同軸型アークプラズマ堆積法を用いた超ナノ微結晶ダイヤモンド/水素化アモルファスカーポン混相膜における放電周波数の影響

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(本文)
超ナノ微結晶/水素化アモルファスカーポン混相(LNCD/a-C:SiD)膜は、粒径10nm以下のナノダイヤモンドと、水素化アモルファスカーポンから構成されており摩擦係数、高い熱安定性、大きな吸収係数を有することから、硬質被膜としても注目されている材料である。本研究では、同軸型アークプラズマ堆積法(CAPD法)を用い、5-20Hzの異なる放電周波数(R.R.)で作製したLNCD/a-C:SiD膜の硬度と弾性率の評価を行い、SAGA-LS BL.15の粉末XRDによりダイヤモンド粒径、DR-12のNEXAFSを用いた炭素の化学結合様式の評価を行った。硬度、弾性率共に5Hzで作製した時が最も高くなり、それぞれ230GPa、184GPaを示し、R.R.の増加に伴い値が低下した。XRDのダイヤモンドビーグクから観測された粒径は5Hzにて約2nmであり、R.R.10Hz、20Hzでは約1.8nm程度であった。NEXAFSの測定結果からR.R.の増加に伴い、C=SiC ビーク、C=H ビークの増加が観測されたことから、放電周波数の増加がダイヤモンド粒子の減少と、ダイヤモンド粒子界面への水素の取込み量を増加させる効果を与え、膜を軟化させたと考えられる。詳細については当報告を行う。
Influence of repetition rate of arc discharge on growth of ultrananocrystalline diamond/hydrogenated amorphous carbon films by using a coaxial arc plasma gun

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Abstract

Ultrananocrystalline diamond/hydrogenated amorphous carbon composite (UNCD/a-C:H) thin films, wherein non-oriented UNCD crystallites with diameters of approximately 5 nm were embedded in an a-C:H matrix, have attracted considerable interest from both the physical and technological viewpoints, because of the following features: (a) some physical properties are similar to those of diamond and diamond-like carbon (DLC) due to sp² bonds; (b) a surface morphology is extremely smooth, which is similar to that of DLC and opposite to that of a polycrystalline diamond film; (c) they are extremely stable up to 1200 °C; and (d) unique optical and electrical properties that might originate from a large number of grain boundaries (GBs) of GBs of UNCD crystallites and between UNCD crystallites and an a-C:H matrix.

1. Introduction

UNCD/a-C:H films have been studied by chemical vapor deposition (CVD), we have succeeded in fabricating them by coaxial arc plasma deposition (CAPD) wherein a coaxial arc plasma gun acts as a plasma source.

2. Coaxial arc plasma deposition (CAPD)

UNCD/a-C:H films have been fabricated by chemical vapor deposition (CVD), we have succeeded in fabricating them by coaxial arc plasma deposition (CAPD) wherein a coaxial arc plasma gun acts as a plasma source.

3. Aim

In this study, we prepared UNCD/a-C:H films using a coaxial arc plasma gun at different repetition rates of arc discharge, and on the basis of the structural evaluation results, the influence of the repetition rate on the film formation is discussed.

4. Experimental

The experimental results show that the UNCD crystallite growth is influenced by the repetition rate since the UNCD crystallite growth is an activated state in internal periods between outward depictions caused by arc discharge. At a low repetition rate such as 1 Hz, the activated state must be lowered by a long internal time between arc discharges. Thus, the UNCD crystallite growth must be suppressed. On the other hand, at a high repetition rate such as 20 Hz, the UNCD crystallite growth after the nucleation might not be advanced due to a short internal time after each arc discharge. In addition, a deposition amount of 3.3 nm discharge corresponds to a large effective deposition rate. This situation might also impede the crystallite growth after the nucleation.

8. Conclusion

We investigated the influence of a repetition rate of arc discharge on the growth of UNCD/a-C:H films. The UNCD crystallite size has a large value at 5 and 10 Hz. At smaller repetition rates, the UNCD crystallite growth including the nucleation might be inactivated due to a long internal time between arc discharges. On the other hand, at a higher repetition rate, the growth that successively occurs after the nucleation might be suppressed due to a short internal time and large effective deposition rate.

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