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INTEGRATING FIELD "MICROMECHATRONICS & NANOMECHATRONICS" - INTEGRATED PART IN NANOSCIENCES AND NANOTECHNOLOGIES

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Abstract: *The scientific work deals with the concepts, theories, scientific achievements, applications and experiments in the integrated field of MICRO-MECHATRONICS AND NANO-MECHATRONICS as an integrated part in NANO-SCIENCES AND NANO-TECHNOLOGIES, with concrete examples of applications in research projects approached by the authors and by the research institute.*
Key words: *micro-mechatronics, nano-mechatronics, nano-sciences, nano-technologies, advances-scientific-concepts*

1. INTRODUCTION

Micro-Mechatronics and Nano-Mechatronics (µM & nM) are the most representative and advanced interdisciplinary fields of engineering and the youngest of the integrated sciences. Currently, they are developing at very fast pace, because of their impact in the fields of physics, solid mechanics, fluid mechanics, optics, pneumatics, electro techniques, thermodynamics, all of them intermingled, interdisciplinary and integrated on one hand with the sciences of electronics, informatics and applied mathematics and on the other hand with chemical, biological, psycho-sociology, economy sciences and arts in general.

Micro-Mechatronics (µM) and Nano-Mechatronics (nM) penetrate daily in other new mechatronic subfields, as well as **micro-nano-robotics, mechatronic micro-nano-technology mechatronics and medical micro-nano-technique.**

This evolution and development at the **Micro** and **Nano** scale of **Mechatronics** cannot be conceived out of the evolution and of the development of components and micro-nano-components and micro-nano-technologies of the materials, intelligently coupled and architected on the basis of dedicated, special and efficient software, integrated into a competent, useful and successful design.

The work shows concepts, applications, laboratory experiments and an original point of view on the current and future problematic of µM & nM, in both a formative and an informative scope.

2. THE CONCEPTS OF MICROMECHATRONICS (µM) AND NANO-MECHATRONICS (nM)

The integration of **µM** & **nM** in the advanced fields of **Nano-sciences** and **Nano-technologies** requires a discussion over the concepts, theories and scientific accomplishments, with tangible examples of applications in research projects taken on by the author and by the dedicated institute.

The concepts of **µM** & **nM** (Amerongen, 2006) were initiated and developed as a consequence of the rapid development of micro-nano-mechatronic structures and micro-nano-structures, as well as due to the perfecting of the perfecting of the micro-nano-programming, micro-nano-command and micro-nano-control.

The concepts of **µM** & **nM** have developed through the synergetic mingling of the micro-nano-structures matrices and of the principles and laws that coordinate the movement of masses, the carriers of electrical charges and the informational transfer at superior logical levels and in the micro-nano-technological integration and fusion of all micro-nano-components.

The concepts of **µM** & **nM** synthesize the simple, mixed and complex phenomena, diverse structures, integrated links of all constitutive sciences and computer sciences and informational technology, subordinated to the generative ensemble at a micro and nano- scale of high and total quality.

The implementation of de **µM** & **nM** concepts (Gheorghe, 2008), in technical and technological applications, arguments their contribution to the evolution and the development of **Nano-sciences** and **Nano-technologies**, justified by the favorable immediate effects on the superior quality of products and services, **high** work **productivity**, rapid increase in the **comfort of life** in as a **whole**, carrying out **lasting economic efficiency** and the **computer management** of all processes in industry, economy and society.

3. APPLICATIONS OF µM& nM APPROACHED IN RESEARCH PROJECTS

A first application in the realization of a micro-mechatronic structure with digital micro-nano-control of the process, shown in fig. 1

In this application, of advanced micro-nano-mechatronic micro-nano-system, (Taniguchi, 2000) the micro-nano-control is carried out discreetly over time, taking the form of digital micro-nano-control, where the variable is monitored and compared to the reference variable, the signals are exposed to a sampling with an identical and synchronic rate (cadence), the result of the comparison is also a digital-binary signal that conserves its digital shape even after processing, the and the algorithm on the basis of which the micro-nano-control is realized is implemented into a memory, through a program, where the A/D and D/A transform analogical variables in digital signals and vice-versa.

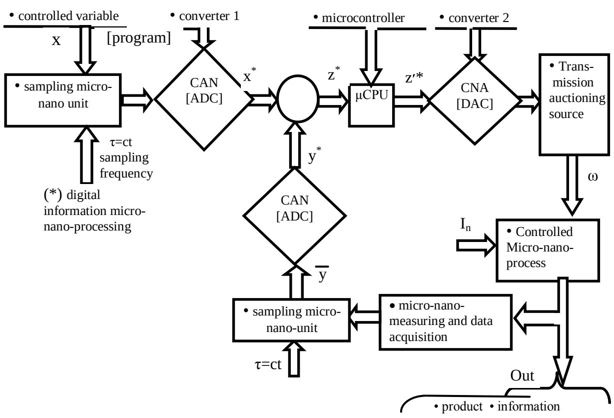
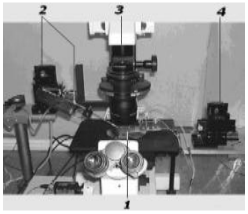


Fig. 1. The structure of the process of digital micro-nano-control

Another application of the micro-nano-robotic micro-nano-system with reaction image and force is depicted in figure 2.



1 - Readout circuit board with a wire-bonded force sensor
2 - Cell holding unit
3 - Inverted microscope
4 - DOF-microrobot

Fig. 2. Robotic micro-nano-system with image and reaction force

This micro-nano-robotic micro-nano-system is used for the development of experiments through autonomous injecting where the micro-nano-robot characterizes a hybrid micro-nano-controller that combines the visual micro-nano-system and the micro-nano-control of the precision position by recognizing the detection model of the nuclei of embryos and the ultra precise auto focus scheme.

For improving the performance of the micro-nano-robotic micro-nano-system, a new concept of cell capacitate micro-nano-sensor with multi-axial NEMS is carried out for ensuring the force reaction in real time. (Brugger, 2003)

This cell NEMS sensor is designed for the researches on characterizing bio-membrane properties.

Laboratory experiments show that **μM, nM, robotics and MEMS & NEMS** micro-nano-technologies can carry out a determining role in the biological studies with the task of automated bio manipulation of bio molecules and bio cells.

In the experiments carried out in the laboratory „a new micro-nano-robotic hybrid" is depicted in figure 3, base don the nano-robotic manipulation of structuring increased nano-materials and that could be used for complex 3D nano-devices.

The advantages of nano-robotic assembly will certainly be found certainly in the next future in the science of nano-materials, bio-nano-technologies and nano-electronics.

Generally, the positioning of nano-robots and of the nano-robotic manipulating devices depends generally on the matrix of nano-actuators and of the sensoric and the miniaturization architecture of MEMS and NEMS. (Considine, 2005)

For the movement at a nano- resolution, it is generated using different principles for auctioning, especially electrostatic, electro-magnetic and piezoelectric ones.

After the performed study and the researches carried out for nano-robotic applications, micro-actuators are used as it follows (table 1, table 2):

The experimental data obtained in the laboratory written in table 3:

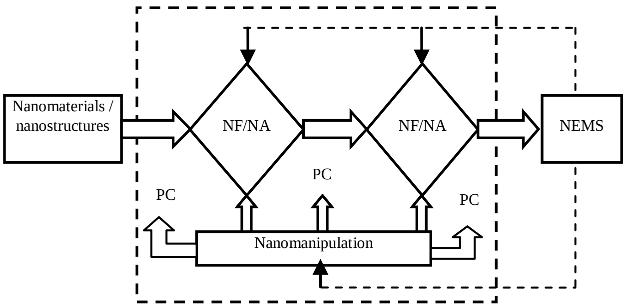


Fig. 3. The structure of a new micro-nano-robotic hybrid

Crt. No	Functioning principle	Type of movem ent	Volume (mm^3)	Speed (s^{-1})	Force (N)	Movement (m)	Resolution (m)	Power density (w/m^3)
0	1	2	3	4	5	6	7	8
1	piezoelectric	linear	22,5x11,5x1,4	4500	300	$0,8x10^{-3}$	$5x10^{-8}$	800
2	magnetical	linear	0,3x0,3x0,4	900	$2,2x10^{-6}$	$1x10^{-4}$	$10 x10^{-8}$	3500
3	electrostatic	linear	350	4800	$0,8x10^{-7}$	$5x10^{-6}$	$10 x10^{-8}$	220

Tab. 1. The characterization of linear microactuators

Crt No.	Functioning principle	Type of movement	Volume (mm^3)	Speed (rad/s^{-1})	Torsion moment	Movement (rad.)	Resolution (rad.)	Power density (w/m^3)
0	1	2	3	4	5	6	7	8
1	piezoelectric	rotation	π/4x1,4x0,4	30	$1,8x10^{-11}$	0,5	6/40π	3500
2	magnetic	rotation	2x3,5x0,5	160	$1x10^{-6}$	2π	5/36π	3200
3	electrostatic	rotation	$π/4x0,5^2x2,8$	35	$2x10^{-7}$	2π	-	950

Tab. 2. The characterization of rotation microactuators

force	resolution	direction
10 μN	0.005μN	y x
15 μN	0.007 μN	y x
20 μN	0.009 μN	y x
25 μN	0.01 μN	y x

Tab. 3. Experimental data obtained in the laboratory

For using an optimal actuator, during the design work, the movement range, the force, the movement, the speed (displacing frequency), power, resolution, precision, the flexibility coefficient corresponding to the robot, the robustness, the loading capacity and so on have to be considered.

For the micro-nano-manipulation functions, determined on the basis of the study and of the researches that were carried out, these were selected and stated according to table 4:

Crt. no.	Functions	• The micro-nano-manipulation involved
1.	Nano-manipulation	• Micro-nano-manipulation of nano-tubes through intermolecular control forces and surface control forces and their micro-nano-positioning in the 3D coordinates
2.	Nano-instrumen-tation	• Electrical properties: their placing between two probes; • Mechanical properties: blending or stretching
3.	Nano-fabrication	• Disposal induced through an electrons flow • Shape modification: deformation by bending, shape bending and fixing • Destructive fabrication: breaking
4.	Nano-assembling	• Welding, with an electron flow • Bending through mechanical and chemical synthesis

Tab. 4. The selecting of micro-nano-manipulation function

4. CONCLUSIONS

The work underlies, in synthesis, the concepts, theories, scientific attainments, applications and laboratory experiments in the advanced integrated field of Micro-Mechatronics and Nano-Mechatronics, of Micro-Nano-Robotics and Micro-Nano-Technologies that are an integrated part of Nano-sciences and Nano-technologies that characterizes in the future the development in the field of Intelligent Advanced Engineering.

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