Obtaining of nano- and microparticles in plasma by CVD method

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In this work carbon nano and microparticles were obtained by the plasma chemical vapor deposition method in RF discharge. The diameter depending of samples on the discharge parameters were investigated. Synthesis of nano and microparticles was carried out in gaseous mixture of argon (98%) and methane (2%) gases at different parameters of RF discharge such as time, pressure and discharge power. Morphology and chemical composition of obtained samples were studied by scanning electron microscopy (SEM). Analyses of obtained results indicate that synthesis and deposition processes depend on plasma parameters. The optimal conditions of nanoparticle synthesis were determined. On the basis of graphical and mathematical calculations the graph of the distribution of carbon nano- and micro-particles by sizes at different values of discharge power and gas pressure was built.

1. Introduction

Currently, nanoparticles and nanostructured materials were formed the basis for creating of great number of modern products, starting of paint products till food industry. Due to the new discovered properties of tiny particles, many research areas have got second life. Therefore, obtaining of nanomaterials with structural and functional characteristics is one of the most important scientific and applied tasks, which determines development of nanotechnology. It is well known fact that nanotechnology is one of the most rapidly developing and important areas of applied science. Regarding to this, the special interest is the problem of development of technologies for creating quality small dispersed (micro and nanoparticles) composite materials (nanoparticles and nanopowder) with given properties.

In this work a plasma chemical vapor deposition (PCVD) method of carbon nano- and microparticles synthesis in plasma of radio-frequency (RF) discharge is considered.

2. Experimental part

2.1. Experimental setup

The experiments were carried out in the plasma of radio-frequency capacitive discharge [1,2]. The experimental setup consist the following devices: the gas-discharge chamber, matching device, radio-frequency generator and module for defining the self-bias voltage. The stainless steel electrodes with diameter 10 cm are located parallel to each other in a horizontal position at a distance 2 cm. The top electrode is grounded. The lower electrode is connected to the RF generator (with a frequency f=13.56 MHz). The mixture of argon and methane gases was used for forming of RF plasma. The pressures of gas were varied in a region of 0.1-2 Torr and discharge powers were in a region of 1 – 50 Watt. The working chamber has lateral windows to monitor the processes in the plasma of RF discharge.

2.2. Results

The growth mechanism of nano- and microparticles consists of several steps; there are nucleation and polymerization phases, saturation, coagulation and surface growth of nanoparticle. The first growth step is formation of nanoclusters by carbon atoms (nucleation and polymerization), then after nucleation the second step is occured a phase of saturation in which these nanoclusters grow to the critical size and begin to agglomerate to each other (phase coagulation, the average size of nanoparticles is 50 nm), then starts the growth phase of the nanoparticle surface, in this case only the size of the nanoparticles is changed [3-5].

Thus, the carbon nano- and microparticles were synthesized by plasma chemical vapor deposition method in the plasma of radio-frequency discharge. The samples of the carbon nano- and microparticles were studied by a Quanta 3D 200i scanning electron microscope (Figure 1).

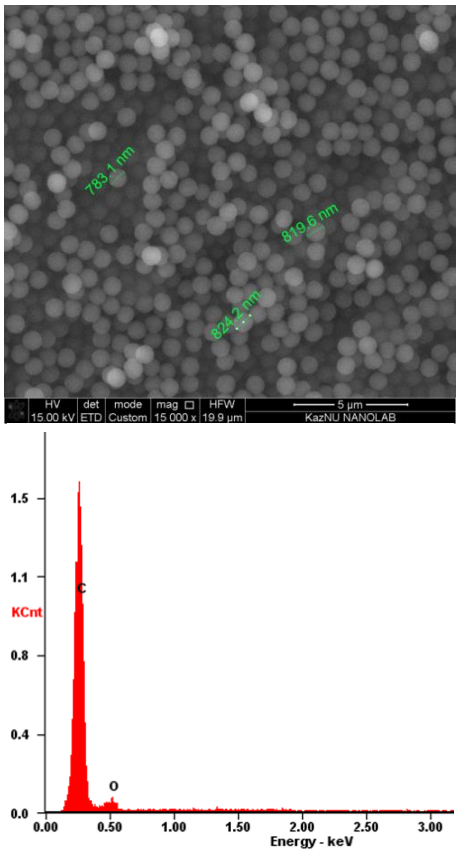

Figure 1– SEM picture of the synthesized carbonous nanoparticles and their chemical composition (P=30 W, p=0.6 Torr)

It is found, that at t=1 min time of plasma CVD synthesis, the diameter of synthesized particles depends on the value of discharge power (Figure 1). With increasing the discharge power, the energy of the electrons and the rate of ionization of gas atoms are increased, due to this, the concentration of ions and the rate of ion deposition are also increased, that leads to the rapid growth of the nanoparticles. This process is well described in Figure 2.

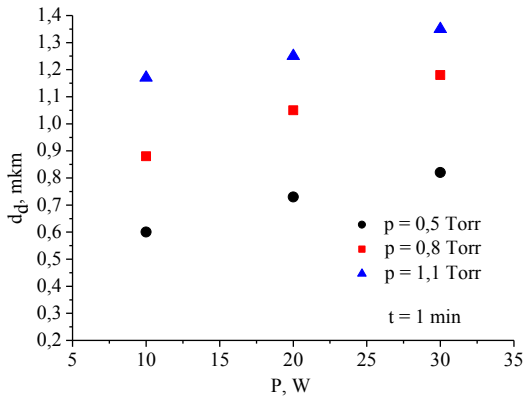

Figure 2 – The dependence of the synthesized particles diameter on the discharge power

3. Conclusion

In this work carbon nano and microparticles were obtained by the plasma chemical vapor deposition method in RF discharge and their size depending on the discharge parameters were investigated. Samples of synthesized carbon nano- and microparticles in the plasma of RF discharge were obtained. Morphology and chemical composition of obtained samples were investigated by scanning electron microscopy. Analysis of obtained results indicates that synthesis and deposition processes depend on plasma parameters. The optimal conditions of nanoparticle synthesis were determined. Synthesized nano- and microparticles have diameter from 200 nm up to several microns. Hence, the rapid growth of nano-and microparticles depends on the discharge power whereas the growth deceleration depends on the gas concentration.

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4. References

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