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The effect of hydrogen addition on the structure of amorphous carbon films in Ar/C2H2 plasma

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The amorphous carbon films were deposited on silicon substrates by plasma jet chemical vapor deposition (PJCVD). Carbon coatings have been prepared at atmospheric pressure in argon/acetylene and argon/hydrogen/acetylene mixtures. Argon (flow rate of 6.6 l/min) and hydrogen (flow rates of 0.06÷0.24 l/min) were used as feed gases, and an acetylene (C_2H_2) (0.066 l/min or 0.044 l/min) as a precursor. The distance between plasma torch nozzle exit and the samples was 0.005 m. The deposition time was 120 s for Ar/C_2H_2 plasma, and 300-600 s for $Ar/H_2/C_2H_2$ plasma. Surface morphology was characterized by scanning electron microscopy. The energy-dispersive spectrometry (EDS)analysis was used to determinate elemental composition of films. Bonding structure and optical properties of carbon films were characterized using Fourier transform infrared spectrometer and Raman scattering spectroscopy. The microhardness measurements were performed using MTS Nanoindenter G200.It was demonstrated that the addition of the hydrogen decreases growth rate of the films, the surface roughness of the coatings decreases. The EDS measurement indicated that coatings prepared without the hydrogen have low fraction of oxygen (~5 at.%), meanwhile the addition of hydrogen increase oxygen fraction up to ~10 at.%. The FTIR spectra showed a clear evidence of C=C and C=O sp^2 bonds and presence of sp^3 CH_2 symmetric (2850 cm^{-1}) and asymmetric (2920 cm^{-1}), and sp^3 CH_3 asymmetric (2960 cm^{-1}) modes in coatings. The addition of the hydrogen increases the intensity of C=O sp^2 and sp^3 CH_{2-3} bonds. The films prepared in Ar/C_2H_2plasma are attributed to graphite-like carbon films with significant fraction of sp^3 C-C sites. The formation of the nanocrystalline graphite was obtained in $Ar/H_2/C_2H_2$ plasma. The hardness of the films deposited without the hydrogen was in range of 7÷9 GPa. The addition of the hydrogen reduces the hardness value down to 0.3 GPa.

Keywords
plasma jet
atmospheric pressure
carbon films