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Strategy for the future in terms of research and development in the field of nano and microtechnology

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Abstract

This paper proposes an accounting of this, and the future for this fascinating field of nano and microtechnology. Also want to set up a strategy for the future of the field in terms of existing research, and development domain correlated with the evolution of Europe, the world in general. Actually in speaking of "Micro-and Nanotechnologies" which allow microsystems, components and subsystems, as well as molds with more "micro" and "nano", but in all cases taking into account important features of the area: miniaturization, integration and incorporation of intelligence

*Keyword:*the nano and microtechnology; strategy; research; development; characteristics of the area; the future;

1. Introduction

The prefix "nano" is of Greek origin, and "nano" means „dwarf". To get a fair idea of the size, remember that the diameter of a human hair is about 50 000 nm, a bacterium is several thousand nanometers, the size of the smallest integrated transistor which can be found into our computer is in about 100 nanometers, and a string of 10 hydrogen atoms (which is the smallest atom) measures about 1 nm. Also, the human eye does not distinguish details below those of 50 000 nm.

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In 1969, Neil Armstrong set foot on the moon and said, „Here's one small step for man made a giant leap for mankind". In the past two decades, in the scientific research' field has been done a step on the nanoscale, a step infinitely smaller than that of Neil Armstrong on the moon. However, this step is likely to be in turn a giant leap for knowledge, technological progress and therefore the whole society.

2. Considerations on the evolution of nanoscience and nanotechnology

One nanometer (abbreviated 1 nm) is one billionth of a meter and a millionth of a millimeter. So, part of scientific and technological research has taken a few years with the prefix nano and is called accordingly, neither more nor less than „Nanoscience and Nanotechnology".

Under these circumstances, it was concluded that nanoscience is the science that deals with the study of fundamental physical, chemical and biological entities or structures whose size is usually between 1-100 nm, entities consisting of several thousand or tens of thousands of atoms connected together. It is therefore not about isolated atoms but ensembles and atomic structures (called nanostructures) the number of atoms is large but of course much smaller than a certain macroscopic body. Such nanostructures can be fabricated in the laboratory by so called „bottom up" processes, i.e. the assembly of atoms and small molecules, or „top-down" processes techniques that appeal to „crush" the macroscopic body into much smaller fragments.

On the other hand, nanotechnology aims to use and transfer the results and knowledge gained in nanoscience to technology applications and super-miniaturized multifunctional devices. Miniaturization has always been a great technological trend, rooted in the natural development of electronics where „less" means „quicker, cheaper and more economical". But, what is really important to remember, it is not simply a matter of size, it is something much more significant, it is just possible that by reducing the size (volume) of artificial structures we create properties or qualities which really does not exist in the world of micro or macroscopic. In addition, it is possible to produce in this way a kind of „nanoscale tools and probes" of size comparable to the size of natural biological structures (DNA, proteins, enzymes, antibodies) and with the tools to be able to interrogate, understand and serve. Nanometer is therefore an appropriate meter to measure both the natural and artificial nanostructures existing in the living world [1].

Nanoscience and nanotechnology represent the convergence and interdisciplinary between nature and life sciences.

The physical properties of a material, properties that we currently know and use on a macroscopic scale - for example color of objects or current flowing – aren't found exactly if those objects have nanoscopic dimensions, and that even if they are made based on exactly the same atoms. In other words, many of the physical properties of materials can be generated and controlled in a totally different way than conventional technologies, in a way that appeals to techniques and reduction of size (volume). In other words, based on nano-structures, there can be produced devices equipped with functions that do not exist on a macroscopic scale. Please note that the appearance of these new properties from reducing the size of the object doesn't violate at all the laws of physics, in contrast, is an acknowledgment of these laws, especially quantum physics, the various quantum effects such as wave-particle duality, effects that become dominant to a very small size. Let me give you an example. Everyone knows how gold looks like, it is a (noble) metal with a specific yellow gloss or, more specifically, in a specific color ... golden. If we take a gold coin and divide it in two, is obvious that we get two halves of the same color. If we repeat this operation once again is no doubt that we will obtain again golden pieces. And yet ... if we perform these operations more often, division will reach a time when gold fragments obtained are nanometer sized and no longer have any gold color but ... red [2, 5].

Yes, nanometric gold is red. Indeed, very finely divided gold particles, called nanoparticles or nanocrystals, substantially changes the optical properties after nanostructuring, that interact differently with light than a total gold jewelry and therefore appear ... red. The same happens with other metals, especially silver. Incidentally, just say, famous stained glass cathedrals are nothing but examples of nanotechnology from a medieval or even older period! Stained glass colors show that gold or silver divided by nanoparticle level (10-100 nm) embedded in glass is no longer gold or silver, but red, yellow or blue.

Here is yet another example. Everyone remembers the passage of current through an electrical cable must meet a well-known law of physics (Ohm's law). Well, this law does not stand the test of the „nano-scale". Concept of power seen as a flow of electrons flowing through the cable as the water pipe is completely inoperative if the wire has a diameter of nanometer: with such nanometric wire electrons no longer obey Ohm's law, they „wait" for their turn to cross one by one in a single file as ... And the examples could go on.

Let us note, however, that the link between the nanometric size of the materials and their fundamental change in physical and chemical properties is the cornerstone for nanoscience and nanotechnology. Concept to control the amount, size and shape of substance at nanoscale and atomic scale - a concept on which nanotechnology is actually based on - was presented for publicly for the first time by Richard Feynman, a famous physicist, Nobel Prized, in a conference held at Caltech in 1959 and entitled „There` s Plenty of Room at the Bottom", see http://www.its.caltech.edu/~ Feynman/plenty.html. For a very long time, nanotechnology belonged to the science fiction of the lack of appropriate research tools. Nanotechnology has gathered momentum especially after the 1990s with the widespread marketing of special microscopes, such as tunneling microscopy and atomic force microscopy. For example, tunneling microscope (STM scanning tunneling microscopy invented in 1980 at IMB) allows not only view but also the movement of atoms and placing them in the desired location on a substrate [3,4].

Nano and microtechnology domain has gained momentum in the 1990s, and is thus a new concern for scientific and academic research. In its early appearance, it was known as „Microsystems" in Europe and „Micro Electro-Mechanical Systems" (MEMS) in the U.S. and Japan. Currently, this area is known as „Micro and Nanosystems", respectively, „Micro and Nanotechnologies" [8, 10].

If we would have to describe this area then we'd have to refer to the following features that are considered the most important, such as: 1) miniaturization, 2) integration, and 3) intelligence. We must point out the following aspects, namely: the spectrum of „nanotechnologies" is in general much broader, encompassing including conducting the development of nanomaterials that are used for very different applications or nanoparticles and others.

Numerous examples demonstrate that micro and nanosystems industry significantly reduce material consumption, reduces energy consumption and, not at least, reduces environmental pollution.

In this area, we are working to extremely fine details, which facilitate the technological process, so it will be found in the products resulting from the production in the field. Special equipment is used in special circumstances with investment of tens of millions of Euros, which allows the research and development of new products, so that for larger series production to appeal to much larger facilities, available only in some countries, more developed, from Europe. Appearance, conception and design of new products cannot be held than conventional engineered due to the multidisciplinary and complexity of the products. These products cannot be conceived than in ultra specialized centers with ultra competent specialists in this field. Also, the research and development in the field are in a permanent connection with fundamental research. This research has a multidisciplinary character, due to the need to always use new materials and the processes to deepen various modern technological processes [6,9].

Due to all these findings ensues the compulsory interaction between fundamental research and industrial research. For the future it is wanted and even more assiduously seeked specialist training in this area in the sense of multidisciplinary. The future method, expected to train specialists will take place through research and this because different fundamental areas such as engineering and medicine are based on completely different paradigm and a new paradigm cannot be treated unless there appear solid and ultra specialized collectives in multi-disciplinary research.

Horizon in this area is expected to continue to be focused primarily on improved activity in research and innovation, but also on a fierce industrial competitiveness brought by social challenges. Industrial challenges will be based on "key enabling technologies" (Key Enabling technologies, KET) and industrial technologies. These are information and communication technologies, nanotechnologies, advanced materials, biotechnology, advanced manufacturing systems and processing of space technologies. These technologies will be used to address social challenges, establishing a synergy between "competitiveness" and "challenges". There will be a correlation between support of "scientific excellence and competitiveness", by focusing on the most promising technologies (future and emerging technologies) [7].

In future, a special interest will be focused on research infrastructure, enhancing human potential, exploitation of innovation potential, namely: support partnership with industry, boosting infrastructure use by industry, encouraging integration in "innovation ecosystems" at local, regional and international.

Also pointed out that innovation activities will be combined with research and development ones, and key enabling technologies (micro and nanoelectronics, photonics, nanotechnology, biotechnology, advanced materials, advanced manufacturing systems) will be integrated addressed. All of these combinations of technologies can lead to enormous technological leaps.

Nanotechnology will have a direct impact on all sectors of the economy in the way of producing energy through clean processes to reduce energy consumption itself, from the nanoscopic sensors produce to new materials with medical applications and new devices for photonics, electronics and technical calculation. Even if in the short term does not intend to make an intelligent robot to travel through the arteries and to decolmate off cholesterol buildup (known as a science fiction novel), nanotechnology will certainly have a beneficial impact on medical diagnosis techniques and treatment. For example, some noble metal or semiconductor nanoparticles, especially gold, wrapped in biomolecular films can enter the cells where they become optical contrast agents, ie a kind of tiny light that illuminate inside cells. It is expected that medical imaging now be able to view and of detecting a early tumor with a resolution of just a few cells. Furthermore, by applying a beam of laser light on these nanoparticles, they can heat them locally and termic destroy only the diseased tissue. Diabetes may also be improved by injecting smart polymeric nanoparticles, conveyors and carrier of insulin able to fix the body and then to controlle the release of insulin dose according to the needs dictated by blood glucose levels.

Although in many areas, nanotechnology has only now demonstrated its benefits, there already are some nanotechnology products that are sold. To mention only quality tennis balls (those used in the latest edition of the Davis Cup) with the inner wall lined with a mixture made of polymer composite nanoparticles, mixture which prevents air loss through the wall, which makes the balls not to be changed so often. Some fabrics and clothing have already labelled “nano”, made from nanometer fiber and branched structures, functionalized, which not only have a heat protection, but can reduce the adhesion of wine or coffee stains on clothing. There are also solar windows and windscreens to loosen and remove any residue on the surface, maintaining the perfect cleaner for longer, or the new generation of cosmetics, lotions and sunscreens based on zinc oxide nanoparticles, etc.

Future strategy in this area is meant to be real, viable and effective. Therefore nanotechnologies are currently located somewhere between hope and fear. In this miraculous and fascinating area, as in many others, which make up the major concerns of reseachers, so that scientific research is concerned, there are issues that could be generated in the coming decades.

While it invokes and demonstrates the positive potential of nanotechnologies on health care, preserving and enhancing the environment, a growing concern about the degree of toxicity appears, about some semiconductor nanoparticles and carbon nanotubes on natural structures (biological). The ability of the nanoparticles to penetrate into a cell can be used in a controlled way to convey a drug to a specific place but, at the same time, used inadvertently; it may cause damage and disruption of intracellular processes and structures. Also, for example, some nanomaterials may be used with success for effective filters for drinking water, but eventually contaminate soil and water. Some semiconductor nanoparticles (quantum dots) are not only toxic by themselves, but they appeal to environmentally harmful synthetic methods or high risk. It is somehow expected that not all nanotechnology’s achievements in the future will have a positive impact. History could repeat that in case of the initial products were well accepted by society, but which were subsequently prohibited by law (DDT, freon, asbestos) [11].

At the same time, nanotechnology raises some ethical issues and will therefore soon be caught in the fire of heated public debate, as was the case with nuclear power and genetic engineering. It is known that any scientific progress implicitly includes its downside ... It is therefore expected that nanotechnology to generate questions more susceptible than say the discovery of a new chemical element, a new planet or a new thermonuclear reactions. Let's imagine for a moment that in turn, prevents the not too distant future, nanoelectronics should be able to create artificial intelligence, using quantum computers, based on DNA structures [13,14,15]. And if this achievement is likely to occur, then we would not really entitle to ask from now on, what would be the status of this intelligence? What rights and privileges should be assigned? As far as interface “between man and machine” will become so perfect that the two cannot be distinguished, and then which will be the future of humanity?

Here is therefore a quite challenging perspective and, of course, far enough removed that nanotechnology offers. It is clear that this plan analysis’ perspective, this involves multidisciplinary evaluation as interdisciplinarity in current business plan requires in scientific research[15]. It is therefore certainly required the contribution of philosophers, theologians and jurists to develop pertinent reflections on the subject.

It is clear that as nanotechnologies will require a source of economic progress, there will be serious issues of ethics, law and civil liability. It is assumed that the development of nanotechnology will have social and geopolitical implications. Some of global issues are not entirely new, but they will become more pressing. This is because a company's access to a concept of "industrialization based on nanotehnologiy" will not be done in any country in the world without huge investment and costs: investment in education, investment in laboratory infrastructure and technological and industrial infrastructure, compliance with specific legislation etc. Above all, nanotechnologies may lead to a new medium-term reorganization of the education system to ensure real convergence of the natural sciences in shaping the individual. What other arguments should be made for a company to sustain investment in programs research in nanotechnology than the very consequences that the first industrial revolution had on the subsequent division of the countries of the world?

It is known that in recent years nanosciences and nanotechnologies experienced a real boom of attractiveness and favorable publicity. This is because nanosciences and nanotechnologies have been associated primarily with innovation and progress in knowledge and technology. On the other hand, by increasing budget allocated to research on the subject, it has reached the inflationary use of nanoscience and nanotechnology terms, inflation is not without risk for the research itself. First, because they have been able to exclude from financing a lot of other interesting and useful researches in physics, biology, chemistry, engineering and microtechnology, not necessarily found on the nanoscale, and therefore it was not perceived as so revolutionary and generating breakthrough as nanosciences and nanotechnologies. Secondly, because it obviously increased the risk of financial resources' allocation to investigate declared "nano" researches, just for show, which does not belong to the sphere of nanosciences and nanotechnologies[12, 16].

Scientific research practiced in this field requires some specific features, so you can be effective, in materialized resulting. The products obtained cannot occur unless there is a steady development of the field, so production would be qualitative and continue to increase. In nanotechnology field, next generation of nanomaterials will be developed, nanodevices and nanosystems, development and application of nanotechnologies in a safe mode, efficient synthesis and manufacturing of nanomaterials.

3. Forecasts. Conclusions.

Nanotechnology - forecasts to 2025.

A study ("Nano2Life") of Tel-Aviv University, conducted among the 139 respondents (experts or people familiar with the area) from 30 countries - including Romania - shows trends in the evolution of nanobiotechnology in the next two decades. Here are, in short, as the technological experts see the future:

In *2006-2010* the chances are high for developing the following technologies:

- Intelligent and adaptive surfaces at nano level, as a basis for biodetection;
- Nanoagents used for intracellular analysis and diagnosis, without affecting the normal functioning of the host cell.

After this period the expected trends are:

2011-2015:

- Nanomaterials replacing the existing materials, for example polymers;
- Medicines with target, based on nanoparticles become a standard tool (for therapeutic purposes, increasing performance)
- Smart probes (which lights up when they reach the target) are basically used for in-vivo diagnostics;
- Nanoinstruments (such as optical tweezers) are used within the cells while preserving the integrity and activity of the cell;
- Nanolaboratorys are widely used for different applications in various sectors, including household;
- DNA-based integrated circuits aimed at specific diagnoses in the current practice of hospitals;
- In vitro tests based on biochips replace animal tests for different applications (eg in pharmaceuticals, cosmetics);
- Biosensors for the detection of single molecules, nano-based devices (eg nanotubes) are commercially available;
- Self-assembly technique is widely implemented as the development of materials and devices;
- Chips based on biomolecules as active elements are produced on a commercial scale;
- Nano chips are manufactured on a commercial scale using DNA or peptide.

2016-2020:

- Funamental processes of the cell cycle are largely known;
- Human bodies can be developed in vitro due to advances nanobiotehnologice;
- Biomolecular motors are used in nano and microsystems;
- The general usage of biochip for personal use;
- Artificial systems have self-healing abilities.

2021 - about 2025:

- Nanomachines are typically used for therapy and diagnosis inside the body.

In conclusion, nanotechnologies have a huge potential of applicability, bearing germ of a new industrial revolution with profound changes in the future society.

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