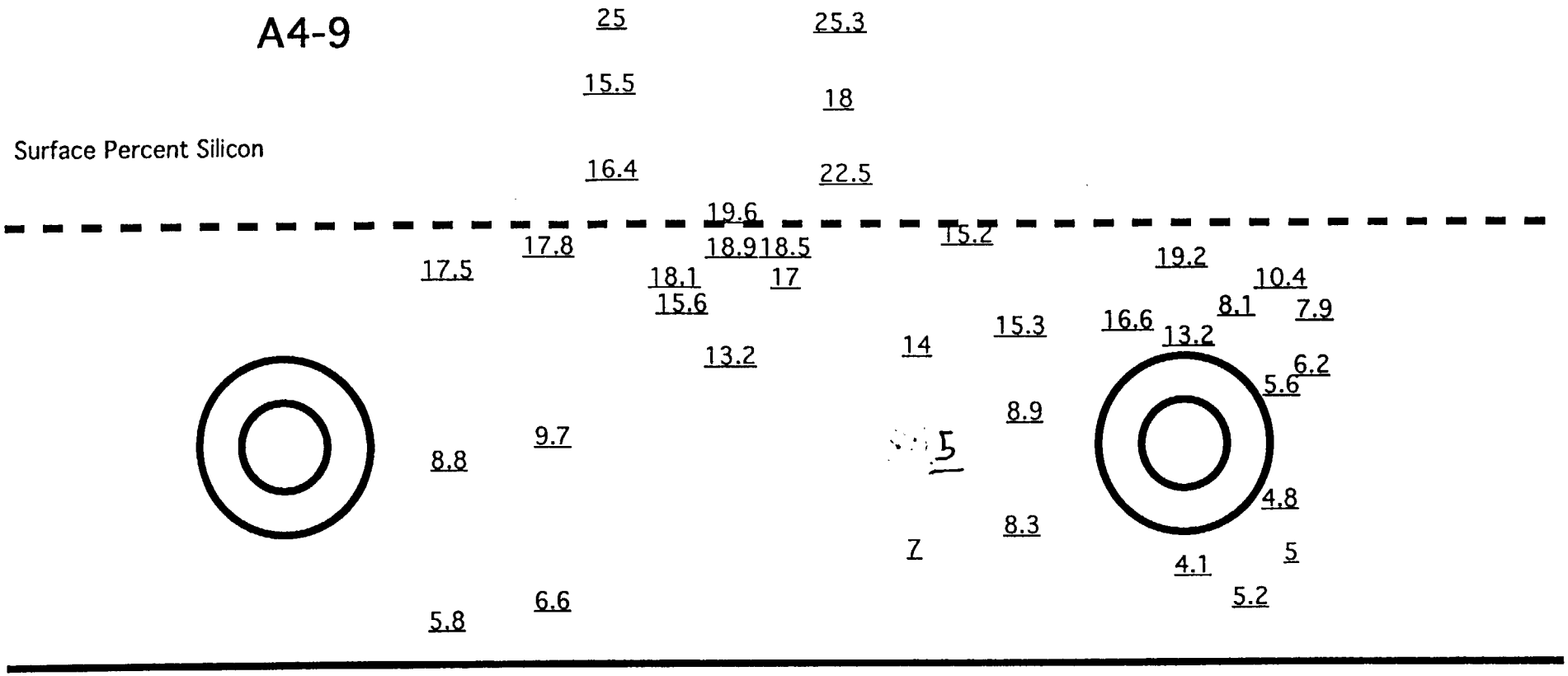
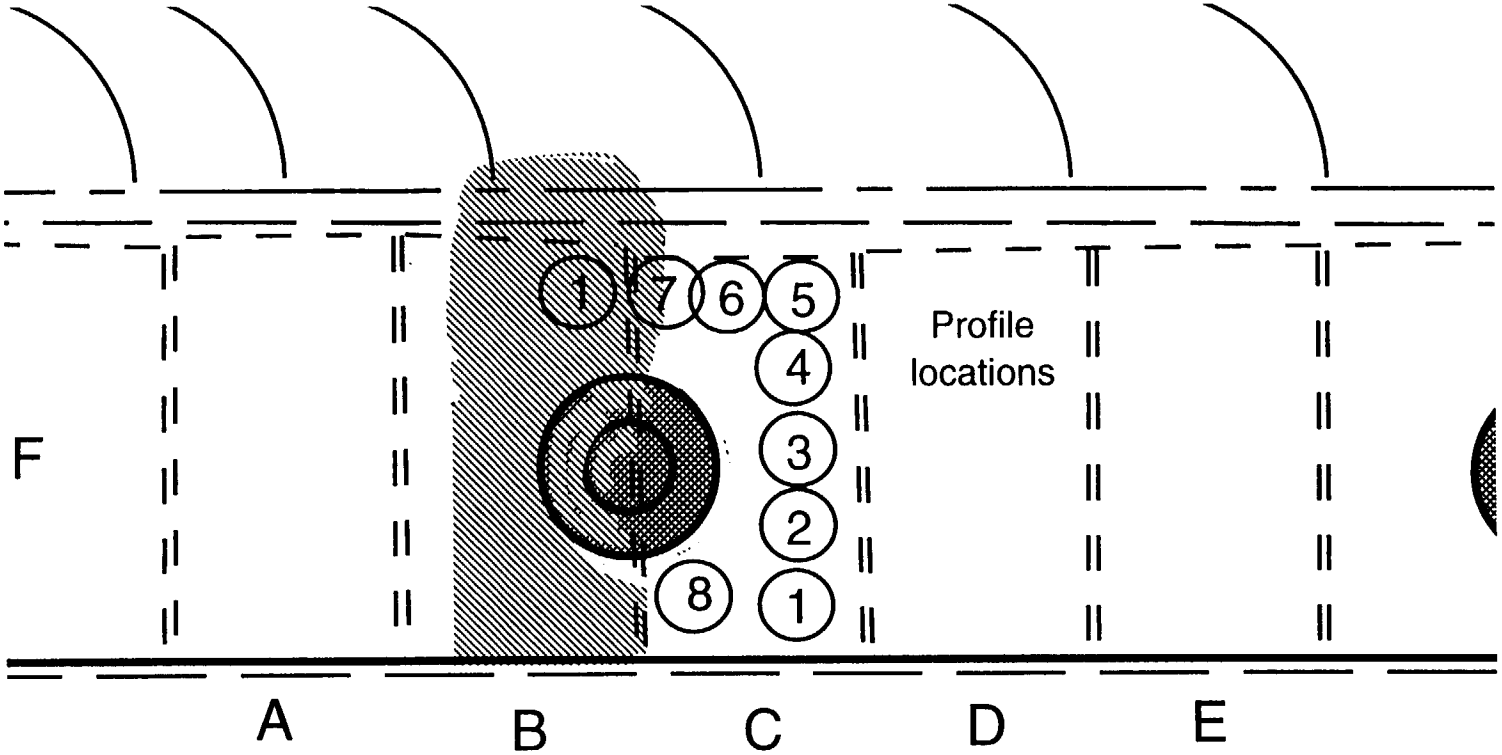


Figure 3. Diagram showing Percent Silicon on the tray surface A4-9 at the measured locations for all individual ESCA measurements.



E10-8

Figure 4. Locations of auger depth profiles obtained to-date from tray location E10-8.

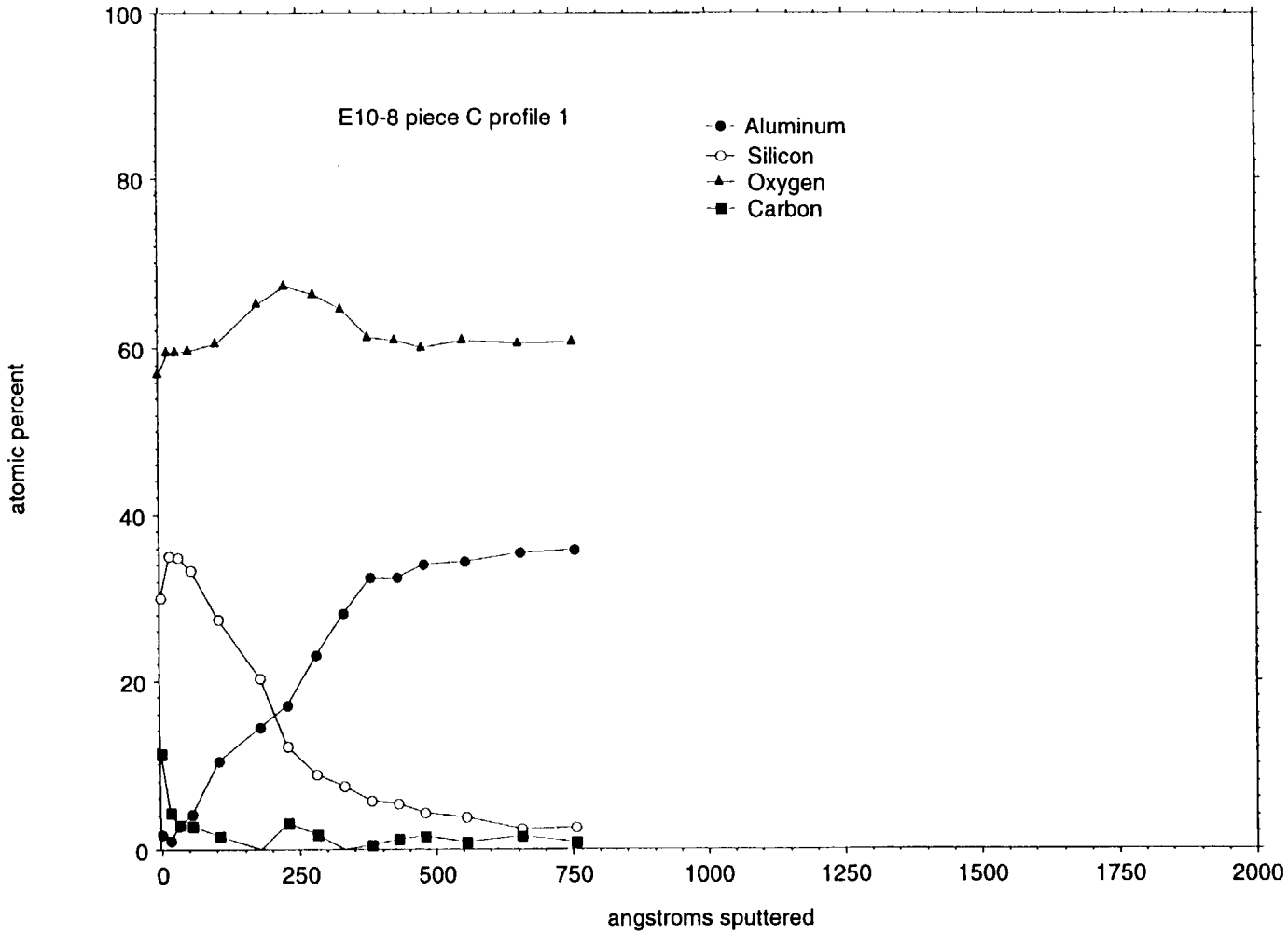


Figure 5. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-1" from tray surface E10-8.

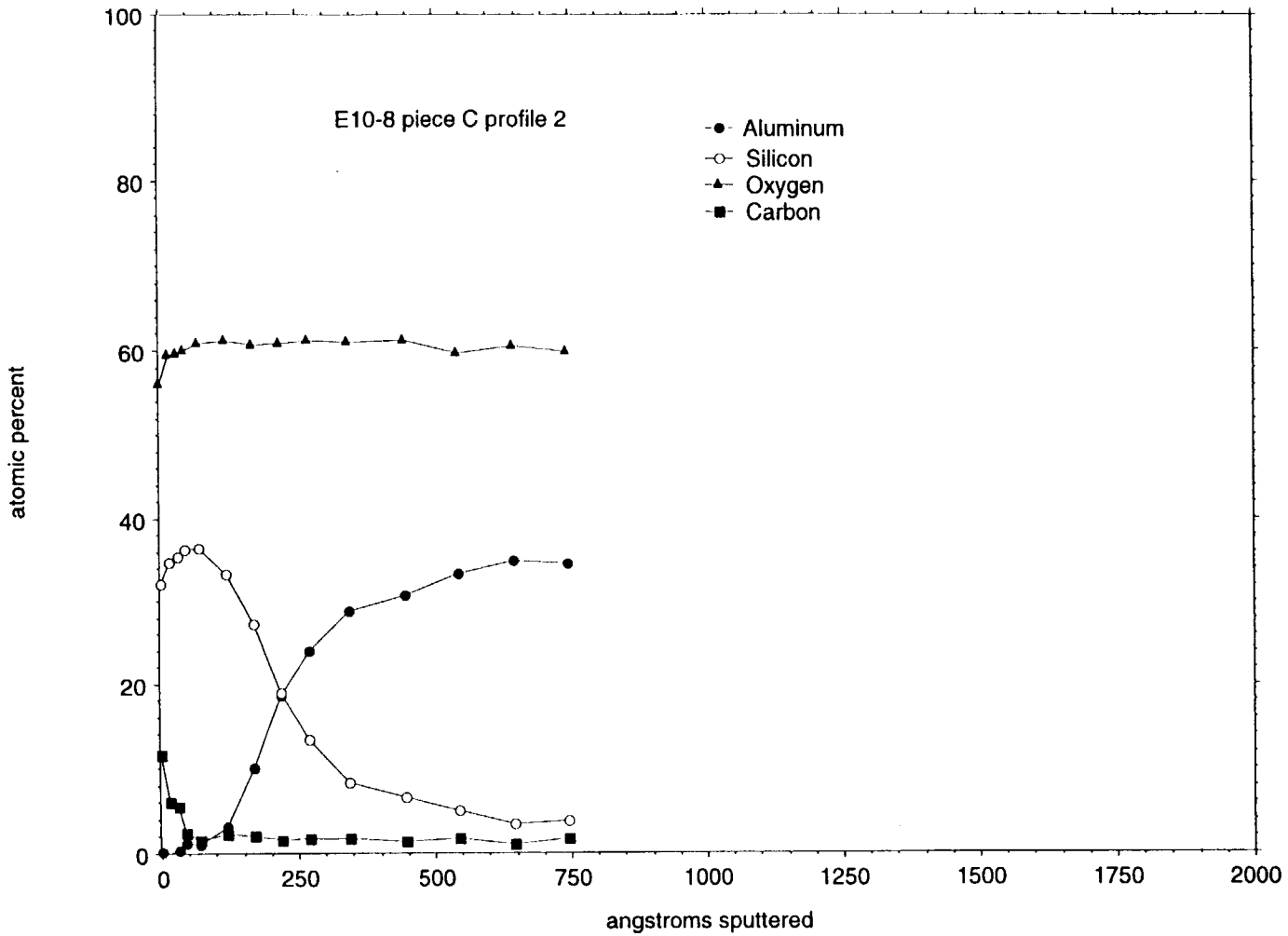


Figure 6. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-2" from tray surface E10-8.

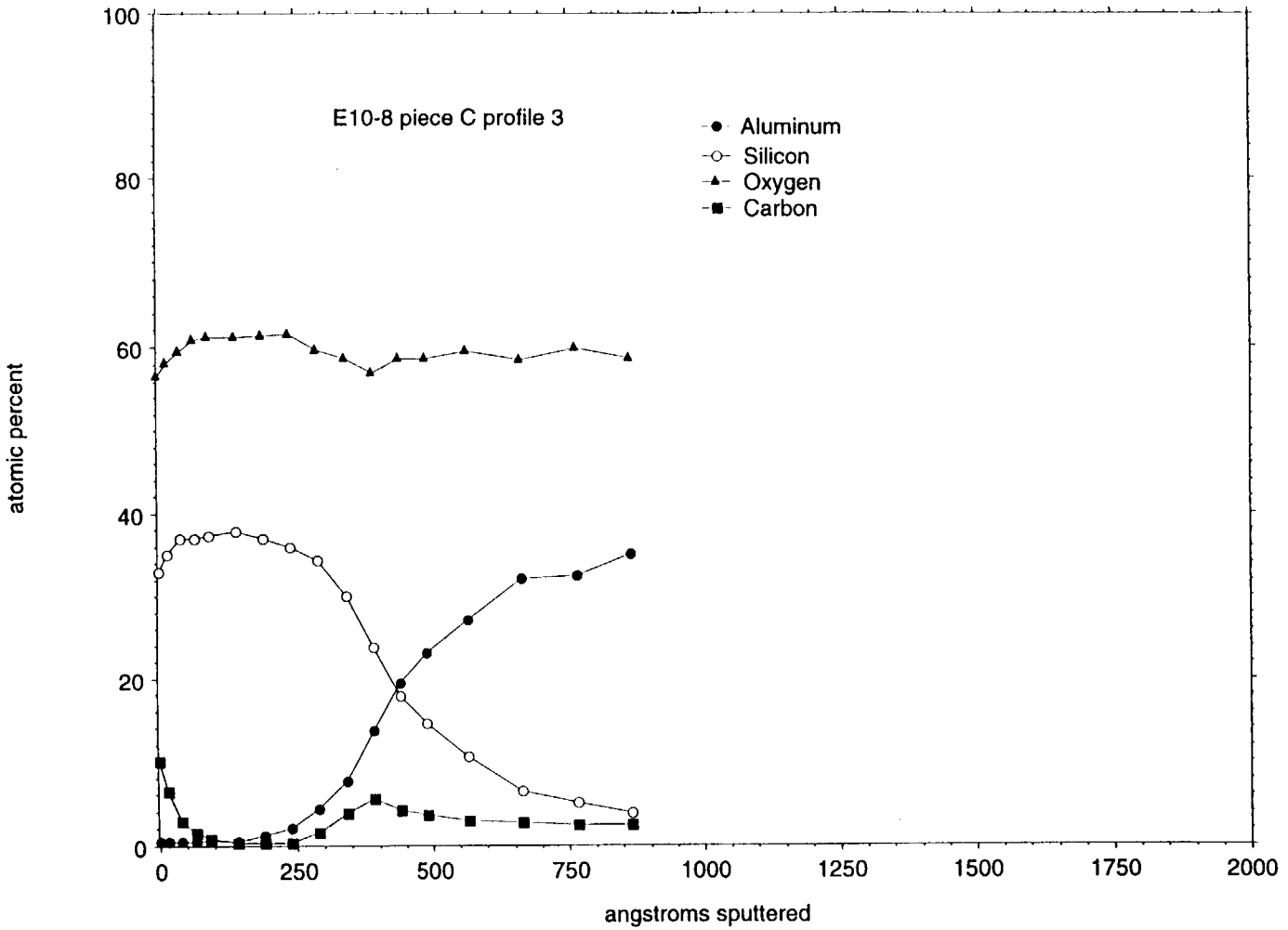


Figure 7. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-3" from tray surface E10-8.

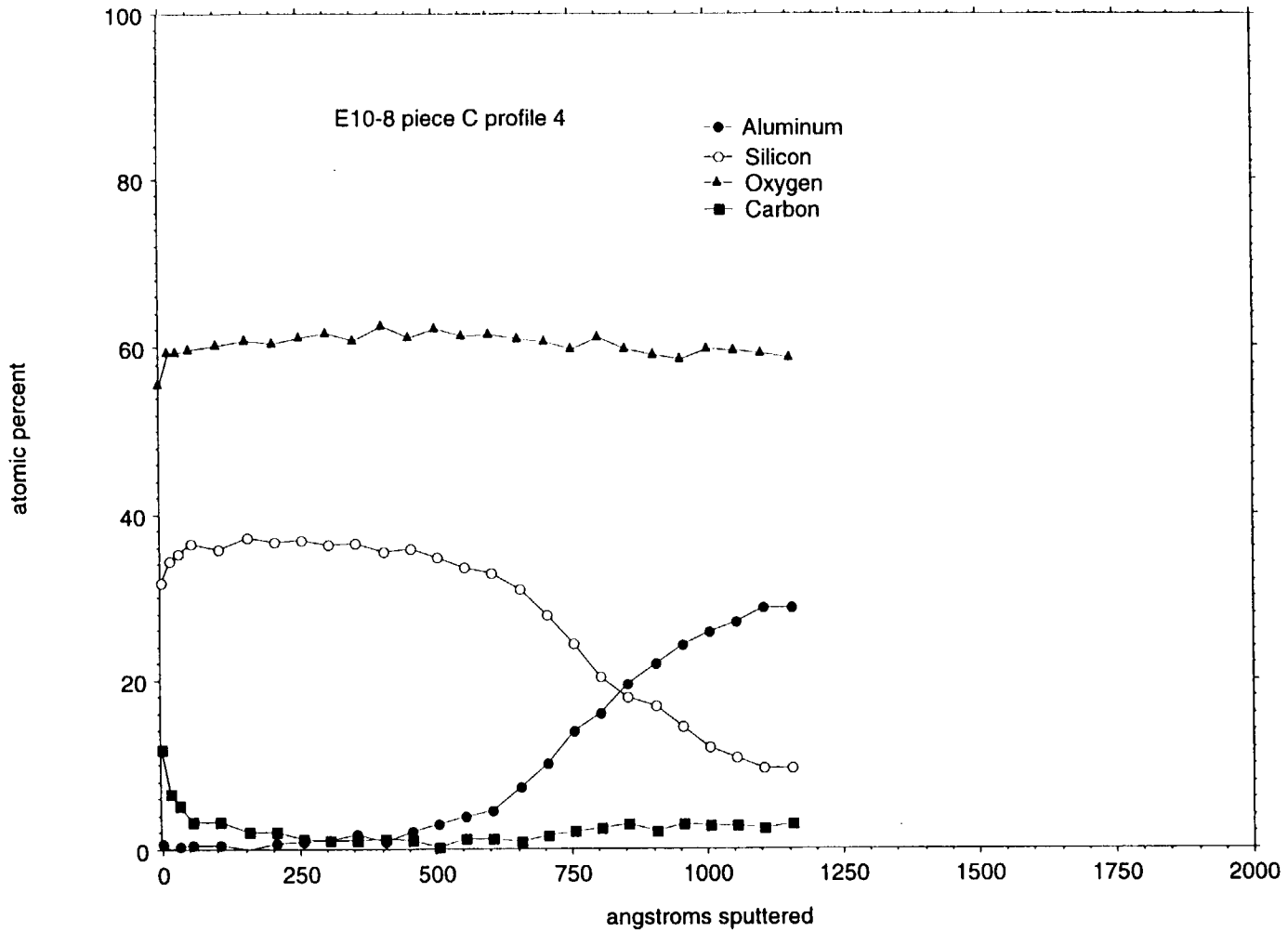


Figure 8. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-4" from tray surface E10-8.

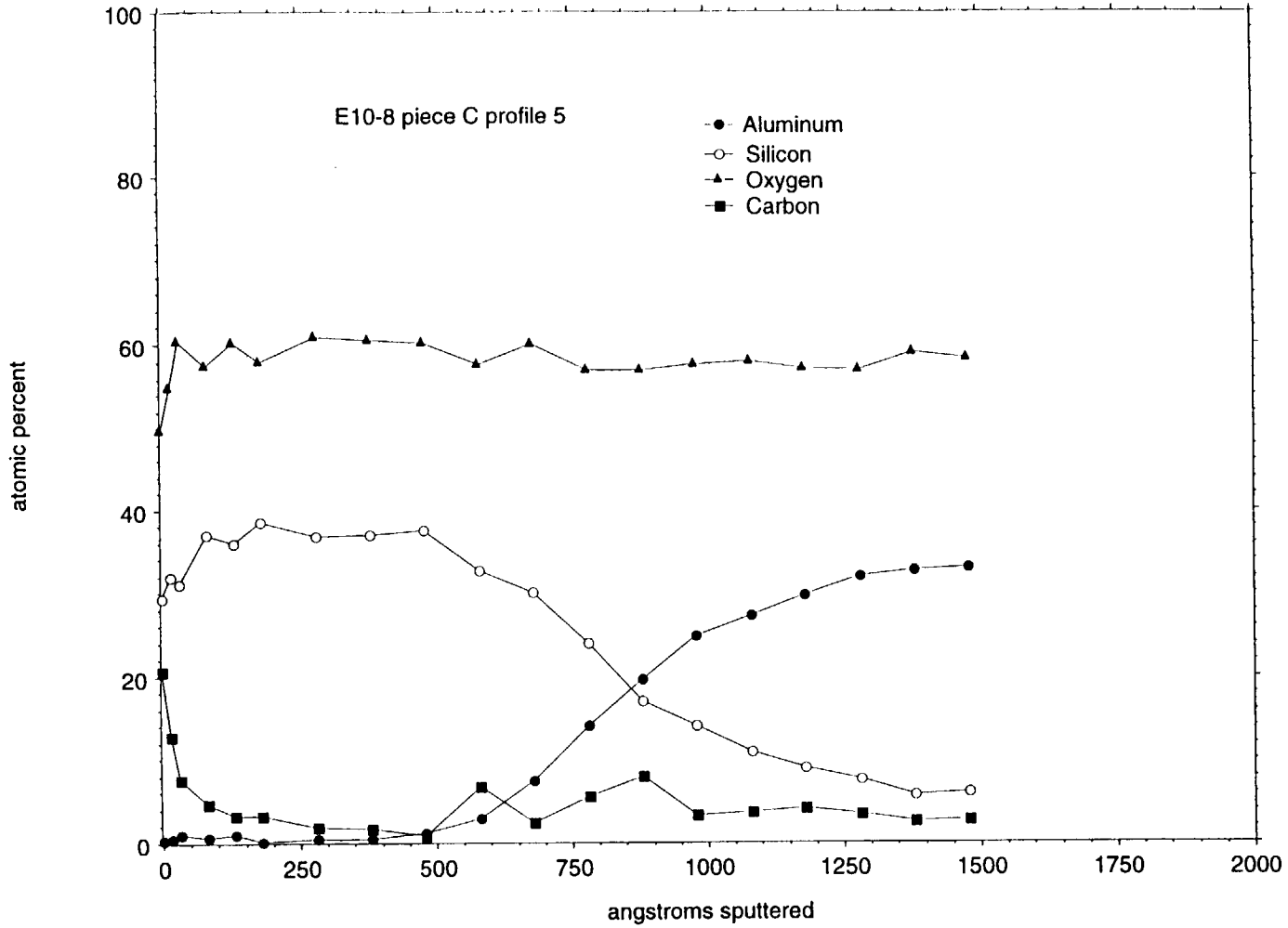


Figure 9. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-5" from tray surface E10-8.

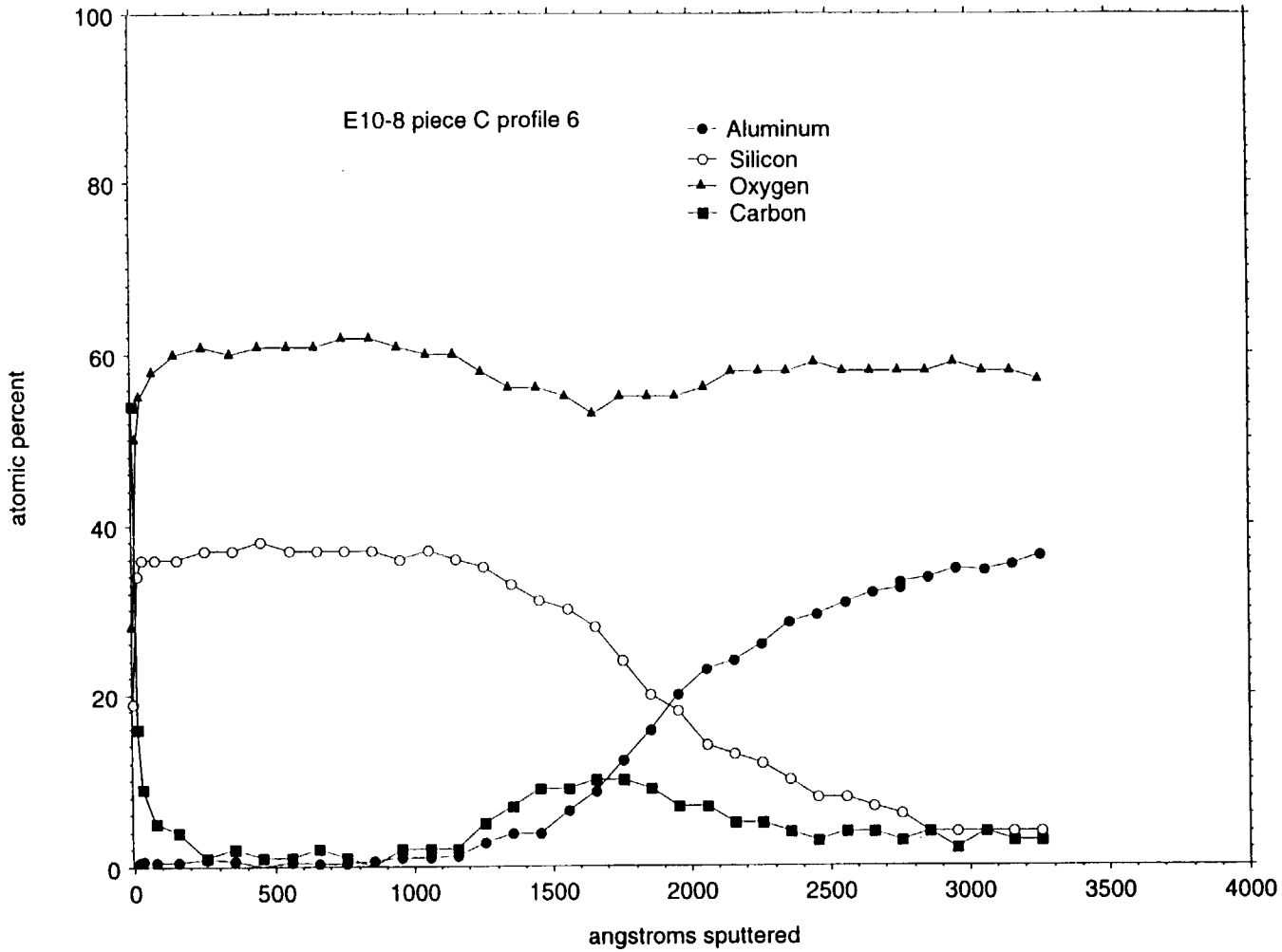


Figure 10. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-6" from tray surface E10-8.

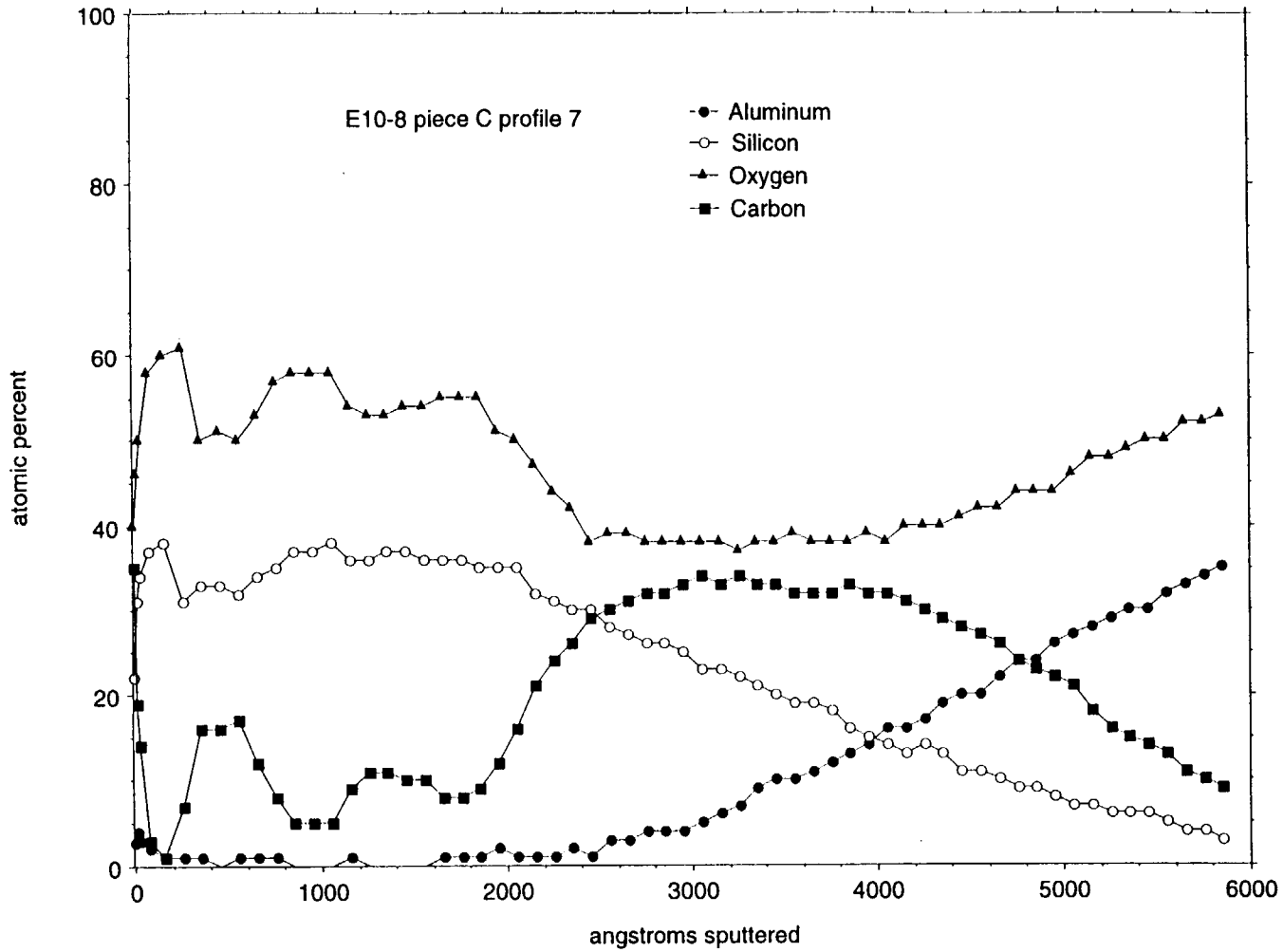


Figure 11. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-7" from tray surface E10-8.

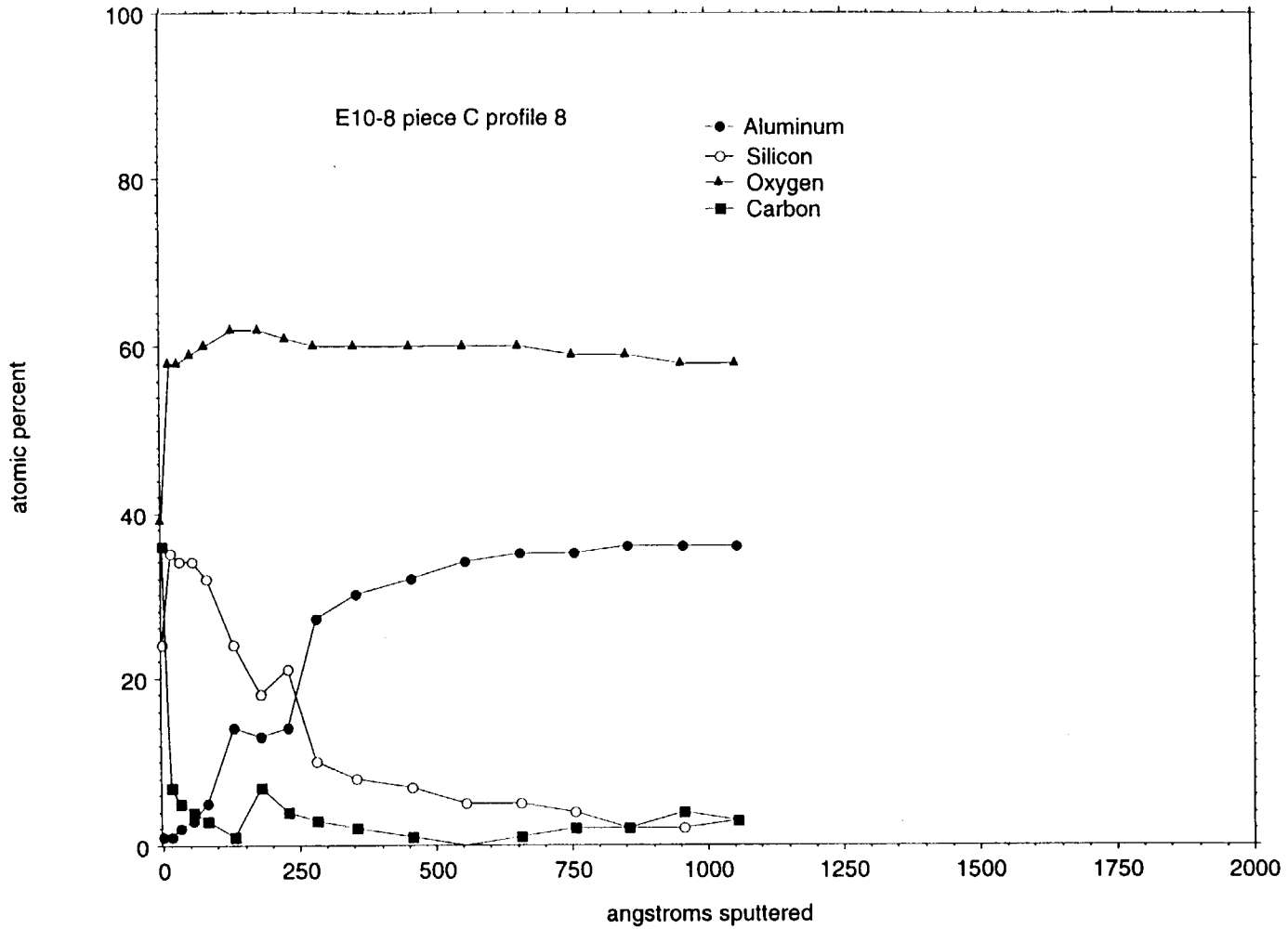


Figure 12. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "C-8" from tray surface E10-8.

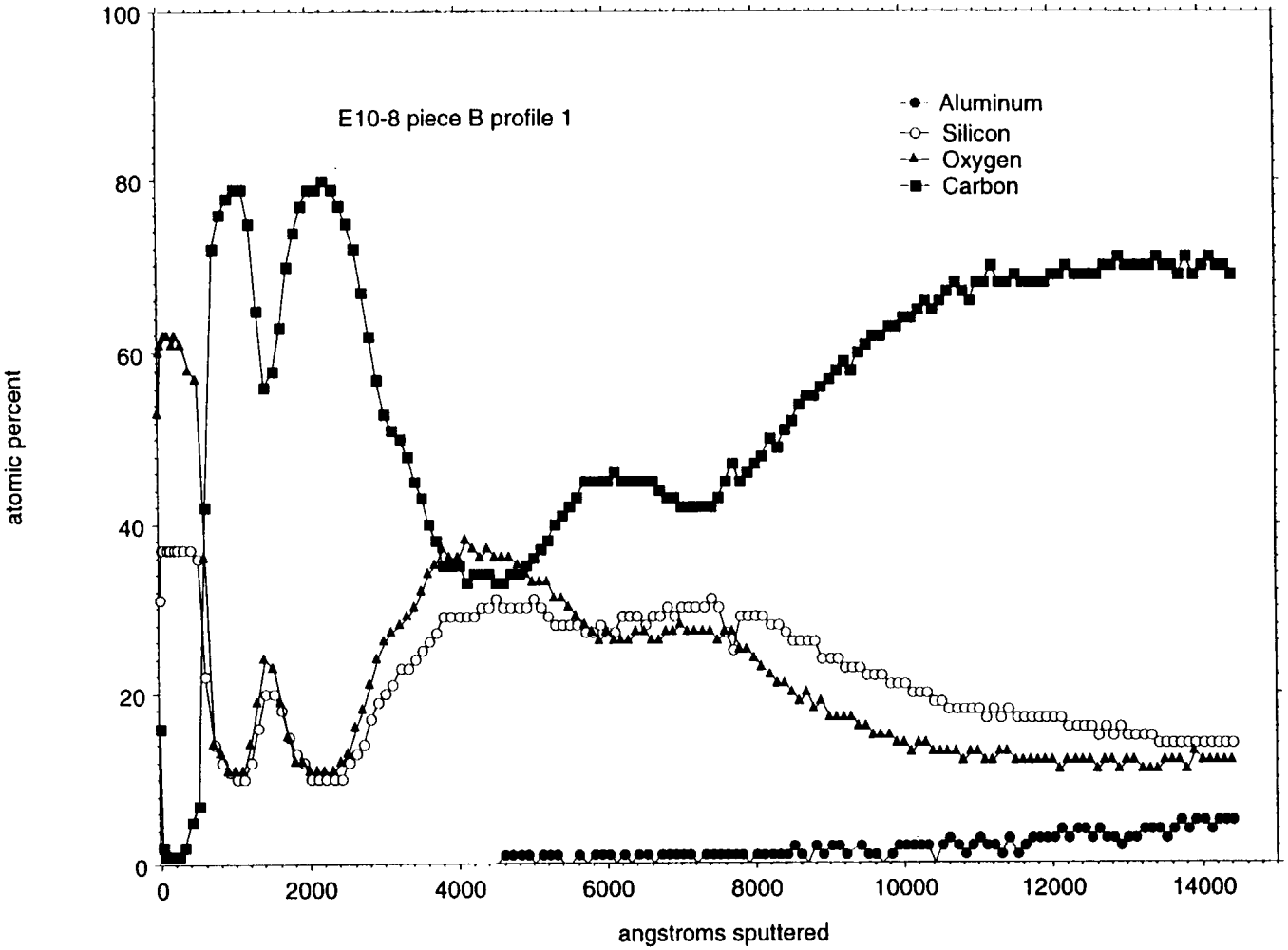


Figure 13. Depth Profile showing Silicon, Carbon, Aluminum, and Oxygen elemental %'s at location "B-1" from tray surface E10-8.

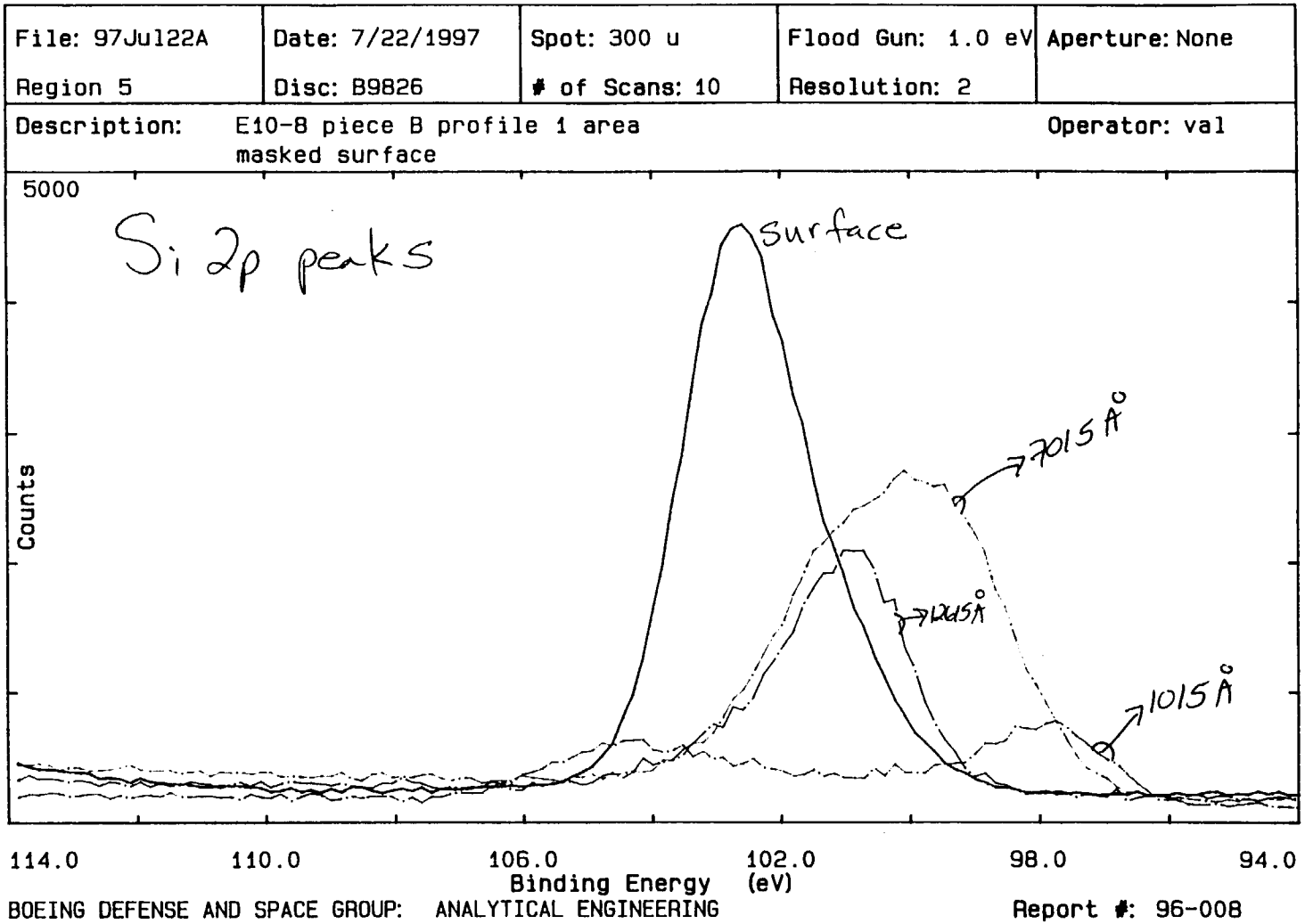


Figure 14. Silicon 2p peaks at selected sputtering depths, showing relative peak areas.

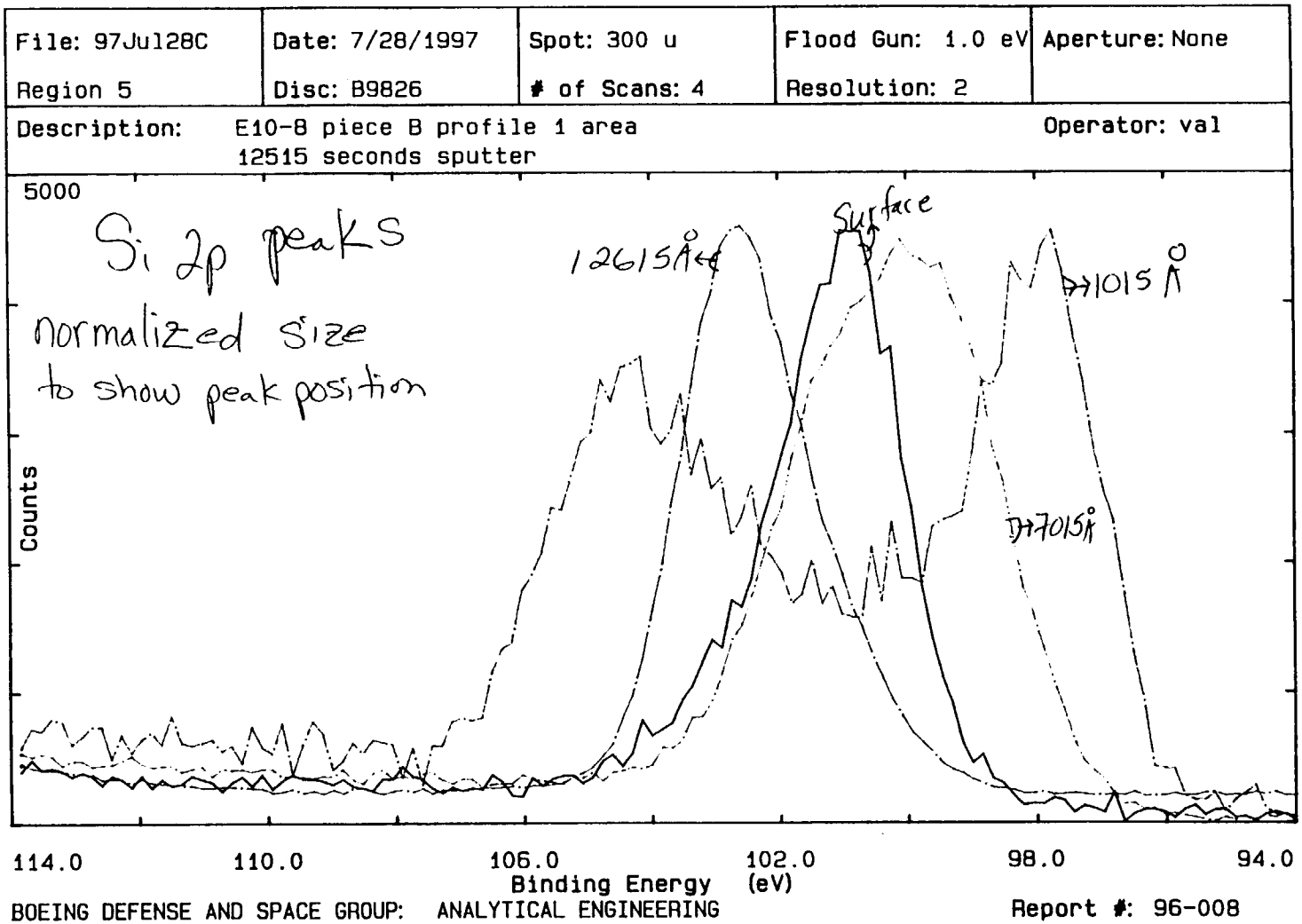
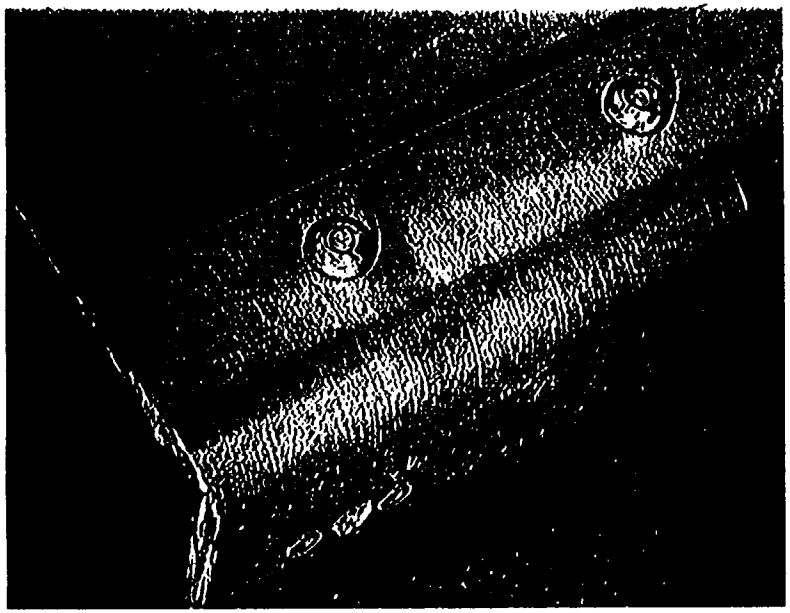


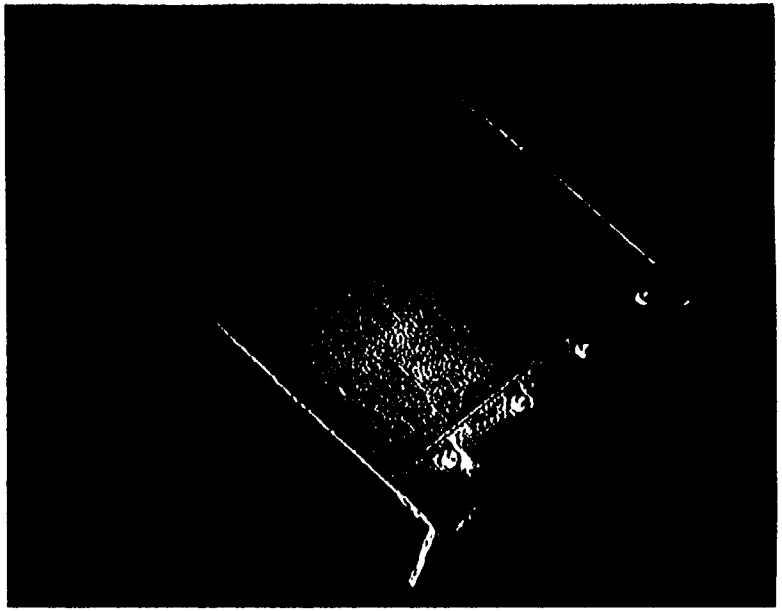
Figure 15. Silicon 2p peaks from figure 14, with areas normalized, to show peak shapes more clearly.

Figure 16. Sequence of photos showing surface morphology for different locations near vent location E10-9. Photos show both results of on-orbit deposition and post-flight contact with tray cover gaskets.

(This figure is four pages of photos and Scanning Electron Microscope images of tray surfaces and deposited contamination)

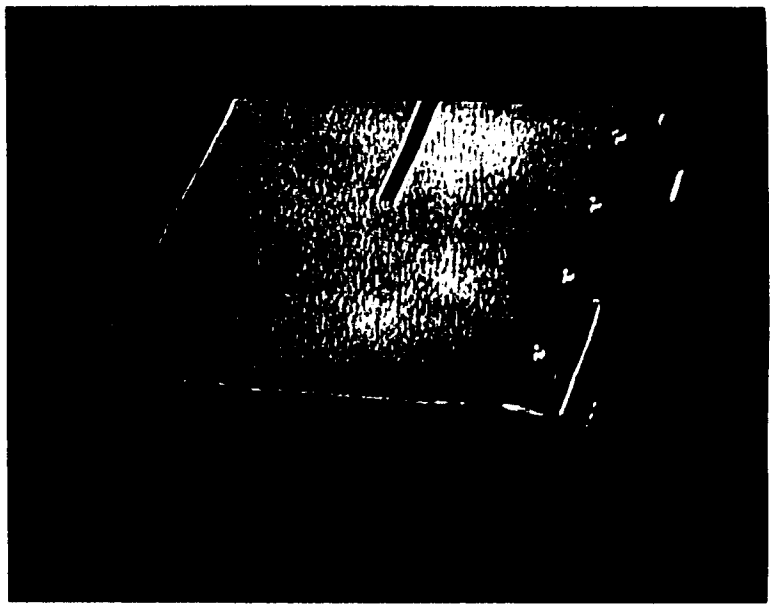


CLOSE-UP OF STAIN

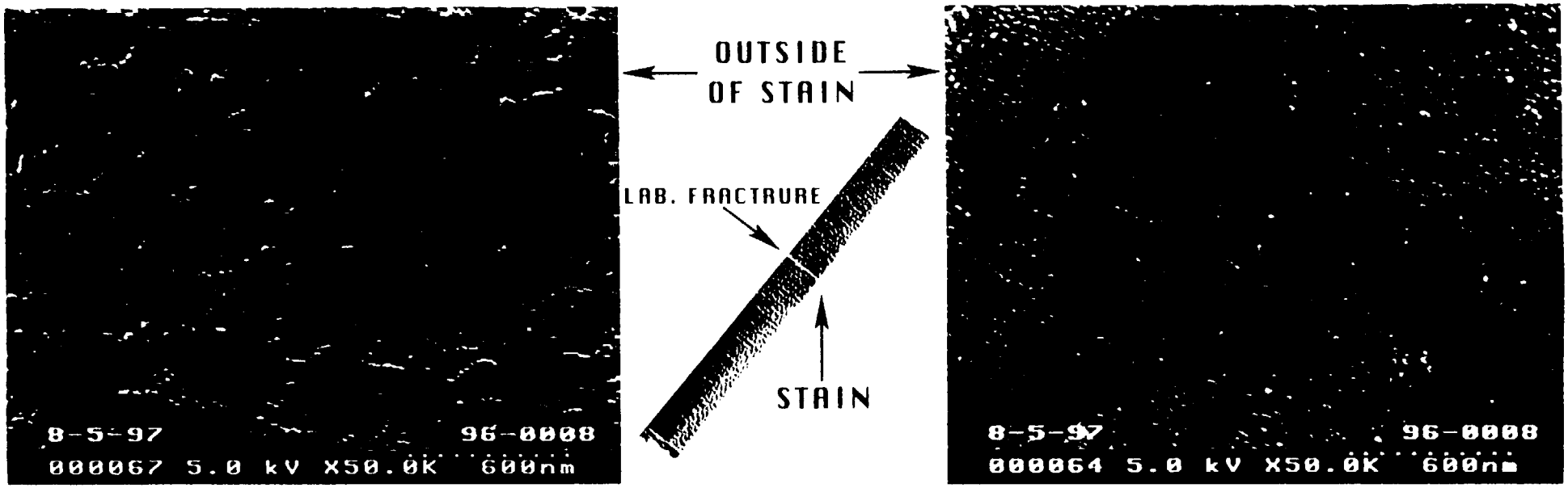


OVER ALL OF SAMPLE

OVER ALL AFTER SAMPLING



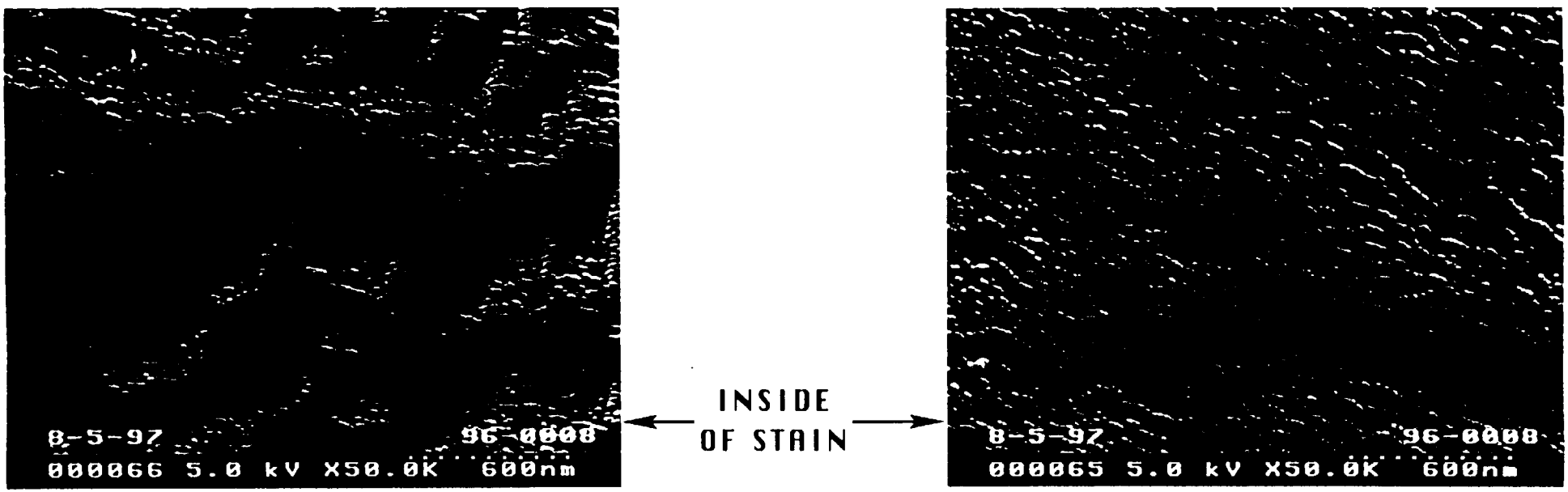
OVER ALL OF SAMPLE AFTER SCANNING ELECTRON MICROSCOPE SAMPLES WERE CUT OUT. NOTE THE AREA WHERE THE STAIN WAS. THIS SAMPLE WAS LABORATORY FRACTURED ACROSS THE STAIN TO GET A PROFILE OF THE SURFACE MORPHOLOGY.

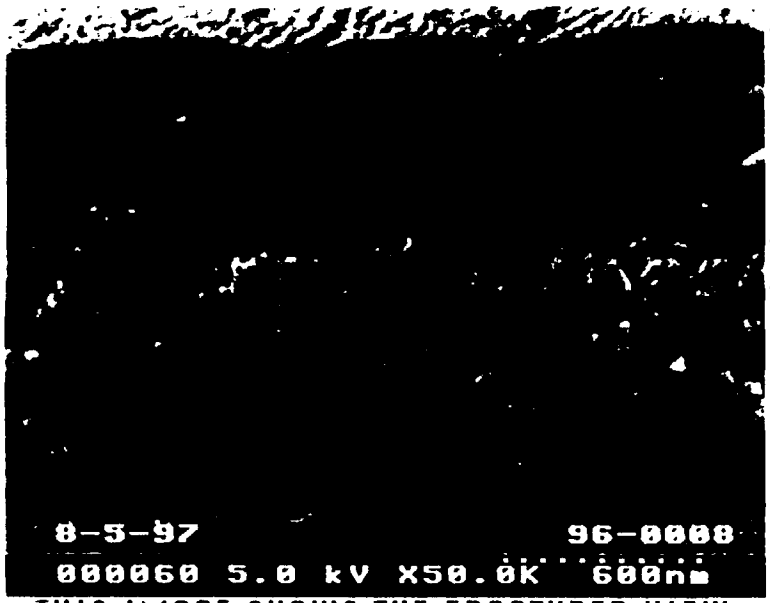


FOR THESE TWO IMAGES THE TILT ON THE SAMPLE STAGE = ~ 30°

SE IMAGES

FOR THESE TWO IMAGES THE TILT ON THE SAMPLE STAGE = ~ 0°





THIS IMAGE SHOWS THE FRACTURED VIEW OF THE STAIN MATERIAL AND ANODIZE.

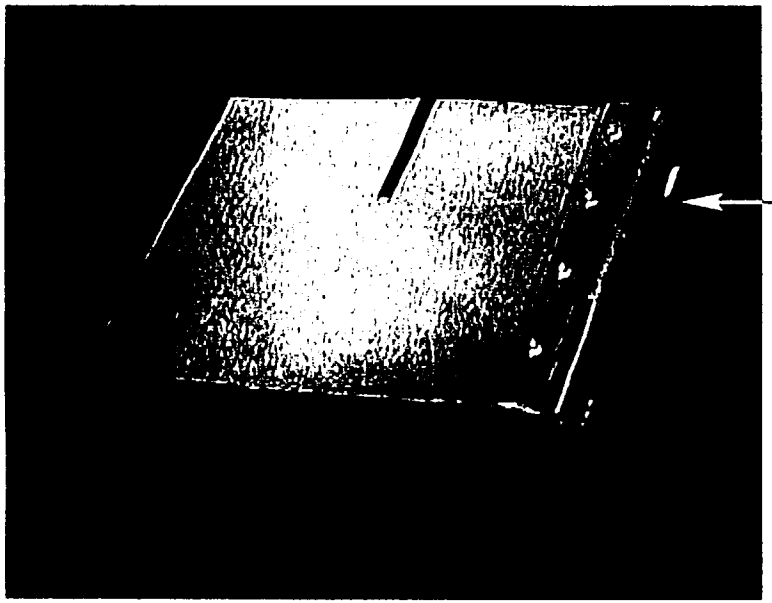
THIS IMAGE IS A LOWER MAGNIFICATION OF LABORATORY FRACTURE IN THE STAIN AREA

AREA #1 STAIN MATERIAL IN PROFILE SHOWING A BRITTLE MORPHOLOGY AND THE POOR ADHESION TO THE ANODIZE LAYER.

AREA #2 TOTAL ANODIZE LAYER

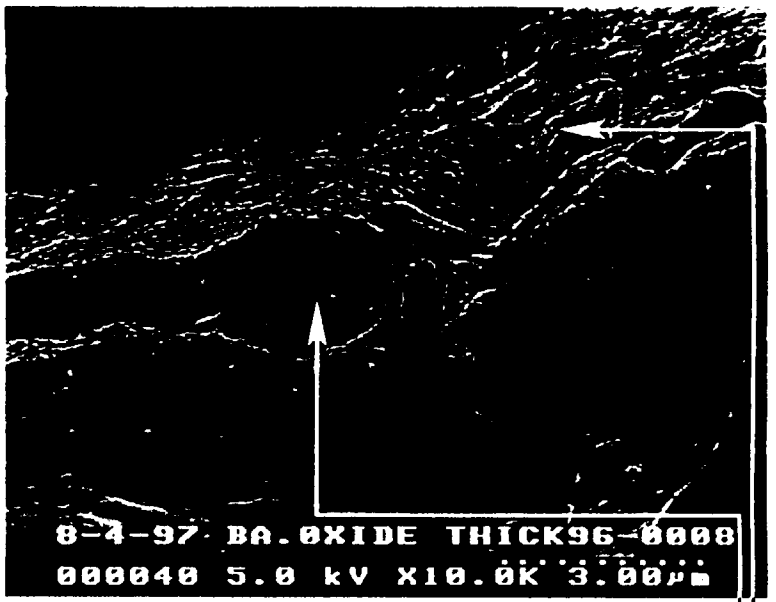
AREA #3 THE TOP PART OF THE ANODIZE HAS BEEN WATER SEALED. THIS CHANGES THE MORPHOLOGY AT THE TOP OF THE ANODIZE LAYER

THIS IMAGE REPRESENTS WHAT THE TOP SURFACE OF THE STAIN LOOKS LIKE.

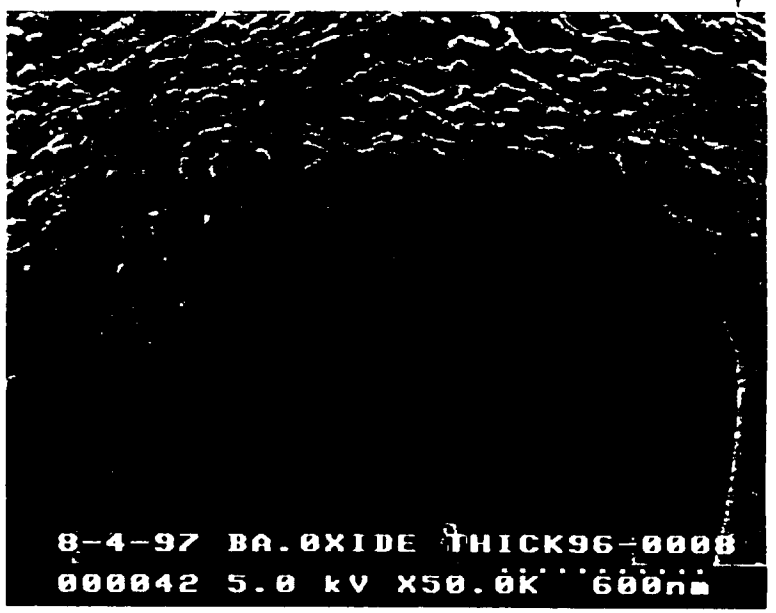


BASE ANODIZE THICK

SAMPLE LOCATION



THESE IMAGES SHOW A THIN RUBBERY MATERIAL COVERING THE ANODIZE LAYER.



NASA MARSHALL

FUNDS PERFORMANCE REPORT

CONTRACT NO.: NAS8-40581

PERIOD ENDING: 7/31/97

40581

QUARTERLY

	CURRENT	CUM-TO-DATE	% OF TOTAL	COST $'S REMAINING	TOTAL COST $'S	ESTIMATED $ AT COMPLETION
COST	$51,612	$389,102 *	81%	$90,344	$479,446	$479,446
WORK COMPLETION			81%			
*Includes Outstanding Commitment of:		$53,843				
TOTAL FUNDING	$479,446		81%			
FEE	$47,826					
TOTAL COST	$527,272					

ESTIMATED COMPLETION DATE: 11/4/97

CONTRACTOR: BOEING DEFENSE & SPACE GROUP
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PROGRAM MANAGER: H. G. PIPPIN 8/5/97

R&E C&S: C. J. COWAN 8/5/97

R&E FINANCE: S. J. ROGERS 8/7/97