Plasma surface kinetic studies of etch process in fluorocarbon plasmas

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Fluorocarbon plasmas are commonly used in microelectronics fabrication of plasma etching of dielectric materials such as silicon dioxide and silicon nitride. Recently, one of the critical issues in the etching processes of the nanoscale devices is to achieve ultra-high deep contact hole without anomalous behaviors such as sidewall bowing and twisting profile. However, the semiconductor industries still suffer from the absence of the robust and predictable modeling tools due to the inherent complex plasma chemistry. As an effort to address this issue, we present a fluorocarbon plasma-surface kinetic modeling based on the experimental plasma diagnostic data for etching processes under inductively coupled fluorocarbon plasmas. For this work, the cut-off probe and QMS (quadrupole mass spectroscopy) were used for measuring the electron denisties and the ion and neutral radicals species. Futhermore, the surface analysis using X-ray photoelectron spectroscopy was performed to investigate the thickness and chemical bonding of polymer passivation layer during the etch process. The surface model of the fluorocarbon film region is based on a complex fluorocarbon balance for steady-state substrate etching conditions considering fluorocarbon deposition, etching and consumption. In this model, thickness of the passivated polymer layer on oxide and nitride substrate is calculated from steady-state polymer consumption balance which is composed of sputtered consumption and polymer deposition during the etching. Finally, the surface kinetic modeling results showed good agreements with experimental plasma diagnostic data as functions of plasma power, pressure and gas ratio.

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