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Reaction of Fluorocarbon Species with Si and SiO_2 Surfaces[1]

HIROTAKA TOYODA, Nagoya University

Highly-selective high-aspect-ratio etching of SiO_2/Si is an indispensable key issue in the ULSI manufacturing processes. Furthermore, recent etching technology utilizes high density plasmas and requires complex fluorocarbon molecules such as C_4F_6 or C_5F_8 to achieve high etching speed and high etching selectivity. To improve etching performance, precise control of fluorocarbon plasmas based on deep understanding of radical reactions on SiO_2 and Si surfaces is required. Well-defined beam experiments in ultra-high vacuum are powerful for basic study of surface reactions. This paper shows elementary surface processes of fluorocarbon etching process, especially focused on the unique chemical reactivity of C_5F_8 molecule under co-incidence of Ar ion. The device was specially designed so as to enable *in situ* measurements of etching yield and etched surfaces. Namely, Ar^+ beam at energies from 50 to 400 eV and various kinds of fluorocarbon neutral species (C_5F_8, C_4F_8, CF_2) are co-incident on a clean SiO_2 surface at a controlled flux. Etching yield of beam-incident surface is measured by profilometer while *in-vacuuo* X-ray photoelectron spectroscopy (XPS) analysis reveals a time evolution of atomic composition of surface layer during the etching. In the case of C_4F_8/Ar^+, surface atomic composition after SiO_2 etching was almost similar to that of pure Ar^+ sputtering except for a small amount of F component. In the case of C_5F_8/Ar^+, however, formation of fluorocarbon layer after SiO_2 removal was observed as in the case of CF_2/Ar^+. The SiO_2 etching yield monotonically increased with the Ar^+ incident energy above 400 eV, and the etching yield of 2.4 was obtained at an Ar^+ incident energy of 900 eV with C_5F_8 co-incidence, which was about 3 and 1.5 times larger compared with pure Ar^+ sputtering and CF_2/Ar^+ co-incidence, respectively. These results suggest that fluorocarbon molecules themselves are important species in fluorocarbon etching plasma.

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