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УДК: 619:615.9:661.183

USE OF THREE-DIMENSIONAL COMPUTER VISUALIZATION IN THE STUDY OF NANOSTRUCTURES

N. Boltianska[1], c.t.s., I. Manita[1], s. teacher,
N. Serebryakova[2], c.p.s., H. Podashevskaya[2], s. teacher
[1]*Dmytro Motornyi Tavria state agrotechnological university, Melitopol, Ukraine*
[2]*BSATU, Minsk, Belarus*

Аннотация. Статья посвящена перспективам использования трехмерных компьютерной визуализации при исследовании наноструктур.
Abstract. The article is devoted to the prospects for the use of three-dimensional computer visualization in the study of nanostructures.
Ключевые слова: наноструктуры, исследование, трехмерная компьютерная визуализация.
Keywords: nanostructures, research, 3D computer visualization.

Introduction

After the discovery of the nanoworld, scientists found that molecules in nature can be very different from each other, which provides such a diversity of matter in the world. Simple molecules consist of two or three atoms, however, there are those that contain thousands of atoms connected to each other in a complex sequence (for example, a rubber molecule consists of approximately 75 thousand carbon atoms and 100,000 hydrogen atoms). The shape of the molecules can be just as diverse: some of them are long threads, others - twisted spirals, and others are rolled into a ball, resembling a soccer ball [1,2].

Main part

There are many different ways to classify nanoobjects. V.V. Eremin classifies nanoobjects by dividing them into two major classes – solid and porous (Fig. 1). The complexity of conducting a physical experiment with nanoscale objects is determined by the following factors [3]:

• The colossal difference in scale between objects of the ordinary world and objects of atomic scale makes extremely difficult experimental research in the field of nanoobjects. The information obtained in experiments with atomic resolution is increasingly indirect, and the experiments themselves often do not allow to obtain sufficient information about complex nanoscale systems, con-

sisting of a large number of different parts that interact with each other in a complex way.

• Difficulty with temporary resolution of experiments. Processes that occur at the level of nanoobjects usually have characteristic times from femtoseconds to nanoseconds. Detailed monitoring of the processes occurring during such times is usually impossible due to the fact that the experimental devices also consist of atoms and molecules, and their temporal resolution is limited to the same temporal scales.

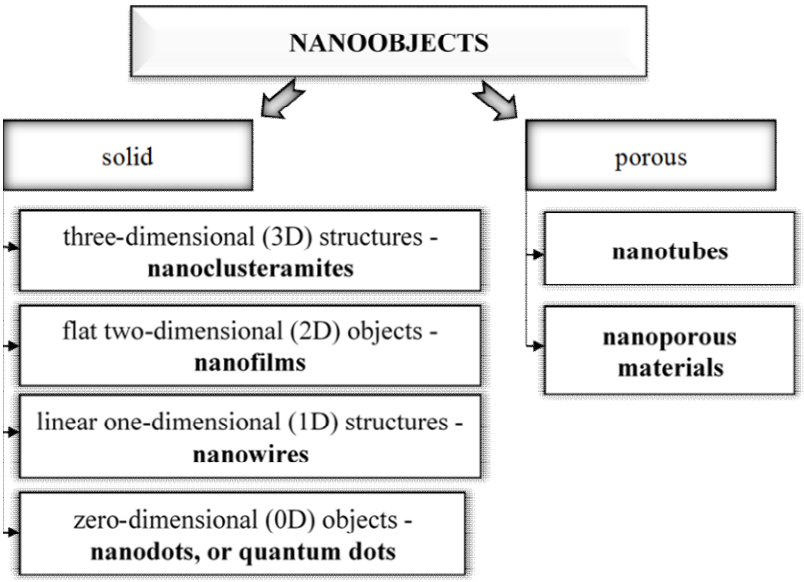

Figure 1 – Classification of nanoobjects

• Interpretation of experimental results. Nanostructures belong to the "intermediate" range of sizes, in which the atomic structure of objects is decisive, but the objects themselves already consist of a large number of atoms.

The most convenient way to understand what is happening at the levels of nanoscale objects is scientific and popular science visualization of processes occurring at these levels. Dynamic, three-dimensional and interactive visualization make it easier to work with information obtained about the object of the nanoworld. Modeling of such complex objects is necessary for scientists to fully study the properties of such objects. In other words, it is the creation of virtual nanoworlds, which exactly repeat all known to man physical processes, but in an artificial computer environment. Graphical interpretation of nanostructures consists of a number of operations that can be performed in two inde-

pendent directions. The first is the artistic direction, which includes the processing of photographs in the environment of two-dimensional register or vector graphic editors to visualize the nanoworld and the presentation of artistic compositions based on it.

The second direction is a subtle technical study to create three-dimensional images based on a series of consecutive two-dimensional images of nanostructures. Where, as a result, a solid-state image of the elements that make up the nanostructures is formed in the environment of a standard graphic three-dimensional editor, with which the modeling process is carried out. Three-dimensional representation of objects expands the possibilities of materials analysis. To increase the reliability of the results, the obtained three-dimensional images are compared with information about the same nanostructures obtained by other, for example, contact methods.

Conclusion

The application of computer modeling methods of nanoparticles has proven to be the most important research tool in the nanoworld. Computer models of nanoobjects are easier and more convenient to study when real experiments are difficult due to physical interference. The logic and formality of computer models allows us to identify the main factors that determine the properties of the studied nanoscale original object.

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УДК: 631.5

DIRECTIONS OF AUTOMATION OF TECHNOLOGICAL PROCESSES IN THE AGRICULTURAL COMPLEX OF UKRAINE

N. Boltianska[1], c.t.s., R. Sklar[1], c.t.s., H. Podashevskaya[2], s. teacher

[1]*Dmytro Motornyi Tavria state agrotechnological university, Melitopol, Ukraine*

[2]*BSATU, Minsk, Belarus*

Аннотация. В статье обозначены направления автоматизации технологических процессов в агропромышленном комплексе Украины.