COURSES IN THE FIELD OF MICROELECTRONICS AT THE FACULTY OF ELECTRICAL ENGINEERING, TECHNICAL UNIVERSITY, BUDAPEST

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Summary

The article presents, after a short historical rewiev the educational and research activities of the Department of Electron Devices and Department of Electronics Technology of the Faculty of Electrical Engineering of Technical University, Budapest. In addition, the Section of Microelectronics and Technology of the Faculty of Electrical Engineering of TUB starting in the academic year of 1983/84 is presented.

Short historical background

Courses on the theory, construction and technology of electronic components were parts of the general educational plan right after the foundation of the Faculty of Electrical Engineering, but at first these courses were held by departments dealing mostly with the questions of electronic equipments. In the first part of the 50's it seemed to be necessary to put more emphasis on these subjects in the education of electrical engineers. Thus the Department of Electron Tubes headed by Prof. I. P. Valkó and the Department of Telecommunication and Instrumentation Technology headed by Prof. R. Kolos were founded. These departments were the initials of the Department of Electron Devices and the Department of Electronics Technology, respectively, at the end of the 60's. The specialists of microelectronics were educated in a separate section of the Faculty, in the Section Electronics Technology. In the first period, when all electronic equipments were based on electron tubes, mechanical and precision-engineering mechanical subjects played an important role in the courses, and it was only from the beginning of the 70's, that these subjects have changed places, step by step, with courses on the active components and circuits of electronics, due to Prof. Ambrózy's work. The increasing importance of discrete semiconductors and hybrid microcircuits shifted the technological education to the direction of chemical-electrochemical technologies. The Department of Electron Devices has been active in the field of transistors and other semiconductors since its foundation, but the electron tube technology and vacuum technics also played an important role in its work at the beginning. The specialists were educated in the Branch of Semiconductor Technics belonging to the Section of Telecommunications, in which branch the Department held courses on integrated circuits technology, measuring methods and measurement technics of integrated circuits, and on construction and design methods of integrated circuits — computer-aided design methods included.

The training of engineers at the two above-mentioned departments has been directed more and more to different fields of microelectronics. The number of graduated students per year:

25—40 at the Section Electronics Technology,

15—18 at the Branch for Semiconductor Technics, Section Telecommunication.

Besides these, both departments have been engaged in courses of the Form "B", Section Engineering Physics, education since its first starting in 1972, when about 12—15 students per two years have graduated.

In addition, both of the departments took part in different forms of postgraduate courses. While being the educational base of the following distance postgraduate courses, staff members of both departments gave parts of postgraduate courses organized by other institutes and departments.

Among the postgraduate courses organized by the two departments the "Semiconductor Technics" courses in 1964 and 1966 played a pioneering role in training the first specialists of the domestic semiconductor industry. The "Electronics Technology" postgraduate course in 1973 also played a very important role in domestic industry. The Department of Electron Devices started, on the initiative and with continuous support of specialists of one of our largest enterprise, the Tungsram works the postgraduate course "Light Emitting Sources" in 1967.

In addition to the above-mentioned correspondence courses, industry's requirements were met by training specialists in engineering physics, technology and computer-aided design during an intensive two-years regular postgraduate course, Form "C", where specialists are trained mainly according to individual curricula under the supervision of the staff, to be able to conduct independent research. Until this time, 15 students in the Department of Electron Devices completed the Form "C" courses. Among these 8 are already holders of the dr. techn. degree, and the taking of another 6 doctor's degrees are in progress. The department has 8 more postgraduate students in its educational courses Form C.

In the Department of Electronics Technology 15 students completed the Form C courses. Among these 7 are already holders of the dr. techn. degree, and the taking of another 8 doctor's degrees are in progress. The Department has 8 more postgraduate students in its educational courses Form C.

Until this time the Department of Electron Devices successfully graduated 750 students and the staff members are holders of one Dr. Sci., five Cand. Sci. and 12 dr. techn. degrees. In addition, four foreign specialists, former special postgraduate students of the department are holders of the Cand. Sci. degree. The Department has at present 4 special postgraduate students, (aspirants) for the Cand. Sci. degree. In addition to this, the Department supervised many university doctoral dissertations mostly deriving from postgraduate courses.

Until this time the Department of Electronics Technology successfully graduated 560 students, and the staff members are holders of one Dr. Sci., four Cand. Sci. and nine dr. techn. degrees. In addition, one foreign specialist, former special postgraduate student is holder of the Cand. Sci. degree. The Department has at present two special postgraduate students (aspirants) for the Cand. Sci. degree. In addition, this Department also supervised many university doctoral dissertations, mostly deriving from postgraduate courses [1].

Scientific research work and industrial relations

The close connection between the scientific activities and the research projects supported by the industry is characteristic of the work of both departments. Main fields of research activities of the Department of Electron Devices are the following (not mentioning the subjects connected to electron tubes):
— measurement technics of semiconductor devices and integrated circuits,
— semiconductor technology,
— theory and physical modelling of semiconductor structures,
— computer-aided design of integrated circuits.

Some details of these activities: the Department developed measuring equipments — in many cases by applying new measuring principles — for the development and mass production of semiconductor devices. These equipments are mostly used in the development laboratories and production lines of the Tungsram Works. Some examples:
— bipolar transistor f_T measuring equipment,
— transistor noise measuring equipment,
— thermal resistance meter,
— measuring equipment for the impurity distribution of $p-n$ junctions (common research and development work with the Department of Electronics Technology).

— automatic varicap diode sorter,
— driving impulse generator for CCD circuits,
— pin electronics for automatic measuring equipments.

The semiconductor laboratory of the Department of Electron Devices has achieved important results in the field of ion and gas sensitive detectors, with respect to both theoretical foundations and putting into practice. Other main fields of interest in this laboratory: special problems of semiconductor technology, e.g. production of low sheet-resistance polysilicon layers or development of thermally sensitive thin films.

Among the results of the Department in the field of theory and physical modelling of semiconductors, the research work on the theory of tunnel diodes, the development of the intervalley scattering model of the Gunn diode and the theoretical and practical development of an entirely passive four-quadrant thermal multiplier gained international reputation. Results exploited in domestic research and industry are parts of the work achieved in the field of modelling of MOS devices and of the activities in the technological modelling and simulation of ion implantation processes.

In addition to the development of the TRANZ-TRAN nonlinear circuit analysis program in the field of computer-aided design of integrated circuits, which program is continuously being used in the domestic industry and is also used in foreign institutes for educational purposes — logic simulation, mask and layout design programs were also developed by the Department of Electron Devices, first of all for educational purposes.

Main fields of research and development in the Department of Electronics Technology are the following:
— physical technologies,
— electrochemical technologies,
— precision-engineering mechanical technologies
— technological equipments.

Research activities belonging to the physical technologies are strongly microelectronics-oriented. Results of greatest importance in this field: production of thin films with a prescribed lateral inhomogeneity, development of the production methods of very hard and thermally resistant thin films, examination of thin films by electric, optical and other methods, fault detection based on the measurement of the excess noise, laser cutting of silicon wafers, application of the electro-erosion and laser trimming methods to hybrid microcircuit resistors, computer-aided layout design of hybrid microcircuit resistors, computer-aided layout design of hybrid microcircuits.

In the field of the electrochemical technologies the main activities were directed to develop technological methods to manufacture printed circuit boards and contacts. Due to the high level reached in the production of fine-lined flexible and multilayer printed circuit boards, the Department has a large capacity of producing large quantities of such printed circuit boards for the electronic production industry and for the research work both in industry and at the Technical University.

In the field of precision-engineering mechanics the precision $x-y$ coordinate table used for 8—10 μm laser and electro-erosion trimming of thin and thick film circuit components is of greatest importance. The precision mechanics of this equipment is of digital (numerical) control.

The thermal printer developed at the Department of Electronics Technology is a result of a complex activity: thermal resistive layers with adequate hardness had to be manufactured a suitable paper-loading mechanism and a microprocessor-based character generator were to be developed.

In the field of technological equipments the main research activities are directed to the microprocessor-based data loggers and control units. Further computer activities belonging to this field are e.g. the development of a computer program calculating the optimal track for the automatic drilling equipment in the production of printed circuit boards.

Actual tasks and future of courses in microelectronics

The field of electronics went through a revolutionary change in the past 1—1.5 decade: the technics based on discrete transistors or perhaps small-scale integrated circuits were changed to microelectronic solutions based on more and more large-scale integrated circuits. Although in recent years both the Section Electronics Technology and the Branch for Semiconductor Technics of the Section Telecommunication at the Faculty of Electrical Engineering followed this evolution in its courses (e.g. with the introduction of the new courses of "Technology and construction of integrated circuits", "Measurement technics of integrated circuits" etc.), it became evident that a fundamental modernization of the educational plans in the Faculty is indispensable. The preparation work has begun in 1980, and, as a result of it, a new section is starting in the Faculty of Electrical Engineering of TUB in the academic year of 1983/84, the Section Microelectronics and Technology. This new section consists of the old Branch for Semiconductor Technics of the Section Telecommunication and of the old Section Electronics Technology, and is responsible of training engineers specialized in the field of microelectronics.

The aim of the new section is to train "... electrical engineers capable of the construction, design work and manufacture of electronic part-units, system components, microelectronic devices and components, and also of doing research work in these fields". Subjects of utmost importance in the courses:

— theory and principles of modern electron devices,
— theory and design of modern electronic circuits,
— design processes of the electronic industry,
— technological processes of the electronic industry,
— application and development of system components and technological equipments.

The new section will consist of two branches:

— Branch for Electron Devices,
— Branch for Component Technology.

Subjects of greatest importance in the courses of the Branch for Electron Devices:

— circuit design methods,
— semiconductor technology,
— measurement technics of semiconductors,
— methods of the application of computers.

Subjects of greatest importance in the courses of the Branch for Component Technology:

— construction and technology of passive elements,
— construction and technology of hybrid microcircuits.
— construction and technology of electromechanical components, outfits and system units,
— measuring technologies of electronic equipments,
— organization and development of electronic equipment production processes,
— development of automatic production equipment and systems.

The subjects of computer programming and digital technics — similar to the other sections of the Faculty — are parts of the educational plan at the beginning of the education in the Section Microelectronics and Technology. In addition, the subjects of materials science, physical and chemical technologies in details are of great importance. The courses of "Electron devices", "Electronic circuits", "Microelectronics" are given in a considerable amount of lessons. Computer-aided methods are presented both in theory and practice. This above-mentioned knowledge is the basis of discussing electronic equipments and digital systems. The subjects of process control, quality control, production automation also play an important role in education.

As concerning branch courses, in the Branch for Electron Devices the stress is laid on the subjects of monolith integrated circuits; technological measurements of integrated circuit production are of most importance. In the Branch for Component Technology, stress is mainly laid to the subjects of bonding and mounting technologies, electronic equipment units, different types of sensors and actuators. Both branches are offering a great number of elective courses in special fields and in main developing tendencies, and, in addition, many lessons of individual laboratory work — supervised by individual staff members in the case of each student — is completing the effectiveness of the education.

All developing trends of electronics presented in the recent years were taken into consideration in determining the educational aims of the new section. Special care was given to the fact that today's electronic engineer very often works in teams requiring three different levels of knowledge:

1. High-level knowledge and independent readiness of application is needed by the specialist of the given special field,

2. Basic knowledge of other fields making the cooperation with other specialists possible are indispensable.

3. General familiarity with all fields of electronics.

Certain displacement of the needed special knowledge also was to be considered as, for example the very critical mechanical and precision-engineering mechanical construction work was a very important, fundamental part in the design of electronic equipments in the electron tube period; in our time this has become a quite different problem. Let me quote the point of view of Prof. Dr. László Kozma, former Dean given in the National Council for Technical Development-supported essay "Examination of the development of professional telecommunication . . .", "Telecommunication equipments of the 3rd and 4th generation are constructed from large-scale integrated circuits. These integrated circuits are mounted to standardized printed circuit boards, and the mounted boards are put tó standardized racks. If the manufacturers of telecommunication equipments are applying these standardized elements, then . . . the production is limited to simple mounting work . . .

If these basic principles were accepted by all research and development institutions then, at the starting of production, many technological difficulties could be surmounted, mounting accessory expenses and production design could be perhaps completely saved, and production times could be essentially reduced".

With the forthcoming era of microelectronics, the knowledge of construction, statics and materials science of mechanical materials has to be replaced by the knowledge of technical-physical characteristics of semiconducting and other special materials of microelectronics.

Many technological methods once playing an important role in ancient electronics are no more tasks of the microelectronics-oriented electronic engineer, but of the highly-trained mechanical engineer. As an example, the high-speed peripheral equipments of computers could be mentioned, e.g. the lineprinter, the proper functioning of which needs solving of intricate kinetical and kinematical problems — do not forget that its mechanical function has to be triggered in the millisecundum range beside extremely large pulses. These problems cannot be solved by a general electrical engineer. It is suitable to limit the training of students in these fields to minimum knowledge needed for the cooperation with the given specialist. This, of course, at the same time, makes the training of special mechanical engineers, precision-engineering mechanical specialists necessary also having minimum knowledge of the field of electronics and microelectronics, to make good cooperation with the microelectronic specialists possible. But some shifts in the field of electronics are also to be considered. The semiconductor designer of the 60's constructed transistors characterized for him by the equipment designer by some fundamental parameters, and they could ensure enough information back to the equipment designer with the data sheets and characteristics of the realized device. The microelectronic designer today constructs more complicated integrated circuits than the large equipment designer of the 60's. This means that in the training of the microelectronic specialists all subjects of devices, circuits and systems have to play an appropriate role, but the designers of electronic systems and equipments, as a matter of fact, are satisfied in our days, by limited knowledge of devices and circuits.

Reference

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