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Influence of duct bias on deposition rate of DLC film in T-shape filtered arc deposition

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Abstract

Diamond-like carbon (DLC) films were deposited by a T-shape filtered arc deposition (T-FAD) apparatus, applying bias voltage to the plasma transportation duct which filters the macrodroplet emitted from the cathode, in order to obtain a higher deposition rate. Ion current, deposition rate, discharge voltage, duct current, and anode current were measured as a function of duct bias. The anode current decreased and the duct current increased when a positive bias was applied to the duct. This fact indicates that the T-shape duct acted as another anode of the vacuum arc discharge. It was found that the maximum deposition rate as well as the ion current was obtained at about 15 V of duct bias. Improvement in plasma transportation to the process chamber through the duct was considered from the viewpoint of the characteristics of duct current against bias voltage. The value of the optimum duct bias was the same as the intersection point of the characteristics of duct current against bias voltage.

Keywords: T-shape filtered arc deposition (T-FAD); Diamond-like carbon (DLC) film; Duct bias; Deposition rate; Ion current

1. Introduction

A diamond-like carbon (DLC) film has many attractive properties: high hardness, low friction coefficient, chemical stability, wear resistance, corrosion resistance, low aggressiveness and adhesiveness to the counterparts, gas barrier ability, infrared optical transparency, biocompatibility, and antibacterial activity. Most typical applications are coating on razor blades, cutting tools, ball valves of water taps, and magnetic heads and media of hard-disk drives [1–3]. Recently, applications of DLC on rubber or polymers have become attractive, and one of the applications is coating O-rings used on a surface that requires a sliding property [4,5]. The practical application of DLC coating is currently advancing in various fields, and more and more extensive utilization is expected in the future.

A DLC film can be prepared by various methods. One of the methods is vacuum arc deposition, which is also called cathodic vacuum arc deposition, and arc ion plating. The method is unique in that the plasma including highly energized ions is directly produced from the solid material target as a cathode of the vacuum arc discharge. However, the cathode emits not only plasma particles (electrons, ions, neutrals) but also macro particles (so-called droplets) of cathode material. When the droplets adhere to the prepared film, the properties of the film deteriorate. For example, the surface becomes rough, chemical composition is microscopically not uniform, and the peeling of the film occurs easily. Therefore, the droplets must be removed or filtered to avoid dusty plasma in the cathodic arc. The well-known technique to eliminate the droplets from the cathodic arc plasma is the magnetically transported plasma from the arc-generating source to the film preparation chamber usually through a curved or bent plasma transportation duct [6–9]. The deposition using such plasma is called filtered arc deposition (FAD), or filtered cathodic vacuum arc (FCVA). In FAD, generally, the electrons with small Larmor radii are transported along the lines of magnetic force in the magnetic field tunnel, and

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