Surface Kinetics Modeling of
Silicon Oxide Etching in Fluorocarbon Plasmas

by

Ohseung Kwon

Submitted to the Department of Materials Science and Engineering on April 30, 2004
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Science in Materials Science and Engineering

Abstract

Fluorocarbon plasma for silicon oxide etching is a complicated system involving many ion and neutral species. Depending on the plasma condition, many difficulties arise such as RIE lag, etch stop, and low selectivity to photoresist. For a better understanding of the process it is necessary to have an appropriate physical model to describe the surface kinetics including simultaneous etching and deposition.

A novel surface kinetic model, the translating mixed-layer (TML) model, has been developed. ABACUSS II, a modeling environment and simulator was used for solving differential algebraic equations that describes the surface kinetics. In the modeling, the effect of many variables were investigated including neutral and ion fluxes to the surface, sticking probabilities, surface composition, sputter etching reactions, ion enhanced chemical etching reactions and neutral-to-ion flux ratio.

The model has been applied to various systems including silicon etching with chlorine chemistry, silicon oxide etching with fluorine chemistry and silicon oxide etching with fluorocarbon plasma.

The verification of the model was done using measured etching yield data determined by quartz crystal microbalance (QCM) in conjunction with plasma neutral and ion concentrations/fluxes determined by mass spectrometry.

The etching and deposition rates have been measured as functions of ion impinging angle, sample temperature, which are necessary for profile evolution modeling of silicon oxide etching in inductively coupled plasma. Angular dependence of etching yield of oxide in fluorocarbon plasma shows very unique behavior unlike typical ion-induced chemical etching or physical sputtering. Ion-induced deposition model was suggested and tested.

Thesis Supervisor: Herbert H. Sawin
Title: Professor of Chemical Engineering and Electrical Engineering and Computer Science