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DLC thin film preparation by cathodic arc deposition with a super droplet-free system

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Abstract

Diamond-like carbon films, which are fabricated by means of a cathodic vacuum arc with a graphite cathode, are investigated from the viewpoint of the number of macrodroplets on the film observed with an optical microscope. A straight-type filtered arc deposition (Linear-FAD) system, a 45° torus-type filtered arc deposition (Torus-FAD) system, and a newly developed T-shape filtered arc deposition (T-FAD) system were tested, comparing them with a normal cathodic arc deposition (normal-CAD) system and a shielded cathodic arc deposition (S-CAD) system. The three filtered arc deposition (FAD) type systems showed a remarkable reduction in graphite macrodroplets. Among the FADs, T-FAD drastically reduced the number of macrodroplets to 0.2–0.4% of that for normal-CAD and S-CAD, and to approximately 1% of that for Linear-FAD and Torus-FAD.

Keywords: Diamond-like carbon film; Magnetically filtered arc deposition; Macrodroplets; T-shape duct

1. Introduction

A vacuum arc discharge has a very active cathode spot that emits ions of cathode material as well as electrons. Therefore, the vacuum arc discharge is used for depositing various kinds of thin solid films. The deposition system is called vacuum (cathodic) arc deposition or arc ion plating. However, the cathode spot also emits macrodroplets of cathode material varying in size from submicrons to tens of microns. If the macrodroplets adhere to the prepared films, the film quality is degraded. Thus, the macrodroplet reduction is usually thought to be the most important technological problem to overcome. In vacuum arc deposition, there are various techniques to reduce macrodroplet generation and a variety of methods to prevent macrodroplets from adhering to the film. The most effective technique employs a method whereby the macrodroplets in the cathodic arc plasma are filtered out while the plasma is being magnetically transported from the arc plasma generation zone to the film-processing zone. This technique is known as filtered arc deposition (FAD). Many types of FAD systems have been developed and reported on so far [1–10].

The macrodroplets emitted from the cathode spot are usually melted particles from most cathode materials. The melted macrodroplet particles become easily caught on the inner wall of the curved plasma transportation duct. However, macrodroplets emitted from the graphite cathode during diamond-like carbon (DLC) film preparation are not melted, so that the graphite macrodroplets repeatedly bounce off the filtering duct wall and pass through the filtering duct. Some FAD systems use baffles in the filtering duct to reduce the number of macrodroplets [2,6,7].

In the present paper, we introduce a new type of FAD system, T-shape FAD (T-FAD), designed especially for graphite cathode. The effectiveness of macrodroplet reduction on the film is tested, comparing it with straight-type FAD (Linear-FAD), torus-type FAD (Torus-FAD), as well as non-filtered normal cathodic arc deposition (normal-CAD) and shielded cathodic arc deposition (S-CAD) [11]. Prior to that, the plasma parameters such as arc voltage and ion current extracted were measured for the three different FAD systems.

2. Experimental details

Fig. 1a depicts a schematic diagram of the Linear-FAD system and its electrical circuit. The magnetic coils

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