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Diamond-Like Carbon Film Produced by Vacuum Arc Deposition Technique and Its Surface Appearance

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SUMMARY

Diamond-like carbon (DLC) films are deposited in a dc vacuum arc plasma with a graphite cathode. The arc current, the flow rate of hydrogen gas and the pressure are 50 A, 10 ml/min and 0.05 Pa, respectively. The substrate materials are Si (111), soda-glass and Mo. Process parameters are deposition time (3 to 30 min). The films are analyzed by laser Raman spectroscopy and the surface appearance of the films are observed with an optical microscope.

The results are as follows: (1) the films deposited under these conditions have diamond-like carbon structure; (2) the films deposited for 3 min on Si or Mo and for 5 min on glass, wrinkle on the substrates; (3) the films deposited for more than 10 min on Si and for more than 15 min on glass, crack and flake off the substrates; and (4) the films deposited for more than 10 min on Mo, plainly stick on the substrate without any wrinkles or flakes.

It is found that plain DLC films are able to be produced by the vacuum arc deposition method if the deposition time is selected appropriately, while never by the conventional plasma CVD method.

Key words: Vacuum arc deposition; graphite cathode; diamond-like carbon film; surface morphology; deposition period; substrate material.

1. Introduction

The vacuum arc deposition method is one of the thin-film deposition methods using low-temperature plasma. In this method, the source material is used as the cathode to evaporate the source material. A high deposition rate is achieved as well as the deposition of a thin film on a large substrate by this technique. The vacuum arc deposition method has been used for depositing wear-resistant material on industrial cutters and molding jigs, and the coating of ornaments.

On the other hand, diamond-like carbon (DLC) film is expected to be usable as an anti-reflection film for magneto-optical discs, and as an anti-wear film in mechanical parts. DLC has been manufactured mainly by the sputtering method and plasma-CVD method [2, 3].

DLC films have also been manufactured by the vacuum arc method in a vacuum of about 10^{-4} Pa [4, 5]. However, to accomplish an easier system design and higher deposition rate, the arc deposition in a medium vacuum (10^{-2} to 10^{2} Pa) has been investigated.

Douyon de Azevedo et al. deposited a carbon film using pulse arc discharge induced by a high-power laser beam to evaporate a graphite cathode in hydrogen atmosphere in a vacuum of 10^{-2} to 133 Pa [6]. They demonstrated the deposition of a diamond-like carbon on negatively biased W and Ni substrates.

In this study, graphite was used as the cathode and dc arc was ignited in a hydrogen atmosphere in a vacuum of 0.05 Pa to form a carbon film on a substrate at low temperature. The structure and surface morphology of the film was evaluated. The substrates were Si (111) of semiconductors, soda glass of insulating materials, and Mo for conductive materials. The deposition periods were 3, 5, 10, 15 and 30 min.

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