ABSTRACT

Title of Dissertation: ELECTRON-INDUCED PROCESSES ON SURFACES: APPARATUS AND RESULTS FOR TRIFLUOROCHLOROETHENE ON SILICON (100)

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Electrons can interact with molecules to ionize, fragment, or excite those molecules. An understanding of these electron-induced processes is important for both scientific and technological applications.

In this thesis we have designed and built an apparatus to study the interaction of gas molecules with a surface and to study the interaction between electrons and molecules on the surface. We then used that apparatus to study trifluorochloroethene (C_2F_3Cl) on a silicon (100) surface. The apparatus consists of an electron gun with trochoidal monochromator, a stage to manipulate and control the temperature of the surface, a quadrupole mass spectrometer, a gas-injection system, and an ultra-high vacuum system.

Two types of experiment are used to study the trifluorochloroethene-silicon-surface interaction, Temperature Programmed Desorption (TPD) and Electron Stimulated Desorption (ESD). In the TPD experiments, the desorption of different chemical species are monitored as a function of surface temperature (180 K - 900 K). The TPD experiments use thermally induced desorption to give qualitative information about the thermally induced chemical reaction between the trifluorochloroethene and the Si surface. In the ESD experiments the electron-induced desorption of ions is monitored as a function of surface temperature (180 K - 900 K) and as a function of electron energy (0 eV – 100 eV). The ESD experiments use electron-induced desorption as a probe of the chemical state of the molecules on the surface.

We found that the trifluorochloroethene molecules dissociate on silicon surfaces. The ESD of F^+, F^-, Cl^+, and Cl^- was observed, and we found that the fluorine ions desorb from chemisorbed molecular species. Chlorine ions similarly originate from molecular species as well as from atomic chlorine on the surface. Negative ions are the result of dipolar dissociation.

The main effort in this thesis was the design and construction of the apparatus. The apparatus works well, reliably performing repeatable experiments. The computer control of the experiment is especially successful, allowing for great flexibility in the control of the apparatus and the kinds of experiments that can be performed. The main problem with the apparatus is the design of the stage, which is too large and unnecessarily complicated.