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MICROFABRICATION AND FUNCTIONALIZATION OF POLYMERIC MATERIAL SURFACES UTILIZING ATOMIC OXYGEN BEAM

Abstract

Atomic oxygen (AO) is a main component of Earth's residual atmosphere in low Earth orbit (LEO), formed by dissociation of oxygen molecules (O2) by solar energy. A spacecraft orbiting in LEO flies at a speed of about 8 km/s. Therefore, the AO collides with the front of the spacecraft at this speed. It is known that the colliding AO oxidizes and erodes polymeric materials that are installed on the spacecraft. Several studies have reported that micro / nano scale protrusions are densely formed on the polymer surface by AO irradiation.

Conventionally, the phenomenon is thought as an issue resulting in damage of materials. Based on such knowledge, we have focused on functionality of such reaction between polymeric materials and AO, i.e., it should be considered as "surface modification" and thought it could be applied to fabrication technology. By using an AO beam irradiation facility developed to evaluate AO-induced damage in spacecraft materials, it is highly likely that unique physical and chemical properties can be developed by processing the polymer surface to form microstructures.

In the fields of material process, the formation of micro / nano structures on material surfaces is expected to have a lot of applications. Typical fabrication methods are those utilizing semiconductor processes, nanoimprinting, and crystal growth. However, since these methods use complicated processes, there are issues such as high cost and time cost, and lack of flexibility in prototype evaluation. On the other hand, processing by AO irradiation does not require a complicated pre-processing step. Microstructures can be formed by a simple process of direct irradiation of cleaned polymers with AO. Therefore, the cost of prototyping can be reduced, and functional evaluation can be performed quickly.

Furthermore, the AO irradiation process can have both high reproducibility and a high degree of freedom for design. In processing tests using several general-purpose polymer materials used in consumer products, it was confirmed that protrusions with almost the same shape were formed even though the materials were different. The shape is often a fir-tree-like structure with a high aspect ratio. By controlling the amount and direction of AO irradiation, it is possible to change the shape of the protrusions.

In this presentation, we will share the research problems and solution approaches to realize micro / nano structure processing on polymer surfaces using AO irradiation, as well as the knowledge obtained for the theoretical explanation of microstructure formation.