

MASTER

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SURFACE MODIFICATION BY ION
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EXTENDED ABSTRACT

Physical and chemical ion erosion surface interactions have been observed for various elements and composite materials including Si, B, C, TiB_2 , WC-Co cermet, and stainless steel samples which have been bombarded by low energy (50 eV-1800 eV) hydrogen ions.

The erosion yield characteristics¹ shown in Fig. 1a where both chemical erosion and physical erosion can occur, can be compared to the yield characteristics for the same materials bombarded by xenon which results in physical sputtering only (Fig. 1b). Here the abscissa represents acceleration potential which directly indicates the energy mode of the ions in the beam. The hydrogen ion data for carbon and boron extrapolate to intercept the ordinate at relatively large erosion yield values for zero hydrogen ion energy, indicating erosion due to chemical reactions. The hydrogen ion data observed for carburized stainless steel, stainless steel, TiB_2 , WC-Co cermet, and silicon extrapolate to intercept the ordinate at lower erosion yield

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REA

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values for zero energy hydrogen ions indicating less chemical activity resulting in volatile compounds. The xenon ion erosion yield curves extrapolate to intercept the abscissa indicating a threshold ion energy necessary to physically sputter material from the bulk.

WC-Co cermet samples were exposed to two different hydrogen ion bombardment doses with ion energies of 50, 100, 500 and 1800 eV (Fig. 2a, b, c and d). The depth and degree of selective carbon removal increases with doses from 10^{19} ions/cm² to 5×10^{21} ions/cm², for increasing ion energies up to 500 eV. For ion energies greater than 500 eV little difference in the depth or degree of carbon removal is observed for increasing ion energies, or ion dosages above 5×10^{19} ions/cm².

Comparable analyses of the elemental composition of the near surface regions of hydrogen ion bombardment of stainless steel and TiB₂ show a similar optimization of the depth and degree of carbon or boron removal for 500 eV hydrogen (5×10^{19} ions/cm²).

Two possible reaction mechanisms can be hypothesized for the formation and subsequent removal of chemically reactive elements. One proposed mechanism presumes reaction in the near surface region with the assumption that hydrogen penetrates initially by way of grain boundaries resulting in superficial fracture and defecting as proposed by West et al.² An alternate reaction mechanism can be proposed in which the bombarding hydrogen ions transfer their energy to the near surface atoms resulting in thermal mixing thus allowing the carbon to migrate to the surface where reaction with hydrogen may occur. Scanning electron micrographs of bombarded

surfaces show no physical features that can not be attributed to the effects of physical sputtering. This suggests that chemical erosion of the near surface region proceeds from thermal migration phenomena rather than from the penetration of hydrogen via grain boundaries which would result in identifiable defects and fracturing of the surface.

Other experiments³ have quantitatively addressed the question of what molecular species ratios result from the reaction of a partial pressure of thermal atomic hydrogen ions and carbon. A similar spectrum of reactions should occur for the carbon containing materials observed in the current study.

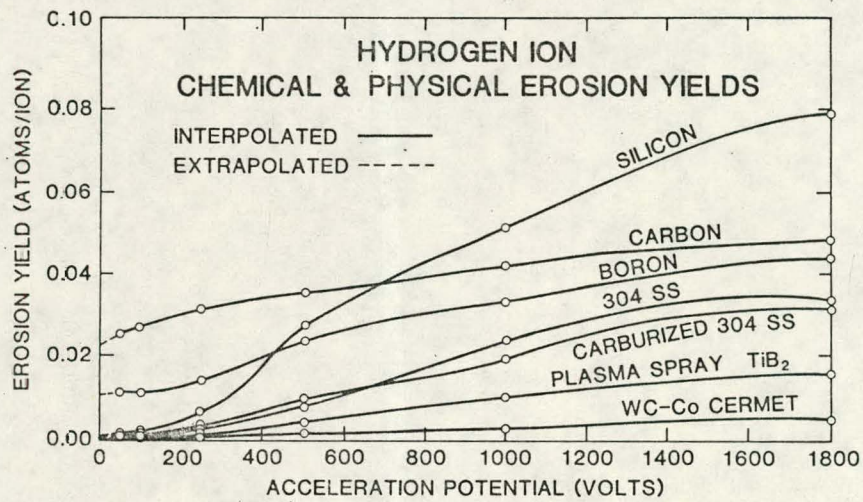
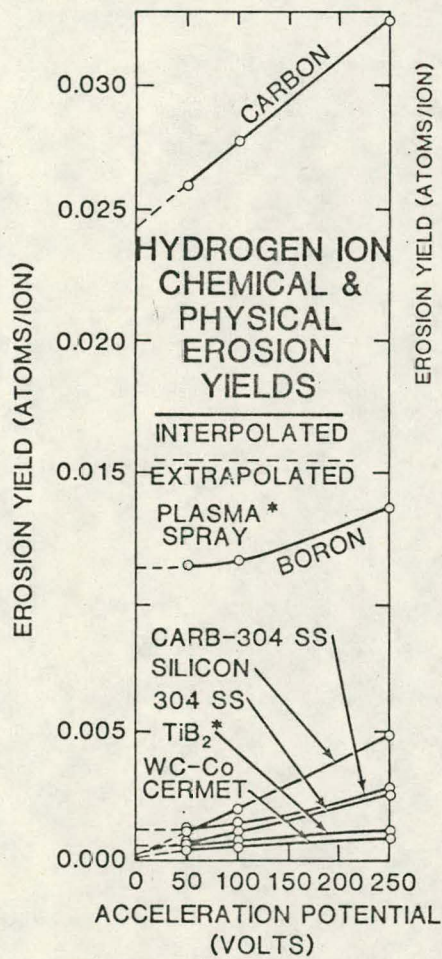
BIBLIOGRAPHY

1. D. J. Sharp, J. K. G. Panitz, and D. M. Mattox, J. Vac. Sci. Technol. 16, (1979) 1879.
2. A. J. West, M. R. Louthan, Metall. Trans. A. 10A, (1979) 1675.
3. R. R. Rye, Surface Science 69, (1977) 653.

FIGURE CAPTIONS

Figure 1. Ion erosion characteristics for 50-1800 eV ions with details of the extrapolation to 0 eV ion energy shown on an expanded scale. a. The curves describing the behavior of materials which can form volatile reaction by-products with the bombarding ion species extrapolate to intersect the ordinate. b. When only physical sputtering occurs, the erosion yield curves extrapolate to intercept the abscissa indicating a threshold ion energy necessary to break cohesive bonds.

Figure 2. AES depth profiles of eight different WC-Co cermet surfaces receiving two different hydrogen ion doses at four different hydrogen ion energies. AES depth profiles of unbombarded control surfaces are shown as references and also as indicators of inherent experimental uncertainty which arises from slight differences in the elemental composition of the cermet samples, variations in reproducing the preliminary state of surface finish from the sample to the next, and resetting the AES amplifier gain from one analysis to the next. Carbon is removed more extensively and intensively by increasing hydrogen ion energy and dose up to 500 eV. The amount of carbon removed by ions above 500 eV, 5×10^{19} ions/cm² is essentially the same independent of energy and dosage.



A ↑
←

↓ B →

