Carbon synthesis in methane plasma

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In this paper, we report a new method to generate amorphous carbon. The growth of amorphous carbons was performed at atmospheric pressure using a high voltage pulsed power supply (20 kV and 25 kHz) under the methane flux. Pulsed discharges of methane gas at atmospheric pressure were generated using high voltage power supply. The pulsed discharge of methane gas was generated between two sharp wolfram electrodes. Three types of carbon was produced by this pulsed plasma namely powder carbon, soft and hard carbon. Carbon samples were investigated by Scanning Electron Microscopy, Energy Dispersive X–ray spectroscopy and X-ray diffraction. The carbon samples have amorphous structure according to XRD results without contamination according to EDX results.

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1. Introduction

Nanocarbon structures represent new type materials with unique mechanical and electrical properties [1]. Among the popular applications, one can mention hydrogen storage, the reinforcement of composites with ceramic and polymer matrices, the development of specialized lamps and flat panels, etc [2-5] . Nanocarbon structures generally are produced by several techniques like Chemical Vapor Deposition (CVD), laser ablation, electric arc methods [6-8].

The aim of this paper is to produce carbon from technical methane gas by using atmospheric pulsed plasma. The conversion of the atmospheric pulsed plasma methane to carbon, presented in this papers is very cheap and simple because no any vacuum equipment is necessary. In addition, this method can be used for carbon deposition to any substrates. In this paper, carbon structures were growth on the sharpened wolfram wires and inner surface of the glass tubing surrounding tungsten electrodes.

2. Experimental arrangement

The discharge tube was made from pyrex glass with an inner diameter of 10 mm, outer diameter of 13 mm and a length of 70 mm. As working gas we used technical methane gas. The discharge tube has as electrodes two sharpened tungsten realized using electropolishing technology. Methane pulse plasma was generated between the sharpened electrodes. Methane gas was flowed through the glass tubing continuously. Produced carbon were growth on the sharpened wolfram electrode. Three type carbons were produced by this pulsed plasma: powder, soft and hard carbon. The parameters of the Power Supply used to ignite and to maintain pulsed discharge are: a high voltage of 20 KV dc voltage and high frequency of 25 KH_Z of the pulsed discharge.

Experimental system is schematically shown in Fig. 1.

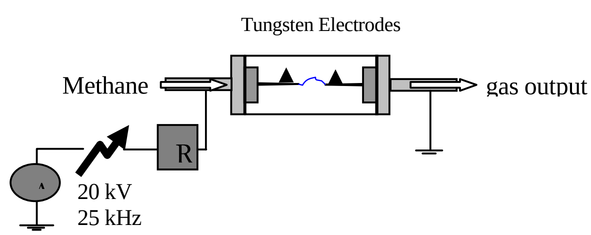

Fig. 1. Schematic diagram of the experimental system.

The working parameters are presented in Table 1.

Table 1. Working parameters used for carbon synthesis in methane plasma.

WORKING PARAMETERS	VALUE
Distance between electrodes d (mm)	8
Methan gas flux (l/min)	0,3
Production time t (s)	240

The photo image of methane gas pulsed discharge is shown in Fig. 2. On the right electrode, two different carbon samples (soft carbon and hard carbon) were growth. The third type of carbon (powder) was growth on the inner surface of the glass tubing and the carbon samples can be easily collected. Hard carbon was growth at the end of the sharpened wolfram electrodes, but in this case, to take this deposited carbon was not so easy.

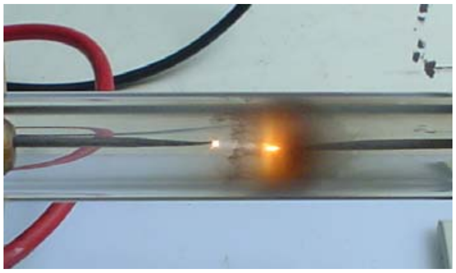

Fig. 2. Photo image of the atmospheric pressure methane pulsed discharge.

3. Experimental results

SEM image of powder carbon are shown in Fig. 3.

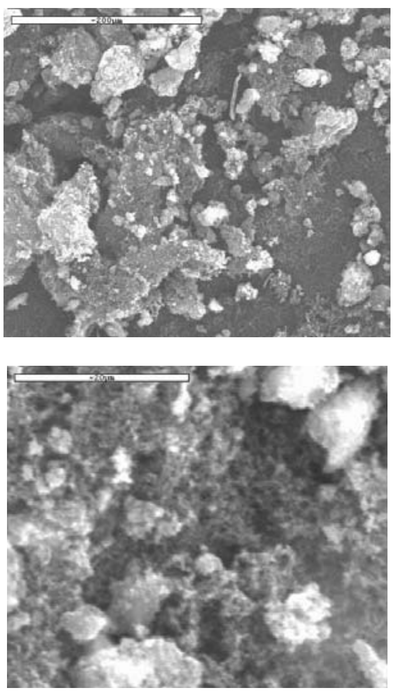

Fig. 3. SEM images of powder carbon.

Obtained powder carbon XRD results are shown in Table 2. The powder carbon samples have amorphous structure according to XRD results.

Table 2. XRD results of powder carbon.

No	2-θ	d(A)	% Height	Phase	d(A)	I %	(hkl)	2-θ	Δ
1	26.516	3.3587	27	100	3.3480	100	(003)	26.603	0.087
2	42.183	2.1405	16	56.8					
3	43.400	2.0833	8	28.5	2.0810	11	(101)	43.450	0.050
4	44.523	2.0333	13	46.2					
5	46.140	1.9658	14	50.2	1.9580	9	(012)	46.334	0.193

In addition, XRD pattern of the produced powder carbon is shown in Fig. 4. 2θ in XRD pattern was changed between 0° and 60°. Maximum intensity of XRD pattern was 300 counts. The powder carbon samples have the strongest peak at 26.516°.

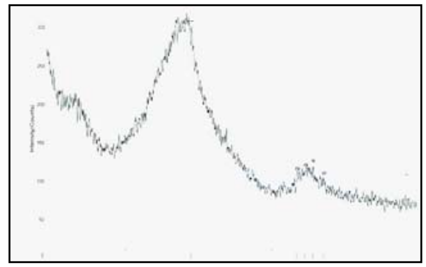

Fig. 4. XRD pattern of powder carbon

The photo image of the obtained soft carbon on the sharpened wolfram electrodes is shown in Fig. 4. Hard carbon structures were collected from the centre of the soft carbon structured. Powder and soft carbon were easily collected and analyzed. The diameters of soft carbon is around 7-8 mm.

Fig .5. Photo image of obtained soft carbon.

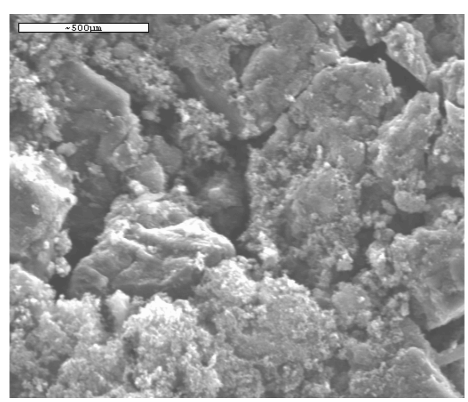

Fig. 6. SEM image of obtained soft carbon

The soft carbon lacks contamination according to EDX results and an EDX spectrum of the soft carbon sample is shown in Fig. 7. According to EDX results, produced soft carbon is very pure as it can be seen in Fig. 6.

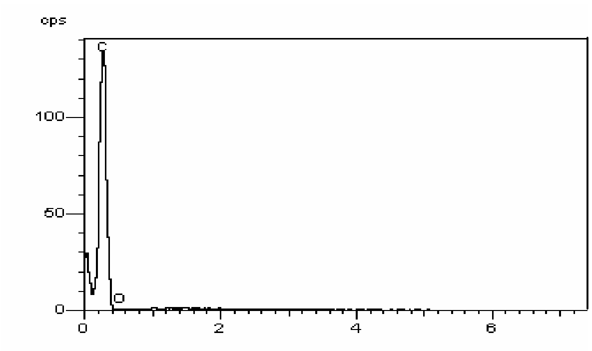

Fig. 7. EDX results for soft carbon.

The mass (m) of the obtained hard carbon was 0.00207 g/ min and the length was about 2 mm. It does not notice a clear geometrical form. We also investigated the hard carbon samples by Scanning Electron Microscopy and Energy Dispersive X-ray Spectroscopy. The SEM images of the hard carbon are presented in Fig. 8.

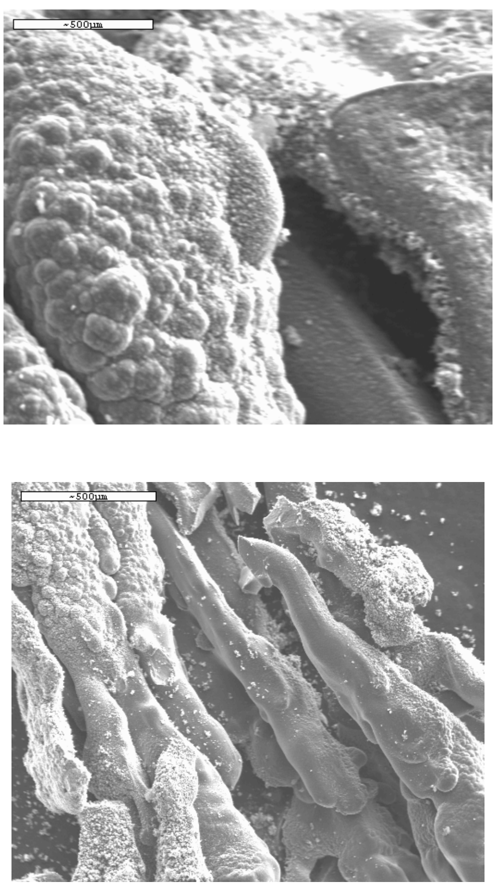

Fig. 8. SEM images of the hard carbon.

According to EDX results, produced hard carbon is very pure as can be seen in Figure.9. Only hard carbon has some traces of oxygen impurity according to EDX spectra.

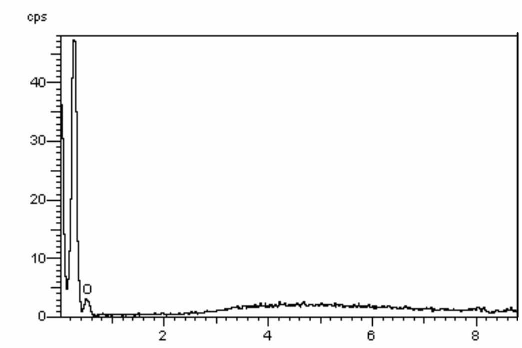

Fig. 9. EDX result of hard carbon.

4. Conclusion

Carbon samples were investigated by Scanning Electron Microscopy, Energy Dispersive X – ray spectroscopy and X-ray diffraction. All the three forms of carbon have amorphous structure according to XRD results and without contamination according to EDX results. Only in the case of for hard carbon a very low percentage of oxygen impurities could be noticed. The samples exhibit the strongest peak at 26.516° at XRD spectra. The production rate is 0.52 mg/min when the inter-electrode distance is 8 mm and the flux of the methane gas is 0.3 l/min.

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