THE PROPERTIES OF METAL-FULLERENE MATERIALS

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Introduction

With the opening of fullerenes at the end of the last century thescientists got a new tools for the construction of materials and structures, and cjntrol of their properties. To research thematerials containing fullerenes, more and more scientists from various specialties, engineers and technologists are involved. The flow of information about the study of fullerenes, fullerenlike particles, their interaction with other atoms and molecules are growing with each passing year. There are more then some dozens of only the major reviews on the problems of obtaining of fullerenes, fullerenlike particles and of the control of materials based on them. In this paper we analyzed the results of studies of fullerenes (mainly C_{60}), the methods of their obtaining, as well as the methods for obtaining metal-fullerene materials, the particularly their structures and properties and the specific application of these materials. A large part of the results is obtained by the authors of this article for the past 4 – 5 years.

1. Methods of preparation of metal-fulerene materials

In our studies the fullerenes were introduced into the matrixes of various metals in varying amounts (from one hundredth shares of the mass percent to several percents). The initial components were used pure metal (no less than 99.999%), fullerene C_{60} with high purity (99,99%). The different methods of obtaining were used.

1. The method combined atomic-molecular flow. Basic principles: 1) the evaporation from two sources, 2) co-condensation on the substrate. Investigated materials: Au - C_{60}, Ag - C_{60}, Cu - C_{60}, Al - C_{60}, Sn-C_{60}, Ti - C_{60}, Ga-C_{60}, In-C_{60}, Fe - C_{60}, Ni - C_{60}.

2. The method of thermal annealing. Basic principles: 1) a layered structure, 2) annealing in a vacuum. Investigated materials: Au - C_{60}, Ag - C_{60}, Cu - C_{60}, Sn-C_{60}, Ti - C_{60}, Fe - C_{60}.

3. Synthesis in arc discharge. Basic principles: 1) the selected metal serves as the anode and the substrate for the condensation of metal-fullerene alloy, 2) the inert gas environment is created for the implementation of the electric arc discharge, 3) the necessary treatments are picked up. Investigated materials: Fe - C_{60}, Cu - C_{60}, Ti-C_{60}.

4. Galvanic method. Basic principles: 1) a suitable electrolyte is selected, 2) a solution of fullerenes are introducedinto the electrolyte, 3) ultrasonic dispergati on of the electrolyte solution with the C_{60} are carried out, 4) the necessary treatments are chosen. Investigated materials: 1) Cu - C_{60}, 2) Ni - C_{60}.

2. The most important properties of metal - fulerene materials

1. We obtained several types of fullerite C_{60} and C_{70} with different crystalline structure. ferromagnetism of romboedric phase of fullerite C_{60} is discovered.

2. The ability of fullerite to polymerized at high temperature and also at the influence of radiation isestablished [1].

3. We showed that the mechanical properties of fullerite are dependent nonlinearly on temperature and the speed of sound init isthe abnormally high (26000 m / s) [2].

4. Different methods (electric, galvanic, metallurgical, evaporation and condensation in a vacuum, pulsed shock-wave treatment) are tested to introduce fullerenes into matrixes of different metals [3].

5. It has been shown that the introduction of fullerene into materials, even in small proportions (up to 1.0 wt.%) significantly changes their physical and physico-chemical properties. Thus, the electrical properties of systems on the base of fullerenes and metals may be vary widely (from 10^{-6} to 10^{9} Ohm · cm) [2, 3].

6. The chemical compounds of fullerenes with other atoms and molecules are obtained with forming of endofullerene and ekzofullerene molecules [1].

7. The superconductive properties of fullerites and fullerides are determined. It is found that the superconductive temperature transition of

fullerides of alkali metals depended linearly on the lattice constant [2].

8. The nonlinear optical effects in fullerene materials (third harmonic generation, limiting of the intensity of outgoing radiation) are revealed [4, 5].

9. The magneto-optical effect such as the lowering of microhardness (or increasing of the plasticity) under the influence of the magnetic field is discovered [2].

10. It has been shown that fullerene materials have improved tribotechnical properties (low coefficient of friction, high wearproof). For example, the materials of Cu -C_{60}, Al -C_{60} have a relatively high electrical conductivity and low friction [6]. They are suitable for use as coatings for the moving electrical contacts. The materials of Ti -C_{60} combine high strength characteristics, low coefficient of friction, high biological compatibility, low adhesion of blood cells.

Conclusions

Metal-fullerene materials can be obtained in several ways. In addition to composite structures, solid solutions with crystal lattices of fullerites, or the metals, there may be chemical compounds Me_xC_{60} or $Me_xO_yC_{60}$. The introducting of fullerenes into the metals, even in small proportions (up to 1.0 wt.%) significantly change their physical and physico-chemical properties (in some cases in several times).

To date, a number of areas in which the fullerenes containing materials can now compete not only in quality but at a cost are identified. These active elements of sensors, devices nanoelectronics, nano-and micromechanics (or electromechanical), coatings (including belong to biomedical).

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