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Control of Fluorocarbon Plasmas for Next-Generation ULSI Devices

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Fluorocarbon (C-F) plasma is widely used in the etching of dielectric materials (SiO2, Si3N4, and SiOCH). Models for controlling C-F plasma [1] and controlling the surface reaction during etching [2] have been proposed. Using these models, good etching results can be obtained after optimizing the absolute densities of reactive species as well as the ion energies. However, next-generation ULSI devices will have smaller pattern sizes, so we need to reduce the pattern-width variation and the degradation thickness of each stacked film to within several nanometers. Even small plasma fluctuations can severely degrade device properties. Furthermore, the densities of reactive species (CFx, O, H, etc.) are sensitive to the surface condition of the chamber wall. The etching properties, therefore, can be shifted by changes in chamber parts, dry cleaning, and/or polymer or metal deposition on chamber walls. To suppress fluctuations in etching performance, we need to understand and completely control the plasma-wall reactions. Using an equipment engineering system (EES) is one way to predict plasma conditions in real time. (An EES is a tool for statistical calculation of etching properties that uses all signals from an etching system, such as flow rate, power, capacitance of matching network, etc.) We analyzed results of plasma-wall reactions and improved the prediction method of etch rate fluctuation using an EES. The simultaneous use of a physical model (supported by in-situ signal monitoring of plasma parameters) and a statistical model is promising for suppressing plasma fluctuation in mass production.

[1] T. Tatsumi et al, Jpn. J. Appl. Phys., Part 1 37 (1998) 2394.
[2] T. Tatsumi, Applied Surface Science, 253 (2007) 6716.