Research and Postgraduate Study in Microelectronics Technology

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Abstract - This paper summarizes both the some theoretical and practical experience and also some results gained in the research and postgraduate study at the Brno University of Technology, Faculty of Electrical Engineering and Communication, Department of Microelectronics. The growth in research activities has been observed at the FEEC from 2004 in terms of founding and quality of research results. Postgraduate study is practically the part of direct interconnection between University and industry. There are new factors in business world that are mentioned in this paper. Very important is adaptation of study program and activities to actual situation in local industry sector. The situation in the Czech Republic is presented. Research activities have to start just during study period importantly one of the first steps that give good base to built effectual system for joining particularly effective postgraduate students with praxis. The establishing of optimal collaboration between industry and research sector must be push from University facilities, as well as from independent research institution closed to concrete industry branch. Adaptation of these facts for Microelectronics Technology education program is indicated.

Index terms - research and education, microelectronics technology, three steps study

INTRODUCTION

There is a need to match education to the changing business world asking new business strategy, which is more and more determined by the industry needs. People in production and market know the most about products and they have actual information to evaluate what the market really needs and what producers should produce to be successful.

To produce excellent students means to find the right equilibration between knowledge and practical needs. In the three step educational system (Bachelor – Master – PhD), the third PhD stage gives the optimal opportunity to reach efficient conformity in it. Establishing optimal collaboration between industry and research sector (which must be pushed both from the University and from research institutions) offers forming experts that are able to bring successful outputs. Actual of the educational/research system at the FEEC BUT is presented in this paper.

The quality of teaching/research activities is guaranteed by accreditation procedures, one at the national level by the Czech Ministry of Education, another by the European Association for Education FEANI.

RESEARCH ACTIVITIES

Research activities at the Faculty of Electrical Engineering and Communication (Fig. 1) are mostly funded from national grant projects (Grant Agency of the Czech Republic, Ministry of Trade and Industry, and others), from the Ministry research projects and from the Research Centers. During 2004-5, research was conducted within the framework of research plans and the new research centre was established.

There are two basic opportunities in the Czech Republic to receive financial supports, specific and institutional.

Specific one can be one of three types of financial support:

- grant projects
- programme projects
- public contracts

First is granted from the Ministry of Industry and the Ministry of Education (GACR, FRVS), second from the state administration body and third means an open contract from some institution.

Institutional one can be of the three following types:

- specific research
- research plot
- international collaboration

There are various programs offered by national, international and multinational institutions and groups.

An important objective at University generally is to give transparent and clear programme for research activities with a possibility to join it, or to offer possibility to join, to start and to develop these activities. Engagement of University staff and constitution of research team in University is good and important step in this operation.

…Members of the academic staff and postgraduate students from the Department of Microelectronics, Radioelectronics, Biomedical Engg., Control and Instrumentation, Telecommunications, Physics, Mathematics, Theoretical and Experimental Electrical Engineering, Electrotechnology and Languages were involved in research carried out in the years 2002 – 2004. Each year of the research plan duration, about 100 University staff and about 70 full-time doctoral students participated in the research plan.

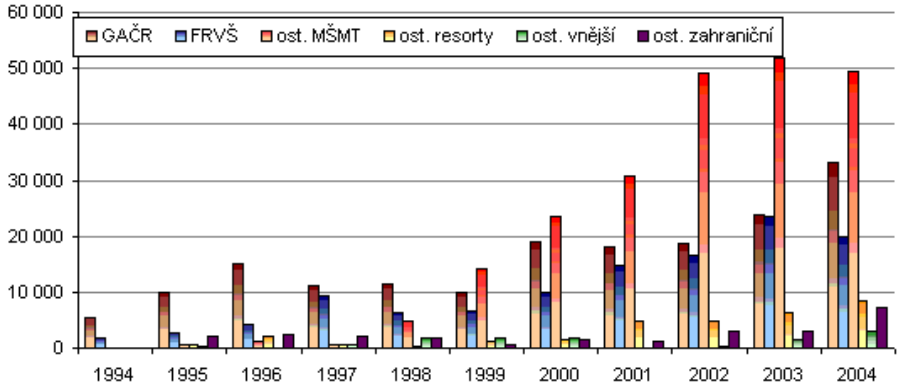

FIGURE 1
DEVELOPMENT OF RESEARCH ACTIVITIES AT FEEC BUT

Particular attention is currently paid to projects for the 6th Framework Programme of EU. Work is underway on Faculty projects, and partnership for joint projects is offered.

The staff is involved in applied research for industrial partners on the basis of contracts, and within the framework of diploma theses and dissertations. Companies interested in cooperation can write directly on email address or contact directly the particular departments. The responsible for the organization of research activities at the Faculty of Electrical Engineering and Communication is the Vice-Dean for Research and Creative Activities.

One good example is the research activity carried out at the Microelectronics Department of FEEC, which has the title "New Trends in Microelectronic Systems and Nanotechnologies" (MIKROSYN), concerning fundamental area of microelectronics technology sector. The research plan deals with advanced microelectronic circuits, chip microsystems and structures. All the research areas involved are focused on new and prospective micro- and nanosystems and technologies. The whole concept of the research plan is scheduled until 2010. Basic and applied research cover five areas:

- Theory, design and diagnostics of low-voltage and low-power integrated circuits in submicron technologies
- Modelling and simulation of integrated circuits
- Microsystems and nanosystems
- Advanced technologies for microelectronics and nanoelectronics
- Up-to-date diagnostics of materials and components

The objectives of research in all areas involved are original findings in microelectronic systems, progressive research and optimization methods, applied research in micro- and nanotechnologies for preparation of advanced electronic structures and semiconductor components.

NEW FACTORS IN BUSINESS WORLD DEMANDS

New business world demands ask new business strategy, which is more and more determined by customers. They know the most about products, and they have the actual information to evaluate what the market really needs and how producers should be successful.

Network application, mass customization and disintermediation are new fundamental principles to ensure prosperity in future world. Information technology speeds things up, increasing productivity and flexibility in inter- and intra-firm relations.

To achieve an efficiency in research needs to ensure more steps one after other. As every system asks to have right input data, the gaining of them is the first principal assumption for later success. Because there is necessity for complex data collection, both education and industry have to supply this system. The establishing of the optimal collaboration between industry and research sector must be pushed from the University, as well as from independent research institutions closed to the concrete industry branch. The basic principle of the system approach is shown in Fig. 2.

In the last years there was one increasingly important area of knowledge in the electronics sector, which is "Microelectronics Technology and Packaging". This area becomes to be increasingly complex and includes increasingly subjects that one's attention to various application areas as for example Automotive, RF/Wireless, Telecommunication, Consumer, PC etc. There is one common factor, that's truth with different evaluation for each sector, quality and cost.

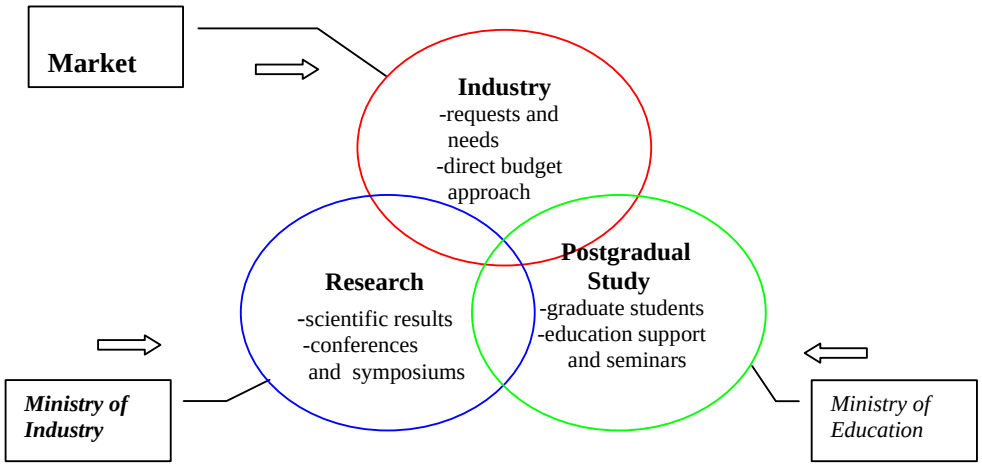

FIGURE 2
TODAY'S COMMON SYSTEM FOR ACHIEVING OF PROGRESS

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THE CZECH ELECTRONIC SECTOR

According to statistics, the Czech Republic attracted more than $7 billion of foreign direct investment for the first 3 quarters of last year and in the 21st century has maintained its number one position per capita in Central and Eastern Europe. The structure of investment is beginning to shift from quantity to quality, which is reflected in the marked increase of projects of technology centers and strategic services.. The Czech Republic has a great potential in this area in particular, courtesy of its industrial tradition and the quality of its system of higher education. The increase of such sophisticated projects can also be largely attributed to the adoption and application of the new program to support technology centers and strategic services, which was approved by the government last year.

The strategy in the electronic sector is supported by good spirit of innovation, high intellectual capital, cost efficiencies and traditional quality assurance. The Czech Republic entered to the European Union in May 2004 with these attributes bringing annual production increase around 40% in the last year. As the Czech Republic was before the 2nd World War one of the leading recipient of automotive projects in Europe (there were 7 brands there), it is once again in the vanguard of electronics and electrical engineering industries.

Major investors in the Czech Republic are shown in the Czech territory in Fig.3.

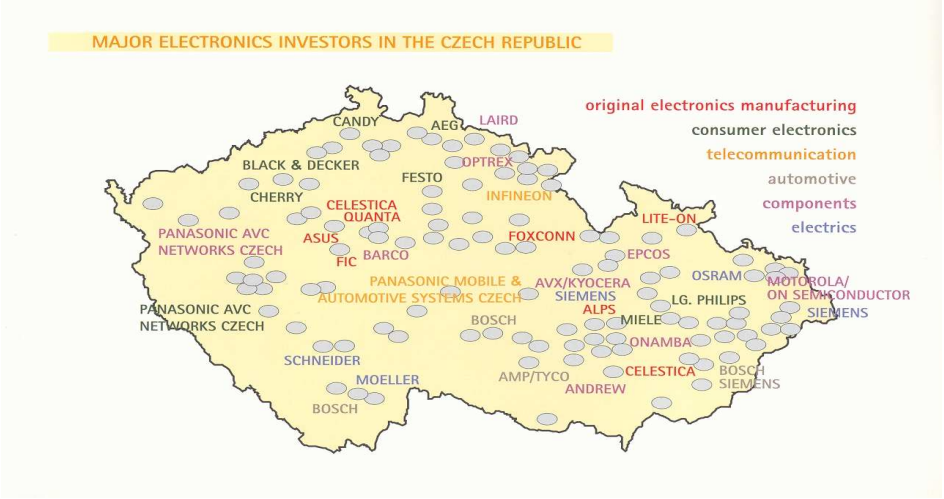

FIGURE 3
MAJOR INVESTORS IN ELECTRONICS SECTOR IN THE CZECH REPUBLIC TERRITORY [7]

TABLE I
SALARY OF THE CZECH ELECTRO ENGINEERS IN VARIOUS POSITION [7]

Position Engineer of electronics/electrical engineering	**CZK per month**	**EUR per month**
Research & Development	17 800 – 45 100	580 – 1490
Designer	16 700 – 42 000	590 – 1350
Supervisor	18 800 – 50 200	600 – 1580
Quality Controller	18 700 – 40 900	620 – 1290
Production Manager	14 400 – 42 000	650 – 1380

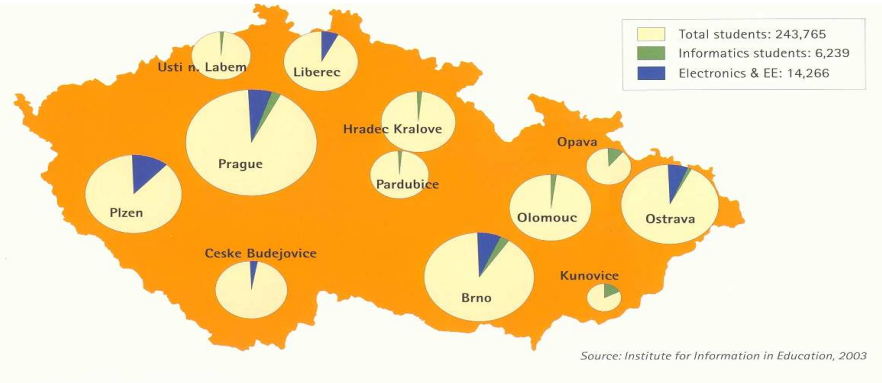

FIGURE 4
: TECHNICAL UNIVERSITY FACILITIES IN THE CZECH REPUBLIC [7]

The movement towards a competitive free market economy has increased unemployment in traditionally strong sectors of the Czech industry such as mining and heavy industry. As industrial restructuring gathers pace, investors can take advantage of a pool of available skilled labour. The Czech Republic boasts one of the most competitive wage structures in the world. The wage structure is competitive with emerging economies in other parts of the world (Tab.I).

In the last years there is in the electronics sector increasingly important area of knowledge, which is microelectronics assembly technology including packaging and interconnection. That is truth this area becomes to be increasingly complex and includes subjects that one's attention to various application areas as for example automotive, RF/wireless, telecommunications, consumer etc.

Quality and cost form today inseparable part of each technical solution that tackles with the technological performance of every one electrical circuit, equipment or system. This fact has to be taking into account by draw up educational program as well.

HUMAN RESOURCES IN THE CZECH REPUBLIC

Although there are obvious wage cost advantages, almost all foreign investors in the Czech electronics sector are attracted even more by the skills demonstrated by Czech workers. In the Czech Republic is one of the highest outputs of engineering graduates in the word as a proportion of total university awarded. In 2003, the total number of university students in the Czech Republic was more than one quarter of million. Approximately about 15 000 electronics-orientated students, are enrolled at six technical universities, producing around 8 000 graduates per year. Placement of Czech universities is shown in Fig .4.

POSTGRADUATE STUDY IN ELECTRONICS TECHNOLOGY

Microelectronics technology becomes highly interdisciplinary area containing different sectors as could be seen in Fig. 5. This fact is closed to technological integration that includes except "pure" technology, many formerly independent areas, as system engineering, material science, computer practical, thermal management, quality management, selected rules of general management not excluding. The development period (product, process, equipment etc.) is more complex and asks approach that is more open than some years ago.

It is obvious the special emphasis must be given on selected parts of the basic subjects (mathematics, physics, chemistry etc.) as well on the extend and supplementary subjects regarding concrete application (sensors, optoelectronics, microwaves and wireless etc.), and depending on the type and character of location and respective production too.

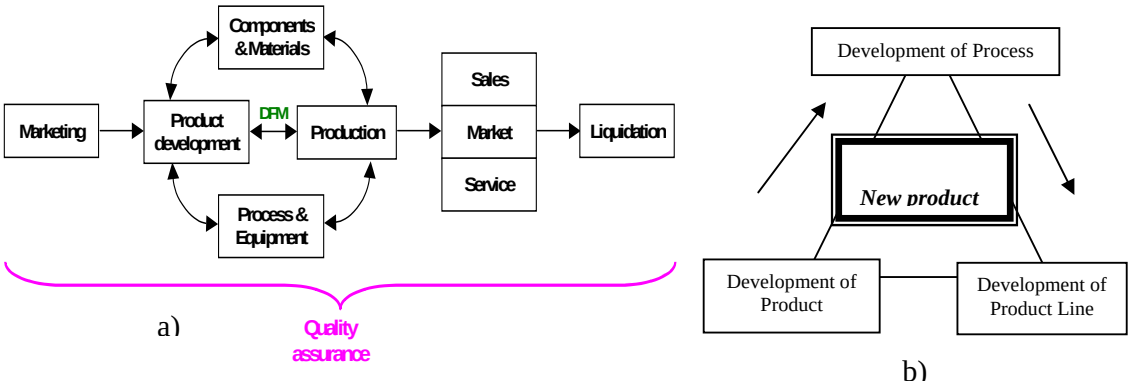

Figure 5: General approach to quality assurance in the sense of the term "Technology Integration" (a) and three stages of a new product introduction (b)

There are two approaches to the Microelectronics Technology and Packaging education. The first is the education one's attention to prepare specialists for this area; the second is general survey with basic area of knowledge for all students of electrical engineering. Both of them have similar structure; only their extent is different, the first is more detailed and has certain continuity. This fact is involved in Fig. 5a because many different knowledge areas are included in modern microelectronics technology.

The three-step study programme have to be focused in every step following intent:

- Bachelor – general knowledge, opening of abilities, motivation for next personality development
- Master (Engineer) – next deepening of knowledge in electrical/electronics engineering, choice of specialization, involving in research activities
- Postgradual (Doctorate) - forming of comprehensive knowledge and full engagement in research activities heading to the leading figure

CONCLUSION

The paper summarizes both theoretical and practical experience in the microelectronics technology education process for the three-step study programme target the postgraduate study. A brief overview of some basic principles in innovated education system of microelectronics technology at Brno University of Technology, with emphasis on the use of postgraduate students for research activities is mentioned. Moreover, there is a fact that a great part of students who have passed this specialization at the Brno University of Technology is going on in the study or scientific activities worldwide.

Microelectronics Technology is today one of the fundamental areas of informatics and communication industry making main part of hardware. There must be an accomplished education system to assure groundwork for marketable products, which means products lower in cost and higher in quality. Research activities starting just during postgraduate study are one of the first steps that give good base to built effective system for joining postgraduate students with practice.

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[7] Czech Republic, The Czech Electronic Sector, Czechinvest, www.czechinvest.org