# ANNUAL REPORT

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**Department of Microelectronics**
**Faculty of Electrical Engineering**
**Czech Technical University in Prague**
**Czech Republic**

# CONTENTS:




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Edited by Jan Vobecký (December 2002)

# FOREWORD

The Department of Microelectronics belongs to The Faculty of Electrical Engineering (FEE) that is one of the five faculties forming the Czech Technical University in Prague (CTU in Prague). The roots of CTU in Prague can be followed as far back as the year 1705, when Christian Josef Willenberg (1655 - 1731) wrote a letter to Emperor Leopold I. in Vienna seeking permission to begin public teaching of engineering sciences. This was granted by a decree of Emperor Josef I (successor to Leopold I.) on 18 January 1707. For these reasons, the priority of CTU to be the first technical school at university level in the world is usually claimed for.

The Department of Microelectronics has been established in January 1977. During the past 25 years more than 1000 students graduated in the branch of Microelectronics and 30 Ph.D and 5 DrSc. degrees have been awarded. Five persons from the Department staff became professors and 14 Associate Professors. The Department offers the B.Sc., M.Sc. and Ph.D. degrees in Electronics.

The Department maintains international co-operation with many universities, research laboratories, and institutes in the Europe, namely in connection with the LEONARDO and SOCRATES Programmes, NEXUS, COPERNICUS and EUROPRACTICE projects and in the frame of the NATO Science for Peace programme and the Fifth Framework Programmes of the European Community, namely in the Programme Access to Research Infrastructure Improving the Human Potential.

The Department gives a high priority to collaborative research with industry, e.g. MOTOROLA, ST Microelectronics, Polovodiče a.s., TESLA Sezam a. s., Dynex Semiconductors, etc.

This brochure is the 13th annual review of our Department. The contents of this report emphasise our effort for continuing the close association of teaching, research and co-operation with external subjects at both national and international levels.

Prague
December 2002

Jan Vobecký
Editor

# STAFF OF THE DEPARTMENT

| | |
|---|---|
| Head of the Department: | M. Husák, M.Sc., Ph.D. |
| Deputy: | J. Schrőfel, M. Sc., Ph.D., DrSc. |

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|---|---|
| Professors: | M. Husák, M.Sc., Ph.D.<br>J. Kodeš, M.Sc., Ph.D., DrSc.<br>J. Vobecký, M.Sc., Ph.D., DrSc. |
| Associate Professors: | Z. Burian, M.Sc., Ph.D.<br>J. Foit, M.Sc., Ph.D.<br>P. Hazdra, MSc., Ph.D.<br>J. Schrőfel, M.Sc., Ph.D., DrSc.<br>M. Šemberová, M.Sc., Ph.D.<br>V. Třeštíková, M.Sc., Ph.D.<br>F. Vaníček, M.Sc., Ph.D.<br>J. Voves, M.Sc., Ph.D. |
| Assistant Professors: | J. Jakovenko, M.Sc.<br>L. Jirásek, M.Sc., Ph.D.<br>A. Krejčiřík, M.Sc., Ph.D.<br>Z. Rozehnal, M.Sc., Ph.D.<br>V. Záhlava, M.Sc., Ph.D.<br>L. Čopák, M.Sc.<br>V. Janíček, M.Sc.<br>J. Novák, M.Sc. |
| Ph.D. students: | P. Čapek, M.Sc.<br>R. Jackiv, M.Sc.<br>D. Kolesnikov, M.Sc.<br>V. Komarnickij, M.Sc.<br>P. Kulha<br>A. Mačkal, M.Sc.<br>B. Palán, M.Sc.<br>V. Prazjler, M.Sc.<br>M. Sawalmeh<br>P. Solařík, M.Sc.<br>O. Telezhnikova, M.Sc.<br>T. Váňa, M.Sc.<br>J. Vít, M.Sc. |

# SUPPORT STAFF

Administration

R. Burianová
H. Kubátová

Teaching Laboratories:

L. Kafka

Technical Service: M. Horník

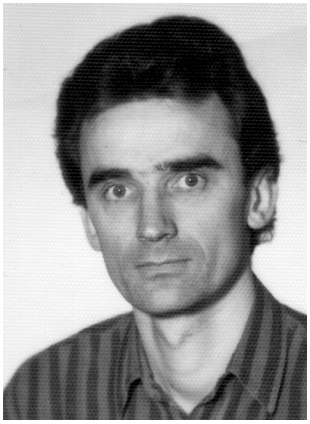
Military Service (duty to compensate):

A. Doubek

# ABOUT THE STAFF

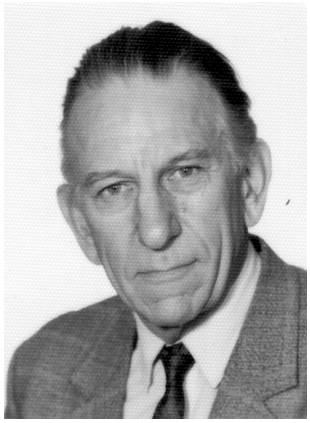
**Miroslav Husák** was born in Kladno in 1953. He graduated in Radioengineering from FEE-CTU in Prague in 1978. Ph.D. in 1985, Assoc. Professor in 1997, Full Professor in 2000. Manager of Microsystems Group. Author or co-author 4 lecture notes and more than 120 scientific and technical papers. Research in the field of microsytems and integrated sensor systems. Teaching the courses Sensor systems, Power Suppliers in Electronics, Electronic Security Systems and Microsystems. Supervisor of Electronics branch (Master and Ph.D. study).

**Jiří Kodeš** was born in 1932. He received MSc., Ph.D., and D.Sc. degrees in electronics, semiconductor physics and microelectronics from the CTU in Prague in 1956, 1963 and 1990, resp. At present, he is Full Professor at the Department. His area of research includes electronic transport in semiconductors and quantum electronics devices. He is the author or co-author of numerous technical papers in journals and conference proceedings. He has written several textbooks for students.



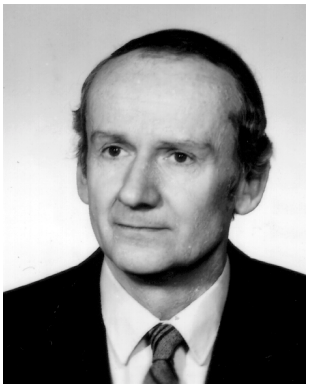
**Jan Vobecký** was born in 1957 in Prague. He graduated in Electrotechnology from the FEE-CTU in 1981. PhD. degree in 1988, Assoc. Professor in 1992, DrSc. degree in 1999, Full Professor in 2000. In 1988, 1989/90, and 1993 visiting fellow in the Univ. of Uppsala, and MOTOROLA Toulouse, resp. Author of plenty scientific and techn. papers, 2 patents, one textbook and 8 printed lectures. Teaching: Electronics, TCAD and Modern Power Devices. Research: Power devices & ICs, Si technology. Senior Member IEEE. Chairmen of the CS Section IEEE.

**Zdeněk Burian** was born in 1944. He graduated from the FEE-CTU in 1966. In 1975 he received PhD. degree. He is the author of 35 technical papers, 10 printed lectures and he owns 7 technical inventions. He is Assoc. Professor and gives lectures on optoelectronics. He is working in the field of integrated optics and planar optical waveguides. He researched the optical waveguides in silica in University of York, U.K.. Member of EOS and Czech Society of Photonics.



**Julius Foit** was born in 1932. He received MSc., PhD. and Ass. Prof. degrees in Radar Engineering, Colour TV Eng. and Multiphase Signal Processing from the CTU in Prague in 1954, 1961 and 1978, resp.. Dean of the Faculty in the University of Maiduguri, Nigeria in 1987-1989 and B. Tech. Programme Coordinator in the University of Zimbabwe, Harare, in 1990-1993. Currently, he is Associate Professor in the Dept. He is the author of many papers, several monographs and textbooks for students. He is a Fellow of ZIE and Past-President of Rotary Int.

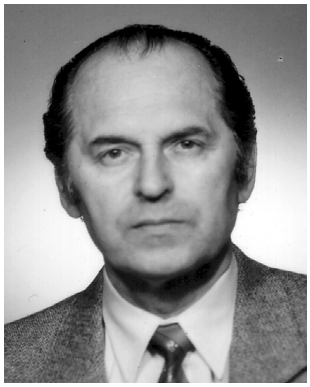
**Pavel Hazdra** was born in 1960. M.Sc. and Ph.D. in Microelectronics from FEE-CTU. In 1987 and 1996 he became Assistant and Assoc. Professor, resp. In 1988, 1992, and 1993 visiting fellow at the University of Surrey, Hull, and Lund, resp. Research on defects in semiconductors and characterization (DLTS, etc.). Manager of the Electron Device Group. More than 100 scientific and technical papers, 2 patents and printed lectures. SM IEEE and chairmen IEEE EDS in the Czech Republic.



**Josef Schrőfel** was born in 1933. He graduated from FEE-CTU in Prague in 1956. PhD. degree from STU Bratislava in 1972, D.Sc. degree from CTU in Prague in 1994, and Assoc. Professorship in 1996. In 1974-1990 he was with Tesla Research Inst., Prague, working in research on electronic components, thin-films, solid state surface phenomena and semiconductors. Since 1975 his field is optoelectronics, optical fibres and integrated optics. He is the author of about 120 papers, 17 patents, 2 monographs and 3 books. Member of IEEE and EOS.

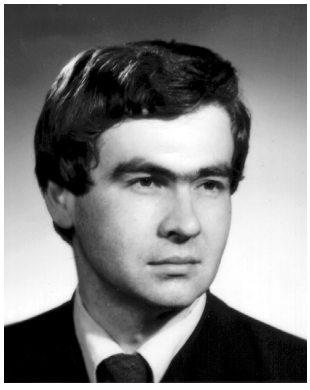
**Miroslava Šemberová** was born in 1939. She graduated in Radioelectronics from the FEE-CTU in Prague, in 1961. She received PhD. degree in 1973 and Associate Professorship in 1985. She is author of 12 technical papers and 10 printed lectures. She gave lectures in the area of electronic and microelectronic components. She was involved in research program concerning MOS integrated circuits and, at present, she is interested in sensors.

**Vladimíra Třeštíková** was born in 1943. She graduated in Automation technique from the FEE CTU in Prague, in 1965. She received PhD. degree in 1980 and became Associate Professor in 1985. She is presently teaching Electronic and Microelectronic Devices. She is the author of 5 printed lectures and 12 technical papers. She was involved in research program concerning MOS integrated circuit technology and, at present, she is interested in sensors.



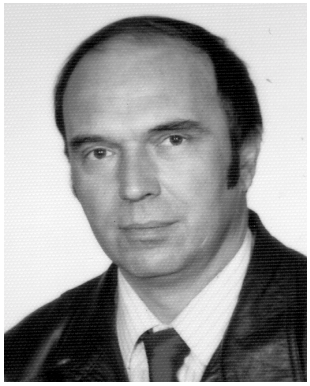
**František Vaníček** was born in 1936. He graduated in Radioelectronics from the FEE-CTU in Prague, in 1960. PhD. in 1972 and Assoc. Professorship in 1978. From 1972 to 1975 he gave lectures in MTC Kahira, Egypt, and from 1981 to 1983 in HIE Beni Walid, Lybia. He is the author of 15 techn. papers and 10 printed lectures. He is teaching in the area of semiconductor structures and their models. The winter term of 1992 and 1993 he spent in KIHWV Ostende in the frame of TEMPUS programme.

**Jan Voves** was born in Prague in 1960. MSc. and RNDr. degree in Physical Electronics and Optics from the Charles' University in Prague in 1984. Since 1984, Research Assistant in the Department (characterisation of ion implanted doping profiles in semiconductors). From 1987 and 1996, Assistant and Assoc. Professor, resp. Ph.D in 1993. Research in the device physical modelling (Monte Carlo Method). Author of about 30 technical papers and 3 printed lectures. Member of the IEEE.

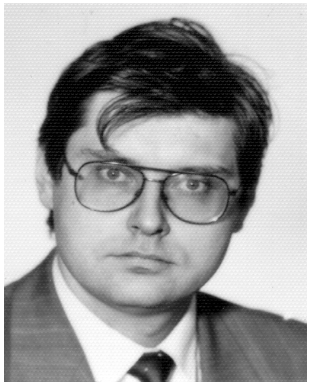


**Lubor Jirásek** was born in Prague in 1953. He graduated from the FEE CTU in Prague, in 1978. He received PhD. degree in Electronics in 1983. From 1978 to 1983 he was working as a Research Fellow in the area of high-power devices. He is author of 7 technical papers and 3 printed lectures. He is teaching in the area of semiconductor devices and solid-state physics. Presently, he is responsible for the curriculum of the Department.

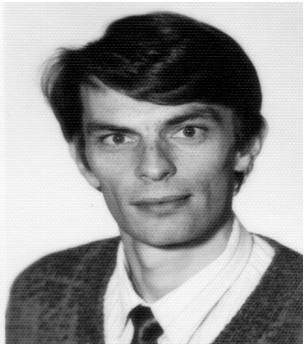
**Jiří Jakovenko** was born in Prague in 1972. He graduated in Microelectronics from FEE-CTU in Prague. He started his PhD. study with Microsystems group where he deals with the MEMS design and modeling. In 1998 he spent four months in Hogeschool Gent in the frame of TEMPUS programme. Since 1999 he is an Assistant Professor at the Department. He is teaching Electronics and IC Design. He is a member of the Academic Senate of the Faculty.



**Alexandr Krejčiřík** was born in 1947. He graduated in Electrotechnology from the Faculty of Electrical Engineering, CTU in Prague, in 1971. He received PhD. degree in Mathematics and Physics – branch Semiconductors. He is the author of 10 technical papers, 21 printed lectures and 6 textbooks. He is teaching courses on Electronics, Power supplies and Computer Peripherals.

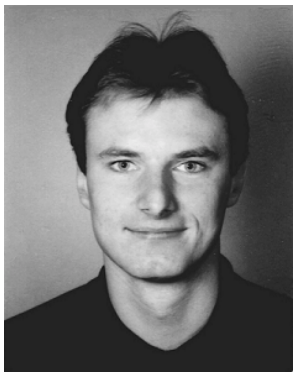


**Zdeněk Rozehnal** was born in Prague in 1963. He graduated in Microelectronics from the Faculty of Electrical Engineering, CTU in Prague, in 1987. At present, he is working as an Assistant Professor. He is teaching electronics, microprocessors, single-chip microcomputers, PLDs and digital technique. He is the author of 20 technical papers, 3 printed lectures and holder of two certificates of technical invention.



**Vít Záhlava** was born in Prague in 1965. He graduated in Microelectronics from the FEE-CTU in 1988. Ph.D. degree in 1994. He is teaching Electronics and PCB design. Active in EMC on PCB, design, application and testing. He is a member of the Academic Senate of the Faculty. He is the author of 3 textbooks, several printed lectures for students, and technical papers on power devices.

**Libor Čopák** was born in Jablonec nad Nisou in 1975. He graduated in Microelectronics from the FEE-CTU in Prague in 2000. He is working toward his PhD. He is a member of the Microsystems group. His activity is concentrated on the temperature fiber optic sensors.



**Vladimír Janíček** was born in 1974 in Most. He graduated in Microelectronics from the FEE-CTU in Prague. He is a member of Microsystems group. He is currently working towards his PhD. His research is in the field of optimization of charge process. At present, he takes care of the Department's computer network.

**Jan Novák** was born in Prague in 1973. In 1998, he graduated in Microelectronics from the FEE-CTU in Prague. He started his PhD. study with the Microsystems group where he deals with Electromagnetic compatibility of integrated circuits and microsystems. Since 2001 he is an Assistant Professor at the Department. He is teaching Electronics, PCB Design and IC Design.

**Pavel Čapek** was born in Prague 13.3.1977. He graduated in Microelectronics from the FEE-CTU in Prague in 2001. He is working towards his Ph.D. in the field of active integrated optical waveguides. He is member of the Optoelectronics group.

**Roman Jackiv** was born in Ukraine in 1980. In 2002, he graduated from Chernivtcy National University, Ukraine, in specialization "Alternative Power Energy". The theme of his magister work was "High Temperature Annealing of CdTe Crystals Doped by Clorine." He is working towards his Ph.D. in Electron Device Group. His work is the characterization of lasers with δ-InAs layers in GaAs.

**Dmytro Kolesnikov** was born in Rjazan, Russia, in 1979. In 2002, he graduated in Physical Electronics from Chernivtsy National University, Ukraine. The theme of his master thesis was "Electrical Properties of the Bulk Monocrystalline $CuInSe_2$". He is currently working as a PhD student in the Electron Device Group. His current research includes physical and technological problems in the field of high-power devices, namely local lifetime control, contact properties and passivation of junction termination.

**Vladimir Komarnitskyy** was born in Ukraine in 1980. In 2002, he graduated Chernivtsy National University, Ukraine, from the specialization physics electronics. The theme of his master work was "Preparation and Properties Structures of Copper-Indium Diselenide". He is currently working as a PhD student in the Electron Device Group. His research is in the field of lifetime control and the defect characterisation of ion irradiated semiconductor devices.

**Pavel Kulha** was born in Písek in 1978. He graduated in Microelectronics from the FEE-CTU in Prague. He is working towards his PhD in the Microsystems group. His work is concentrated on microsensors and microsystems for high temperature applications.

**Adam Mačkal** was born in Kaplice in 1976. He gradated in Microelectronics from the FEE CTU in Prague in 2001. In 1999-2001 visiting student at Bournemouth University. He is working towards his Ph.D. in the Electron Device Group. He is the member of IEEE and LEOS.

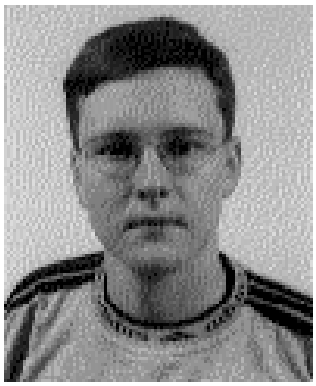
**Bohuslav Palán** was born in Pelhřimov, CZ, in 1973. He graduated in Microelectronics from the CTU in 1997. He joined TIMA Lab., Grenoble, France, (analog IC design of ISFET and pressure sensor interfaces - BARMINT ESPRIT III European project). His current research includes analog ASIC design, microsensors and microsystems for biomedical applications. Student member of Audio Engineering Society.

**Václav Prajzler** was born in Praha in 1976. He graduated in Microelectronics from the FEE-CTU in Prague, in 2001. He is working towards his Ph.D. He is member of the Optoelectronics group. His work is concentrated on the fabrication and diagnostics of optical passive and active planar waveguides.

**Mohammed R.D.Sawalmeh** was born in Nablus, Palestine, in 1972. In 1999, he graduated in Industrial Electronics from West Bohemia University in Czech Republic. The theme of his master thesis was “Control of Step-Motor for Robot Merlin”. He is currently working as a PhD student in the Electron Device Group. His current research is in the field of nanometer semiconductor devices.

**Petr Solařík** was born in 1973 in Kyjov. He graduated in Microelectronics from the FEE -CTU in Prague, in 2000 . At present he is PhD. student at the Department of Microelectronics. He is a member of the Optoelectronics group. He is working in the field of fiber optics sensors for applied spectrophotometry.

**Telezhnikova Olga** was born in 1977 in Kiev, Ukraine. She graduated in Microelectronics and Semiconductor Devices from National Technical University of Ukraine - "Kiev Polytechnic Institute". At present she is working towards her PhD. She is a member of the Optoelectronics group. Her work is concentrated on the fabrication and measurement of glass optical waveguides.

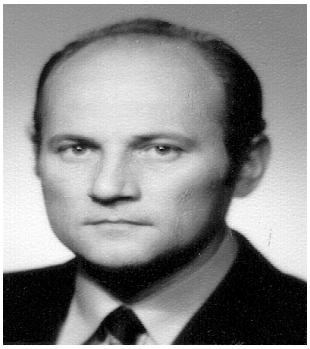


**Tomáš Váňa** was born in 1975 in Pardubice. He graduated in Microelectronics from the FEE-CTU in Prague in 2000. He is currently working as a PhD student in Microsystems group. His research is in the field of optoelectronics sensors and microsystems.

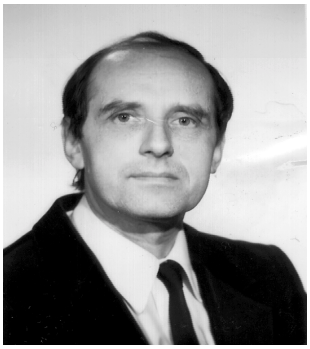
**Josef Vít** was born in 1974 in Třebíč. He graduated in Microelectronics from the FEE-CTU in Prague in 1999. He is currently working as a PhD student in the Electron Device Group. His research is in the field of bipolar power devices, lifetime engineering, and TCAD simulation of electron and ion irradiated power semiconductor devices.

**Renáta Burianová** was born in Prague in 1960. She graduated from grammar school in 1979 and Secondary school for librarians in 1981. She joined the Department of Microelectronics in September, 1981. From that time she has been in charge of administrative work of the Department.

**Hana Kubátová** was born in Český Brod in 1941. She graduated from Secondary Business school in 1958. She joined the Department of Microelectronics in 1977. Since that she has been in charge of organisational and administrative work of the Department, mainly as the Departments secretary.



**Lubomír Kafka** was born in 1943. He attended the grammar school from 1958 to 1961. From 1961 to 1963 he studied the secondary school on "Mechanic of electronic equipments". In 1965 he joined the CTU in Prague as a technician. At present, he is working as a technician in the Department. He is responsible for teaching laboratories. He is engaged in mechanical and electronic service.

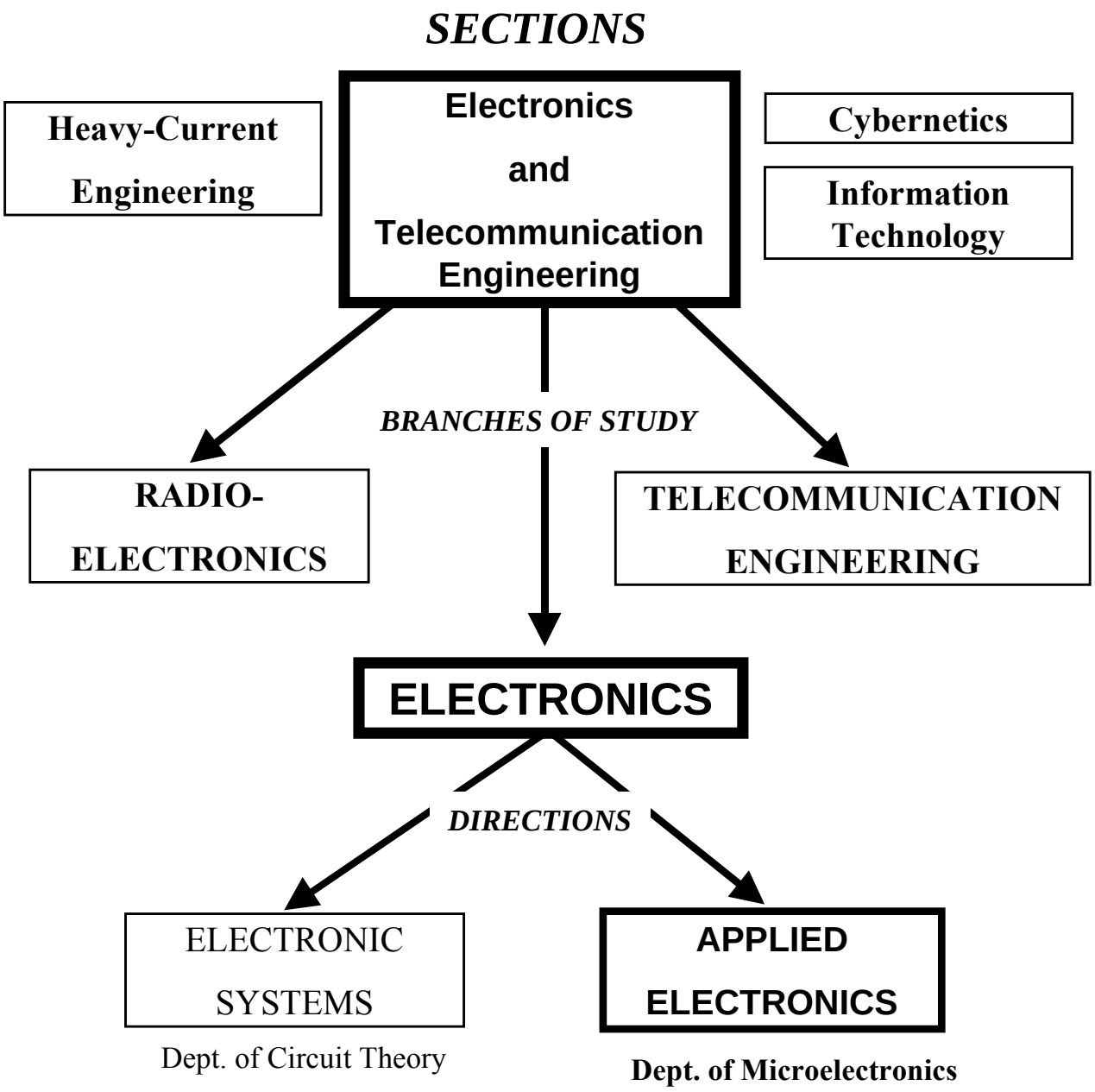


**Miroslav Horník** was born in Prague in 1946. He graduated in 1966 at a Secondary school specialized in Machinery engineering in Prague. He joined CTU Prague, then the Institute of Physics, Czechoslovak Academy of Science and, nowadays, he is working in the Department as a technician. He provides repair and service of miscellaneous tools and equipments.

**Aleš Doubek** was born in 1982 in Prague. In 2001 he graduated from Secondary School of Transport with specialisation on marketing and logistics in civil aviation. At present, he is a member of technical service of the Department in the frame of the civil military service.

# UNDERGRADUATE TEACHING

## Organization of study at the Faculty of Electrical Engineering



# BRANCH OF STUDY ELECTRONICS

The objective of the electronic branch of study is to educate electrical engineers competent to solve problems concerning the wide spectrum of the structure of electrical industry and also extending to the field of information and computing technology, ecology, health care, mechanical engineering, robotics, etc..

The study involves the necessary theoretical introduction into subjects that provide general education for an electrical engineer which is followed by specialized courses. As to specialized orientation, the stress is laid on electronic components, semiconductor structures, digital and analog electronic circuits, microelectronics, application specific integrated circuit design, microcomputers, signals and electronic systems, sensors, design of electronic equipment, integrated and coherent optics, radiation sources and detectors, applications of optoelectronics and telecommunication systems.

The study of the applied electronics and electronic systems aims to prepare engineers who are able to solve problems of the applications of integrated circuits and of the special electronic structures and systems, as well as the electronic instrumentation design. The students master the digital signal processing methods and the implementation of algorithms in the special processor systems.

The optional subjects in the higher terms provide the students an opportunity of individual choice of their further specialisation emphasising the applications of electronics, electronic systems, optoelectronics and physical electronics.

The topics of lectures, laboratory and seminar exercises have been selected so that a student can master the reported stuff perfectly also in practice. The Department of Microelectronics endeavours to give the students, especially those with excellent results, the possibility of satisfying their professional ambition home, as well as abroad. The graduates are also offered a possibility of further postgraduate (Ph.D) studies. We believe that the graduates of our specialisation will find good jobs in industry of developed countries.

At present, a completely new curriculum comprising both the Bachelor and Master degrees is designed and acknowledged to come in effect in the year 2003.

# CURRICULUM OF THE BRANCH ELECTRONICS

## Obligatory and facultative subjects

(first two years of study):

| Course name | Lectures and exercises in hours per week | Term |
|---|---|---|
| **Obligatory subjects:** | | |
| Mathematics I | 3 + 4 | Winter |
| Introduction to Algebra | 2 + 2 | |
| Introd. to Computers Design and Programming I | 3 + 2 | |
| Physical Chemistry | 2 + 1 | |
| Introduction to Electrical Engineering | 1 + 1 | |
| Technical Documentation | 2 + 2 | Win/Sum |
| Economics | 2 + 2 | |
| Mathematics II | 3 + 3 | Summer |
| Mathematical Logic | 2 + 1 | |
| Introd. to Computers Design and Programming II | 2 + 2 | |
| Physics I | 3 + 3 | |
| Circuit Theory I | 3 + 2 | |
| Mathematics III | 3 + 2 | Winter |
| Physics II | 4 + 3 | |
| Circuit Theory II | 3 + 2 | |
| Material Technology for Electronics | 2 + 1 | |
| **Electronics** Microelectronics Dept. | 2 + 2 | |
| Electrical Measurements | 3 + 3 | |
| Mathematics IV | 3 + 3 | Summer |
| Electromagnetic Field Theory I | 3 + 3 | |
| Introduction to Computer Systems | 2 + 2 | |
| **Facultative subjects:** | | |
| Basic Course on Power Electronics | 3 + 2 | Summer |
| Materials and Technology | 3 + 2 | |

# Obligatory and facultative subjects of the branch Electronics

**Bachelor Study** (beginning from the third year of a study (Microelectronics, Optoelectronics, Applied Electronics)

| Course | Lectures and exercises in hours per week | Term |
|---|---|---|
| **Obligatory subjects:** | | |
| **Electron Devices** Microelectronics Dept. | 3 + 3 | Winter |
| Electronic Circuits | 4 + 2 | |
| Mathematics V | 2 + 2 | |
| Electromagnetic Field and Waves | 3 + 3 | |
| **Facultative subjects:** | | |
| **Power Supply for Electronics** Microel. Dept. | 2 + 2 | |
| CAD for High Frequency Techniques | 2 + 2 | |
| Analysis of Electronic Circuits | 2 + 2 | |
| **Obligatory subjects:** | | |
| Basic Course on Digital Techniques | 3 + 3 | Summer |
| Linear Circuits and Systems | 2 + 2 | |
| Signals and Systems | 4 + 2 | |
| **Facultative subjects:** | | |
| **Microcomputers** Microelectronics Dept. Circuit Tech. of Electronic Systems | 2 + 2<br>2 + 2 | |
| Antennas and Wave Propagation | 2 + 2 | |
| **Obligatory subjects:** | | |
| Telecommunication Systems | 3 + 3 | Winter |
| Bachelor Project (only for st. ended as BSc.) | 0 + 6 | |
| **Facultative subjects:** | 2 + 2 | |
| **Microelectronics** Microelectronics Dept. | 2 + 2 | |
| **Optoelectronics** Microelectronics Dept. | 2 + 2 | |
| **Sensor Systems** Microelectronics Dept. | 2 + 2 | |
| Introd. to Digital Signal Processing | 2 + 2 | |
| Electrical Filters | 2 + 2 | |
| Application of Signal Processing for DSP | 2 + 2 | |

# MSc. COURSE
# CURRICULUM OF THE BRANCH ELECTRONICS

Obligatory and facultative subjects (beginning from the fifth year of a study)

| Course name | | Lectures and exercises in hours per week | Term |
|---|---|---|---|
| **Obligatory subjects:** | | | |
| Mathematics VI | | 2 + 2 | Winter |
| Digital signal processing | | 3 + 2 | |
| **Electronics of Semiconductors** | Microelectron. Dept. | 2 + 2 | |
| **Facultative subjects:** | | | |
| **Sensors in Security Systems** | Microelectronics Dept. | 2 + 2 | |
| **Design of Integrated Circuits** | Microelectronics Dept. | 2 + 2 | |
| Architecture and Using of Programmable Circuits I | | 2 + 2 | |
| Electronic Systems | | 2 + 2 | |
| **Obligatory subjects:** | | | |
| **Optoelectronics II** | Microelectronics Dept. | 3 + 2 | Summer |
| Analogue and Digital Systems | | 3 + 2 | |
| Semestral Project | | 0 + 4 | |
| **Facultative subjects:** | | | |
| **Practices on IC Design** | Microelectronics Dept. | 1 + 3 | |
| **Applications of Power Devices** | Microelectronics Dept. | 2 + 2 | |
| Radiation Sources and Detectors | | 2 + 2 | |
| Implementation of DSP | | 2 + 2 | |
| Architecture and Using of Programmable Circuits II | | 2 + 2 | |
| **Obligatory subjects:** | | | |
| **Diploma Project** | Microelectronics Dept. | 0 +14 | Winter |
| **Practices in Laboratories of Electronics** | | 0 + 4 | |
| **Facultative subjects:** | | | |
| Design of Analogue and Digital Mixed Signal Systems | | 1 + 3 | |
| Communications in Data Networks | | 2 + 2 | |
| Satellite Communication and Navigation Systems | | 2 + 2 | |

# FACULTATIVE SUBJECTS

Facultative subjects offered by the Dept. of Microelectronics for the whole Faculty are as follows:

| Course name | Lectures and exercises in hours per week | Term |
|---|---|---|
| **Microelectronics Department only** | | |
| Appliccation of Microelectronic Devices | 2 + 2 | Summer |
| Device Interconnection Techniques | 3 + 1 | S/W |
| PLD - Architecture and Application | 2 + 2 | Summer |
| Computer Interfaces | 2 + 2 | Summer |

Facultative subjects offered by the Department of Microelectronics to Ph.D. Students of the whole Faculty:

| Course name |
|---|
| Advanced Semiconductor Power Devices and Ics |
| Applications of TCAD Tools |
| Crystaloptics and Nonlinear Optics |
| Diagnostics and Testing in Microelectronics |
| IC Design |
| Integrated Optics |
| Microsystems |
| Optical Radiation Detection and Detectors |
| Programmable Logic Devices |
| Prospective Electronic Devices |
| Semiconductor Radiation Sources |
| Technology of Optoelectronic Structures |
| VLSI Structures and Technologies |

# A BRIEF DESCRIPTION OF COURSES GIVEN BY THE DEPARTMENT

## Electronics, (Basic course)

Semiconductors, PN junction, diodes, bipolar transistors, unipolar transistors, power amplifiers, small signal amplifiers, switching circuits. Power amplifier classes. Multilayer switching devices. Op-Amps. Optoelectronics: sources and detectors. Thermistor, posistor, Hall sensors. Power triode, klystron, magnetron, TWT. Applications.

## Electron Devices, BSc

Diodes, unipolar and bipolar transistors, switching, optoelectronic and passive components, vacuum tubes. Physical mechanisms, principles of device operation, properties, characteristics, parameters and models of devices. Basic circuits, recommended applications, switching operation. Noise parameters. Basic structures of integrated circuits. Computer modeling and experimental verification.

## Power Supplies in Electronics, BSc

Rectifiers. Stabilisers - parametric, with continuous control. IC voltage regulators. Fly-back converter. Forward converter. Push-pull converter, double forward converter. Monolithic regulators. EMC. Over current protection. Over voltage, under voltage, output reverse voltage protection. Overload and thermal protection. Batteries, solar battery, accumulator, chargers. References.

## Application of Microelectronic Devices, BSc

Parasitic parameters of Op. Amps. Suppression of DC and AC residual errors in Op. Amps. Power amplifiers, stabilizers, switch mode power supplies. Logic circuit families. Interference: signal, supply, external, switching. Timing errors, data refresh, grounding. Integrated signal coders and decoders, telecommunications devices, AD and DA converters. Requirements, tolerances, application directions.

## Microcomputers, BSc

Motorola 68HC05 and 68HC11 families. I/O tasks, MCS-48, 8243 expander, programmable peripheral ICs. Development and debugging tools. Design and programming of instruments and systems based on single-chip computers. Individual students' projects.

## Computer Interfaces, BSc

Architecture of computers oriented mainly on IBM PC platform (Microprocessors in PC, available chip sets, trends, suppliers). Hardware and software description oriented on different kinds of interfaces. PC interface standards, throughput and data flow. Protocols, basic boards in PC. Floppy Disc, Hard Disc interfaces. Serial interfaces: RS232C, RS422A, RS485. Parallel interfaces: CENTRONICS, IEEE488. Computer networks. Internet, e-mail, conferences, WWW.

## Microelectronics, BSc

Basic functional structures of ICs. Passive and active elements. Technological process. Bipolar and unipolar structures. Logic integrated circuits, VLSI circuit systems. Analogue integrated circuits. Design of vertical structure, layout, design rules. System of IC process quality control. IC functional and parametric testing, test structures, yield and reliability.

## Optoelectronics I, BSc

Basic principles of optoelectronics. Planar and fiber optical waveguides. Semiconductor lasers and LEDs. Semiconductor light detectors. Structures for distribution and harnessing of optical radiation. Optoelectronic processors. Optical communication systems. Optical amplifiers. Display devices. Optical memories. Optical fiber sensors. Integrated optical and photonic structures.

## Sensor Systems, BSc

Sensor - classification, materials, production. General characteristics - static and dynamic parameters, errors, noise, linearisation, calibration. Microelectronic sensors materials, physical principles, design, integration. Temperature sensors, pressure sensors, SAW sensors, optoelectronic sensors, fibre optic sensors.

Radiation sensors. Magnetosensors. Chemical sensors, biosensors. Humidity sensors. Flow meters. Level sensors. Sensor signals processing. Smart sensors. Application of sensors.

## Physics of Semiconductor Devices, MSc

Semiconductor crystal lattices, band structure of semiconductors, statistical distributions, charge transport, scattering mechanisms, non-equilibrium carrier densities, non-homogeneous semiconductor systems, heterostructures, physics of bipolar and unipolar devices, semiconductor sources and detectors of radiation, laser physics, low dimensional structures.

## Design of Integrated Circuits, MSc

Importance of ICs. Economic aspects of IC. Design methodologies: gate arrays, standard cells and functional blocks, full custom design. Design hierarchy: behavioural description, logic and electric design, simulation, layout capture and verification. CAD tools for IC design: HDL, front end tools, simulators, layout editors, structural synthesis, silicon compilers. IC testing.

## Sensors in Security Systems, MSc

Security, safety and multi-channel systems. Dynamic analysis and optimisation. Signal interference and system internal noise. Input quantities. Analog and digital signal processing, conversions. Signal representation and sensor signal code. System calibration. Communication in system, interface. Output unit - communication, indication, registration, protection, switch, local and remote control, actuators.

## Optoelectronics II, MSc

Optocouplers. Sensors (spectral, amplitude, interferometric, polarimetric). Distributed fiber-optics sensors. Fiber-optics communications, components of the optical fiber link, modulation. Modulation, multiplexing and coupling. System performance. Receiver sensitivity. Coherent optical communications. Optical memories. Optical processors. Laser measuring system. Laser Doppler velocimetry. Spectral analyzers.

## Application of Power Devices, MSc

Static and dynamic processes of power structures in forward, blocking and reverse mode of operation. Power diodes, BJTs, thyristors and special thyristor structures, field controlled power devices, HF and HV devices, power ICs, characteristics and features. Packaging and cooling, transient thermal impedance. Principles of application in power circuits, basic trigger and application circuits.

## Radiation Sources and Detectors, MSc

Optical radiation Thermal sources, electroluminescent diode. Lasers active medium, optical resonators, gas, liquid, dye, solid-state and injection lasers, laser modes: mode controlled, frequency agility, spectral width, frequency stability, amplifiers, mode locked. Photomultipliers, photoresistors, photodiodes, nonselective detectors. Optical receivers, PIN and APD coupling, optical preamplifiers.

## Practice of IC Design I, MSc

Main purpose of this course is to enable students to design their own integrated circuit. Students will work in groups (of 5 to 10 students) on the design project using industrial standard CAD tools (CADENCE, SYNOPSYS). Successful circuits could be fabricated via EUROPRACTICE project. The lectures will be concentrated in the first three weeks of the term and will be devoted to IC design methodologies, CAD tools, description of available libraries and design rules.

## Advanced Semiconductor Technologies, MSc

Electrical characteristics of processed materials. Bulk crystal growth. Oxidation. Lithography. Doping. Etching. Chemical vapour deposition. Physical vapour deposition. Ion implantation. Packaging. VLSI Processes. Microsystems. Cleanliness and purity in the process environmental.

## Applications of Modern Devices, MSc

Analog devices, optimisation. Interference of different types of signal transmission, optimisation. Rules for optimisation of large arrays, power distribution, interfacing. Mixed-mode devices. Diagnostics in ADC's and DAC's, minimising residual errors. Standards for interface buses, sensors, actuators, ergonomics. Processing of small and large signals, noise, insulation.

## Design of Power Supplies, MSc.

This represents extension of the subject "Power Supplies in Electronics". The main field comprises Integrated circuits for SMPS (principles, design, verification.) Coils, transformers, regulators, synchronous rectifiers, resonance power supplies.
Switcher CAD. Magnetic design Tool. Filter CAD. MicroPower Switcher CAD.

## TCAD for Electronics I

Principles of Technology CAD. ATHENA technology simulator. Introduction to the ATLAS device simulator. Drift-diffusion approximation. Poisson and continuity equations. SRH model. Models of Auger, optical generation-recombination and surface recombination, impact ionisation and mobility. Heat flow equation. Boundary conditions. Boltzmann transport equation. Mathematical background of simulation techniques.

## Device Interconnection Techniques

Computer design of printed circuit boards (PCB). System OrCAD. Design rules for PCB according to EMC in analog, digital and power applications. Supply and grounding techniques. Technological processes and fabrication of PCB, classes of accuracy. Surface mount technology and devices, circuit layout process and soldering. Technological and design trends. Design of student PCB by use of PC in departments computer room.

## Programmable Logic Devices

Programmable logic devices (PLD): history and perspectives, principles of operation, overview of basic architectures and production technologies. Simple PLD (PAL, GAL, PLA), Complex PLD (EPLD and CPLD), Field Programmable Gate Arrays (FPGA) : internal architecture, device types, properties, design principles and development systems. PLD design: design procedure, hardware description languages (ABEL, VHDL), partitioning, design implementation. Design economy, comparison with other ASIC methodologies. Design of SPLD and CPLD using various development systems (Lattice – Synario, Xilinx – Foundation).

## TCAD for Electronics II, MSc

Technology CAD. Application of ATHENA technology simulator and ATLAS device simulator. Drift-diffusion and hydrodynamic models. Models of recombination, impact ionisation and mobility. Simulation of optoelectronic and power devices. Heat flow equation. Boundary conditions. Boltzmann transport equation. Monte Carlo Method. Simulation of quantum coupled devices. Simulation techniques. Examples.

## Design of CMOS and BiCMOS Circuits, MSc

Trends in CMOS and BiCMOS technologies. Parameters of basic structures. Modeling and simulation. Parasitic structures. Design rules, layout design. CMOS and BiCMOS logic gates. Standard CMOS and BiCMOS ICs families. CMOS and EECMOS memories. PLDs, FPGAs. Analogue CMOS and BiCMOS circuits. Switched-capacitor and switched-current techniques, MOST-C filters. Comparators, operational amplifiers, OTAs.

## Applications of TCAD Tools, PhD

Fundamentals of TCAD. Technology, process, device and mixed device-circuit simulators. ATHENA, principles and application. ATLAS, principles and application. Semiconductor equations. Boundary conditions. Numerical methods. Models of recombination, impact ionisation, mobility. Practical exercises according to individual projects on SUN workstations.

## Crystaloptics and Non-linear Optics, PhD

Optical medium type classification. Single- and double-axis optical anisotropy. Chiral media. Propagation of planar waves, polarisation, phase and group velocity vectors. Energy balance and reciprocity. Reflection and refraction. Electro-optical and piezoelectric tensors. Theory and design of beam handling devices.

## Diagnostics and Testing in Microelectronics, PhD

Physical and electrical methods of measurement of material properties, operational structures and electronic devices. Test structures and test chips.

Functional and parameter testing of integrated circuits.

## Programmable IC Design, PhD

IC reasons of integration, IC design methodologies and approaches. Application Specific Integrated Circuits (ASIC) and programmable devices. Principles, architecture, technologies and internal structure of Programmable Logical Devices (PLD), Complex Programmable Logical Devices (CPLD) and Field Programmable Gate Arrays (FPGA). Automatic design tools. Design using Hardware Description Languages (HDL): Abel, VHDL. Design methodology, optimization and partitioning.

## Integrated Optics, PhD

Theoretical and technological principles of IO. Light propagation in dielectric waveguide structures. Methods of waveguide structures solution. Basic physical effects and interactions used for IO structures. Fabrication of dielectric waveguides and IO structures. Passive and dynamic waveguide devices. Non-linear devices. Semiconductor integrated optoelectronics.

## Optical Radiation Detection and Detectors, PhD

Electromagnetic radiation spectrum. Radiometric and photometric units. Detection of optical radiation. Ideal detector, internal and external photo-effect. Optical receivers, design principles, properties. Noise. Detectors based on external or internal photo-effect, on thermal phenomena and others. Solar cells, properties.

## Advanced Electron Devices, PhD

Energy band engineering, quantum well, wire, point. 2-D electron gas devices (HEMT, MOD FET) and double-barrier resonance tunneling (RDTB, RHET) as memories, generators, multipliers etc. Heterostructures, microwave and cryotronic devices. Recording media.

## Advanced Power Semiconductor Devices and ICs, PhD

Physical and technological principles of advanced power devices. Trends of

evolution. Parameters and applications of advanced devices. Bipolar structures. MOS structures. BiMOS structures. PN diodes. Schottky diodes. BJT transistors. DMOS and IGBT transistors. Thyristors, including GTO and MCT. Secondary breakdown theory and design rules. Smart-power devices. High voltage devices, applications.

## Semiconductor Radiation Sources, PhD

Stimulated emission in semiconductors, Homogeneous junction and heterojunction. Double heterostructure lasers. Waveguide resonators, DFB structures. Types and properties of lasers. Bistable and memory devices, switches. Non-coherent LEDs. Super-LEDs. Laser injection amplifiers. Applications and measurement of various types.

## Technology of Optoelectronic Structures, PhD

Preparation of optoelectronic materials and structures, diagnostic and testing methods. Fabrication of semiconductor waveguides, LEDs, lasers, photodetectors and QW structures. Design and fabrication of planar dielectric waveguide structures for distribution and harnessing of optical radiation. Measuring and testing methods. Properties of various structures, practical examples.

## VLSI Structures and Technologies, PhD

Functional structures of integrated circuits, unipolar and BiMOS structures. 3D structures, submicron technologies. Problems associated with dimensional reduction. Memory cells. Test structures. VLSI processes. New technologies. IC design, layout, design rules. Reliability and yield. Limitations in ICs.

## Electrical Transport in Semiconductors, PhD

Electrons and holes in semiconductor crystals. Boltzmann transport equation, scattering. High field transport. Quantum transport, resonant tunneling. Single electron transport, Coulomb blockade. Ballistic transport. Transport in magnetic field, quantum Hall effect.

# RESEARCH ACTIVITIES

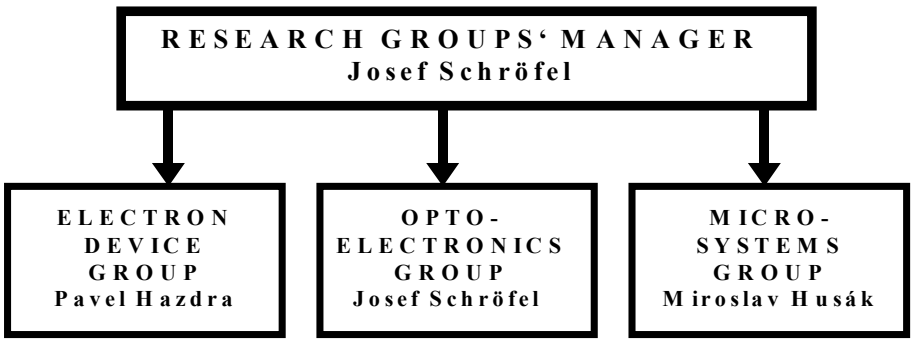
The Department has continued in research activities through grants and contracts from the Ministry of Education of the Czech Republic, Grant Agency of the Czech Republic, and CTU in Prague. A significant part of research activities was supported by the Programmes of the Ministry of Education in the following fields:

- Energy Quality and Savings,
- Environmental Research,
- Information and Communication Technology,
- Laser Systems and their Applications,
- New Measuring Methods of Physical Quantities,
- Reasoning and Control in Production,
- Trans-Disciplinary Biomedical Engineering Research.

The international projects were those of the NATO Science for Peace Programme and the 5$^{th}$ Framework Programme of the European Community, Access to Research Infrastructure Improving the Human Potential.

In the field of research contracts, co-operation with foreign institutes and companies has continued, namely with Motorola.

The research activities of the Department are focused on Electron Devices, Optoelectronics and Microsystems as listed below in the order of their date of origin. These three directions constitute the organisation scheme of research in our Department and are schematically shown below. This scheme is supplemented by a brief summary of activities of individual research groups and list of their members. This is followed by description of relevant research projects of individual research groups. The list of contracts is given as well.



# ELECTRON DEVICE GROUP

Head of the Research Group: P. Hazdra
Members: J. Vobecký, J. Voves, Z. Rozehnal, V. Záhlava, J. Kodeš, R. Jackiv, D. Kolesnikov, V. Komarnickij, A. Mačkal, M. Sawalmeh, J. Vít

**Research Activities:**

- Quantum Devices and Nanostructures
- Device and Process Simulation
- Lifetime and Defect Engineering
- Ion Irradiation
- Power Devices and Integrated Circuits
- Current Injection Capability of Microcontroller Units
- Programmable Logic Devices

# OPTOELECTRONICS GROUP

Head of the research Group: J. Schrőfel
Members: Z. Burian, V. Prajzler, P. Čapek, V. Drahoš, J. Cakl, J. Zvěřina, O. Telezhnikova

**Research Activities:**

- Preparing and Testing of Planar Waveguides Based on Various Deposition and Diffusion Techniques
- Analysing, Preparing and Testing of Novel Planar Electro-Optic Structures for Distribution and Harnessing of Optical Radiation
- Research toward the Integrated Optic Circuits for Measuring and Sensor Applications

# MICROSYSTEMS GROUP

Head of the Research Group: M. Husák
Members: J. Jakovenko, L. Jirásek, F. Vaníček, B. Palán, L. Čopák, V. Janíček, T. Váňa, J. Foit, J. Novák, P. Kulha

**Research Activities:**

- Semiconductor Microsystem Structures
- Sensor Signals Processing and Wireless Transmission
- Sensor Control Systems
- Biomedical, Temperature, Pressure Sensors
- Integrated Circuit Design

# RESEARCH PROJECTS

# ELECTRON DEVICE GROUP

## HIGH-POWER P-I-N DIODE WITH THE NOVEL METHOD OF LOCAL LIFETIME CONTROL

**J. Vobecký, P. Hazdra**

Project support: Research Programme No. JE MSM 212300017

The dynamic parameters of the state-of-the-art high-power devices are usually optimized using electron, proton or helium irradiation. A major drawback of these methods is that the improvement of dynamic parameters is paid by substantially increased leakage current. In this project, it was demonstrated for the first time a high-power P-i-N diode with local lifetime control using the proximity gettering of platinum in the Float Zoned silicon. The region of maximal damage resulting from the low-dose helium implantation was decorated by substitutional platinum that diffused from the PtSi anode contact at low temperature (700$^{o}$C) through the $P^{+}$-P anode doping at the distance of 70μm. The diodes show both very low forward voltage drop and leakage current while keeping the major advantages of the ion irradiated devices like low turn-off losses and soft recovery.

## CONTROLLED GETTERING OF IMPLANTED PLATINUM IN SILICON POWER DIODES BY DEFECTS PRODUCED BY HELIUM CO-IMPLANTATION

**P. Hazdra, J. Vobecký**

Project support: European Community – Access to Research Infrastructure Action of the Improving Human Potential Program project HPRI-1999-00039 ref. 72

The project is primarily focused on finding the optimum conditions for radiation-enhanced platinum (Pt) in-diffusion and subsequent gettering in the depths of several tens of micrometers. In contrast with studies using the PtSi layer as a source of Pt, we used the implantation of Pt at different doses to create a limited and laterally homogeneous diffusion source. Proximity gettering of implanted Pt was studied on the low-doped (phosphorous concentration below $10^{14}$ cm$^{-3}$) <100>-oriented FZ *n*-type silicon substrate forming the *n*-base of the planar $p^{+}nn^{+}$ diodes. Diodes were first implanted with 1 MeV Pt ions using the 5MV Tandem facility in FZ Rossendorf to create a homogeneous and limited source for Pt in-diffusion. The diodes were subsequently co-implanted with 7 MeV helium ions to create a damaged layer in the depth of 40 μm which served

for Pt gettering. The Pt in-diffusion was performed by furnace annealing. Five different diffusion temperatures in the range from 650 to 750°C were selected for each set of samples which also included the reference diode without helium implantation. The results show, that He co-implantation substantially enhances Pt in-diffusion and well resolved gettering at the depth of the maximum damage. At lower temperatures, the evolution of the peak of the substitutional Pt is limited by trapping of the in-diffusing Pt interstitials on defects located at the *p-n* junction and in the anode area. Temperatures above 725°C, on the other hand, lead to fast anneal of the radiation damage and lowering of the Pt gettering efficiency.

## IGBT LIFETIME KILLING PROCESS USING SIMULATION TOOLS

**J. Vobecký, P. Hazdra,** X. Jorda[*], P. Godignon[*], M. Vellvehi[*], J. Rebollo[*],

[*]CNM Barcelona, Spain

Project support: European Community – Access to Research Infrastructure Action of the Improving Human Potential Program, Project No.HPRI-CT-1999-00107 – MicroServ, Ref. 14

The goal of the project was design of the ion irradiation experiments for localised IGBT lifetime reduction using the state of the art simulation tools. The works were performed on a well-known IGBT structure and the comparison between simulation and experimental results provided information about simulation limits, data for calibration of relevant model parameters, and validity of the previously established irradiation design procedure. A specific run of 600V - 25mm$^2$ vertical PT - IGBTs was fabricated at CNM, Barcelona. CTU in Prague performed all the simulation works and design of the irradiation procedure. The processed wafers were sent to accelerator facilities in Forschungszentrum Rossendorf, Germany, to perform the proton irradiation. After irradiation, the wafers were characterised in terms of the electro-thermal behaviour (static I-V curves and dynamic switching tests at different voltage, current and temperature levels) at CNM Barcelona. The devices were packed using TO 247 package to allow for measurements at supply voltage of 300 V. The resulting reduction of the fall time and turn-off times was found excellent.

## 6.6 kV IGBT&FRD LIFETIME KILLING PROCESS

**J. Vobecký, P. Hazdra,** J. Rebollo*, X. Jorda*, P. Godignon*, M. Vellvehi*, L. Coulbeck**

*CNM Barcelona, Spain, ** Dynex, Semiconductor, U. K.

Project support: European Community – Access to Research Infrastructure Action of the Improving Human Potential Program, Project No.HPRI-CT-1999-00107 – MicroServ

The aim of the project is the design of the optimal procedure for the local lifetime control of the IGBT and Fast Recovery Diode (FRD) chipset for high-power modules. A specific run of 6.5 kV vertical PT - IGBTs and FRDs was fabricated at Dynex Semiconductor. CTU in Prague performs all the simulation works and design of the irradiation procedure, namely the proton, helium and combined platinum-helium implantation. The processed wafers will be implanted in accelerator facilities in Forschungszentrum Rossendorf, Germany. The device characterization will be carried out in Dynex Semiconductor in the conditions of real application.

## RADIATION DEFECT DISTRIBUTION IN SILICON IRRADIATED WITH 600 keV ELECTRONS

**P. Hazdra, H. Dorschner***

*Inst. of Polymer Research Dresden, Hohe Straße 6, D-01069 Dresden, Germany

The aim of this project is a detailed characterization of radiation defects and their profiles produced in low-doped n-type FZ silicon by the irradiation with low-energy (> 600 keV). This is necessary to evaluate a possible application aspects of the low-energy electron irradiation in silicon power electronics. Low-doped n-type float zone (FZ) silicon was irradiated with 600 keV electrons to fluences from $2x10^{13}$ to $1x10^{15}$ $cm^{-2}$. Radiation defects, their introduction rates and full-depth profiles were measured by two complementary methods – the capacitance deep level spectroscopy and the high-voltage current transient spectroscopy. Results show that, in the vicinity of the anode junction, the profile of vacancy-related defect centers is strongly influenced by electric field and an excessive generation of vacancies. In the bulk, the slope of the profile can be derived from the distribution of absorbed dose taking into the account the threshold energy necessary for Frenkel pair formation and the dependency of the defect introduction rate on electron energy.

## ACCURATE IDENTIFICATION OF RADIATION DEFECT PROFILES IN SILICON AFTER IRRADIATION WITH PROTONS AND ALPHA PARTICLES IN THE MeV RANGE

**P. Hazdra, V. V. Komarnickij**

Project support: European Community – Access to Research Infrastructure Action of the Improving Human Potential Program Project HPRI-1999-00039, Ref. 72

The aim of this project is to characterize in detail full-depth distributions of defects arising from proton and alpha-particle irradiation in the MeV range. By contrast with our previous studies, the planar diodes with very low leakage are being used to increase sensitivity and accuracy of the measurement. Radiation defect profiles were investigated in the low-doped (phosphorous concentration below $10^{14}$ $cm^{-3}$) <100>-oriented FZ *n*-type silicon substrate forming the *n*-base of the planar $p^+nn^+$ diodes. The diodes were irradiated with 2, 3 and 3.6 MeV protons and 8, 12, and 14.5 MeV alphas at fluences from $1x10^9$ to $1x10^{11}$ $cm^{-2}$ using the 5 MeV Tandem accelerator in FZ Rossendorf. The energies and fluences for both the proton and alpha-particle irradiation were chosen in that way to produce an equivalent damage and to cover a typical range of energies used in practical applications. Resulting radiation defects and their full-depth distributions were characterized by the I-V and C-V profiling. Distributions of divacancies, one of the two dominant secondary defects resulting both from proton and alpha-particle irradiation, were characterized in the wide depth scale far beyond the ion projected range which was 48, 95, and 126 μm, resp. The measured profiles were compared with simulated distributions of elastic energy deposition to investigate the effects connected with primary defect diffusion and pairing. The possibility to look behind the end-of-range allows us to check the influence of ion channeling on the distribution of the resulting damage.

## DIAMOND LIKE CARBON LAYERS FOR JUNCTION TERMINATION OF HIGH-POWER DEVICES

**J. Vobecký**, S. Vacková[*], J. Gurovič[*], A. Macková[**], M. Trchová[***], **D. Kolesnikov**

[*]Dept. of Physics, Faculty of Mechanical Eng., CTU in Prague

[**] Nuclear Physics Inst., Academy of Sciences of Czech Republic, Řež near Prague

[***]Institute of Macromolecular Chemistry, Academy of Sciences of C.R., Prague 6

Project Support: Research Programme no. JE MSM 212300017

The traditional passivation material for beveled junction termination of high-power devices is a rubber. However, this material features unstable behavior

above the voltage of 4 kV. In this project, a possibility to replace the rubber by a thin layer of the Diamond Like Carbon (DLC) is studied. The DLC layers are prepared by the Plasma Assisted CVD method on the beveled edge of high-power $p^+nn^+$ diodes from Polovodiče Prague. The parameters to study in the given experimental arrangement are the layer thickness, $sp^3$ to $sp^2$ concentration ratio, hydrogen content, methan pressure, substrate temperature, leakage current, etc. The quality of the DLC layers is evaluated using physical methods and the measurement of the reverse I-V curves of the $p^+nn^+$ diodes. The reverse I-V are compared with the reference $p^+nn^+$ diodes with rubber passivation.

## CHARACTERIZATION OF LASERS WITH δ-InAs LAYERS IN GaAs

**P. Hazdra , J. Voves** , **A. Mačkal**, J. Oswald[*], E. Hulicius[*], J. Pangrác[*], K. Melichar[*] and T. Šimeček[*]
[*]Institute of Physics, The Academy of Sciences, Prague

Photocurrent, electroluminescence, and photoluminescence spectroscopy were used for the characterisation of laser structures containing ultrathin InAs δ-layers in GaAs matrix surrounded by AlGaAs waveguide and grown by Low Pressure Metal Organic Vapour Phase Epitaxy (LP MOVPE). Three types of δ-layer structures for laser active layers were investigated: single layers with different thickness ($W_L$), different numbers of identical layers (N), and seven 0.5 nm thick δ-layers separated by GaAs spacers of variable thickness ($S_L$). Measurement revealed two fundamental optical transition between electron and heavy and light hole states in the δ-layers. Both transitions are shifted to lower energies by hundreds of meV when $W_L$ and N increases or $S_L$ decreases. While the effect of $W_L$ can be explained by a quantum model accounting for the influence of stress and quantum state coupling, data received from multilayer structures exhibit significant deviation from theory.

## ANALYSIS OF THE BLOCH OSCILLATIONS IN SUPERLATTICES BY THE MONTE CARLO 2D SCATTERING MODEL

**J. Voves**, H. Moravcová

The behavior of Bloch Oscillations (BO) in AlGaAs/GaAs superlattices has been studied by the Monte Carlo method. Two different scattering models (3D and 2D) based on the effective mass approximation were developed for the modeling of the electron miniband transport. Scattering on polar optical and acoustic phonons as well as impurities were taken into account. Behavior of BO was studied under different conditions such as the intensity of electric field, temperature and ionized impurity density. Our results clearly show the level of

inaccuracy obtained when the electron confinement in superlattices is not considered. The possibility of tuning oscillations in superlattices by changing applied electric field was confirmed by this work. This behavior can be practically used in Terahertz frequency generators. The lifetime of experimentally observed oscillation is still rather low due to the influence of scattering. The presented realistic model of electron scattering allows valuable discussion of superlattice parameters suitable for the design of durable Bloch oscillation generator.

### CHARACTERIZATION AND SIMULATION OF MBE GROWN HEMT AND RTD STRUCTURES

**J. Voves**, **P. Hazdra**, V. Stejskal, **R. Jackiv**, M. Cukr[*], Z. Výborný[*],
[*]Inst. of Physics, Academy of Sciences, Czech Republic

Quantum electronic devices based on GaAs/GaAlAs heterostructures suitable for electronic applications and education purposes are designed in the framework of this project. The design is based on the device simulation using standard TCAD tools and specific quantum equations solvers, as well. Devices based on heterostructures grown by molecular beam epitaxy are prepared at the Institute of Physics, Czech Academy of Sciences in Prague. This year, the different types of High Electron Mobility Transistors and Resonant Tunneling Diodes were designed and characterized. Fabricated devices will be used for student education in the subject of Semiconductor Electronics.

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## OPTOELECTRONICS GROUP

### OPTICAL WAWEGUIDE STRUCTURES BASED ON ION - EXCHANGE IN GLASS SUBSTRATES

**J. Schröfel**, J. Špirková -Hradilová [*], J. Čtyroký[**], P. Nekvindová [*], P. Nebolová [*], J. Denk[*], **V. Drahoš**
[*] Dept. of Inorganic Chemistry, ICT
[**] Inst. of Radio Eng. and Electronics, Academy of Sciences, Czech Republic
Project support: Research Programmes no. JW MSM 213200014 and no. JA MSM 210000022

Planar and channel waveguide structures fabricated by ion-exchange in glass could be potentially utilised in large variety of components for distribution and harnessing of optical radiation. The research work deals with study of preparation and properties of single and multimode planar waveguides based on pure thermal or field-assisted exchange of $K^+$-$Na^+$, $Li^+$-$Na^+$ and $Cu^+$-$Na^+$ ions.

The research has continued in fabrication of single mode channel waveguides and verification of their application in distributive and sensor structures.

## OPTICAL WAVEGUIDE STRUCTURES BASED ON APE IN $LiNbO_3$

J. Špirková -Hradilová *, **J. Schröfel**, J. Čtyroký**, P. Nekvindová*, **Z. Burian, P. Čapek,** P. Nebolová*, **V. Drahoš,** J. Zvěřina, J. Cakl
*Dept. of Inorganic Chemistry, ICT
**Inst. of Radio Eng. and Electronics, Academy of Sciences Czech Republic
Project support: Research Programmes no. JW MSM 213200014 and no. JA MSM 210000022

Annealed proton exchange (APE) provides a perspective alternative for fabrication of high quality single mode channel waveguides in lithium niobate. The last experimental works are concerned on explanation of the relations between lithium and hydrogen subsurface distribution and refractive index profile and properties of the waveguides. The research has continued in verification of possible application of prepared waveguides in optical modulators and sensors.

## FABRICATION AND PROPERTIES OF ACTIVE PLANAR WAVEGUIDES IN GLASS AND LITHIUM NIOBATE SUBSTRATES

**J. Schröfel**, J. Spirková -Hradilová *, **Z. Burian**, J. Čtyroký**, M. Slunečko, P. Nekvindová*, P. Nebolová*, **V. Drahoš**, V. Jeřábek, J. Zvěřina a J. Cakl
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Project support: Research Programmes no. JW MSM 213200014 and no. JA MSM 210000022

Active channel waveguides in lithium niobate and glass substrates are perspective candidates for planar optical amplifiers for optical communications. Our research starts with experimental study of doping of lithium niobate and glass substrate with $Er^{3+}$ ions and will continue in fabrication of waveguides in erbium-doped substrates. The very important task of the research is study of relations between properties of the substrates, technological conditions waveguides fabrication and properties of the fabricated waveguides. Last but not least, the necessary measurements methods, for example for absorption or luminescence properties, are to be developed.

## RESEARCH OF OPTICAL WAVEGUIDE GaAs/GaAlAs STRUCTURES

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Project support: Research Programmes no. JW MSM 213200014 and no. JA MSM 210000022

The aim of the project is to fabricate and investigate waveguide structures for wavelength 1.00 - 1.55 micrometers based on various types of semiconductors. Main method of fabrication of the test structures is metalorganic chemical vapour deposition. At present time, the structures based on GaAs/GaAlAs system have been studied. Very important task of the research is to design suitable methods of measurements. The research will continue by verification of possible applications of prepared waveguides in optical sensors

## OPTICAL WAVEGUIDES ON SILICON SUBSTRATE

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** Inst. of Radio Eng. and Electronics, Academy of Sciences, Czech Republic
Project support: Grant Agency of the Czech Republic, No.102/00/0895

The aim of the project is to fabricate and investigate carbon and carbon nitride planar waveguides on silicon substrates. Planar waveguides are created by a carbon or carbon nitride layer which is deposited in PECVD apparatus on layer of silicon oxide providing optical shielding of the substrate and is prepared by the oxidation of silicon wafer. The present works are concentrated on determining of suitable conditions of technological process and on measuring of waveguides properties. We have proved that is in principle possible to dope the deposited layers by erbium ions so that resulting structures can be used as the active waveguides as well.

## DESIGN OF A FIBRE SENSOR WITH LIQUID CORE FOR TRACE CHEMICAL ANALYSIS

**Z. Burian, P. Solařík**
Project support: CTU Research Programme DN MSM 212300016

The project treats the development and design of optofibre sensor with liquid core for trace chemical analysis. The project is directed to design multimode waveguide with liquid core for spectro-photometric measurements. The project is related to the previous work, where the literature was studied and the method

of the sensor design was chosen. The sensor was modelled, simulated and the most suitable technology and materials were searched for.

### DESIGN OF OPTICAL FIBRE SENSORS FOR THE WASTE WATER AND THE ENVIRONMENT MONITORING

**Z. Burian, P. Solařík**

Project support: CTU Research Programme DN MSM 212300016

The project treats the development and design of chemical optical fibre sensors with evanescent wave for waste water and environment monitoring. The goal is to develop and design chemical sensors especially for the purpose of monomode fibre waveguides with evanescent wave. The project is related to the previous work, where the literature was studied and the method of the sensor design was chosen. The sensor was modeled, simulated and the most suitable technology and materials were searched.

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## MICROSYSTEMS GROUP

### ELECTROMAGNETIC COMPATIBILITY IN MICROSYSTEM DESIGN

**J. Foit, J. Novák**

Project support: Grant Agency of the Czech Republic, No. 102/00/0939

In the year 2001, the measurements regarding crosstalks in PC boards were finished. All measurement results were in excellent agreement with the results of the suggested simulation procedures, they were generally more accurate than the results of common simulation methods used up till now. The principal points of the work, i.e. the suggested simulation models, procedures and results of experimental verifications were published. Further work will be done in the future, aiming to EMC solutions in systems of considerably smaller dimensions, first of all inside the encapsulations of miniaturized systems as integrated circuits, microsensors and the like. The theoretical works for simulations of parasitic couplings in such systems, especially regarding the differences from macroscopic cases, are close to finish. The work planned for the next year or so will be devoted to experimental verifications of the theoretical results, provided that the necessary instrumentation can be secured (in part obtained already).

## ELECTRO-THERMAL SIMULATION OF GaAs POWER SENSOR MICROSYSTEM

**J. Jakovenko, M. Husák**

Project support: NATO SfP Project No.: SfP-974172

In this work we report on the thermo-mechanical simulations performed in the aim of optimising the temperature distribution of microwave power sensor microsystem. By means of thermal simulations we propose a GaAs cantilever beam design and layout of the HFET heater and temperature sensor placed on micro machined cantilever beam. Spatial temperature dependences, thermal time constant and power-temperature dependencies at different ambient atmospheres are calculated from the heat distribution. The 3D thermal and thermo-mechanical simulations of the sensor structures are performed using Memcad and CowentorWare from Microcosm Technologies.

## POWER SUPPLY FOR MICROSYSTEMS

**M. Husák, V. Janíček**

Project support: Grant Agency of the Czech Republic, No.102/00/0939

This project solves the problem of power supplies for implanted microsystems without a physical contact to outer world. Today, there are two modules solutions consisting of microsystem with sensor and the external power supply block. Today's common solutions of power supplies are very voluminous and can't be implanted with the microsystem. Therefore, there is an idea to integrate the power supply into a microsystem. There are in principle two attractive approaches, namely the rechargeable batteries and super capacitors. The aim is to propose a self-powered microsystem.

## INTEGRATED INTELLIGENT BIOMICROSYSTEM WITH pH, PRESSURE AND TEMPERATURE SENSOR AND WIRELESS COMMUNICATION SYSTEM

**B. Palán, M. Husák**

Project support: Grant Agency of the Czech Republic, No. 102/00/0939

The basic building blocks of the system are the pH sensors (ISFET type), pressure and temperature sensors, analog interface with the possibility of autocalibrating and set-up function, A/D converter for conversion of the measured data to digital signal, controlling and communication block for measured data transmission and microsystem control. The project solves some partial problems, e.g. integration of microsensors and electronic circuits, A/D

conversion, autocalibrating solution of analogue interfaces, integration of external wireless high frequency communication at frequencies 20-200 MHz.

## INTEGRATED WIRELESS COMMUNIACTION SYSTEM FOR BIOMICROSYSTEM

**M. Husák, J. Jakovenko, V. Janíček, J. Novák**

Project support: Grant Agency of the Czech Republic, No. 102/00/0939

The aim is to design and realize prototypes of a rf receiver/transmitter on Si Chip, in the range 20-200 MHz, definition of the communication protocol, encapsulation and testing of the integrated microsystem. Design, testing, design of one-chip inductor for input circuits of the receiver.

## INTELLIGENT INTEGRATED MICROSENSOR FOR UV RADIATION FOR BIOMICROSYSTEM

**L. Jirásek**

Project support: Grant Agency of the Czech Republic, No. 102/00/0939
CTU Research Programme JD MSM 210000012

Development of UV radiation microsensor suitable for integration into biomicrosystem. It is supposed to develop microsensors for UV radiation of a few types: microsensor for detection in all UVA, UVB and UVC regions, microsensors for UVA region, UVB region and UVC region, physiological microsensor simulating skin sensitivity to dangerous UV radiation, spectral sensitive microsensor for detection of radiation of different wavelengths.

## INTERFACE DESIGN FOR A NEW TYPE OF AN ISFET SENSOR

**B. Palán, M. Husák**

Project support: Grant Agency of the Czech Republic, No.102/00/0939
CTU Research Programme JD MSM 210000012

The design has been done in co-operation with IMEC Leuven in Belgium where the technology of organic polymer based ISFET sensors was developed. With respect to low output currents (in the order of nA with the sensitivity about 30 nA/pH) and low-power low-noise interface, this sensor can be used for continuous monitoring.

## REALISATION AND EXPERIMENTAL VERIFICATION OF PRODUCTION OF CHEMICAL ISFET SENSORS IN 0.6 μm CMOS TECHNOLOGY

**B. Palán, M. Husák**

Project support: Grant Agency of the Czech Republic, No.102/00/0939

Considerable effort has been exerted towards development of a fully integrated single-chip ISFET micro-system for pH measurements. A few N-type and P-type channel structures were fabricated in standard CMOS technology and tested. One of the N-ISFET structures with oxonitride passivation as ion-selective layer exhibits sensitivity about 25mV/pH.

## ON-CHIP REFERENCE ELECTRODE FOR BIO-MEDICAL MEASUREMENTS

**B. Palán, Husák, M.**

Project support: Grant Agency of the Czech Republic, grant No.102/00/0939
CTU Research Programme JD MSM 210000012

The objective is to find a simple, easy to make reference electrode for bio-medical measurements. Production of a tiny reference electrode for an ISFET sensor which is a basic part of a micro-system for ”in vivo” measurements, is still a problem. The functionality of the reference electrode determines the precession of the ISFET. One of the applications is measurement of blood gases during hyperventilation in patients with respiration diseases.

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European Community – Access to Research Infrastructure Action of the Improving Human Potential Program, Project No. HPRI-1999-00039, Ref. 72
Project Manager: **P. Hazdra**

Integrated Intelligent Microsensors and Microsystems
Project of the Grant Agency of the Czech Republic
Grant no. 102/00/0939
Project Manager: **M. Husák**

Microwave Monolithic Integrated Transmitted Power Sensors and Their Industrial and Metrology Applications.
Grant EU NATO Science for Peace Programme, no. SfP-974172
Project Manager: T. Lalinský (Slovak Academy of Science, Institute of Electrical Engineering, Bratislava, Dept. of Microelectronics: **M. Husák)**

Trans-Disciplinary Biomedical Engineering Research.
Research Programme no. JD MSM 210000012
Project Manager: Konvičková (Faculty of Mechanical Engineering, CTU)
(Dept. of Microelectronics: **M. Husák**)

Research of New Methods for Physical Quantities Measurement and Their Application in Instrumentation.
Research Programme no. JB MSM 210000015
Project Manager: V. Haasz (Faculty of Electrical Engineering CTU in Prague)
(Dept. of Microelectronics: **M. Husák**)

Formation and Monitoring of Environment
Research Programme no. DN MSM 212300016
Project Manager: R. Bálek (Faculty of Electrical Engineering CTU in Prague)
(Dept. of Microelectronics: **M. Husák**)

Reasoning and Control in Production
Research Programme no. JD MSM 212300013
Project Manager: V. Mařík (Faculty of Electrical Engineering CTU in Prague)
(Dept. of Microelectronics: **Z. Rozehnal**)

Microsystem Design for RF Power Measurement
Grant Agency of the CTU in Prague, Project No. 0210113
Project Manager: **J. Jakovenko**

Parasitic Electromagnetic Coupling in Integrated Circuits
Grant Agency of the CTU in Prague, Project No. 0210213
Project Manager: **J. Novák**

Information Technologies, Research Project of the Ministry of Education
Research Programme no. JW MSM 213200014
Project manager: J. Vejražka (Dept. of Radioelectronics, FEE-CTU)
(Dept. of Microelectronics: **J. Schrőfel**)

Laser Systems and Their Applications
Research Programme no. JA MSM 210000022
Project manager: J. Vrbová (Faculty of Nuclear Science, CTU in Prague)
(Dept. of Microelectronics: **J. Schrőfel**)

New Technologies for Passive and Active Planar Structures Based on Carbon and Carbon Nitride for Integrated Optics,
Grant Agency of Czech Republic, Project no.102/00/0895
Project Manager: I. Huttel ( Institute of Chemical Technology, Prague)
(Dept. of Microelectronic : **J. Schrőfel**)

IGBT Lifetime Killing Process Design Using Simualtion Tools
European Community – Access to Research Infrastructure Action of the Improving Human Potential, Project No.HPRI-CT-1999-00107, Ref. 14, MicroServ, (2001 - 3)
Project Manager: X. Jorda, (CNM Barcelona, Spain)
Project Manager: **J. Vobecký (**Dept. of Microelectronics)

6.6 kV IGBT&FRD Lifetime Killing Process
European Community – Access to Research Infrastructure Action of the Improving Human Potential, Project No.HPRI-CT-1999-00107, MicroServ (2002 - 3)
Project Manager: J. Rebollo, (CNM Barcelona, Spain)
Project Manager: **J. Vobecký (**Dept. of Microelectronics)

Energy Quality and Energy Savings
Research Programme no. JE MSM 212300017
Project Manager: J. Tůma (Dept. of Electronergetics, FEE-CTU)
(Dept. of Microelectronics: **J. Vobecký**)

Current Injection Capability Investigation of Microcontroller Units
MOTOROLA, Munich, East Kilbride
Project Manager: **J. Vobecký**

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  The Ministry of Education, Project of the University Development Fund
  No. FRV 2198/2002
  Project Manager: **P. Hazdra**

- Higher Education
  SOCRATES Programme 1999/2000, 2000/2001, 2001/2002.
  (Dept. of Microelectronics: **M. Husák**)

- Foreign Training in the Area of Electronic System Design
  LEONARDO DA VINCI Programme 2001- 2003
  (Dept. of Microelectronics: **M. Husák**)

- Support of Interdisciplinary Project Education of Sensors and Microsystems
  The Ministry of Education, Project of the University Development Fund
  No. FRV2195/2002
  Project Manager: **M. Husák**

- Innovation of Seminars and Lectures of the Teaching Subject Device Interconnection Techniques
  The Ministry of Education, Project of the University Development Fund
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