Effects of Bias Voltage on Microstructure and Properties of Al-doped Hydrogenated Amorphous Carbon Films prepared by a Hybrid Deposition Technique

Songsheng Lin[a,b,c], Wei Xu[a,d], Hong Li[a,b,c], Mingjiang Dai[a,b,c], Qian Shi[a,b,c], Chunbei Wei[a,b,c], Hao Wang[a,b,c], Kesong Zhou[a,b,c,d]

[a]Guangdong Research Institution of New Materials, Guangzhou 510651, P.R. China

[b]State Engineering Laboratory of Surface Engineering Technology of Modern Materials, Guangzhou 510651, P.R. China

[c]Guangdong Academy of Sciences, Guangzhou 510070, P.R. China

[d]School of Material and Engineering, Central South University, Changsha 410083, P.R. China

Abstract: Al-doped hydrogenated amorphous carbon films were deposited on Si wafers and stainless substrates by a hybrid deposition technique composed of middle-frequency magnetron sputtering and anode layer ion source. Effects of substrate bias voltage on the deposition rate, surface topography, microstructure, residual stresses and mechanical properties were characterized using scanning electron microscope (SEM), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy and nano-indentation. It was shown that the aluminum atoms were embedded in carbon matrix without bonding with C atoms. The surface of the films evolved from a rough surface with quasi-columnar characteristic to a smoother surface with the applied bias voltage increased from 0 to -400V. The residual stresses of the films deposited at 0V and -50Vwere tensile stress, while it transformed to compressive stress with bias voltage increased to -100V or higher. The hardness of the film stayed in the highest level of nearly 17GPa, while the bias voltage ranging from -150 to -300V. The ball-on-disk tribo-meter was further used to study the tribological behavior, the results demonstrated that the film deposited at -150V exhibited excellent lubrication performance with a fiction coefficient of about 0.047 and good wear resistance.

Keywords: Al-doped, Amorphous carbon, Bias voltage, Residual stress, Tribology