INFLUENCE OF NITRIC PLASMA ON FULLERITES AND CARBON NANOTUBES

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Introduction

For most elements of periodic table nitric compounds far fewer are known, what oxide. It also justly for basic 4th groups. In principle, all binary compounds carbon-nitrogen can be examined as nitrides of carbon. Hard fase compounds of the C-N system well described, but not very much are characterized [1]. On the basis of metals and non-metals the vast class of materials, used in the different areas of science and engineering [2]. Possibility of existence of carbon nitride seem to very credible, as a carbon and nitrogen feel like formation of single, double and triple chemical connections [3]. In theory, on the basis of quantum-mechanical and molecular-dynamic calculations, principle possibility of existence of superhardness crystalline carbon nitride with tetrahedron and cube structures have been shown, with hardness the same, as well as diamond, and possibly and higher [4]. In 1990th the number of publications, touching the synthesis of crystalline C_3N_4 by the CVD, PVD methods of high pressures and temperatures increase sharply [3, 5]. However, crystalline C_3N_4 so not obtained, and the attempts of the use of other methods and new initial matters proceed.

The purpose of this work was finding out of possibility of formation of binary compounds carbon-nitrogen (C-N) at interaction of fullerites and carbon nanotubes with nitric plasma.

Terms of experiment

For the researches was used fullerites and carbon nanotubes, obtained in a laboratory N 67 IPM of NAN of Ukraine. Treatment in plasma of nitrogen fullerites of two kinds was exposed to: initial and preliminary treated in plasma of hydrogen.

The principle scheme of the plasma unit is presented on Fig.1. Reactionary quartz vessel 1 through a faucet 3 vacuumized by pumps 2. From a capacity 4 through a faucet 3 in the system molecular nitrogen is given to working pressure of 13 Pa, which is controlled a manometer 5. Investigated sample 8, being in a glass cup, placed in central part of inductor 7. By a high-frequency generator 6 and inductor 7 plasma of nitrogen is created in a reactionary vessel.

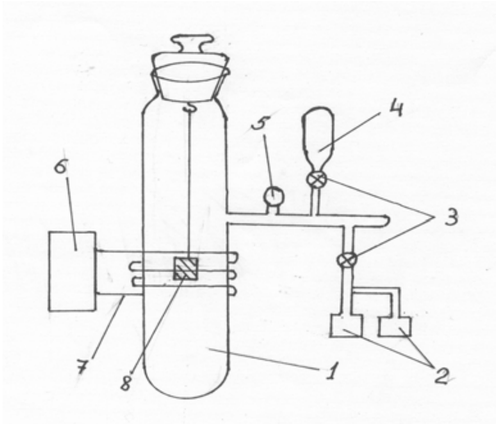

Fig.1. The principle chart of the plasma setting.

Additional external heating of the investigated samples was not produced. Constancy of plasma parameters - a concentration N_e and temperature T_e of the electrons supported regulation of anodic current of I_a, mA of generator lamp. In the series of experiments N_e=4•10^{18} cm^3, T_e=2,5•10^{16} K [6].

Results and discussion

X-Ray research of fullerites powders in the initial state (a), after treatment in plasma of nitrogen (b), in hydrogen plasma (c) and after treatment in hydrogen and nitric plasma (d) (Fig. 2) were performed on setting of DRON-3 in copper Cu-K_α radiation, in the angle interval 10 ^{o}<2Θ<35 ^{o} with a step of 0,1 and by an account in every point 4″ with digital registration of reflections and their computer treatment. A phase analysis was executed from data of ASTM. It was determined that a basic phase in initial fullerite powder is a phase of C_{60} with a cube grate. On a X-ray diagram present 2 weak additional lines: d = 4,12 and d = 4,57, which behave to the strongest lines of 2-Hydroxyfluorene (S13N100) and, presumably, are an admixture, accompanying fullerite After treatment of fullerite in plasma of nitrogen and in plasma of hydrogen and nitrogen of changes take place with an admixture phase.

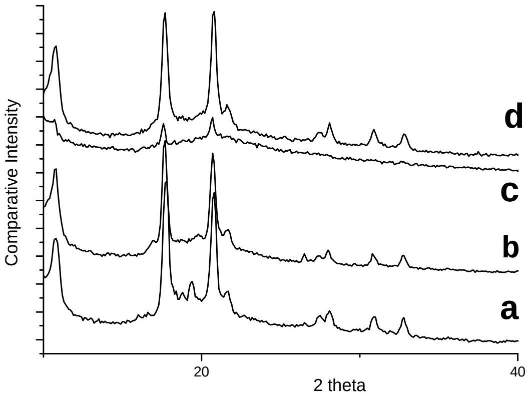

Fig.2. Diffractograms of fullerites:
a – initial state, b – after treatment in nitric plasma, c – after treatment in hydrogen plasma, d – after treatment in hydrogen and nitric plasma.
Treatmen time 120 min.

In plasma of nitrogen it is evident that former 2 reflection line of d = 4,72 and d = 4,57 disappear and appear new with d = 5,22, d = 4,48, d = 3,36. These lines can be ascribed to compounds of C13H9N (acridine) and C13H11N (N - Benzilidine aniline). The phase of fullerite is saved, but there is an increase of its lattice constants. In initial fullerite a = 4,16 Å, after nitric plasma a = 4,20 Å, and hydrogenic and nitric a = 4,18 Å. After treatment in the environment of hydrogen plasma there is an amorphisation of basic phase of fullerite, as demonstrated by the sharp increase of background. Three strongest reflections line are visible only by which it is possible to conclude about the considerable increase of lattice constant of fullerite up to 4,23 Å. We suppose that the effect of increase of lattice constant of fullerite is related to introduction in its pores of components of used plasma.

At consideration of carbon nanotubes, treated in nitric plasma, there is an increase of interplanar spacings, related to intercalation of atoms of nitrogen in interplanar spacing UNT. Formation of binary compounds of carbon with nitrogen under investigated conditions is not found out.

References

1. Edwin Kroke, Marcus Schwarz. Novel group 14 nitrides // Coordination Chemistry Reviews 248 (2004) 493-532.
2. Samsonov G.V. Nitrides. Moscow: Metallurgy, 1969. (in Russian).
3. Korsunskii B.L., Pepekin V.I. On the way to the nitride of carbon // Uspehi himii. 1997; **66**(11): 1003-1013. (in Russian).
4. Liu F.Y., Cohen M.L. Structural properties and electronic structure of low-compressibility materials: ß-Si_3N_4 and hypothetical ß-C_3N_4 // Phys. Rev. B. – 1990; 41**(**15): 10727 – 10734.
5. Batov D.B., Polyakov E.V. On the possibility of production of superhard carbon nitride (review) // Superhard materials. 2004; 3: 18-35. (in Russian).
6. Chekhovskiy A.A. The effect of plasma parameters of argon, hydrogen, oxygen and air on properties of carbon fibres and composites on their base // The current problems of physical materials science. Works of IPMS NASU, P. 58-70. (in Russian).