Negative Bias Effects on Growth and Mechanical Properties of Ultrananocrystalline Diamond/Amorphous Carbon Composite Films Deposited on Cemented Carbide Substrates by Coaxial Arc Plasma Deposition

Tsuyoshi Yoshitake[1], Ali M. Ali[1,2], Mohamed Egiza[1,3], Kouki Murasawa[1,4], Yasuo Fukui[4], Hidenobu Gonda[4], and Masatoshi Sakurai[4]

[1] Dept. of App. Sci. for Electr. and Mat., Kyushu Univ., Kasuga, Fukuoka 816-8580, Japan.

[2] Mechanical Eng. Dept., Kafrelsheikh Univ., Kafrelsheikh, 33516, Egypt

[3] OSG Corporation, 2-17 Shirakumo-cho, Toyokawa, Aichi 442-0018, Japan

[4] Physics Dept., Faculty of Sci., Al-Azhar University, p.o. 11884, Nasr city, Cairo, Egypt

E-mail: tsuyoshi_yoshitake@kyudai.jp

Ultrananocrystalline diamond (UNCD) /nonhydrogenated amorphous carbon (a-C) composite (UNCD/a-C) films are new candi-dates applicable to hard coating because of the high hardness and Young's modulus. Various methods have been employed for depositing UNCD/a-C films. Although microwave plasma assisted chemical vapor deposition (CVD) and hot filament CVD are representative methods, the deposition time of more than 10 hrs for several micrometers deposition due to low deposition rates. The deposition rate of CAPD is at least two orders of magnitude high-er than that of CVD.

In our previous studies, we realized the the formation of 51 GPa hardness UNCD/a-C films with thicknesses of more than 3 μm on cemented carbide (WC-Co) substrates by coaxial arc plasma deposition (CAPD), without applying negative bias to substrates, which is effective for enhancing the mechanical properties and generally employed for existing methods..

In this work, UNCD/a-C films were deposited on negatively biased WC-Co substrates by coaxial arc plasma deposition, and the effects of negative bias on the growth and mechanical properties of the films were studied. The negative bias voltage was applied in pulsed process at 40, 60, and 80 kHz. The 49 GPa hardness films were deposited at a thickness of 8.8 μm, which is more than an order of magnitude more than that of comparably hard diamond like carbon films deposited by arc ion plating deposition. In addition, the deposition rate evidently increased under the negative bias. This might be because the negative bias enhances the at-traction of positively charged carbon species to the substrates, which results in enhanced film adhesion on the substrates and the release of film internal stresses.

This research was partially financially supported by Osawa Scientific Studies Grants Foundation, Advanced Machining Technology & Development Association, and and JST A-STEP Stage II (seed development type) funds. The experiment at SAGA-LS was performed with the approval of the Kyushu Synchrotron Light Research Center (Proposal No. 1704022S).