

HIGHER EDUCATION IN LASER APPLICATIONS

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ABSTRACT

Problems of special high education in laser applications are discussed. Education in the field of laser techniques, applied optics, interaction of laser radiation with matter is imperative and in demand for many application areas.

At laser technology chair (St.PIFMO), besides laser technology, the basic education in three subject areas of laser applications is given: lasers in environment studies, laser medicine and laser safety.

The education in laser technology is considered in more detail. The information about optical systems for technological lasers, laser techniques and physics, and laser beam interaction with solids are given in theoretical courses, in laboratories of lasers in microelectronics and lasers in optics technology and in the practical classes.

This education offers an opportunity for professional activity in R&D and production in many fields of laser applications.

1. INTRODUCTION

Now it is well established that the focus of attention has moved from the laser physics to the laser applications. It is due to the fact is that the laser application market is expanding with the rate of approximately 25% per year for the last 8 - 10 years, and most of forecasts give the same rate to the end of the century.

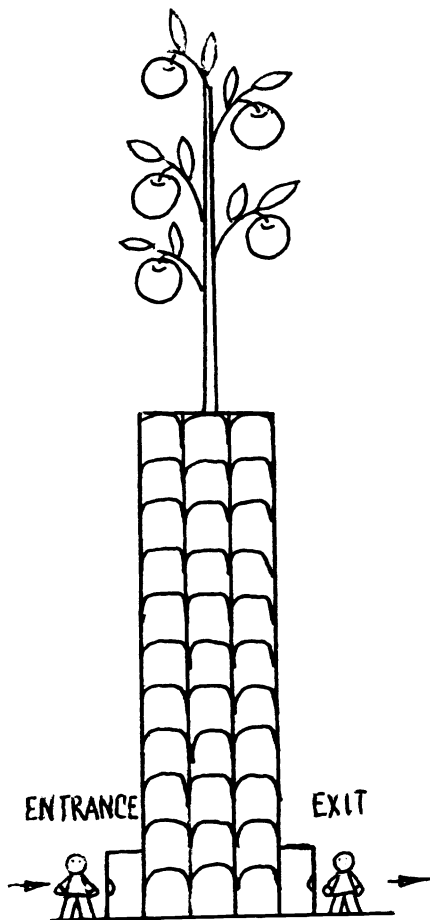
It puts a task before high school to teach students in this field. This task is not so easy, as it could be seen from outside. Primarily the problem is in optimal combination of the knowledge in laser fields with the and knowledge in the field of application, such as technology (welding, hardening, microelectronics), medicine, environment studies, etc.

It is possible to solve this problem in two ways (fig1). The first one is to build a big tower of the little bricks from every subject area.

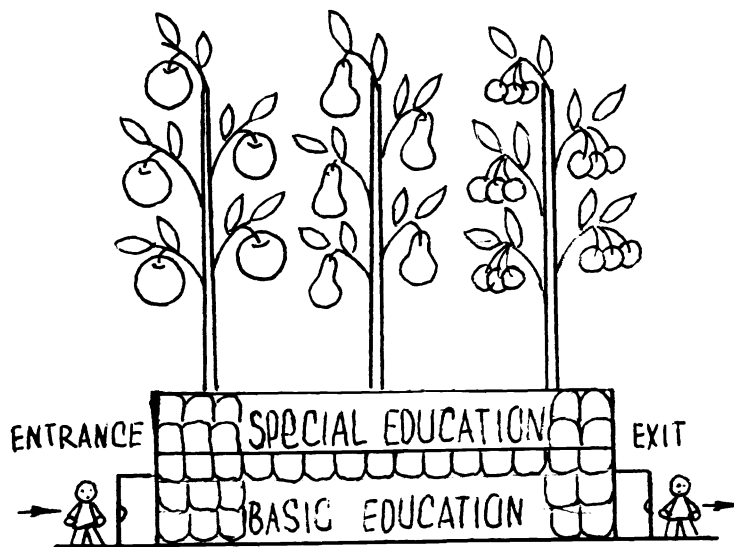
The second one is to give a good basic knowledge. In any case the time of education is the same.

But following the first way one can receive only one kind of education fruits because it is very hard to change the specialty. The second way is to give on opportunities to be more flexible, and permit one to hope for the different kinds of results depending on the requirements of life.

Two ways of high education



First way



Second way

$$\int_{\text{ENTER}}^{\text{EXIT}} F(\text{first way}) dt = \int_{\text{ENTER}}^{\text{EXIT}} S(\text{second way}) dT = T_{\text{education}}$$

Here we present the experience of laser technology chair of St. PIFMO. This chair was founded in 1987 on the basis of the problem laboratory, working from 1965. Of course, in our institute we can teach only engineers and physicists in optics.

And here is the second problem: optimal combination of basic and special subjects.

Naturally, higher university education in laser applications include the general and the special parts. General part contains a number of physical and engineering courses.

Education in laser applications involves the knowledges in mathematical physics, physical optics; laser techniques and applied optics which is given within general courses (see table.1).

2. GENERAL STRUCTURE OF SPECIAL HIGH EDUCATION IN LASER APPLICATIONS AT LASER TECHNOLOGY (LT) CHAIR OF LIFMO.

At laser technology chair (St.PIFMO), in addition to laser technology the basic education in three other subjects of laser applications is given: laser medicine, laser environment studies and laser safety.

Four basic and three optional courses are given every year (Table 1).

Certainly each subject, i. e. technology, medicine, environment, safety is supported by all basic courses. They have many common issues in interaction of radiation with matter, in optics, laser equipment and processes control.

Students have laboratory training in every subject. Some of them are located in the premises of production facilities (technology) institutes (environment) and clinics (medicine).

Theoretical seminars are held under items 1, 2, 3. There by students acquire practical skills in quantitative estimates of laser-matter interaction models and selection of machining processes.

We consider the laser technology education in more detail.

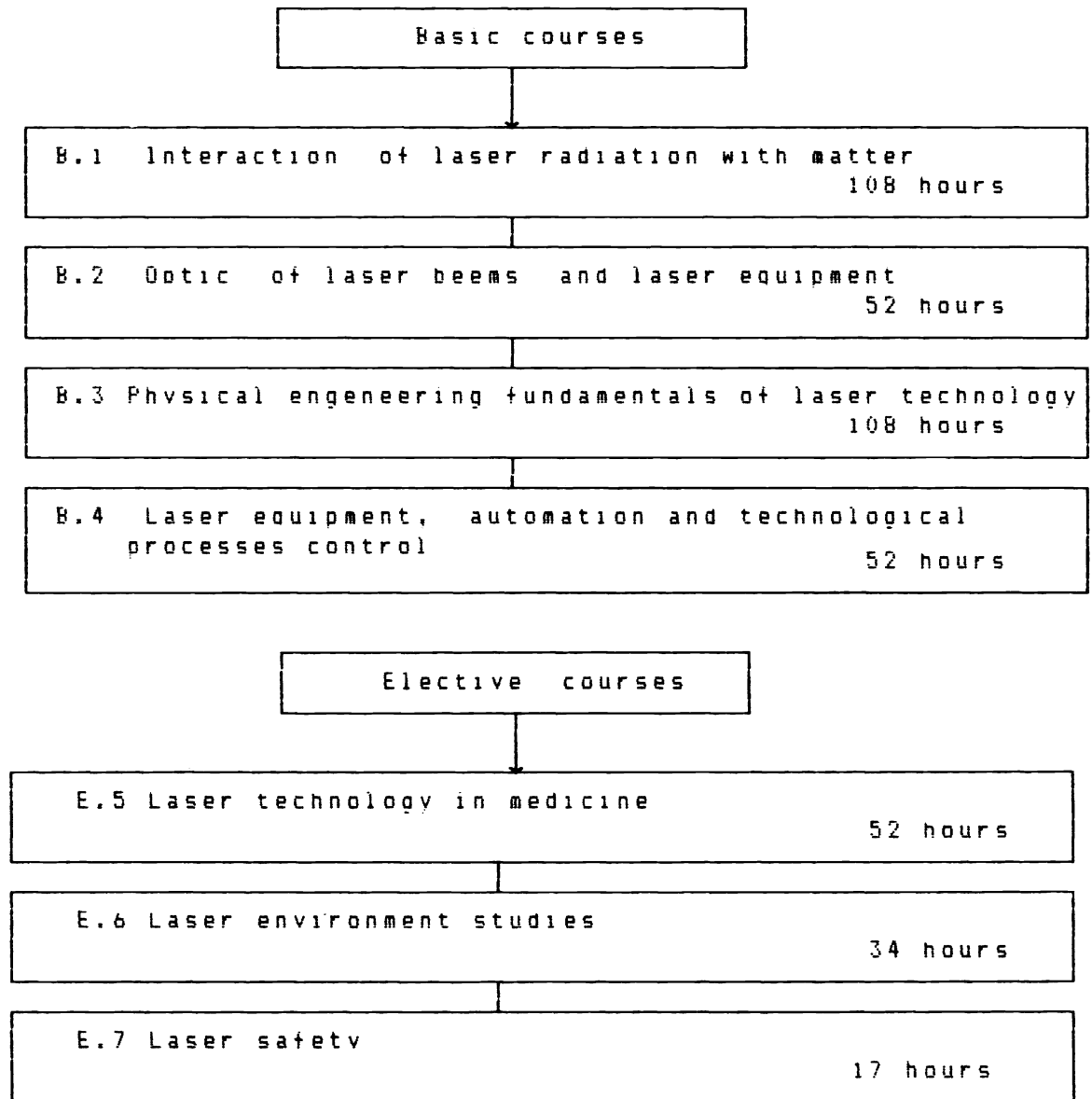
3. LASER TECHNOLOGY HIGHER EDUCATION

This subject is the core one at the LT Chair of St.PIFMO and it is supported by research laboratory.

The structure of basic courses for laser technology education is presented below.

Table.1

STRUCTURE OF SPECIAL COURSES AT LASER TECHNOLOGY CHAIR



3.1 B.1 INTERACTION OF LASER RADIATION WITH MATTER

The interaction of laser radiation with various substances is the basic course for broad education in each laser application. It contains the problems of laser interaction with absorbing solids (for technology), with biological tissues (for biomedicine), with light - scattering media - air and water (for environment). Table 2 illustrate the structure of this course.

Part 1. is devoted to detailed consideration of the thermal model of laser action on metals and absorbing semiconductors. Basic knowledge is presented on the optical properties of these media and optical processes resulting in light absorption and heat production. Thermal - physical aspects of laser heating are thoroughly outlined. Much attention is paid to acquaintance with basic physical and chemical processes accompanying heating: emission, diffusion chemical and thermomechanical processes phase transitions. Laser - induced modifications in optical materials properties are examined as well as the complex nonlinear modes of laser heating due to those modifications in case of reciprocal relations between optical and thermal processes substantially affecting the kinetics at temperature variation. The problems of basic thermal mechanisms of laser damage of bulk materials and thin films, and the domains of their realization are outlined. Special attention is brought to laser action on a surface and the specific processes occurring in this case: generation of surface electromagnetic excitations and periodic structures forming.

Part 2. covers certain problems of laser interaction with weakly absorbing materials. Basic concepts are presented of light absorption mechanisms and optical breakdown of transparent media (homogeneous and containing optical inhomogeneities). Specific features of high - power radiation effects on biological objects are discussed. In view of rapid development of ultrashort laser pulses techniques and studies of substances behavior in ultra strong light fields, a number of nonequilibrium laser - induced processes in condensed matter are considered.

3.2. B.2 OPTICS OF LASER BEAMS AND LASER EQUIPMENT

The content of this course is illustrated by table 3.

Part one is devoted to methods of calculation of basic optical schemes for laser beams. The following topics are given: calculations for single mode and multimode lasers, the comparison of several calculation methods from the coherence of radiation point of view, the calculation and design of some special optical systems; scanning, fiber optics etc. All this part is devoted to the optical systems for high power laser beams. In the second part the additional optical systems for laser equipment are considered. In this part the methods of calculation and design for non - laser sources, non - coherent beams are given. But it is very important for creation of laser equipment for technology, medicine, etc.

Table.2
Basic sections of the course
"LASER - MATTER INTERACTION IN "LASER TECHNOLOGY"
SPECIALITY

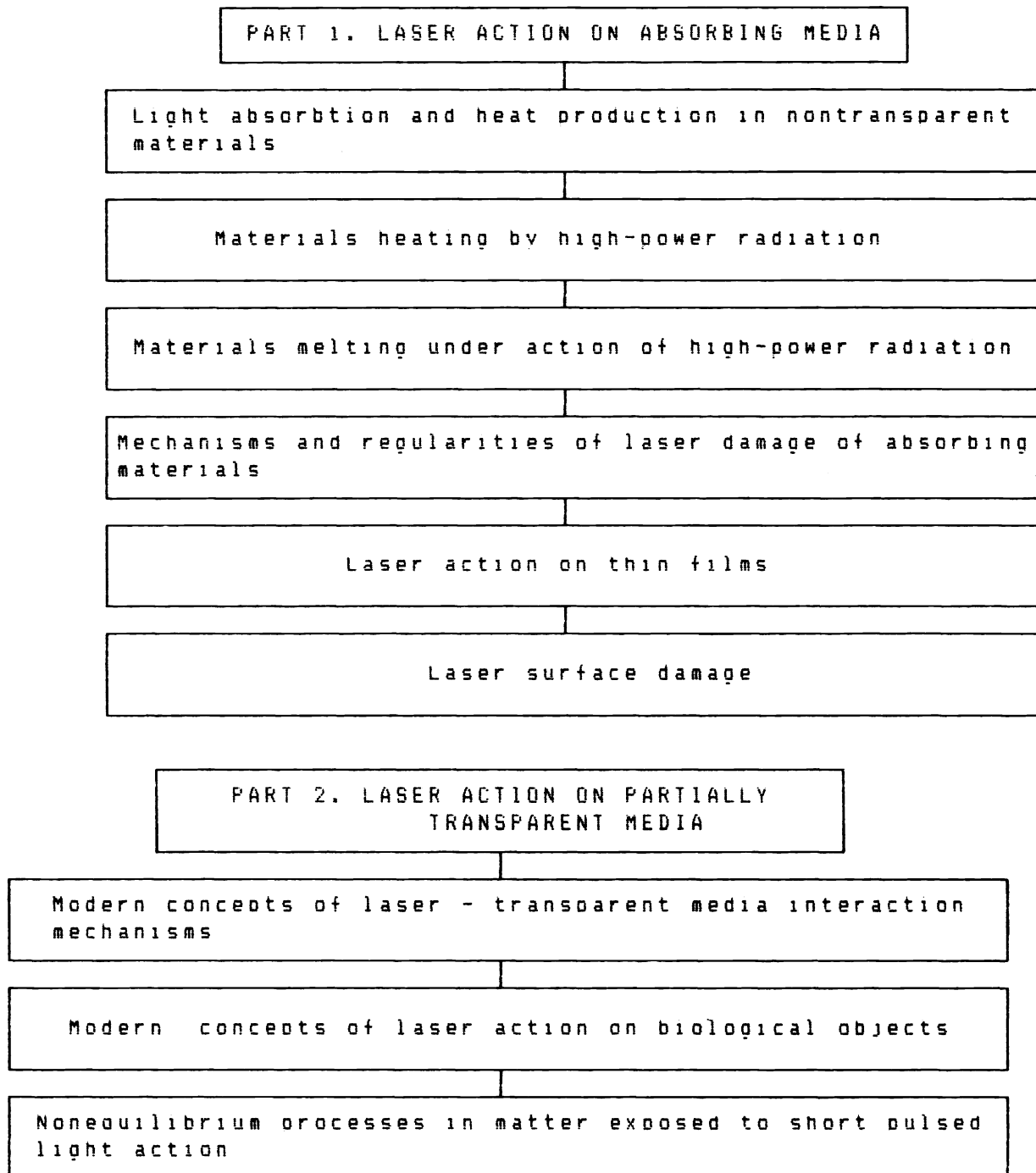


Table.3

Basic sections of the course
OPTICS OF LASER BEAMS AND LASER EQUIPMENT
(CALCULATION AND DESIGN)

PART 1. LASER BEAM OPTICS

1. Optical resonators and transverse structure of laser beams
2. Waves and geometrical approaches to the calculation of laser optics
3. Basic models of lasers as light sources
4. Calculations of collimation, transmission, focusing and projection systems
5. Laser beam scanning systems
6. Control systems for beam energy distribution
7. Fiber - optic systems for transmission of laser beams
8. Optical elements and systems design for high-power laser beams

PART 2. LASER EQUIPMENT OPTICS

9. Characteristics of different types of technological, measuring and medical equipment
10. Basic functions of optical systems in ILE: illumination aiming, observation, measurements etc
11. Main types of observation optical system of ILE: monocular, binocular, television etc
12. Illumination systems: polychromatic, monochromatic, fiber and laser optics
13. Different aiming systems: by the light beams, by the special marks etc
14. Complex optical systems for technology, medicine and other purposes

3.3 PHYSICAL - ENGINEERING FUNDAMENTAL OF LASER TECHNOLOGY

Structure of this course is shown in table. 4.

Table.4

Basic sections of the course
PHYSICAL - ENGINEERING FUNDAMENTALS OF LASER
TECHNOLOGY

PART 1. GENERAL PRINCIPLES OF LASER TECHNOLOGY

1. Technological lasers and laser radiation
2. Optical configuration and laser beam forming systems
3. Laser action on the materials

PART 2. LASER TECHNOLOGY PROCESSES

4. Laser heat treatment and hardening
5. Laser welding and soldering
6. Laser machining of thin films
7. Laser dimensional machining, drilling, marking and printing
8. Laser cutting and scribing
9. Laser modification of semiconductor structure
10. Laser plasma film deposition
11. Laser thermo- and photochemistry in microelectronic technology
12. Laser fusion technology of optical components
13. High power laser materials treatment
14. General principles of laser technological equipment

Part one is devoted to the consideration of basic knowledge in lasers, optics and physical problems as applied to laser technology. Basic education of laser radiation parameters which is most important for energy and dimension relations for laser action threshold are given.

Part two is devoted to detailed consideration of different kinds of laser technological processes, such as welding, drilling, cutting, hardening, resistors trimming etc. Some new topics have been recently presented: laser thermo- and photochemistry in microelectronics laser technology in microoptics, laser-plasma film deposition.

3.4. LASER EQUIPMENT DESIGN, AUTOMATION AND TECHNOLOGICAL PROCESSES CONTROL.

Part one (table.5) is devoted to consideration of general principles of industrial laser equipment (ILE) design. Design and action, elements of calculation and selection of basic systems of ILE - lasers, optical systems, executive electromechanical systems, and computer control systems are presented.

Table.5

Basic sections of the course
LASER EQUIPMENT, AUTOMATION AND
OF TECHNOLOGICAL PROCESSES CONTROL

PART.1 GENERAL PRINCIPLES OF INDUSTRIAL LASER EQUIPMENT
(ILE) DESIGN, COMPOSITION AND ELEMENTS

1. Industrial lasers: solid state and gas lasers
2. Optical systems for industrial laser equipment
3. Optical systems for medical equipment
4. Executive mechanical systems of ILE and handling
5. Measuring systems and control of ILE parameters
6. Computer control systems for ILE
7. Safety requirements and systems for ILE

PART 2. INDUSTRIAL LASER EQUIPMENT

8. Classification of ILE
9. Equipment for laser cutting
10. Equipment for welding and soldering
11. ILE for drilling
12. ILE for marking and engraving
13. Laser trimmers
14. Laser generators of images
15. High-power ILE.

In the second part the main types of ILE are overviewed: ILE for laser heating, hardening and welding, drilling; for thick - film machining, trimming etc.

Most part of all of these courses B.1 - B.4 are based on the original results, which are published in books, reviews and articles of the authors [1-9] and have no direct analogies in other high schools.

4. AREAS OF PROFESSIONAL ACTIVITY OF LT CHAIR GRADUATE

During the last few years approximately 6 - 9 students graduated from the chair annually and 4 - 5 post graduate students studied, some of them from Bulgaria, Hungary, Germany. Most of them work at the industrial institutions and enterprises, some of them at the medicine clinics and LT chair.

Good connections of LT chair with other higher schools in the USSR (Moscow State University, St. Petersburg Technical University, Kiev Technical University,) and foreign institutes - San-Diego State University, University of Arizona, Tucson; USLA, Bremen Institute of Applied Beam Optic ensure the high level of laser technology education.

ACKNOWLEDGMENTS

Authors are thankful to their colleagues Dr. Y.D. Berezin, Dr. S.N. Natarovski, Dr. G.D. Shandibina, Dr. B.M. Yurkevich, Dr. V.I. Feigels, Dr. A.I. Kajdanov, M.D. Abbakoumov, Dr. S.N. Belov for helpful discussions and assistance in preparing this paper.

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