

# EDUCATIONAL PROGRAMS IN HIGH-TECH

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**Abstract** – During the last years Tomsk Polytechnic University (TPU) has successfully followed world trends in the evolution of education. One of the prospective strategies is innovative international educational programs development and implementation. Now the stress is laid upon innovative activity in Masters Degree Programs in Hi-Tech. The basis these programs is integration of the scientific and educational potential of TPU and academic research institutes in Tomsk; international cooperation with the foreign universities; innovative technology of studies. In the 2003/04 academic year TPU calls students' attention to six M.Sc. Programs: in Material Science (Computer Design of New Materials, MegaElectronics), in Electrical Engineering (Discharge and Plasma Technology, Methods and Instruments for Non-Destructive Quality Testing), in Applied Physics (Physics of Condensed Matter, Generation and Application of Electromagnetic Radiation). The aim of this paper is to present the TPU practical experiences in development of innovative educational programs, and to encourage foreign partners to take part in the implementation and development of new educational programs.

**Index Terms** – Masters degree program, e-learning studies, international cooperation, innovative technology of studies.

Tomsk Polytechnic University, the first higher educational institution (HEI) in Siberia, established on the initiative of the enlightened minds of the Russian intelligentsia, marked the beginning of the engineering education in the Asian part of Russia and trained more than 100 000 engineers for the years of its existence. [1] Today TPU includes eight institutes: The Institute of Language Communication, The Institute of Geology and Oil & Gas Industries, The Institute of Distance Learning, The Cybernetic Center, The Professional Development Institute, The Institute of Electrical Engineering, The Institute of International Education and The Institute of Engineering Education; eight faculties: Applied Physics & Engineering, Electrophysics & Electronic Equipment, Mechanical Engineering, Chemistry & Chemical Engineering, Thermal Power Engineering, Economics & Management, Humanities and Natural Science & Mathematics; three research institutes: Nuclear Physics, High Voltage and Introscopy. More than 20000 students take their studies in the university.

Tomsk Polytechnic University is the leading HEI, focused on the mobilization of intellectual elite, training of highly qualified specialists with the broad scientific views. Its' graduates work in the leading Russian and foreign scientific centers. The university actively pursues a policy of integration in world educational space; international contacts of the university are intensively developed, including contacts with educational and scientific

establishments in the USA, Great Britain, Germany, France, Japan, Cyprus, Southern Korea, China, India, Vietnam and others. [2]

One of the prospective trends is development and realization of international educational programs. In 1998 the strategy of educational services export to ex-USSR countries and foreign countries was developed at TPU.

The first experience was gained by realization of international Bachelor Degree Programs. At present more than 60 international students take their Bachelor Degree studies at TPU (Electrical Engineering, Material Science, Chemistry, Computer Science, Environmental Protection and others). The Global Alliance for Transnational Education (GATE, USA) awarded certification to TPU Bachelor Degree Programs. Today the programs are in the process of accreditation and validation by Open University Validation Services (OUVS, UK) and the Accreditation Board for Engineering and Technology (ABET, USA). [3]

The next step was the development of international Masters Degree Programs. The year 2000 saw the initial preparation of Masters Degree Programs in High-Tech. Multi-stage system of education and Masters Degree Programs have existed in Russia since 1994. At present Tomsk Polytechnic University has 65 Masters Degree Programs in 16 fields of study. Special requirements are established for Masters Degree Programs for the international market. In accordance with the results of the university contest, the development of the six pilot Masters Degree Programs in High-Tech were started in cooperation with the leading scientific and research institutes of Tomsk (Nuclear Physics, High Voltage, Non-Destructive Testing, Institute of Strength Physics and Materials Science of Russian Academy of Science and others). It represents a uniquely innovative project. The Masters Degree Programs are synthesized on the basis of the Russian educational standards and the educational programs of the leading foreign universities. As a result, foreign students recognize the programs, which retain the best traditions of Russian high school, scientific and the methodical experience of Tomsk Polytechnic University.

These Masters Degree Programs in High-Tech represent three fields of knowledge:

## **Material Science**

Specialization: Computer Design of New Materials  
Specialization: MegaElectronics

## **Electrical Engineering**

Specialization: Discharge and Plasma Technology  
Specialization: Methods and Instruments for Non-Destructive Quality Testing

## **Applied Physics**

Specialization: Physics of Condensed Matter  
Specialization: Generation and Application of Electromagnetic Radiation

## Masters Program – Computer Aided Design of Advanced Materials and Technologies (M.Sc. in Materials Science)

The Masters program is developed and administered by Mechanical Engineering Faculty, TPU. Institute of Strength Physics and Materials Science (ISPMS) of The Russian Academy of Science highly qualified professors, modern laboratory equipment of ISPMS (automated laser measuring system, optical microscopes, atom and scanning tunneling microscopes, X-ray installations and a unique optic-television installation for the testing of plasticity and strength of materials of the new generation) are engaged in the studies process. The scientific basis of the program includes the following topics:

Metals science and Mesomechanics of materials after surface hardening;

Materials Science and Technology of new constructional and tool materials;

Metals science, Computer aided design and the technology of surface treatment.

## Masters Program – MegaElectronics (M.Sc. in Materials Science)

“MegaElectronics” is widely used in the modern industry with products whose value is in the trillions of dollars.

“MegaElectronics” studies:

Fundamental principles and technology of the particles fluxes generation and forming;

Principles and mechanisms of the sources of fluxes operating;

Principles and laws of the interaction between particles and plasma fluxes and substance;

The basic processes and phenomena, initiated by particles and plasma fluxes;

Modern technological equipment for beam and plasma treatment of materials.

The Program is run by the Faculty of Natural Sciences and Mathematics in cooperation with the TPU Research Institute of Nuclear Physics in company with our highly professional foreign partners – the University of Rostok, Germany and Ecole Polytechnique, Palaiseau, France.

TABLE 1  
M.S.C. IN MATERIALS SCIENCE

M. Sc. in Material Science		
MegaElectronics	Computer Design of New Materials	
<b>1<sup>st</sup> semester</b>	<b>Core Courses</b>	
	• Modern Issues of Science (in Material Science)	
	• Computer-aided Technology in Science	
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; text-align: center;">• Theory and Properties of Crystals and Disordered Materials</td> <td style="width: 50%; text-align: center;">• Diagnostics of Loaded Materials and Constructions</td> </tr> </table>	• Theory and Properties of Crystals and Disordered Materials
• Theory and Properties of Crystals and Disordered Materials	• Diagnostics of Loaded Materials and Constructions	

	<b>Electives</b>	
	<ul style="list-style-type: none"> <li>• Effectiveness of High Technology</li> <li>• Project Management</li> </ul>	
<b>2<sup>nd</sup> semester</b>	<b>Specialization Courses</b>	
	<ul style="list-style-type: none"> <li>• Interaction of Charged Particles and Radiation with Matter</li> <li>• Physics of Atoms, Ions, Molecules, and Chemical Bonds.</li> <li>Plasmochemistry</li> <li>• MegaElectronics of Dielectrics, Semiconductors and Metals</li> </ul>	<ul style="list-style-type: none"> <li>• Mesomechanics and Computer Simulation of Materials</li> <li>• Modern Technology of Coating and Surface Hardening</li> <li>• Thin Films and Multilayer Materials for Electronics</li> </ul>
	<ul style="list-style-type: none"> <li>• Defects in Solids</li> <li>• Generation and Application of Synchronized Pulse Electron and Ion Beams</li> <li>• High-Energy Pulse Electron and Ion Treatment of Materials</li> </ul>	<ul style="list-style-type: none"> <li>• Metal and Ceramic Based Nanostructural Materials</li> <li>• Simulation of Ceramic Materials Based on Silicate and Oxide Systems</li> </ul>
<b>3<sup>rd</sup> semester</b>		
<b>4<sup>th</sup> semester</b>	Master's Thesis	

## Masters Program – Discharge and Plasma Technology (M.Sc. in Electrical Engineering)

At present “Discharge and Plasma Technology” includes:

- Destruction of materials and products;
- Rock crushing;
- Fragmentation of products and wastes;
- Recovering and cleaning of heat exchangers;
- Generation of ozone and ultraviolet radiation, air, water and sewage refinement;
- Materials and products hardening;
- Products and materials functional coating;
- Modification of substance surface and properties.

The Masters Program is run by the TPU Institute of Electrical Engineering, The TPU High-Voltage Research Institute and the Institute of High-Current Electronics of the Russian Academy of Sciences.

## Masters Program – Methods and Instruments for Non-Destructive Quality Testing (M.Sc. in Electrical Engineering)

The scientific basis of the Masters Program is exemplified by the advanced achievements of TPU Research Institute of Introscopy. The Department of Physical Methods and Instruments for Non-Destructive Quality Testing and the TPU Research Institute of Introscopy comprise a unique scientific and technical complex, which undertakes research in the field of Methods and Instruments for non-destructive quality testing and diagnostics of products, materials and constructions. The devices and methods,

developed here, enable to test a wide range of products from miniscule objects of radioelectronics to large-sized constructions. The program is run in cooperation with the University of Saarbrucken.

TABLE 2  
M.SC. IN ELECTRICAL ENGINEERING

M. Sc. in Electrical Engineering	
Discharge and Plasma Technology	Methods and Instruments for Non - Destructive Quality Testing
<b>Core Courses</b>	
• Modern Issues of Science (in Electrical Engineering)	
• Computer-aided Technology in Science	
• Computational Mathematics	• Electronic Devices and Systems
<b>Electives</b>	
• Effectiveness of High Technology	
• Project Management	
• Optical Electronics	
• Microprocessors	
• Power Electronics	
<b>Specialization Courses</b>	
• Generation and Measurement of High Voltage and High Current Signals	• Radioactive Diagnostics
• Theory and Properties of Crystals and Disordered Materials	• Acoustic Diagnostics
• Physics of Low-Temperature Plasma and Technology for Material Treatment	• Measuring Instruments
• Electrical Discharge Technology for Material Treatment and Fragmentation	• Electromagnetic Diagnostics
• High-Energy Pulse Electron and Ion Treatment of Materials	• Infra-Red Testing
• Beam-Radiation Technology of Materials' Modification	• Statistical Analysis and Quality Management
	• Methods of Direct Diagnostics
<b>Master's Thesis</b>	

### Masters Program – Physics of condensed Matter (M.Sc. in Applied Physics)

This Masters Program is aimed at training specialists in the field of research of surface, nearsurface layers of solids and thin films; development of new technologies for creating materials with particular electrophysical properties; nuclear physics; the interaction of radiation with substance. The Masters Program is run by the Faculty of Natural Sciences and Mathematics in cooperation with the TPU Research Institute of Nuclear Physics, Universitat des Saarlandes and the Fraunhofer Institut Zerstorungsfreie Prueferfanner (Saarbrucken, Germany).

### Masters Program – Generation and Application of Electromagnetic Radiation (M.Sc. in Applied Physics)

Training of Masters in the field of generation of electromagnetic radiation beams is carried out by the Faculty of applied Physics and Engineering, TPU. The department studies new techniques of generating electromagnetic radiation in cooperation with the scientists of Hiroshima University in Japan. The educational process uses modern laboratory equipment of the departments of the TPU Research Institute for Nuclear Physics, the Institute of High-Current Electronics of the Russian Academy of Sciences and the Department of Applied Physics at TPU.

TABLE 3  
M.SC. IN APPLIED PHYSICS

M. Sc. in Applied Physics	
Physics of Condensed Matter	Generation and Application of Electromagnetic Radiation
<b>Core Courses</b>	
• Modern Issues of Science (in Applied Physics)	
• Computer-aided Technology in Science	
• Forecasting of the Fatigue Properties of Materials	• Macroscopic Electrodynamics
<b>Electives</b>	
• Effectiveness of High Technology	
• Project Management	
• Non-Linear Physics	
• Quantum Mechanics	
• Fractal theory	
<b>Specialization Courses</b>	
• Special Physical Practicum	• Special Physical Practicum
• Isotope, Chemical and Structural Analysis of the Surface	• Interaction of Charged Particles and Radiation with Matter
• Experimental Methods for Studying of Solids	• Physics of High-Energy Accelerators
• Theory and Properties of Crystals and Disordered Materials	• Modern Sources of X-ray and Gamma Radiation
	• Application of Accelerators in Industry and Research
• Hydrogen in Metals and Alloys	• Radiation Effects in Condensed Matter
• Computer Simulation in Physics	• Generation of Radiation with Relativistic Electron Beams
• Scanning microscopy	• Monte-Carlo Method in Theory of Radiation Transport
	• Simulation of Radiation Transport by Using "GEANT" Code
<b>Master's Thesis</b>	

The technology Masters Programs realization is interesting enough. The normative period of studies for Masters

Degree is two years in accordance with the State educational standard. The educational program includes core courses, specialization courses, electives, scientific and research students' work and the preparation of a master's thesis.

TABLE 4  
PROGRAM OF STUDIES

Courses	Credits
Core Courses	12
Specialization Courses	16
Electives	4
Research	4
Master's Thesis	6
Total Required for Graduation	42

The technology of studies assumes an element of distance learning (1st year) and laboratory practicum with preparation of a master's thesis based at TPU (2nd year). Distance learning assumes direct contact between student and professor at adjusting lectures and examinations (10% of the total time for distance learning) and independent work on the part of the student with teaching materials (textbook, tasks, testing materials), which are available in an Internet teaching environment. In the process of Internet teaching the student – professor dialogue is carried out by e-mail and by means of specialized chat-seminars. The first semester (17 weeks) is devoted to distance learning of core courses and electives. During the second semester (21 weeks) study process is structured as follows: 14 weeks of distance learning of theory of specialization courses of Masters Program and 8 weeks of studies in Tomsk laboratory and practical studies. The third and the fourth semester (2nd year) assumes studying of specialization courses, work on unique laboratory equipment in Tomsk, and as a result the defense of the master's thesis. Depending on his or her participation in research the student can be coauthor and coowner of any resulting project.

The unique aspect of any given Masters Degree Program is the fact that a part of the program (core courses, theory of specialization courses) is carried out on the branches of the university. This technology allows international students a portion of their period of study to live in their home country, to contact with the professors through Internet and listen to our professors' lectures in TPU branches. The TPU branch on the basis of Czech Technical University in Prague can serve as an example.

Thus, the TPU Masters Degree Programs have the following specific features:

The use of the newest scientific and technical developments, as well as the results of fundamental scientific researches, recognized in the world market;

The close integration of the TPU educational potentiality and scientific potentiality of Tomsk Research Institutes;

Joint realization of educational programs with the foreign universities-partners;

The innovative mechanisms of its' realization.

The Masters Degree Programs at TPU are original, fundamental and of universal application. They are characterized by the width of subject fields combined with the balance of theoretical and practical skills. The experience of pilot realization of the given programs in Tomsk Polytechnic University for Russian students in 2002/03 academic year demonstrated an interest from both students and the enterprises, which may employ them. It gives us hope that the given programs during the academic year 2003/04 will find consumer interest among international students. We hope as well that it will attract the attention of foreign universities with the aim of future cooperation in realization of TPU Masters Degree Program.

## References

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