# Preparation of multi-layer film consisting of hydrogen-free DLC and nitrogen-containing DLC for conductive hard coating

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**Abstract.** Conductive hard-coating films have potential application as protective films for contact pins used in the electrical inspection process for integrated circuit chips. In this study, multi-layer diamond-like carbon (DLC) films were prepared as conductive hard-coating films. The multi-layer DLC films consisting of DLC and nitrogen-containing DLC (N-DLC) film were prepared using a T-shape filtered arc deposition method. Periodic DLC/N-DLC four-layer and eight-layer films had the same film thickness by changing the thickness of each layer. In the ball-on-disk test, the N-DLC mono-layer film showed the highest wear resistance; however, in the spherical polishing method, the eight-layer film showed the highest polishing resistance. The wear and polishing resistance and the aggressiveness against an opponent material of the multi-layer DLC films improved by reducing the thickness of a layer. In multi-layer films, the soft N-DLC layer between hard DLC layers is believed to function as a cushion. Thus, the tribological properties of the DLC films were improved by a multi-layered structure. The electrical resistivity of multi-layer DLC films was approximately half that of the DLC mono-layer film. Therefore, the periodic DLC/N-DLC eight-layer film is a good conductive hard-coating film.

## INTRODUCTION

Contact pins are used in the electrical inspection process[1,2]. During inspection, the contact pins make contact with the solder of the integrated circuit chip and sends a test signal; the returned signal makes it possible to judge whether the product is good or defective. Most contact pins are plated with gold. However, gold plating has problems, such as low wear resistance and low adhesion resistance.

Diamond-like carbon (DLC) films are amorphous carbon films with $sp^2$ and $sp^3$ bonds of carbon atoms[3]. DLC films have superior properties such as high hardness, high wear resistance, and excellent adhesion resistance[4]. In addition, the DLC surface is very smooth owing to its amorphous structure[3]. In cathodic vacuum arc deposition (CVAD), which is one of the DLC deposition methods, it is possible to fabricate hard DLC films[5–10]. Among the CVAD methods, T-shape filtered arc deposition (T-FAD) method enables the preparation of high-quality hydrogen-free DLC films with high hardness, high surface flatness, and less droplets[8–10].

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