PO1057

Deposition and structure characterization of carbon films prepared at atmospheric pressure by plasma jet

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The amorphous carbon films were deposited on stainless steel substrates by plasma jet chemical vapor deposition (PJCVD). Carbon coatings have been prepared at atmospheric pressure in argon/acetylene mixture. The Ar/C_2H_2 gas volume ratio varied from 100:1 to 200:1, while the distance between plasma torch nozzle exit and the samples was 0.005÷0.02 m. Plasma torch power was 600 W and the deposition time was 180 s. Surface morphology was characterized by scanning electron microscopy (SEM) model JEOL JSM–5600. Bonding structure and optical properties of carbon films were characterized using Fourier transform infrared (FTIR) spectrometer (GX FT-IR) and Raman scattering (RS) spectroscopy. The elemental composition of the carbon films was analyzed by Rutherford backscattering (RBS) and elastic-recoil detection analysis (ERDA) techniques. The microhardness measurements were performed using MTS Nanoindenter G200.

It was demonstrated that by varying the Ar/C_2H_2 ratio the composition, growth rate of the films, and consequently the structure of the film, can be controlled. SEM analysis demonstrated that the surface roughness and growth rate of the coatings increases with decrease of Ar/C_2H_2 ratio. The ERDA results showed that the hydrogen concentration falls from 27 at.% to 5 at.% with the decrease of the distance from 0.02 to 0.005 m. The increase of the Ar/C_2H_2ratio from 100:1 to 200:1 slightly increases the hydrogen and oxygen concentration in the films. 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 Raman spectroscopy indicated that the film prepared at Ar/C_2H_2=100:1 and 0.005 m has the highest sp^3 C-C fraction, while the coating prepared at 0.02 m has the highest fraction of sp^3 CH_x bonds. The hardness of the carbon films deposited at 0.005 m was in range of 7.1-9.3 GPa.

Keywords
plasma jet
acetylene
atmospheric pressure
carbon films
plasma generator