The Effect on Profiles and Etching Yield Curves for Oxide Etching

Ohseung Kwon, Weidong Jin and Herbert H. Sawin
MIT
77 Massachusetts Ave. #66-217
Cambridge, MA 02139

Surface kinetics study of silicon oxide etching with fluorocarbons in inductively coupled plasmas
High density fluorocarbon plasma for silicon oxide etching has various ion and neutral species. Depending on the plasma condition, many difficulties arise such as RIE lag, etch stop, and low selectivity of photoresist. Profile evolution modeling can provide understanding of these difficulties in etching as well as trenching, bowing, and faceting. In this research we have measured etching and deposition rates as functions of ion bombardment energy, ion impinging angle, ion-to-neutral flux ration, which are necessary for profile evolution modeling of silicon oxide etching in inductively coupled plasma. In this work, ions and neutrals are extracted directly from plasma to differentially pumped side chambers. Surface reaction is studied by measuring etching and deposition rate with quartz crystal microbalance(QCM). At the same time, ion and neutral composition of the plasma is determined with mass spectrometer. Angular dependence of etching yields of oxide in fluorocarbon plasma show very unique behavior. Ion-enhanced deposition model is suggested and tested. To test the role of deposition in etching feature profile Monte-Carlo simulation is used.

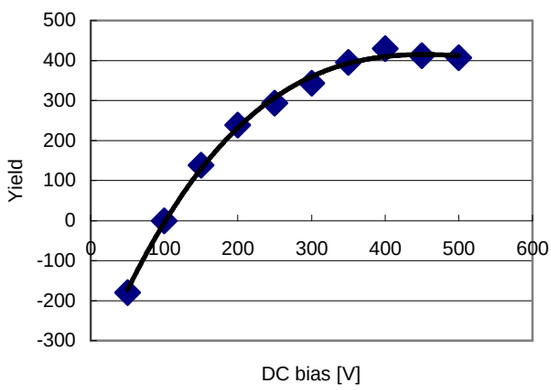

Figure 1 Effect of DC bias on etching yield of silicon oxide in CHF_3 plasma. Below 100 eV deposition dominates while above it etching dominates. The etching is done in 5 mTorr CHF_3 plasma

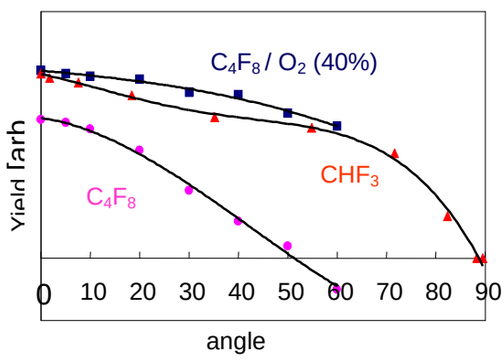

Figure 2 Effect of ion impinging angle on etching yield.

Unlike conventional physical sputtering curve or ion-induced chemical etching without etching chemistry, oxide etching yields in fluorocarbon plasma show very unique shape with etching to deposition crossover depending on the experimental condition.

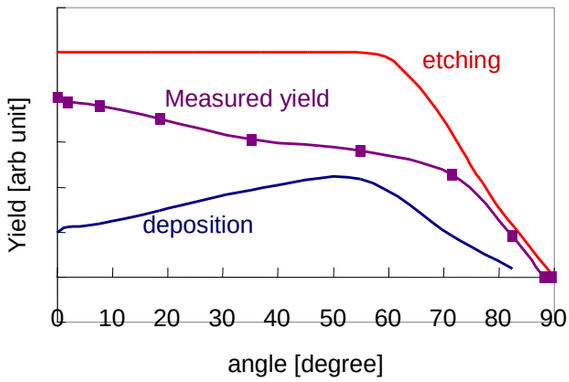

Figure 3 Subtraction to Determine Deposition Angular Dependence. Since the overall yield is the result of the combination of etching and deposition occurring simultaneously, subtraction of supposed etching yield curve from measured yield curve gives deposition component. The resulting deposition component curve shows sputtering-like angular dependence suggesting the deposition is ion enhanced deposition process

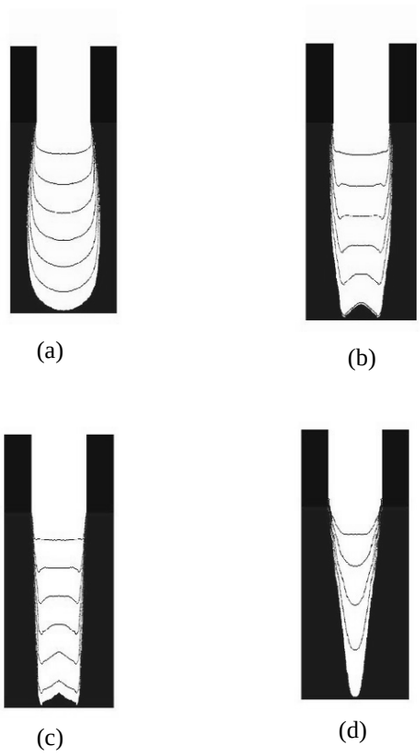

Figure 4 Monte-Carlo Simulation showing the effect of angular dependence of etching yield. Ion incident angle has a gaussian distribution with 5 degree of FWHM. (a) with uniform angular dependence. (b) with ion induced chemical etching angular dependence. (c) with deposition chemistry with 80^o crossover point. (d) with heavily deposition chemistry with C_4F_8 plasma