HISTORY OF NANOTECHNOLOGY

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Summary

This chapter sets out in brief the development of nanotechnology in certain scientific and technical areas. The material contained herein is available to the students studying physics, chemistry, biology, materials technology.

1. Introduction

It's rather difficult to describe the history of nanotechnology which, according to R.D. Booker, is due to two principal reasons: 1) ambiguity of the term "nanotechnology" and 2) uncertainty of the time span corresponding to the early stages of nanotechnology development.

Absence of generally accepted, strictly established definition of the term nanotechnology is explained by a wide spectrum of various technologies that nanotechnology covers, which are based on various types of physical, chemical and biological processes realized on nanolevel. Besides, nanotechnologies at the current stage of development are being constantly updated and improved, which explains why many concepts about principles of their implementation are not completely clear.

Generally, nanotechnology can be understood as a technology, which allows in the controllable way not only to create nanomaterials but also to operate them, i.e. to influence them or to use them according to their intended purpose. Accordingly, nanomaterials can be understood as the materials, which are characterized at least in one of three measurements by nanometer scale concerning both the sample of a material as a whole and its structural elements.

Absence of the generally accepted, strictly established time span for the beginning of nanotechnology development is explained by the fact that nanotechnology has its backgrounds in the distant past when people used it without knowledge of it.

The first mention of purposely created and applied technological processes and means, which were subsequently termed nanotechnology, is usually connected with the well-known lecture of Mr. R. Feynman, the professor of Californian institute of technology, delivered in 1959 at the session of the American Physical Society. In this lecture called "There is a lot of space down there" for the first time the possibility to create nanosized products with the use of atoms as building particles was considered. Nowadays this lecture is referred to as the origin of the nanotechnological paradigm.

The word "nanotechnology" was introduced for the first time into a scientific world by N. Taniguchi at the international conference on industrial production in Tokyo in 1974 in order to describe the superthin processing of materials with nanometer accuracy and the creation of nano-sized mechanisms.

Ideas of nanotechnological strategy, which were put forward by Feynman, were developed by E. Drexler in his book "Vehicles of creation: the arrival of the nanotechnology era" published in 1986.

In the second half of 1980s to the early 1990s a number of important discoveries and inventions was made, which created an essential impact on the further development of nanotechnology. Since then, a considerable intensification of nanotechnological researches and designs is underway, the number of publications on nanotechnological subjects increases sharply, practical application of nanotechnology expands; project financing in nanotechnology increases significantly, as well as the number of organizations and countries involved in it.

In 1991 the first nanotechnological program of National Scientific Fund started to operate in the USA.

In 2001 the National Nanotechnological Initiative (NNI) of the USA was approved. The principal idea of this program was formulated as follows: "National Nanotechnological Initiative defines the strategy of interaction between federal departments of the USA for the purpose of prioritizing nanotechnology development, which should become a basis for the economy and national security of the USA in the first half of the 21st century».

During 1996-98, prior to NNI approval, a special committee of the American Center for Global Technology Assessment monitored and analyzed the development of nanotechnology in all countries and published the survey newsletters on the basic trends

of development and achievements for scientific, technical and administrative experts in the USA. In 1999 the session of the Interbranch group on nanoscience, nanoengineering and nanotechnology (IWGN) took place, the result of which was the forecast on research in nanotechnology for the next 10 years. The same year the IWGN conclusions and recommendations were supported by the Presidential Council on Science and Technology (PCAST), whereupon NNI was officially approved in 2000.

In a preamble to NNI the US president Clinton declared: “I earmark 500 million dollars in the current fiscal year for the state nanotechnology initiative, which will enable us to create new materials in the future (surpassing in characteristics the ones we have today thousands of times), to download all data in the Congress Library on a tiny device, to diagnose cancer in a few affected cells and to achieve other amazing results. The initiative being offered is for at least twenty years and promises to lead to important practical results”.

As in the USA, considerable attention to nanotechnology development is given in Japan. In 2000 the Japanese Economic Association organized a special department on nanotechnology under the auspices of the Industrial and Technical Committee, and in 2001 the Framework Plan of nanotechnology research was developed. The main provisions of this plan were: to designate the following as the basic directions of nanoscience "breakthrough": information technology, biotechnology, power, environmental studies and materials technology; to provide for significant capital investment to manufacturing based on nanotechnology; to intensify the research in the areas above and to apply their results in manufacturing so that these became "drivers" of the future nanotechnology revolution; to work out the national strategy of nanotechnology development, and, first and foremost, to organize effective cooperation between industrial, state and scientific departments and organizations in the research.

Countries of Western Europe carry out research in nanotechnology within the framework of national programs. In Germany research in nanotechnology is supported mainly by the Ministry Of Education, Science, Research and Technology. In England nanotechnology development is supervised by the Council of Physics and Technology Research and by the National Physical Laboratory. In France the nanotechnology development strategy is defined by the National Center of Scientific Research.

More and more attention is given to nanotechnology development in China, South Korea, and other emerging countries. Recently nanotechnology research began in the CIS countries, usually within the framework of state scientific programs.

Thus, the nanotechnology paradigm was formed at the turn of the 1960s, while the 1980s and 1990s are the start of development of nanotechnology in its own right. Accordingly, one could say that the whole period up to the 1950s may be considered as pre-history of nanotechnology. The end of this period was the appearance of conditions for managed nanotechnology development, which was facilitated by the scientific and technical revolution, by which the second half of XIX and the beginning of XX centuries were marked.

2. Background of Nanotechnology

2.1. Nanotechnology of the Past

Even long before the start of "nanoera", people were coming across various nanosized objects and the related nanolevel processes, and using them in practice. However, intuitive nanotechnology antiquities developed spontaneously, without due understanding of the nature of these objects and processes. For example, the fact that small particles of various substances possessed properties different to those of the same substances with larger particle size was known for a long time, but the reason for this was not clear. Thus, people were engaged in nanotechnology subconsciously, without guessing that they were dealing with the nanoworld phenomena. In many instances secrets of ancient nanoproduction simply passed from generation to generation, without getting into the reasons why the received materials and products derived from them acquired their unique properties.

Thousands of years BC people knew and used natural fabrics: flax, cotton, wool, silk. They were able to cultivate them and process into products. What makes these fabrics special is the fact that they have a developed network of pores with the size of 1-20 nanometers, i.e., they are typical nanoporous materials. Due to their nanoporous structure natural fabrics possess high utilitarian properties: they absorb sweat well, quickly swell and dry.

Since ancient times people mastered the ways of making bread, wine, beer, cheese and other foodstuffs, where the fermentation processes on nanolevel are critical.

In Ancient Egypt it was rather common to dye hair in black. For a long time it was believed that the Egyptians used mainly natural vegetative dyes - henna and black hair dye. However, recent research into hair samples from ancient Egyptian burial sites, conducted by Ph. Walter showed that hair was dyed in black with paste from lime, lead oxide and small amount of water. In the course of the dyeing process nanoparticles of galenite (lead sulfide) were formed. Natural black hair color is provided with a pigment called melanin, which in the form of inclusions is spread in hair keratin. The Egyptians were able to make the dyeing paste react with sulfur, which is part of keratin, and receive galenite particles a few nanometers in size, which provided even and steady dyeing.

The British museum boasts Licurg's bowl as part of its heritage – an outstanding product of glass makers of Ancient Rome. This bowl, on which Licurg, the tsar of Edons, is depicted, possesses unusual optical properties: it changes color with change of location (inside or outside) of the light source. In natural light the bowl is green, if illuminated from within, it turns red. The analysis of fragments of the bowl, carried out in the laboratories of General Electric in 1959 for the first time, showed that the bowl consists of usual soda-lime-quartz glass and has about 1% of gold and silver, and also 0,5 % of manganese as components. The researchers then assumed, that the unusual color and disseminating effect of glass is provided by colloidal gold. Later, when research techniques became more advanced, scientists discovered particles of gold and silver from 50 to 100 nanometers in size using an electronic microscope and

roentgenograms. It is these particles which are responsible for the unusual coloring of the bowl. In the review on plasmons, published in 2007 in the “Scientific American” magazine, H.A. Atwater explained this phenomenon by effects of plasmon excitation of electrons with metal nanoparticles.

In the Middle Ages the engineering of manufacturing of multi-colored church stained-glass windows in Europe achieved high perfection. As the recent research shows, the windows contained additives of gold and nanoparticles of other metals.

In the days of crusades the European knights faced the extraordinary strength of blades in fights against Muslims for the first time, made of an ultrastrong Damask steel. All attempts of armoring of medieval Europe to replicate such steel had no success. In 2006 P. Paufler carried out the research of sabre fragments made from the Damask steel using an electronic microscope. The results showed, that the steel had nanofibrous structure. It is supposed, that such structure was received after a special thermomechanical processing of steel, which was made from the ore of special structure.

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Biographical Sketch

Tolochko Nikolay Konstantinovich has a scientific degree of Doctor of physical and mathematical sciences in speciality “physics of a firm body” (1992) and an academic status of professor on specialty "technology" (2000). Since 1976 he worked at the Institute of technical acoustics (till 1994 - Vitebsk branch of the Institute of physics of a firm body and semiconductors) of National Academy of Sciences of Belarus, since 1991 – laboratory manager of composite materials, in 1999-2002 - deputy director of the institute on scientific work, in 2002-2003 – acting directors of the institute. Since 2004 – a chair holder of

general and theoretical physics of Vitebsk state university of P.M. Masherov. Since 2008 - professor of technology of metals department of Belarus state agrarian technical university (Minsk).

The basic area of scientific interests is materials technology, physics and technology of production and processing of materials. In different years he was engaged in design of processes of crystals cultivation, selective laser sintering of powders, laser thermosplitting of glass, laser gettering of semi-conductor materials, solid-fluid casting of metals and metallomatrix composites, crystallization methods of medical products reception; design of ceramic nanoporous filtering materials, armored ceramic materials; research of formation laws and properties nanosuspensions on basis of carbon nanoparticles.