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Deposition of Si-incorporated a-C:H films on inner surface of microchannel

Hydrogenated amorphous carbon (a-C:H) film has attracted attention for its excellent properties including its high hardness, low friction, resistance to wear, abrasion, corrosion, and erosion, and transparency to infrared wavelengths. The industrial applications of a-C:H films include the surface reformation of various machine parts (such as engine parts, tools, and molds), electronics, optics, and biomedical engineering. However, most machine elements have complex three-dimensional structures, and the technology required to deposit a-C:H films on these complex structures has not yet been established. Previously, we have reported that the a-C:H coatings were successfully deposited on the inner surfaces of the microtrench, nanotrench and microchannel. However, there remains many issues in both film properties and uniformity on the inner surfaces. In this study, Si-incorporated hydrogenated amorphous carbon (a-C:H:Si) films were prepared on inner surface of 100-um-width microchannel by using a bipolar-type plasma based ion implantation and deposition. It was expected that the Si-incorporation increases sp3 bonds in a carbon network, resulting in a high hardness due to the amorphization of film. A mixture of toluene and tetramethylsilane gas was used as a precursor gas for the Si-incorporation. The microchannel was fabricated using a silicon plate. The distribution of thickness and hardness of films was evaluated by SEM and nanoindentation measurements, respectively, and the microstructures of films were evaluated by Raman spectroscopy. Furthermore, the behavior of ions and radicals was analyzed simultaneously by combining the calculation methods of Particle-In-Cell/Monte Carlo Collision and Direct Simulation Monte Carlo to investigate the coating mechanism for the microchannel. In a result, the a-C:H:Si films were successfully deposited on the entire inner surface of a microchannel. The deposition rate of the a-C:H:Si films on the inner surface of microchannel decreased as the Si content and the microchannel depth increased. It was found that the film hardness increased and the films became dense with increasing Si content.

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