

論文 / 著書情報  
Article / Book Information

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著者(和文)	LIYUCHENG
Author(English)	Yucheng Li
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(博士課程)  
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## 論文要旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	機械 機械	系 コース	申請学位 (専攻分野)： Academic Degree Requested	博士 Doctor of	(工学)
学生氏名： Student's Name	LI YUCHENG		審査員主査： Chief Examiner	大竹 尚登	

### 要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words )

In this research, the objective is to synthesize a DLC composite film possessing both mechanical properties and antimicrobial properties by incorporating Cu or TiO<sub>2</sub>. Chapter 2 described the methodology of multilayer film fabrication employed in Chapter 4 and Chapter 5. Chapters 3, 4, and 5 introduced the film formation techniques and property evaluations of Cu-DLC composite films. In Chapter 3, films are fabricated using CH<sub>4</sub> and a Cu target as raw materials through a combination of CVD and MS methods. Chapter 4 utilized C<sub>2</sub>H<sub>2</sub> and a Cu target to deposit multilayer Cu/DLC films on segmented DLC films, incorporating Cu into the DLC. Chapter 5 also employed C<sub>2</sub>H<sub>2</sub> and a Cu target, but alternated layers of DLC and segmented Cu. This method synthesized multilayer films that can simulate the structure of mixed films. Chapters 3, 4, and 5 all focus on Cu-DLC composite films, with Chapters 4 and 5 refining the film formation techniques from the preceding chapter, thus forming a progressive relationship. Chapter 6 introduced TiO<sub>2</sub>-DLC films synthesized using arc vacuum deposition and MS methods. Chapter 7 provided conclusions and systematization of the film properties.

Chapter 2 demonstrated the synthesis of multilayered DLC films via CVD and magnetron sputtering. The synthesized films with a DLC/Cu/DLC structure exhibited antiseizure properties that prevented the adhesion of instant adhesives. The appearance of the DLC film after peeling allowed the retention of wear resistance, and this indicated the successful development of a functional coating. The peeling interface of the film was subjected to SERS analysis. The results revealed that the deposition of the Cu film via magnetron sputtering induced the transformation of the DLC film at the polar interface into nanocrystal graphite. This chapter introduced the genesis of multilayer films and provides a methodological framework for film deposition techniques. The initial focus of this chapter is on discussing methods to facilitate easier delamination of multilayer films. Based on the conclusions drawn in this chapter, methods to prevent delamination were subsequently obtained.

Chapter 3 introduced the Diamond-like Carbon coatings doped with copper were prepared on silicon substrates by means of chemical vapor deposition and magnetron sputtering using methane gas and copper targets. Approximately 25 at. % copper was incorporated in DLC film according to XPS element analysis. Different from Cu film independently deposited on DLC film, Cu particles embedded in DLC films formed three-dimensional structures in hybrid films. Due to high content of copper particles, the roughness of DLC films was significantly increased and the hardness was significantly decreased. Despite having similar coefficient of friction comparing with pure Cu film, Cu-DLC film can withstand longer friction tests and exhibited higher hardness. In addition, Cu-DLC composite film can improve antibacterial properties. It showed hydrophobic surface and was hard for bacteria suspension to adhere to film after inoculating the bacteria.

Chapter 4 proposed a structure in which DLC/Cu multilayer films are deposited on segment DLC films. To achieve a hybridization of copper and DLC without compromising the sputtering efficiency of copper, a segmented structure DLC film was employed. Their mechanical and antimicrobial properties were evaluated. There are discontinuous layers with a low Cu content of 0 at. % and layers with a higher Cu content of approximately 30-40 at. % in Cu/DLC multilayered samples. Despite the coefficient of friction were 0.1 higher than DLC films, Cu-DLC multilayered film (with or without segment structure) can withstand 10 thousand rotations in wear tests. With slight wear progression, Cu/DLC multilayer films displayed sufficient antibacterial properties against E. coli and demonstrated a lower viral infectivity tendency against A-type influenza virus.

Chapter 5 demonstrated DLC films and Segmented Cu layers that alternately deposited on Si substrate. Compared to the simple DLC/Cu multilayer deposited on segment DLC films, the DLC/segment-Cu films exhibit different properties. After reducing the deposition time of the copper layers, no delamination phenomenon was observed in the multilayer films. In multilayer films where the intermediate layer was segmented, the individual DLC layers exhibit an uneven cross-section. The coefficient of friction of DLC/segment-Cu films generally stabilize around 0.2, which exhibited outstanding wear resistance. Additionally, they also showed higher antibacterial activity against E. coli than pure DLC. The samples in this chapter integrated the advantages of those from Chapters 3 and 4.

Chapter 6 introduced TiO<sub>2</sub>-DLC films synthesized using arc vacuum deposition and MS methods. As time progresses, the quantity of titanium dioxide particles on the surface significantly increased. However, the particle size remains between tens to over 100 nanometers. The thickness of TiO<sub>2</sub>-DLC 1h and TiO<sub>2</sub>-DLC 2h was approximately 127nm and 258 nm. The synthesized TiO<sub>2</sub> film and the titanium dioxide in the TiO<sub>2</sub>-DLC are both in an amorphous state. Under otherwise identical

conditions, the elemental distribution of the two TiO<sub>2</sub>-DLC samples exhibits different results when the film formation times vary. The BoD results indicate that the coefficient of friction for TiO<sub>2</sub>-DLC 2h was lower than that for TiO<sub>2</sub>-DLC 1h.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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