Incident Angle Effect of Energetic Carbon Ions on Thickness, Morphology, and Structure of Ultrathin Amorphous Carbon Films Deposited by Filtered Cathodic Vacuum Arc

N. Wang and K. Komvopoulos
Department of Mechanical Engineering, University of California, Berkeley, California, 94720, USA

Abstract

In oblique deposition, the microstructure and film properties are strongly dependent on ion depositing and self-sputtering. The effect of the incident angle of energetic carbon ions on the deposition of ultrathin amorphous carbon (a-C) films by filtered cathodic vacuum arc (FCVA) was examined in the context of numerical and experimental results. The thickness of a-C films deposited at different incident angles was investigated in the light of Monte Carlo simulations, and the calculated depth profiles were compared with those obtained from high-resolution transmission electron microscopy (TEM). The surface morphology and structure of the a-C films were studied by atomic force microscopy (AFM) and X-ray photoelectron spectroscopy (XPS), respectively. The film thickness decreased with increasing incident angle, while the surface roughness increased and the content of tetrahedral carbon hybridization ($sp^3$) decreased significantly for incident angles above 45° measured from the surface normal. TEM, AFM, and XPS results indicate that the smoothest and thinnest a-C films with the highest content of $sp^3$ carbon bonding were produced for an incident angle of 45°. The findings of this study have direct implication in ultra-high-density magnetic recording, where ultrathin/smooth a-C films of high $sp^3$ content are of critical importance.

Index Terms – Amorphous carbon, hybridization, filtered cathodic vacuum arc, structure, surface morphology, ultrathin films.

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