Electrocomponent Science and Technology, 1982, Vol. 9, p. 235–238
0305–3091/82/0904–0235 $6.50/0

COURSES IN MICROELECTRONICS AT THE TECHNICAL UNIVERSITY, BUDAPEST

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(Received April 16 1981; in final form October 20 1981)

After a short introduction to the organization of the University and the Faculty of Electrical Engineering the structure of education is examined. Attention is paid to the obligatory courses as well as electives for the various groups specializing in microelectronics. Research areas listed include computer aided design, technology and tests; all are illustrated by many successful projects.

1. THE UNIVERSITY

The Technical University, Budapest – which will celebrate its bicentennial anniversary in 1982 – is the largest university in Hungary. The total number of regular students is around 8,000. The University is divided into six faculties: architecture, chemical, civil, electrical, mechanical and transport engineering. The largest one – by the way, the largest and sole in Hungary – is the faculty of electrical engineering with roughly 2,000 regular students. Considering the five-year long education and some dropout, mainly during the first semesters, this means about 450 freshmen yearly.

The electrical engineering students are grouped into four branches: those of telecommunications, of power, of measurement and control, and of electronics technology – in descending order of student population. The academic staff is some 300 strong and they are organized into twelve departments (institutes or chairs). These are shown in Figure 1.

2. AIM AND STRUCTURE OF EDUCATION

A continuously increasing part of the engineering activity is research and development which require a thorough knowledge of physics and the use of systems theory which applies mathematical models of increasing complexity. In engineering, furthermore, the search for optimal solutions taking into account all the technical, economic and other aspects also plays a rather important role. The students, therefore, must learn the skill of using scientific methods. As a consequence, the electrical engineering education had to be matched to the new requirements. Development was further influenced by the establishment of technical high-schools in Hungary which modified the functions of technical universities.

In order to improve education, new educational forms were introduced in the early seventies (Fig. 2). Thus, in addition to the traditional but continuously modernized five-year long course, 'Form A', a new course was started in 1972, 'Form B'. The objective

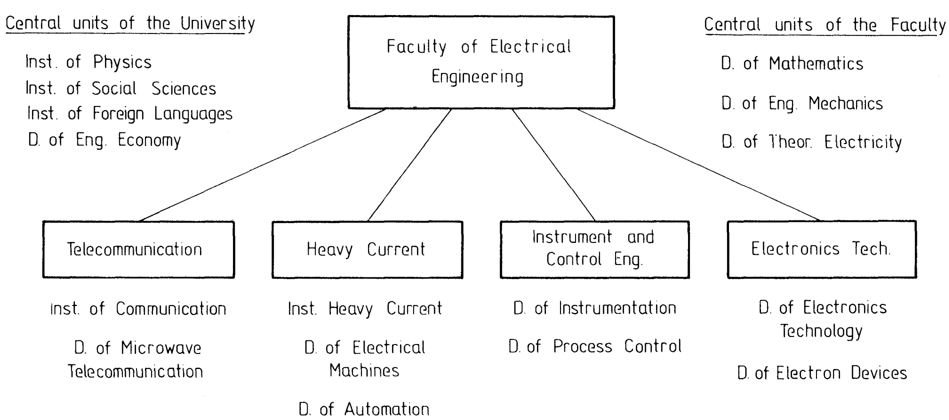

FIGURE 1 Organization of the Faculty of Electrical Engineering.

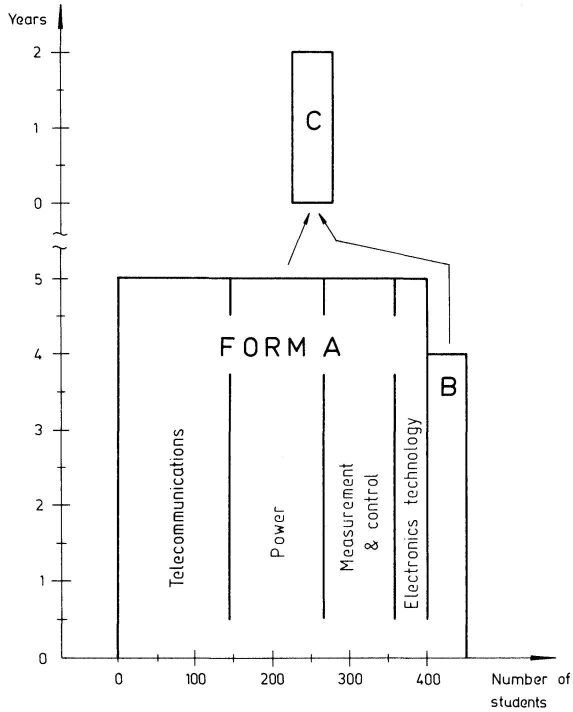

FIGURE 2 General education plan.

was to train electrical engineers who, after four years of studies, on the basis of their high level knowledge in mathematics and physics will be able to carry out design and development activities in the electronic and power industries as well as to solve the problems of production and operation for which a very special knowledge is required.

The pattern of subjects followed in 'Form B' is not the same as in 'Form A'. Instead of telecommunication and electronics technology taken in 'Form A' the corresponding courses in 'Form B' are Communication Systems and Engineering Physics.

Students graduating in Forms A or B may attend an intensive two-year postgraduate course, Form C, where they are trained mainly according to individual curricula under the supervision of the staff, to be able to conduct independent research. This form aims at the training of professionals for research and high level development work.

3. SUBJECTS

All students of the Faculty of Electrical Engineering receive core-teaching in mathematics, physics and theoretical electricity. In addition, all students receive teaching in electron devices; in the case of 'Form A' students this is within the subjects of Telecommunications and also Electronic Technology whereas in the case of 'Form B' students it is within the subject of Engineering Physics. There are three groups specializing in subjects related to microelectronics:

(i) a group consisting about one-seventh of the population studying telecommunication
(ii) a group of one third to one half of the electronics technology students
(iii) the total group of engineering physics.

Some differences can be found among the curricula. The obligatory courses are shown in Table I.
The obligatory courses are supplemented with elective ones: These are shown in Table II.

There are no electives for group (iii) because of the shorter (4 year) course. Students belonging to all the groups however, perform an individual project.

TABLE I
Obligatory courses for the various groups

Group (i)	Vacuum technology Physics and chemistry of semiconductors Design and technology of IC's Testing IC's
Group (ii)	Principles of technology Advanced chemistry Quality control
Group (iii)	Vacuum technology Surface physics and thin films Physical chemistry Dielectrics, magnetics and semiconductors Microelectronics Engineering physics measurements

TABLE II
Elective courses for the various groups

Group (i)	Surface physics and thin films Ion implantation Power electronics Consumer electronics Special integrated devices
Group (ii)	Vacuum technology Surface physics and thin films Semiconductor technology Design and technology of IC's Hybrid microelectronics CAD in electronics technology Optoelectronics

4. RESEARCH AREAS

4.1 *Computer Aided Design*

A program family has been developed by the Department of Electron Devices. It is centered around a circuit analysis program called TRANS-TRAN. This can analyze the DC, transfer, small-signal, transient and sensitivity properties of a nonlinear circuit. Its support is provided by other programs for device specification, logical design, layout design and silicon process technology.

For placing and wiring components on hybrid circuits the Department of Electronics Technology has developed suitable programs. The necessary hardware is relatively small: some programs work with desktop calculators, others with microcomputers.

Both departments are interested in thermal problems; the TRANS-TRAN is extended with mutual thermal-electrical interaction parameters and the design of a novel thin film thermal printer also needed to take the thermal effects into account.

Postgraduate research or theses submitted for higher scientific degrees in this will have included:-

- Simulation of ion implanted doping[1,2,3]
- Equivalent circuits of IC's developed from layout[4]
- Identification of MOS model parameters[5]
- Functional models for digital MOS IC's[6,7]
- Computer modelling for I^2L cells[8-9]
- Placing and wiring components in hybrid microcircuits[10,11]

4.2 *Technology*

Universities are generally not very well equipped with microelectronic facilities. Up-to-date equipment is prohibitively expensive and their throughput rate is much higher than necessary. On the other hand, however, there is a demand for student's knowledge and skill in microelectronics.

The above dilemma can be solved only partly and in stages. University departments can introduce students to the basics only and they need very often the help of industry in order to be taught some of the technology.

At the Technical University, Budapest, a very simple MOS laboratory has been established. The circuits to be made by students consists of a flip-flop and a few gates and it is based on P-MOS technology.

Similarly a hybrid microelectronics laboratory has been constructed. Thin and thick film circuits are manufactured, trimmed and encapsulated. According to our experience the students work in the above laboratories with great enthusiasm.

Academic staff and postgraduate students do some narrow but interesting research in the same laboratories. Studies have included the depositing of very homogeneous thin films or ones with prescribed inhomogeneity, and the examination of thermal and transport processes during trimming or laser cutting of silicon wavers to list but a few. Equipment developed for different processes are also worth mentioning, e.g. microprocessor controlled electro-erosion trimming apparatus and an injection moulding machine with wide range controllable parameters.

Postgraduate reasearch or theses submitted for scientific degrees in the area include:-

- Gas sensors from MOS structure[12]
- Surface phenomena in MOS structures[13,14]
- A new MISS switching device[15-20]
- Novel thermal printer[21,22]
- Laser scribing of silicon wafers[23,24]
- Deposition of thin films with prescribed thickness distributions[25-27]
- Electro-erosive and laser trimming of thin films[28-29]

4.3 *Tests*

It is self evident that the role of tests and measurements in microelectronics cannot be overestimated. This territory is generally well matched to the possibilities of university departments as it needs less complex and expensive equipment than a complete technology production line. Even apparently peripheral research can improve the reliability of microelectronic devices.

Postgraduate research work or theses submitted for higher scientific degrees in this area have included

- Reliability tests of RAM's[30-32]
- Reliability tests of microprocessor CPU's[33]
- Mechanical stresses in hybrid substrates[34]
- Excess noise in thick-film resistors[35,36]
- Photoinjection phenomena in CCD structures[37]

5. CONCLUSION

University level microelectronic courses are given at the only electrical engineering faculty in Hungary, at the Technical University, Budapest. The early development of the courses was promoted by faculty members who quickly recognized the significance of the new technology and called the attention of the leaders of higher education by writing several reports during the early sixties.

Systematic education in microelectronics was gradually intensified during the sixties. The first forms were mainly post-graduate courses; their material progressively infiltrated to normal undergraduate courses.

At present two departments are responsible for education in microelectronic design and technology:

the Department of Electron Devices and the Department of Electronics Technology.

Besides the organized taught courses all the students perform an individual project. The laboratory activity during which the students make some simple hybrid and monolithic circuits is important also.

Those students who do not become specialized in microelectronics have their own courses mainly concerned with the applications of microelectronics.

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