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Study of the ion induced etching for Si and SiO2 with F+ and CFX(X=1,2,3)+ ions

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Dry etching with reactive plasma has been widely used in the fabrication of semiconductors. For the development of integrated semiconductor devices, more precise control of the etching process is required for further progress. It is known that reactive ion species and reactive neutral species, which are produced in plasma, play a great role in etching reactions. However, the mechanism for the etching reaction has not yet been quantitatively described because the individual reactive species cannot be controlled independently in the conventional etching apparatus. It is necessary to clarify the roles of individual reactive ion bombardments and neutral species. A beam experimental method is a very useful tool for investigating the interactions of individual species with surfaces. Thus, we developed a mass-analyzed low-energy ion beam system for investigating the interaction of reactive ion with surfaces. It irradiates analyzed single-species ions onto sample surfaces. The irradiation chamber was maintained in the ultrahigh vacuum condition throughout our experiments. The system has neutral beam sources that independently irradiate a neutral species onto the sample surface. The system can simulate an etching reaction in a plasma environment. To investigate surface reactions for etching processes, we have determined the etching yields by incident ion, detected the scattering species and desorbed products with a differentially pumped rotatable quadrupole mass spectrometer (QMS), and measured surface modification during ion irradiation by X-ray photoelectron spectroscopy. The QMS provided time-resolved measurements and could be synchronized with pulsed ion beam. In the present work, we have investigated etching yields and time of flight distribution and angular distribution of desorption products for Si or SiO2 by F+ and CF+ (x = 1-3) ion bombardments which are considered to be the main ion species in fluorocarbon plasmas. These results clearly show that the etching reaction on SiO2 differs from that on Si surface.