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Improvement of drilling performance by overcoating diamond-like carbon films on diamond-coated drills for carbon fiber reinforced plastics processing

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ABSTRACT

The hardness and hydrogen content of diamond-like carbon (DLC) films vary depending on the film deposition methods and conditions. Carbon fiber reinforced plastics (CFRP), known as hard-to-machine materials, have been widely used for industrial aircrafts that require structural materials. In this study, the effects of the hardness and hydrogen content in DLC films on the drilling performance of CFRP drills were investigated. Various DLC films, prepared using the T-shaped filtered arc deposition method, were used to coat diamond-coated drills for CFRP processing. The drilling test of the CFRP plates revealed that the occurrence of burrs was suppressed using the drill coated with a hard DLC film containing small amounts of hydrogen, classified as a hydrogenated tetrahedral amorphous carbon (ta-C:H) film. The spherical polishing test of the CFRP plate using DLC-coated balls demonstrated that the DLC films containing hydrogen suppressed the adhesion of the resin material constituting the CFRP. The coating of hard DLC films containing small amounts of hydrogen, such as a ta-C:H film, significantly improved the drilling performance of diamond-coated drills for CFRP processing. The performance improvement of CFRP drills expands the range of CFRP processing conditions.

1. Introduction

Carbon fiber reinforced plastics (CFRP) are composite materials consisting of carbon fibers bound by a polymer matrix, such as a thermosetting resin (epoxy, polyester, phenolic, polyimide resins) or thermoplastic resin (polypropylene, Nylon 6.6, PMMA, PEEK) [1,2]. CFRP have been widely used for industrial aircrafts that require structural materials with superior properties such as high strength-to-weight and stiffness-to-weight ratios [1,2]. CFRP, which are regarded as hard-to-machine materials, are cut using diamond-coated drills made of tungsten carbide (WC). The polycrystalline diamond film on the drill acts as a protective film and enhances its performance and durability. Diamond-coated drills have been widely used for CFRP cutting; however, their cutting performance, in terms of accuracy and durability, has been insufficient. Coating diamond-coated drills with diamond-like carbon (DLC) films has been proposed to improve the cutting performance of drills [3]. The cutting performance of aluminum alloys of diamond-coated drills improves when coated with a DLC film as it provides a low surface-friction coefficient against the aluminum alloy. The coating is composed of a hydrogen-containing DLC film prepared by RF plasma chemical vapor deposition (CVD).

DLC films are hard amorphous carbon films that are used as

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