Improvement of Adhesion of Hydrogen-Free DLC Film by Employing an Interlayer of Tungsten Carbide

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Abstract. Materials with poor adhesion present a problem for the application of diamond-like carbon (DLC) films. As a method for solving this problem, there is a technique that deposits an interlayer of metal between the DLC film and substrate. A tungsten carbide film (W-C film) is used as the interlayer. In this study, the effect of introducing the W-C interlayer on the adhesion of the DLC film was investigated. The W-C films were deposited using two types of cemented tungsten carbides (WCs) as the cathode, one containing Co (WC-Co) and the other containing Ti (WC-Ti), as a binder for forming the cathode shape. It is necessary to control the film thickness of the interlayer to introduce the interlayer to the DLC film. The film thickness control of W-C films became possible by using a discharge counter. DLC films were deposited using a bias voltage of -100 V. The film thicknesses of the W-C interlayer and DLC film at the time of investigating adhesion were 30 nm and 300 nm, respectively. The result of the tape-peeling test showed that the adhesion of the DLC film was improved by employing the W-C interlayer. In addition, adhesion was further improved by removing the oxide layer on the intermediate layer.

INTRODUCTION

A diamond-like carbon (DLC) film is an amorphous carbon film composed of sp^2 and sp^3 bonds[1]. It exhibits excellent material properties, such as high mechanical hardness, wear resistance, low friction coefficient and high chemical inertness[2]. DLC films are generally grouped into four classes according to their features: hydrogen-free tetrahedral amorphous carbon (ta-C), hydrogen-free amorphous carbon (a-C), hydrogenated tetrahedral amorphous carbon (ta-C:H), and hydrogenated amorphous carbon (a-C:H)[3]. In particular, ta-C has high electrical resistivity, mechanical hardness, flatness and a low friction coefficient[4, 5].

A problem with DLC films is that they have materials with poor adhesion[6]. The main cause is the internal stress of the DLC film, and the adhesion of the DLC film decreases with an increase in mechanical hardness. Generally, two methods using metal materials are used to solve the adhesion problem. In the first method, the metal materials are doped to DLC during the deposition process[7, 8]. In the second method, the metal materials are deposited on the substrate as an interlayer[9, 10]. In the second method, because the film thickness of the interlayer may affect the adhesion of the DLC film, it is necessary to control the film thickness when the interlayer is deposited[11]. Because cemented tungsten carbide (WC) has good adhesion to the DLC film, the tungsten carbide film (W-C film) is expected to be used as the interlayer of the DLC film.

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