Me-DLC with Self-assembled Layered Nanostructures

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This paper reports self-assembled thin films consisting of alternating layers of DLC and metal. The thin films were obtained using a sputter deposition technique equipped with a single magnetron gun. Experimental observations indicate the formation of such self-assembled alternation structure is controlled largely by the type of metal used.

In physical vapor deposition multi-layer thin films are normally obtained using co-sputtering techniques or more than one sputtering targets. In this paper we report the use of a dc sputter deposition system equipped with a single magnetron gun to deposit metal-containing diamond-like carbon (Me-DLC) with self-assembled layered nanostructures. Me-DLC has been used in applications where enhanced tribological properties are sought [1 2]. Recently, many potential applications of Me-DLC films, including microelectrodes in electrochemical analysis and field emission properties have been suggested [3 4 5].

The self-assembled structures were obtained through controlled deposition parameters and the selection of target materials in a dc sputter deposition system. The 3-inch metal targets were nickel (99.99%), platinum (99.99%), and copper (99.95%). Single crystal wafers of (100) Si were used as the substrates. The sputter system was evacuated to a pressure lower than 6.67×10^{-3} Pa prior to the deposition and then filled with an argon/methane gas mixture to a desired deposition pressure. The dc powers were 100 W and 200 W. The electrode distances were 40 and 70mm. The deposition time was kept at 30 minutes. The substrates were not heated during the deposition under all conditions. The resulting Me-DLC thin films consist of alternating layers of DLC and either layers of platinum or copper. Surface morphologies and cross-section views of Me-DLC thin films were examined using scanning electron microscopy (SEM). Deposition rates of Me-DLC films were determined from the thickness, measured using the SEM cross-sectional images. Crystallinity and microstructure of the Me-DLC thin films were examined using low-angle x-ray diffractometry, high-resolution transmission electron microscopy (HRTEM), and micro-Raman microscopy.

From the cross-sectional images obtained using the HRTEM, alternating layers of DLC and either Pt or Cu were observed. Fig. 1 shows such a alternating layers of DLC (bright bands) and Pt (dark lines). The micro-diffraction patter of Pt is also given in the figure as an insert, which shows that the Pt is polycrystalline. It was also found that the DLC layer is thicker than the metallic layer. The former has an average thickness of 20 nm, while the latter has an average thickness of less than 3 nm. In a few cases, it was found that the DLC layer is in fact composed of a matrix of carbon and either platinum or copper nano-particles. The metallic layer, on the other hand, is pure metallic in any cases.

On the other hand, when Ni was used as the target material, it was found that the combination of carbon and nickel did not lead to such alternating layers. It is noted that platinum is a noble metal, copper and carbon are immiscible, and nickel and carbon form carbide. Discussion is thus given concerning the carbon-metal interaction, which is thought to dominate the formation of the self-assembled multi-layer structure.

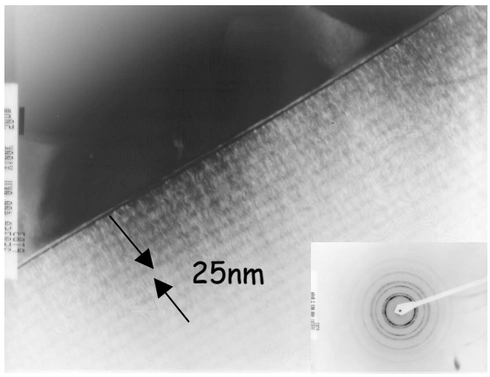

Fig. 1. Alternating layers of DLC and Pt. The insert is a micro-diffraction patter of the Pt which indicate the polycrystalline nature of Pt.

References

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