Electron Stimulated Desorption of Hydronium Ions from Chromium Oxide Surfaces

CHARLES RANDAL COLE

College of William & Mary, Department of Applied Science, 2005
Field: Surface and Interface Science, Degree: PhD

Advisor: Brian Holloway, Associate Professor of Applied Science

Abstract

The mass spectral peak observed at 19 amu in residual gas analyzers at very high (< 10^{-6} Torr) and ultrahigh vacuum (< 10-9 Torr) has often been attributed to fluorine. Using Fourier Transform Mass Spectrometry, the hydronium ion, H3O+, has been fully resolved from F+ and its correlation to water vapor concentration was determined to be linear as expected for a gas phase process. The comparison of the mass 19 signals for a conventional quadrupole mass spectrometer and a Fourier transform mass spectrometer on the same vacuum chamber indicated hydronium was the source of mass 19.

The partial pressures of H_2O in the very high vacuum range and higher suggest there is sufficient H2O density for the hydronium ions to form through ion-molecule interactions because hydronium formation was found to directly correlate with the H2O partial pressure. However, in a QMS at UHV, formation of H_3O+ appears to occur principally by electron stimulated desorption (ESD). Introducing hydrogen into the system from 1 Langmuir exposure to saturation (1 × 10-6 Torr for 8 hours) increased the H3O+ ESD yield detected by the QMS by as much as a factor of 10. The initial hydronium ESD cross section from a hydrogen saturated grid was ~ 1 × 10-19 cm2.σestimated to be

TOF-SIMS sputter yields from the stainless steel grid of a quadrupole mass spectrometer also showed small signals of H_3O^+, as well as its constituents (H^+, O+ and OH+) and a small amount of fluorine as F-, but no F+ or F+ complexes (HF+, etc.). Using x-ray photoelectron spectroscopy, a small amount (0.4%) of fluorine was found in the surface of stainless steel. Electron bombardment reduces the fluorine bound in surface complexes, but not metal halides found below the surface. However, heating the sample eliminated the F 1s signal entirely, indicating that fluorine is not likely to be the source of mass 19 in residual gas analysis. Also, changes in the spectral shoulders on the O 1s and Cr 2p3/2 peaks show that hydrogen dosing stainless steel and chromium increases the amount of hydroxides at the surface, while heating and electron bombardment reduce them.