NANOTECHNOLOGY : A MULTIDICIPLINARY CHALLENGE
MATERIALS AND FUNCTIONALITIES

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ABSTRACT

After the prophetic conference of Richard P. Feynmann: <<There is plenty of room in the bottom >> in 1959, date for scientists to become aware of atom by atom manipulation can bring new possibilities.
Nanotechnologies are bringing all around the world the breakthroughts of tomorrow
We would first give the definition : not a new word, but a new world of materials and functionalities with specific properties and behaviour, very different of the macro ones , but the second result of the first :Nanosciences objectives, which are strongly increased with a multidiciplinarity approach , are to study its characteristics.
Nanotechnologies concern matter elements of nanoscale : we can found them for example in biologic living matter, from one atom to billions of them : man.
On the ground of fondamental Sciences , Scientific pragmatic advances become Studies and making of many Nano-objects , are produced in laboratories, then some of them in the industrial plants, to build required functional structures.
Several examples will be presented; in the mean fields of : Nanobiotechnologiy (with medical application), Nanomaterials themselves with macroscopic ones, (specially carbon nanotubes), Nanoelectronics with consequences in New Information and Communication technics and Cognitive approach., and technical measures.
Governmental, Industrial and Research Institutions set off on this unprecedented race, favourable for new economic and commercial strategies.

I would make a general survey of Nanotechnology issue , applicated field of Nanosciences
After the prophetic conference of Richard P. Feynmann: <<There is plenty of room in the bottom >> in 1959, date for scientists to become aware of atom by atom manipulation can bring new possibilities. More recently , we can notice this assertion :

" If I were asked for an area of science and engineering that will most likely produce the breakthroughts of tomorrow, I would point to nanoscale science and enginneering"

- ***Neal Lane***
- ***Assistant to the President for Science and Technonology – USA - April 1998. [1]***

And most recently :

"NANOTECHNOLOGY HAS GIVEN US THE TOOLS … TO PLAY WITH THE ULTIMATE TOY BOX OF NATURE - ATOMS AND MOLECULES -. EVERYTHING IS MADE FROM IT…THE POSSIBILITIES TO CREATE NEW THINGS APPEAR LIMIT LESS Horst Stormer

Lucent Technologies and Columbia University, Physics Nobel Prize Winner.[1]

Theses citations show what the USA intend to do, such way is undertake by main industrial countries like France [2].Optimist or realistic point of view ? A philosophical issue.? [3]

First we would give the **definition** of nano science and nanotechnology.

Nanotechnology is a new word , but it is not an entirely new field.

Biologists have observed in the nature several years before, nano structures like chloroplasts which contain nanoscale arrangements that convert light with carbon dioxide to produce organic matter. Chemical catalysis employed in petroleum huge cracking plants work in the same nanoscale way.

"Nano" concern a world of materials and functionalities with specific properties and behaviour very different of the "Macro" ones , but the second result of the first.

For example in the organic living species evolution, at the beginning is the atom,less than a nanometer, then DNA molecules , about one nanometer, then biological cells ,thousands of nanometers, then simple bio-organ, a million , and one man (or woman) billions of nanometers.At theses differents scale levels , specific arrangements are working, like different nanoscale machines. At each stage some next component is prepared and built, this the nanosaga to understand in all details and to highlight as the great universal construction.

Second, we would show how **all scientific disciplines** would contribute also at this dimension level to develop nanotechnology.

The presentation of all disciplines , sciences and applications in connection with nanotechnology would request three or four-dimensional array.

Thermodynamics macroscopic or statistic and others physical sciences, work at an abstract "molecular" (real or abstrait particles) level, with fondamental approachs; molecular dynamics, for example, or studies of interactions between spherical colloids, with use of big computers, explain some tiny components behaviour. There is also an evolution of molecularbiology in biology systems representation.

CODATA have explored this field in the Symposium M , Materials and Structural Properties, of 14th CODATA'94 International Conference , held in Chambéry, France [4] .Polyphase Structures, Materials Surfaces, Soft chemistry, Intelligent Materials and Microsensors, Dynamics of complex Biosystems, … have been presented.

Also ,in Japan, at Tsukuba, the 15th CODATA' 96 International Conference [5] , in the Materials Session, some nanosystems behaviour have been studied.

We can notice also the important works made in micro materials and devices which have open out the road for nano ones: many meetings show increasing results.[6].

In others ways we can notice also mathematicians who reproduce the natural (and to-morrow artificial) complexe structure using computer calculations on the basis of abstract tiny objects like fractal generators [7] and arithmetic relators [8]. I think that theses works show an undeniable correspondence between matter nanoproperties and spirit ones.

Bringing knowlelge from all scientific domains at nano level , one can said "shaping the word atom by atom" [1]

Third, in a **pragmatic point of view**, more and more , biologists, chemists and physicians found new nanomaterials with new properties and new functionalities about general matter constituants at the nanoscale.
The nano sciences handle various subjects and domains : nano-sized electronics or optoelectronic devices and components, as said before, nanointerface between quantum and classical physics, chemical and biological systems;
But there is also , at the moment , fabrication and testing of nanometrical materials and machines : experimentation at this scale demand special skills. For example news , revues and specific list (given by editors like Springer or Elsevier) furnish many informations on various laboratory studies made, to-day.

Among theses **scientific advances** one can notice , for examples (various references)
There is an new family of carbon nanotubes, with various morphologies, and built with Ab Initio Density Functional Methods, which show a rich variety of metallic and semi-condutive behaviours !
NANOparticles , in stead of MICRO particles of the same component, for example in composites, give very increased mechanical Strenght
Glasses with Nano-organic or mineral component show optic non-linear properties
Molecular Dynamics Calculations have shown specific deformations in nanocrystalline metals.
SUSPENSION of Nanoparticles present GIANT electro-rheological effect
A new form of carbon:MAGNETIC CARBON"NANOFOAM" is attracted to magnets.
We can say once again that CHEMISTRY HAVE ALWAYS work about NANOSCALE OBJECTS but To-Day it is question also to CONTROL MATTER ORGANISATION.
PHYSICS , in MICROELECTRONICS , for example, have use mainly OHM LAW with only a flow of electrons, To-Day it is more question to OBSERVE and HANDLE NANOSCALE OBJECTS.
In BIOLOGY there is combination of theses approaches with specific COMPLEX biologic matter.

In theses conditions the NEW PARADIGM consists of new LINKS between USERS and VERY HIGH MULTIDISCIPLINARY RESEARCH
to built
NANOTECHNOLOGY PRODUCTS

Finally What are Nanotechnology ? in brief,
NEW STRUCTURES LIKE CARBON NANOTUBES
NANOSCALE SILICIUM COMPOSANTS
ATOM by ATOM ARRANGMENTS and MANIPULATIONS
AUTO-ASSEMBLAGE ATOM by ATOM
MOLECULAR TECHNOLOGY TO DRAWN UP TO 50 YEARS
INDUSTRIAL DEVELOPMENT OF NEW TECHNOLOGIES AT SCALE LEVEL UNDER 0,1 µm [9]

There is three mean fields well developed :

The nanobiotechnologies : covering :
Functional biologic nanostructures : the proteins, and artificial super molecules, self-organized nanostructures, monocoatings, membranes, ADN and protein chips, …and nanomanipulations by various strenghts : optical, magnetic fluidic fields ,… and nano machines, … and molecule target detection…[10]
In theses approachs and also in following others, successfull developments for the making of high hierarchical systems can be done by combination of "bottom-up and also "top-down synthesis of nanoobjects as building blocks for the fabrication of larger functional devices.
On the other hand for, for example, in the third field after, patterns produced by microphotolithography bring production of structures about 100 nanometers scale.
There is also possibilities of autoassemblage which can give, in all fields, nanostructures on nanofeatures patterned substrates, which can be characterised by physical measures.
We can notice than artificial and natural living matter present at nanoscale complexity and physical and chemical properties quite similar. Some nanoparticles show already biomedical application. Some nanosystems auto-assembled on specific support are biomimetic. Polymers, with stereomark can increase reliability of living active elements.
Nano physical tools associated with electronic means can been used to observe, to count and to manipulate living matter. Nano motors can be built for ATP pumping.

The nanomaterials themselves on top of theses which are presented in many applications briefly before., or in nanoelectronics after, directly or in macrosopic ones like composites are very wide spread: the last is the most industrial increasing market.
Thus several types of nanostructures can be built as tubes , wires, rods with great specific surfaces and unusual physical (magnetic or electrostatical) and chemical (catalytic) properties.
So, nanocarbons tubes can make up industrial filters.

The nanoelectronics , which pursue its course from micro to nano and nearly with advanced materials as :
Memories of the future , molecular electronic circuits, hybrid memory devices, nanocells for molecular computing, molecular programmability, conduction in individual molecules , nanoelectronics on a bio-scaffold, nanowire heterostructures and lasers, …electronics beyond the conventional, nanowriting,… [11].
Very many improvements are been made in this field.
But consequences affect the Information field and further the cognitive field.
The world of communication and information will be very transformed, and **data** archiving, **data** access,… and **infoscience technology** will be improved.
Presently , microelectronics developments are already so considerable than we would take care on possible more valuable and accurate data, more speed in access and generaly more browsing and finding tools, as it is scheduled in satellite Symposium for **Materials Informatics and its Evolution.**
The nano materials , on top of that electronics developments , which are formed, or made up by nanoobjects , give to these materials increased or new properties.

There is several forms of nanotechnologic products :,
Nanomaterials as particles with two or tri or multi dimensions: carbon tubes, tree of tubes …
Macroscopic materials with nano particles, like composites, with better mechanical properties, or in medecine bio compatible (biomaterials), new active membranes ,..or protective materials against pollution or radiations.
Coatings nano sized , to give surface properties on solids,..

Different nanocomposants to give assembly (like ones used in electronics), and also new alloys in metallurgy…
These nano components are made in new processes very specific , in mainly soft chemistry , with use of many physical and eventually biological actions.
Mathematical computations are made to represent nanocomposant systems behaviour to construction of control algorithms
Some applications have been listed before , we can give also : new energetic materials in faster combustion and new fuel and solar cells.

Let us see some more actual applications chiefly coming from micro-nanoelectronics :
In chemical field : **-Sensors** – chips (transistors) to measure contents in fluids of traces of gazeous components like H2, O2, CH4, CO2, ..COV, ..
-Sensors-chips (modified transistors) to detect biomacromolecules
-Sensible films to measure or detect chemical or biological species.
-Electro-catalytic active chemical reaction.
In physical field : - Mechanical string sensor devices

- Off-line physical quantities sensors
- Nanosensors of strenghts in cristallized materials
- Tunnel effect microscope to oberve and manipulate nanocomponents

After theses scientific and technical pictures, we can resume the works undertaking on several research network organised by most industrialzed contries, as this :
Nanoworks are supported by several National impulses:
NATIONAL NANOTECHNOLOGY INITIATIVE IN USA , [1]
Same Project is recommended by FRENCH SCIENCES ACADEMY [2]
Several monographs and Technical Books are edited on the subject.
French Industry Ministere have created one data : www.nanomateriaux.org
Industrial Research Centers are regrouped, start-up created.
University Specific Centers are created
Specific Computing Tools are built.

According to strategic point of view, one can see, with use of a matricial crossing between different nano products and different application domains, great many opportunities.
Important funds are earmarked for theses objectives.
. Many forces and tendancies are running through the core of nanotechnology and their related aeras. Information and Formation issues are posed. Ethics also intervene in the issue.[3]
Investments in research and developpement being made by public authorities are increasing : between 1998 and 2003, these investments rose sixfold in Europe , eightfold in the United States according to National Nanotechnology Initiative [13] and Japan, and reached three billion euros worldwide.
In France many Associations and University groups (RMNT net) are devoted to this issue, in conjonction with industrial and research government departments.[12]. Many conferences on this subject are scheduled in France and in Europe.
Volume world market have ben evaluated to thousand billions of dollars in 2015..

WHY ? BECAUSE

INNOVATIONS BROUGHT by NANOTECHNOLOGY Are
ECONOMIC/ POLITICAL / COMMERCIAL ISSUES

THEY LEADS TO

NEW INDUSTRIAL MATERIALS AND DEVICES

NEW MEDICAL DIAGNOSTICS and TREATMENTS

NEW SPATIAL AND DEFENSE POSSIBILITIES
(see NASA NANOTECHNOLOGY ROADMAP)

NEW COMMERCIAL COMMUNICATIONS, SUPPLIES and MARKETING

NEW ENERGETIC WAYS

IT IS A MULTIDISCIPLINARY, MULTINATIONAL, MULTI INDUSTRIAL, MULTICOGNITION CHALLENGE

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