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QUARTERLY PROGRESS REPORT:

INVESTIGATION OF KILOVOLT ION SPUTTERING

by

HAROLD P. SMITH, JR., F. C. HURLBUT, T. H. PIGFORD,
JHAN KHAN AND N. THOMAS OLSON

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Technical Management
Nasa Lewis Research Center
Cleveland, Ohio

Electric Propulsion Office
Mr. J. A. Wolters

2 SPACE SCIENCES LABORATORY 3

1 University of California, Berkeley 2 94720

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I. INTRODUCTION AND SUMMARY

This report is a summary of progress from November 1966 through January 1967 on work supported by the Lewis Research Center of NASA. This work, begun in 1964, constitutes an area of surface physics involving the interactions of ions and protons with material surfaces. Specifically, heavy ion (cesium and mercury) surface interactions are observed by measuring sputtering yields, angular distribution of sputtered atoms, energy distribution of ejected atoms, and implanted ion distributions within the target lattice. The proton-surface interactions studies constitute an investigation of the proton-induced characteristic oxygen x-rays as a possible surface analysis device for measuring oxygen contamination of material surfaces.

The following is a brief summary of the quarter's progress in each area. The contract terminates on February 15, 1967; the complete results of the research program will be presented in the final report. Thus, results of completed work are not presented in this progress report.

II. SURFACE DENSITY MEASUREMENTS*

The density of oxygen atoms adsorbed on an aluminum substrate will be measured by the oxygen characteristic x-ray yield produced under 100-keV proton bombardment. The experimental apparatus (see Figure 1, NASA CR-72012) consists of a duoplasmatron ion source, an analyzing magnet, a collimator-target assembly, and a low-energy photon detector (gas proportional counter).

During the quarter, improvements in the system were required to filter out intensity modulations in the target current. AC ripple on the arc and filament DC power supplies had caused an undesirable modulation of the beam intensity that was eliminated by suitable filtering of the power supplies. An additional improvement to the system was the fabrication and calibration of a voltage divider to facilitate measurements of the proton beam energy to less than 1 % uncertainty.

The reliability of the entire experimental apparatus will be checked by comparing the measured thick target yield of aluminum k-shell x-rays with the results reported by Khan, et al.[1] Initial measurements of the aluminun k-shell x-ray yield are 25 % below those reported,[1] but this may be a result of surface contamination created during target preparation. Different aluminum target preparation techniques are being used, and it is expected that the oxygen x-ray yield measurements will be completed during the last contract period.

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* The work reported in this section was performed by R. R. Hart

III. VELOCITY SPECTRUM MEASUREMENT*

The objective of this experiment is to measure the energy spectrum of cesium ion sputtered copper particles using a time-of-flight technique. The time rate of arrival of copper sputtered by a pulsed cesium ion beam is monitored by a quadrapole mass spectrometer that is a known distance from the target (see Figure 3, NASA CR-72012).

During this quarter initial runs made at a cesium ion energy of 5 keV indicated the presence of sputtered ions and neutrals of copper. However, stray fields, due to the ion extractor and focusing lens structures, perturbed the ejected ions; modifications to the system to shield the fields are being made. When these modifications are complete, energy spectrum measurements of the sputtered copper ions will be made.

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* The work reported in this section was performed by G. Cowell

IV. MERCURY ION SPUTTERING*

The mercury ion source-target chamber system (see NASA CR-54908) has been used to complete the sputtering yield for a nickel target and the sputtering yield and angular distribution measurements for a molybdenum target. For both target materials the ion energy ranged from 1 to 10 keV and the ion beam was incident normal to the (100) crystallographic face.

The complete results of these experiments will be presented in the final report to be submitted at the termination of the contract.

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* The work reported in this section was performed by R. G. Musket

V. ALUMINUM-ALUMINUM OXIDE SPUTTERING*

Using the surface-charge-neutralization method of electron flooding of the ion beam area (see NASA CR-72012, pg. 7), the sputtering yield of the insulator aluminum oxide (Al_2O_3) was measured for cesium ion energies in the range 2.5 to 10 keV. Sputtering yield measurements were also made in the presence of a contaminating oxygen atmosphere in which the poisoning ratio (incident oxygen rate/sputtering removal rate) varied from less than 0.1 to 10.

The entire cesium ion sputtering results of aluminum-aluminum oxide targets will be presented in the final report.

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* The work reported in this section was performed by E. H. Hasseltine

VI. ION IMPLANTATION*

The distribution of cesium ions within targets of aluminum, copper, and silicon are being measured by neutron activation of the implanted cesium. Chemical stripping of successive surface layers (approximately 40 Å thick) from the target and measurement of the cesium in each layer by conventional radioactivity-counting techniques give the distribution of implanted ions.

During this quarter several aluminum targets of a (100) and (110) orientation, plus polycrystalline orientation, have been implanted with 20-keV cesium ions for exposures ranging from 10^{16} to 10^{19} ions per square centimeter. These targets have neutron irradiated, chemically stripped, and radiation analyzed, and the implantation distribution has been determined by use of the computer data-reduction program, which has now been expanded to give a plot of the results. The complete results will be presented in the final report.

The implantation distributions in copper and silicon are expected to be completed during the remainder of the contract period.

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* The work reported in this section was performed by W. Siekhaus, B. Southworth, and T. H. Pigford

REFERENCES

1. Khan, J. M., D. L. Potter, and R. D. Worley, Studies in X-Ray Production by Proton Bombardment of C, Mg, Al, Nd, Sm, Gd, Tb, Dy, and Ho, Phys. Rev. 139, A1735 (1965).