Magnetron Glancing Angle Deposition of Nanocomposite Thin Films

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1. Introduction

It has been shown recently that Glancing Angle Deposition (GLAD) can be used as a method of depositing films with tunable nano- and microstructure [1]. GLAD utilizes an effect of self-shadowing which occurs when a flux of vaporized atoms or molecules arrives at a substrate tilted at oblique angle (>70˚) to direction of the flux. In this case, the growing nuclei shadow the area opposite to incoming flux and therefore the film grows through formation of columnar structures separated from each other by voids and inclined toward the source of the flux. The choice of the material of the substrate and its temperature are of paramount importance in GLAD as they may significantly decrease the surface mobility of adatoms and hence improve the separation of columns. Furthermore, the variation of the tilt of the substrate during the deposition may produce variety of shapes from zigzag to helical pillar structures.

Majority of GLAD has been performed so far on metals and inorganic compounds by using PVD under high vacuum which ensures a directional flux of particles moving in a collisionless regime. A limited number of studies dealt with plasma sputtering technique [2]. In this case, however, higher pressure was mandatory to maintain plasma.

In this work, an attempt has been made to combine magnetron sputtering and GLAD for the deposition of the Mo and Ti films as well as Ti/CH nanocomposite films.

2. Experimental

The experiments were performed in a bell-jar reactor pumped by rotary and diffusion pumps. A DC planar magnetron was designed to produce the enhanced magnetic field of 0.2 T above the erosion track. This allowed the operation of the magnetron at reduced pressures down to 0.08 Pa. The mixture of argon and hexane was used as a working gas. The substrates (silicon and glass) were located 7 to 10 cm from the magnetron and their angle position could be varied with respect to the target normal.

3. Results and Discussion

Fig. 1 shows the cross-section of the molybdenum film deposited on glass under 0.08 Pa Ar pressure. In the middle of the deposition the substrate angle was changed from 75 to -85˚ for a certain period of time and then the angle was restored to its previous value. Such manipulation led to formation of zigzag columnar structure. Obviously, magnetron sputtering in combination with GLAD may prove to be powerful technique to sculpturing the structure of thin films.

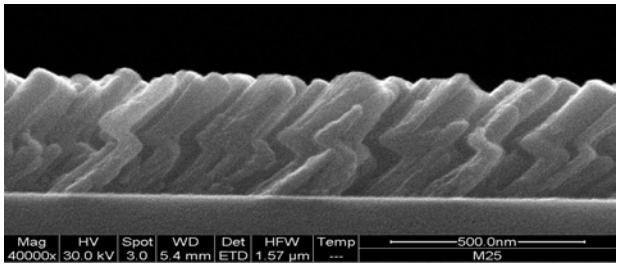

Fig. 1 Cross-section of molybdenum GLAD film.

Titanium behaved similarly to molybdenum and produced nanocolumnar films when sputtered in Ar. Ti was also sputtered in a mixture of argon and hexane. In this case, sputtering of titanium was accompanied by plasma polymerization processes which lead to increase of the C and decrease of the Ti content in the films. The columnar structure was retained at least up to 5% of hexane in the working mixture. At higher hexane concentration the discharge became unstable because of the target poisoning effects. Titanium carbide as well as titanium oxides and hydrocarbons detected in the films prove the complex chemistry involved in such deposition.

GLAD of hydrocarbon plasma polymer film was also performed by magnetron sputtering of polypropylene in the RF mode. The film deposited on glass appeared continuous without distinguishable columnar structure. However, when deposited over the structured Ti layer from the previous GLAD experiments the hydrocarbon film followed the direction and angle of the Ti columns. The direction and angle of the hydrocarbon columns could be changed by varying the tilt of the substrate.

4. Conclusions

Nanostructure of Mo and Ti films can be tuned in a wide range by using magnetron sputtering in the GLAD configuration. Plasma polymerization can be implemented with GLAD to produce composite films. The structure of the substrate may trigger the morphology of organic films deposited by GLAD from continuous to nanostructured thin films.

References

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