Current Needs and Offers in Engineering Education in Micro/Nano-electronics and Smart System Integration

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ABSTRACT

The analysis of the current industrial needs and university offerings is provided. The continuous miniaturization of minimum feature size to dimensions less than 100 nm and corresponding growing integration of circuits and systems to Gigascale range require for multidisciplinary education. Simultaneously the non-technical competencies requested by industrial partners have to be addressed during education period. Another identified task relates to the problem of implementation of new courses and material in new curricula within a limited time frame and capacity of human brain. To prevent the men power shortage the necessity of motivation and attraction of young generation towards to technology oriented fields is discussed.

1. INTRODUCTION

The dynamic and innovative nature of micro/nano-electronics industry, development, integration, and application of smart systems which provide the increasing intelligence to products in almost all sectors of societal and human life requires a large number of new, highly educated experts. They should be educated and trained at research universities which are able to provide the state of the art education and training in advanced R&D laboratories in a multidisciplinary area of micro/nanoelectronics and smart system integration (SSI).

The innovated curricula have to reflect the actual needs identified and specified by the industrial partners. To built the knowledge society and ensure the European competitiveness and sustainable growth the education environment should be in line with Strategy Research Agenda (SRA) defined by the expert groups of European Technology Platforms ENIAC, ARTEMIS and EPoSS. The selected application oriented priorities, local traditions, presence of high tech industry in a particular geographical region are other necessary conditions which considerably contribute to motivation of young students and creation of a stimulating education /learning environment.

2. ANALYSIS OF CURRENT STATUS IN EDUCATIONAL ENVIRONMENT

Currently most of the European universities undergo a transformation adapting Bologna declaration [1] with the 3 + 2 + 3 year timeframe structure (3 years undergraduate, 2 years graduate and 3 years postgraduate). The changes in curricula both from content and structure point of view are considerable particularly in countries with traditional 5 years Diploma Engineer curricula (e.g. Austria, Germany, Italy, Slovakia and many others). To follow and address the very dynamic development in nanoelectronics/nanosystems and SSI area (new materials, technologies, systems, assembly etc. and their integration) the multidisciplinary aspects should be implemented in new curricula to diminish the shortage of highly qualified experts. Such objective is not an easy task due to a limited available time (credit) frame, finite human brain capacity and generally low interest of young generation in technology oriented studies.

3. IDENTIFICATION OF PROBLEMS AND RECCOMENDATIONS

In spite of the challenging nature and tremendous marketing potential of nanoelectronics, its irreplaceable contribution for the human society in the future and current shortage in highly educated experts there exist factors which can slow down the education innovation process in micro/nano-electronics and SSI area. They identification and some recommendations can be summarized as:

A. *Conservatism of universities, slow implementation of multidisciplinary curricula*

The conservatism of many professors and local national rules related to the accreditation process represent an important drawback which may slowdown the fast innovation process of establishing the multidisciplinary curricula. The increased motivation of teachers by industry and more proactive legislation defined by policy makers (creation of the European Education Area) to address the industrial and/or society needs by introducing the new multidisciplinary curricula is a must. As the timeframe is limited the deep and wide scientific theoretical background and acquired engineering methodology will provide the good starting point to address the needs required from members of the wide multidisciplinary and international R&D teams.

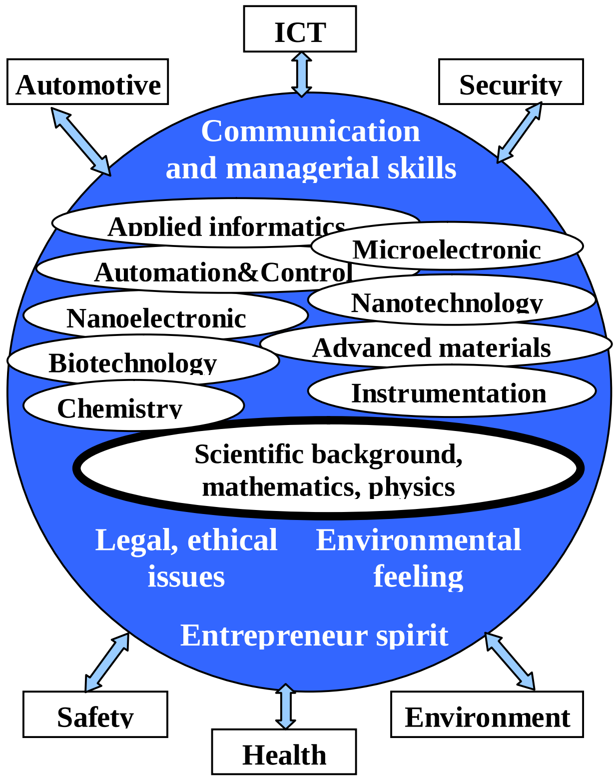

Figure 1. Pool of profiles and competencies required for multidisciplinary teams in ENIAC and EPoSS areas

B. *Inadequate interest of young generation in technology oriented area*

The technology oriented curricula are considered as a difficult study programs and therefore the interest of young generation to enroll is pretty low. This is reasonable particularly for multidisciplinary micro/nanoelectronics and SSI related curricula where the workload on students is even higher. To improve the situation and increase the motivation of youngsters the global society awareness and acceptance of technology oriented disciplines should be increased. Big role in this process can play the companies who are looking for new highly qualified experts and suffer with inadequate supply chain. They should build up particularly on the local tradition, obtained results, international recognition and contribution of the industry to a development of individual regions. To promote this process some incentives to the students, e.g. scholarship, summer internship programs, creative environment for diploma works, and others should be provided. Also the university professors should create the advertising materials addressing the challenges and potential of nanoelectronics in a popular form to address the communities of high and primary school students as well as their parents. To attract some students to micro/nanoelectronics from informatics curriculum which is still very popular, some courses with basic physics and technology of electronic devices, sensorics, and optoelectronics should be implemented (top down approach) for student with major in VHDL design.

C. *Inadequate feedback from industrial partner*

Another problem of a weak collaboration between industry and academia arise from the confidentiality individual company policy in human resources field. In spite of the conclusions concerning the shortage of highly educated experts the specification of requirements on competencies and numbers of graduates for hiring process by industrial representatives is inadequate. Although not all problems can be solved, particularly due to a cyclic nature of high tech (microelectronics) industry, the more proactive, update and open targeted collaboration with universities can contribute to improve the situation.

D. *Insufficient preparation of graduates in the non technical competencies*

The European students comparing to their US colleagues in general suffer with the low entrepreneur spirit, therefore the universities should pay attention and be active to promote the graduates competency to fast capitalize the obtained knowledge. Also the legislation and/or environmental problems should be addressed appropriately to provide students with better feeling for environmental, ethical and legal issues connected e.g. with the use of a new potentially hazardous materials and/or broken privacy using smart cards.

E. *Insufficient resources for high initial investment*

To update the curricula and R&D laboratories to ensure the graduates will have hands on advanced technologies is a growing problem because the new materials, fabrication and characterization tools, architecture platforms, devices, circuits and systems prepared by nanotechnologies with smaller dimensions and higher degree of integration require more investment.

The more coordinated approach, collaboration and creation of international clusters and consortia providing complementary study program in multidisciplinary field and enhanced support of mobility of teachers and students can help to solve the problem. The established International Master Degree in Micro & Nano Technology for Integrated Systems provided by the so called "Triangle structure" created by Polytechnico di Torino, EPFL Lausanne and INP Grenoble [2] and the Erasmus-Mundus Program in Nanoscience and Nanotechnology provided by KU Leuven, TU Delft, TU Dresden and Chalmers University Gothenburg [3] may be used as a best practice examples.

Training the trainers in advanced fields approach like in 7 FP project IDESA [4] and/or web remote access to advanced laboratories and technologies is another way how to provide the academia with additional technical support in advanced fields.

New scheme for public-private partnership and funding to ensure the EU competitiveness, increasing private funding, and specific approach to member states should be adapted.

4. Summary

The analysis of the actual status of educational environment related to industrial needs and university offerings with some proposal how to address the actual problems and improve the potential shortage and gap in new highly educated experts was presented.

To innovate the curricula and address the current needs referred to effective and up to date education the **Triple M challenge** should be in centre of gravity. It comprises: **Multidisciplinarity –** in background, new materials, progressive fabrication technologies, advance metrology, handling and assembly, modeling and simulation, design, architecture platforms, interfaces of nano-world to real world, automation and control, information and communication technologies, autonomous power supply. **Methodology –** critical analysis of a problem, creative thinking, definition of a solution strategy and timing, verification of obtained results, optimization of design, technology, and/or product, final evaluation of results, dissemination and capitalization of gained knowledge, overall project management, responsibility, marketing issues, team project leadership, control.
Motivation – to attract more and talented students to technology, high school students to technology oriented fields, undergraduate students to micro/nano-electronics and nanotechnology curricula – using best practice examples, involvement of students in challenging R&D projects – to have hands on advance technology, increasing global society awareness.

The support the mobility of EU students and creation of programs to attract more foreign students from countries outside Europe is another strategic goal which should be supported by European authorities.

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