Effect of argon ion implantation on the properties of plasma-polymerized acetylene films

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Abstract

This work describes an investigation of the properties of plasma-polymerized acetylene (PPA) films treated by plasma immersion ion implantation (PIII). The films were deposited from radiofrequency (13.56 MHz, 80 W) plasmas of acetylene at low pressure of 12.7 Pa. Afterwards, the films were polarized with high voltage negative pulses (25 kV, 30 Hz) and simultaneously bombarded with ions created in argon glow discharges (13.56 MHz, 70 W, 1.8 Pa). Exposure time to the implantation plasma varied from 15 to 120 min. The elemental composition of the pristine and bombarded films was evaluated by X-ray photoelectron spectroscopy (XPS). With rising exposure time, XPS analysis reveals an increase of oxygen-to-carbon (O/C) atomic ratio from 0.24 to 2.44. It is explained by recombination processes between dangling bonds or radicals created in the structure and atmospheric O2 and H2O. Besides, the film structure is predominantly formed by sp2 hybridization states, but there was an increment of the proportion of sp3 hybridization states from 11 to 23% upon argon PIII. Film wettability was investigated by the contact angle measurements. Right after the implantation, the water contact angle was reduced from 55 to 24∘, attributed to incorporation of polar groups in the structure. Upon aging in atmosphere, all films lost the high wettability, but their hydrophilic character was preserved. Atomic force microscopy (MFA) was employed in the roughness measurements. After argon PIII, roughness of the films was decreased from 8.2 to 5.6 nm, mainly due to sputtering process. Nanoindentation technique was performed to determine the hardness and reduced elastic modulus of the films. Hardness was enhanced from 0.68 to 5.35 GPa, while elastic modulus was increased from 28 to 114 GPa, which is attributed to increase of chain crosslinking. In general, the results show that argon PIII turned the PPA films smoother and mechanically more resistant, but its effect depends on exposure time.

Keywords: plasma polymer, acetylene, argon, XPS, wettability, roughness, hardness

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