Physics Status in the Nanotechnology Education Project at the VŠB-Technical University of Ostrava

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ABSTRACT: *The emerging fields of nanoscience and nanotechnology are leading to a technological revolution in the near future. All sectors of the economy will be profoundly influenced and altered by nanotechnology. There is clearly a growing demand for scientists and engineers to train in an interdisciplinary approach and cope with research and production based on nanotechnology. Number of institutions supposes creating new university centers and courses in nanotechnology.*

Universities reform their courses and create new ones to prepare students for the arising opportunities in nanotechnology. The traditional separation of academic disciplines has to be exceeded. Nanotechnology education should be integrated into mainstream undergraduate engineering curricula.

Nanotechnology is extremely rapidly developing and transforming next branch. Consequently, the education schedule of the subject should be flexible and timeless based on: fundamental knowledge in nanoscience (particularly physics and chemistry), recent advanced research in nanoscience, and collaboration with nanotechnological laboratories from academic and industry areas.

VŠB-Technical University of Ostrava follows these new trends and is preparing multi-disciplinary course named: Nanotechnology. In the framework of this project physics plays an important role and it constitutes one from the basic branches of the study.

It is necessary to prepare undergraduate engineering students with an ability to design, analyze and manufacture nanocomponents and nanosystems, to create nanodevices, innovative the applications of nanotechnology in all spheres of our life.

1 INTRODUCTION

In the United States, Europe, Japan, and other industrial countries in the world much initiatives have been arisen both by research and development and education in nanotechnology. This advanced technology promises incredible possibilities in the future. Colossal quantum of dollars is invested in nanotechnology and nanoscience [1].

The traditional practices of design, analysis, and manufacturing for a wide range of the technical products have to be changed [2]. Of course, research and development in nanotechnology require specialists who manage education in accordance with new emerging opportunities in nanotechnology [3]. Academic community is forced to educate engineering students with necessary knowledge, understanding, and competence to respond in the new world of nanotechnology. A recent estimate of people needed for nanotechnology in years 2010-2015 is 0.8-0.9 million in the United States, 0.5-0.6 million in Japan, 0.3-0.4 million in Europe, 0.1-0.2 million in the Asia-Pacific region without Japan, and about 0.1 million in other regions.

Aim of nanotechnology education is to provide an interdisciplinary education to students with a comprehensive understanding of natural sciences: e.g. physics, chemistry, biology, engineering sciences: including mechanical, electrical, and information sciences. Nanotechnology education should be integrated into mainstream undergraduate engineering curricula. Universities reform their courses and create new ones to prepare students for the arising opportunities in nanotechnology.

Our country will be collected to at the European Union. If we wish to cooperate with EU research and development activities in nanotechnology we will prepare young people for these opportunities.

VŠB-Technical University of Ostrava follows these new trends and is preparing a multi-disciplinary course named: Nanotechnology.

2 GENERAL TEACHING STRATEGIES

Nanotechnology is an interdisciplinary subject. The fundamental target of nanotechnology is to model, design, simulate, and manufacture nanostructures a nanodevices course with special properties for future revolutionary abilities [4]. Every university has its specific research and development sights, which depend on its history, tradition, and position.

At present, VŠB-Technical University of Ostrava consists of seven faculties (Electrical Engineering and Informatics, Mechanical Engineering, Metallurgy and Material Engineering, Mining and Geology, Civil Engineering, Safety Engineering, and Economics) and three institutes (Institute of Material Chemistry, Center for European studies, and Energy Research Center). In the interdisciplinary course Nanotechnology are engaged first four faculties and the first institute.

The goals of this course in nanotechnology should be:

1. Provide understanding, characterization, and measurements of nanostructure properties.
2. Provide ability for synthesis, processing, and manufacturing of nanosystems.
3. Applications in electronics, optics, magnetism, chemistry, and mechanics.

The project has been begun in 2003 and will be concluded in 2005. This project supposed basic undergraduate courses and a subsequent postgraduate course to consist of Nanotechnology education. In the framework of the solution of the project 37 subjects has been selected which to offer the course Nanotechnology. Our program contains three general modules:

1. Technology of nanostructured materials, preparation, and synthesis.
2. Application of nanostrucures in electronics, optics, magnetism, chemistry, and mechanics.
3. Measurement and analysis techniques of the nanostructured materials.

Physics plays an important role in this project and it constitutes with chemistry the main branches of the study. Physics ensures 13 subjects.

3 PHYSICS STATUS IN THE PROJECT

One from the principal group at the Department of Physics is engaged in optics and magnetism branches, which determine view of the sight supposed subjects by our Department. Subjects such as Electromagnetic Field, Quantum Mechanics, Statistical Physics, and Solid State Physics will create necessary standard.

Introductory nanotechnology courses such as Applied Optics for Nanotechnology, Applied Magnetism for Nanotechnology, and Electronic Structure of Solids should be taught from the perspectives of concept development, qualitative analysis, and mathematical derivations. Each course should be taught at the appropriate level with required pre-requisites.

University faculty staff should be collaborated with international teams in order to educate and train students in the field of nanotechnology. This requirement is particularly very important in our country because there are only limited capacities dealing with nanotechnology in practice, manufacturing particularly. Students should be given opportunities to work directly with established research laboratories which sight is focused on nanotechnology or research and development close to one to gain hands-on experience. Our Department planes such cooperation in both theoretical and experimental areas in the framework of the project solution.

In addition to theoretical teaching we will prepare for practical one too. Three laboratories are disposable to students at our Department: Laboratory of magnetooptics and waveguide techniques, Laboratory of magnetism, and Laboratory of ellipsometry.

The first laboratory is oriented on fundamental and applied research of planar and periodic structures with magnetic ordering. Experimental set-ups enable measurements of the Kerr magneto-optical effect, waveguide processes in thin films, and application of ATR method.

The second laboratory is oriented on applied research in the area of material magnetic properties. Experimental measuring arrangement are equipped for specification of hysteresis loops of magnetic materials, determination of relative and differential permeability, and measurement of leakage magnetic fields of magnetized bodies.

The third laboratory is oriented on ellipsometric measurements of materials. It is able to determine optical parameters of chosen materials and thickness of thin films. All of our labs will serve to nanotechnology students. Students would be complete at least two years laboratory rotations: one in the home Department and the second in other, respectively.

Integral part of the nanotechnology project is also an international cooperation, which has started since 1994. Our cooperative institutions are:

1) Institut National des Sciences Appliquées de Toulouse (INSA), Département de Génie Physique, France, where cooperation was started in 1994 in the framework of the bilateral BARRANDE and C.N.R.S. projects. Two of our postdoctoral students finished their Ph.D. thesis ahead of Czech-French committee. Our workplace has common participation in an international research and development project: „Magnetoelectronics and Spintronics“. This project takes advantages of qualities both workplaces. Département de Génie Physique is oriented on the nanostructures preparing and Department of Physics VŠB-TU Ostrava on the magneto-optical measurements of prepared samples [5].

2) Research Institute of Electronics, Shizuoka University, Hamamatsu, Japan, where the common project KONTAKT has started since 2002. This project refers ellipsometry analysis and measurement of the isotropic and anisotropic 1D and 2D periodical structures [6].

3) Department of Physics, Simon Fraser University, Vancouver, Canada. Department of Physics VŠB-Technical University of Ostrava creates contacts with this University since 1998 in magnetism of nanostructures.

4) Department of Experimental Physics, University of Bialystok, Poland, where the Marie Curie TOK project of European Commission has started since 2004. This project deals with magnetooptical study of magnetic nanostructures.

The physical subjects corresponding with nanostructure and nanotechnology problems are divided generally into two groups: optical and magnetical. Optical range represents subjects: Optical Spectroscopy of Nanostructures, Lasers and Nanooptoelectronics, Integrated Optics and Photonic Crystals, Optical Sensors and Nanosensors. Magnetical range represents subjects: Magnetic Properties of Nanostructures and Composite Materials, Spintronics and Magnetic Storage, Magnetical and Magnetooptical Sensors. The program is supported by our research and development activities and international contacts very well.

4 CONCLUSIONS

Nanotechnology is a very actual fast advancing range; therefore creative and critical thinking and life-long learning should be given the highest priority. It is necessary to prepare undergraduate engineering students with an ability to design, analyze and manufacture nanostructures and nanosystems, to create devices in nanoscales for innovative applications of nanotechnology in all spheres of our economy and industry. Nanotechnology education should be integrated into mainstream undergraduate engineering curricula. Government, industry and universities have to collaborate closely among themselves in order to educate students in nanotechnology.

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