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Surface Interaction and Processing Using Polyatomic Cluster Ions

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Ion beam technology is one example of ion-assisted material processing that has recently attracted attention due to the controllability and variety of ion beams that can be used. The energy, current, and size of the ion beams can be controlled over a wide range by applying electric and magnetic fields, and they are used in applications such as material modification, etching, implantation, and plasma chemistry. Furthermore, the variety of ions is ascribed to the characteristic of orbital electrons, and various ions such as positive ion, negative ion, multiply charged ion, polyatomic ion, and cluster ion are available. Among these ions, we have focused on the polyatomic cluster ions. In a polyatomic molecule, various kinds of radicals such as alkyl and hydroxyl radicals are available, and these play important roles in chemical erosion and chemical sputtering. In addition, a cluster state of polyatomic molecules has several unique features, for example, the clusters enable a link between the atomic state and bulk state. Furthermore, the impact process of the polyatomic cluster ions represents specific features. For example, the high energy density irradiation effect enhances the surface temperature of the impact region, which enhances the chemical reactions occurring on the surface.

In this article, polyatomic clusters such as alcohol and water clusters were produced using a nozzle beam method. In order to investigate the interactions of the cluster ion beams with solid surfaces, energetic cluster ions were irradiated on various substrates such as Si, SiO₂, Au and PMMA substrates at different acceleration voltages. The sputtering process was investigated, and chemical sputtering was found to be predominant for the Si surfaces irradiated by alcohol cluster ion beams. Also, the irradiation damage of the Si surfaces by alcohol and water cluster ion beams was smaller than that by the Ar monomer ion irradiation at the same acceleration voltage. Furthermore, to demonstrate engineering applications of high-rate sputtering and low-damage irradiation by alcohol and water cluster ion beams, micro-patterning was performed on the Si and PMMA surfaces.

Keywords

Polyatomic ion

Cluster ion

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