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Physical–chemical hybrid deposition of DLC film on rubber by T-shape filtered-arc-deposition

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Abstract

Stretchable and bendable diamond-like carbon (DLC) film was fabricated on rubber substrates using T-shape filtered-arc-deposition (T-FAD) with an acetylene (C_2H_2) gas flow, in order to provide a surface sliding property to the rubber. When the C_2H_2 gas was introduced, the deposition rate became higher. The film obtained under C_2H_2 gas was supposed to be deposited physically with cathodic ion and chemically with decomposed particles of the gas. The smoothest surface was obtained at the optimum gas flow rate at which the deposition rate was highest. The DLC film on the rubber was composed of small meshed islands. When the rubber substrate was bent several times, the islands cracked further to form smaller pieces. Hence, the reason for the deformation of the elastic DLC film together with the rubber deformation was the gradual expansion of the small DLC islands in relation to one another as more and more cracks occurred.

Keywords: T-shape filtered-arc-deposition (T-FAD); Diamond-like carbon (DLC) film; PVD; CVD; Rubber substrates; Deposition rate; Morphology

1. Introduction

Recently, diamond-like carbon (DLC) coating on rubber surface is of interest in industrial applications [1–3]. DLC film has attractive properties especially for tribology, such as low friction coefficient, high hardness, wear resistance, corrosion resistance, and low damage to the counterpart [4–6]. The principal objective in DLC coating of rubber is to provide a surface sliding property while maintaining the elastic property of rubber. Among many methods to prepare DLC film [5], the modulated radio frequency (RF) plasma chemical vapor deposition (CVD) with methane (CH_4) gas source developed by Nissin Electric Co. Ltd., has been employed to realize the commercial applications of the DLC coating on rubber O-rings for zoom cameras by Nippon ITF Inc. It is called Flexible DLC (F-DLC)^{TM}. However, this plasma CVD requires substrate pretreatment by hydrogen plasma irradiation to obtain flexible DLC film deforming together with rubber without peeling off.

The authors have developed a T-shape filtered-arc-deposition (T-FAD) system, which has been

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