Structural Investigation of Nanoscale Detonation Carbon Obtained Using a Pulse Gas-Detonation device

In this work, properties of nanoscale detonation carbon (NDC) which was produced in a Pulse Gas-Detonation Device (PGDD) by detonation of C_2H_2+kO_2 mixtures, with variation of k from 0.11 to 0.82 were investigated. Interaction of NDC with argon which used as an additive gas was studied. The structure of NDC which was obtained under various conditions of initiation of detonation such as various barrel length of detonation gun and various ratio of oxygen to carbon in initial mixture was investigated.

In experiments on detonation of rich acetylene-oxygen explosive mixtures in unsteady conditions, namely, upon detonation in tubes having an open end, it was found that under certain conditions, a black precipitate (carbon condensate) forms through of a chemical reaction between acetylene and oxygen. Based on these observations, a new method of obtaining nanoscale detonation carbon (NDC) was proposed [1]. In this method, the production of detonation carbon is conducted on a Pulse Gas-Detonation Device (PGDD) developed on the basis of a CCDS*2000* detonation spraying facility. Using PGDD, experimental samples of NDC were produced using explosive mixtures having a molar ratio of oxygen to acetylene from 0.11 to 0.82. It was found that the structure, bulk density and the specific surface area of NDC depend on the oxygen concentration in the initial explosive mixture. The XRD analysis showed that there is a clear dependence of the content of graphitized carbon in the samples on the concentration of oxygen in the initial explosive mixture. The sample of NDC obtained at O_2/C_2H_2=0.51 has the highest content of the graphitized carbon.

Fig.1 shows XRD diagrams of NDC obtained at various molar ratios of oxygen to acetylene in initial explosive mixture.

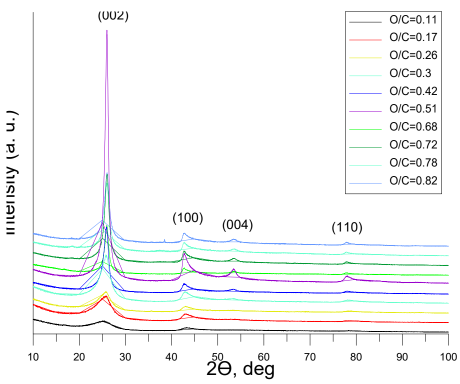

Fig. 1 XRD data of NDC samples

The morphology of the NDC samples was studied by Scanning Electron Microscopy. A dependence of the morphological characteristics of NDC on the composition of the explosive mixture was observed. Thus, at O_2/C_2H_2=0.3, carbon forms spheres with diameters of 20-100 nm. At O_2/C_2H_2=0.51, the diameter of individual spheres reaches 200 nm and sintering of the carbon particles to each other to form large agglomerates was observed. At O_2/C_2H_2=0.68, a transition occurs: the spherical particles disappear and graphene-like particles of complex (curved) shapes with a thickness of up to 20 nm appear. A further increase in the oxygen content in the initial explosive mixture does not lead to visible changes in the morphology of NDC.

Fig. 2 shows modification of morphology of the investigated NDC samples.

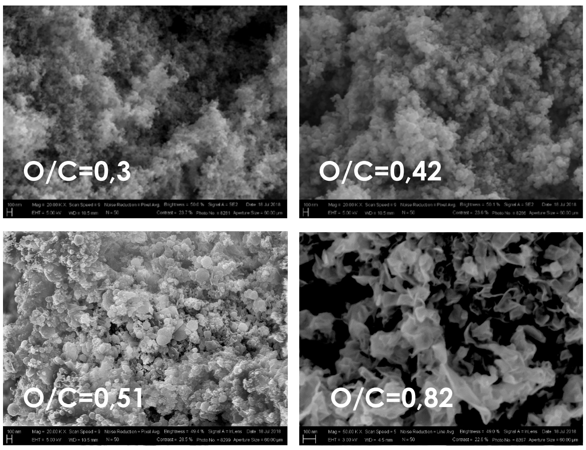

Fig. 2 Changes of the structure of NDC

The structure of NDC which was obtained under various conditions of detonation initiation of the initial explosive mixture was investigated. When argon was used as an additive and purge gas instead of nitrogen, it was found that the graphitization degree of NDC markedly increased only in the case of using argon as the purge gas. It's validated by Raman data: at O_2/C_2H_2=0.42

the ID/IG value in case of nitrogen equal 0.81, while for argon its equal 0.49.

Also influence of changing of geometry of PGDD on NDC structure was investigated. It was observed that Increasing of barrel length increases the graphitization degree of NDC. It's confirmed by Raman data: at O_2/C_2H_2=0.68 the ID/IG value in case of long barrel (L=1500mm) equal 0.29, at the same time in case of short barrel (L=750 mm) this value equal 0.51.

This investigation is extremely important from the point of view of understanding the process of graphitization of NDC formed during the detonation of rich acetylene-oxygen mixtures and the obtained data highlight promising directions for further research in this area.

References

[1] Shtertser A.A., Ulianitsky V.Yu., Batraev I.S., Rybin D.K. Production of Nanoscale Detonation Carbon using a Pulse Gas-Detonation Device // Technical Physics Letters. 2018. V. 44, No 5. P. 395-397.

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