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Graphite Nanostructures Produce in the Acetylene, Argon-Acetylene and Argon-Hydrogen-Acetylene Plasmas

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The amorphous carbon films were deposited on silicon-metal substrates by plasma jet chemical vapor deposition (PJCVD) and plasma enchanted CVD (PECVD). PJCVD carbon coatings have been prepared at atmospheric pressure in Ar/ C_2H_2 and Ar/H_2/C_2H_2 mixtures. The films prepared in Ar/C_2H_2 plasma are attributed to graphite-like carbon films. Addition of the hydrogen decreases growth rate and the surface roughness of the coatings, but coatings have low fraction of oxygen (~5 at.%) The formation of the nanocrystalline graphite was obtained in Ar/H_2/C_2H_2 plasma. The carbon nanotubes were synthesed by PECVD using Au/Cr catalyst particles at low (≤ 450 C; p = 40 Pa) temperature in pure acetylene.

Keywords: Graphite nanostructures, Acetylene, Plasma.

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1. INTRODUCTION

Carbon nanostructures (nanotubes, nanoonions, carbon black, fullerene and etc.) have received considerable attention due to their unique mechanical, optical, electrical and electronic properties. These fascinating properties make the carbon nanostructures great candidates for application in a wide variety of fields [1, 2].

Various deposition techniques are used to produce graphite nanostructures. It was shown that the synthesis temperature and characteristics of the catalyst play a key role in controlling the structure of carbon nanostructures [1-3].

In this paper graphite nanostructures were fabricated from acetylene gas at 40 Pa and at atmospheric pressures. Experimental work was done to investigate the effect of various acetylene gas flow and temperatures on the graphite structure formation.

2. EXPERIMENTAL SETUP

The amorphous carbon films were deposited on Si-metal substrates by plasma PJCVD and PECVD. PJCVD carbon coatings have been prepared at atmospheric pressure in Ar/C_2H_2 and Ar/H_2/C_2H_2. Ar (flow rate of 6.6 l/min) and H_2 (flow rates of 0.06÷0.24 l/min) were used as feed gases, and C_2H_2 (0.066 l/min or 0.044 l/min) as a precursor [4]. The distance between plasma torch nozzle exit and the samples was 0.005 m.

PECVD carbon films have been prepared at ~ 40 Pa pressure in pure acetylene. Carbon nano-structures, as a function of substrate temperature and plasma activation of reactive species using catalyst particles forming with electron beam lithography, laser radiation and thermal annealing methods.

Surface morphology was characterized by SEM, elemental composition of formed thin films determinate by energy-dispersive spectrometry (EDS). Bonding structure and optical properties were determined by Fourier transform infrared (FTIR) and Raman scattering spectroscopy. RS was investigated using Spectra – Physics YAG: Nd laser (532.3 nm, 50 mW, spot size 0.32 mm).

3. RESULTS AND DISCUSIONS

The coatings deposited from argon-acetylene plasma are rough and consist of columnar structure (Fig. 1). The films growth rate decreased, oxygen concentration and sp^2 sites fraction increased with decreasing C_2H_2 flow rate. The surface roughness and growth rate of the graphite films decreases with introduction of the hydrogen and with the increase of H_2 flow rate.

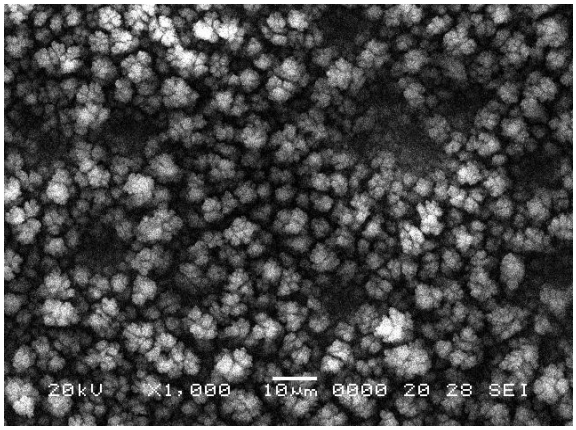

Fig. 1 – Surface morphology of structures formed in Ar/C_2H_2 plasma

The EDS measurement indicated that coatings prepared without the H_2 have low fraction of oxygen (~5 at.%), meanwhile the addition of hydrogen increase oxygen fraction up to ~10 at.%.

The films prepared in Ar/C_2H_2 plasma at high temperature (800-1200 °C) are attributed to graphite-like carbon films with significant fraction of sp^3 C-C sites. The synthesis of the nanocrystalline graphite was ob-

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tained in $Ar/H_2/C_2H_2$ plasma. The formation of carbon nanostructures of 1-2 μm length and up to 200 nm diameters were obtained using argon-hydrogen-acetylene plasma on Si-Ni and Si-Au substrates (Fig. 2). The variation of the technological parameters allows changing the IR reflectance values of carbon films in wide range.

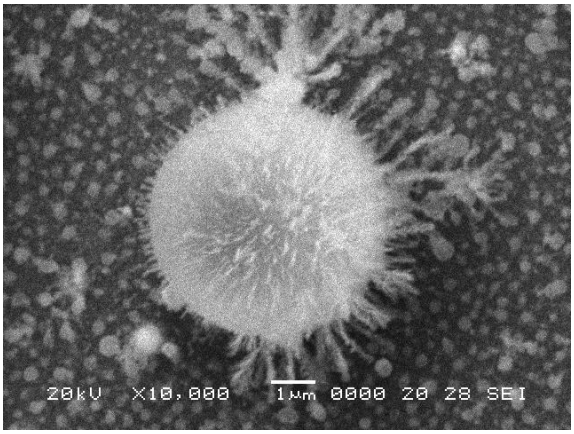

Fig. 2 – Surface morphology of structures formed using $Ar/H_2/C_2H_2$ plasma

It was found that the formation of the carbon nanotubes begins on the Si substrate covered by Au/Cr nano-islands (forming with electron beam lithography and laser radiation methods) in pure acetylene gas plasma at ~ 450 °C temperatures.

4. CONLUSIONS

The films prepared in Ar/C_2H_2 plasma are attributed to graphite-like carbon films. Addition of the hydrogen decreases growth rate and the surface roughness of the coatings and lead to formation of nanocrystalline graphite. The carbon nanotubes were formed at low ($\leq$ 450 °C; p = 40 Pa) temperature in pure acetylene.

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