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Oxygen Interaction With Space - Power Materials

NASA Cooperative Agreement NCC 3-141

Final Report for Period June 1, 1989 to January 12, 1995

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March, 1996

Four Investigations were undertaken during the period of this grant:
(1) oxidation of molybdenum and of niobium-1% zirconium,
(2) preparation of and examination of EOIM-3 samples,
(3) sputtering of Teflon by oxygen ion bombardment,and
(4) sputtering of ions from copper and aluminum by oxygen and argon ion bombardment.

Investigations (1),(3),and (4) used a low-energy ion gun to bombard surfaces within an ultra-high vacuum system. Particles ejected from the surfaces were detected by a mass spectrometer.

Investigation 1

The purpose of this investigation was to look for enhancement of the oxidation of refractory metals due to the kinetic energy of the incident oxygen. For molybdenum, a strong MoO_3 signal was detected by the mass spectrometer from a Mo surface held at 1500 K, even when the ion gun was turned off. This signal was produced by thermal O_2 molecules from the ion gun and the background O_2 in the vacuum system. A 90 nA, 93 eV oxygen ion beam (~90% O_2^+ and 10% O^+) produced no change, above noise, in this signal.We conclude that the kinetic energy of the 93 eV oxygen ions does not enhance their ability to oxidize Mo by more than a factor of 10.

For Nb-1% Zr, no niobium oxide signals were seen from a surface held at a temperature of 1400 K, produced either by thermal O_2 or 93 eV oxygen ions. Raising the oxygen ion energy to 450 eV still failed to yield detectable niobium oxide signals from the mass spectrometer.

The details of this work were communicated in an informal report to the interested people at the NASA Lewis Research Center (NASA LeRC).

Investigation 2

As part of NASA LeRC's participation in the third Evaluation of Oxygen Interaction with Materials experiment (EOIM-3), molybdenum and tungsten samples were prepared. After the flight these samples and eleven other sets of conducting samples were examined by Auger electron spectroscopy. Eleven of the thirteen sets had 3 samples in each set: one exposed at 60 C, one exposed at 200 C, and the control, which was not carried into space. The remaining two sets had only the sample exposed at the higher temperature and the control. Four of the sets (Nb-1% Zr, PWC-11, Mo, and Ti) were also examined by Rutherford backscattering spectroscopy. A technical report on the results of our measurements ("Auger Electron Spectroscopy and Rutherford Backscattering Spectroscopy Measurements on Conducting Samples from EOIM-3" by C.A.Zorman, T.G.Eck, and R.W.Hoffman - July 1993) was prepared for NASA LeRC.

Investigation 3

Teflon surfaces were bombarded with oxygen ions with kinetic energies from 12 to 185 eV. CF,CF_2,and CF_3 signals from the mass spectrometer were analyzed to deduce the equivalent CF_2 units removed from the target surface per incident oxygen ion as a function of the ion energy. The yield increased from 0.013 at 12 eV to 0.17 at 185 eV. This work formed the basis of Abbas Lamouri's Ph.D. thesis ("Low-Energy Sputtering of Teflon by Oxygen Ion Bombardment" - May 1991).

Investigation 4

Copper and aluminum surfaces were bombarded with oxygen and argon ions with kinetic energies from 50 to 500 eV. Secondary ions (Cu^+,Al^+, Na^+,and K^+) sputtered from these surfaces were detected by the mass spectrometer. The relative yields of these secondary ions and the kinetic energy distributions of the sputtered ions were determined as a function of incident ion energy. The principal motivation for this work was concern about erosion of space vehicle components from interaction with the ambient atmosphere, which is principally atomic oxygen. Also, we were interested in using these data to test thermal models of sputtering. The results of this investigation are given in the Ph.D. thesis of Liang-yu Chen ("Secondary Ions Sputtered by Low-Energy Ion Bombardment of Cu and Al Surfaces" - November 1994). Though the experimental part of this investigation has been completed, work continues on the theory of thermal models of sputtering.

We are grateful to NASA for the support of this work, and are especially grateful to Dr. Dale C. Ferguson for his encouragement and input at each stage of these investigations.