

# Materials science virtual laboratory as an example of the computer aid in materials engineering

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## Education and research trends

### ABSTRACT

**Purpose:** The purpose of the presented article is to describe the material science virtual laboratory, which is an open scientific, investigative, simulating and didactic medium for the realization of the didactic and educational tasks performed by traditional and e-learning methods.

**Design/methodology/approach:** The laboratory is an aggregate of testers and training simulators, placed in the virtual reality and created in various languages and the programming techniques, which represents the properties, functionality and manual principles of real equipment installed and accessible in the real laboratories of scientific universities.

**Findings:** Application of the equipment, that is practically imperishable, cheap in exploitation and easy in the use certainly will encourage students and scientific workers to independent audits and experiments in situations, where the possibilities of their execution in the true investigative laboratory will be limited because of the high material costs, difficult access to real equipment or the possible risk of his damage.

**Practical implications:** The use possibilities of the virtual laboratory are practically unrestricted; it can be a base for any studies, course or training programme. It is assumed, that the project of the laboratory as fully multimedial. The participants of this laboratory can e.g. investigate training experiments from the definite field of material engineering, give questions, pass tests, contact with lecturers and the different users of the laboratory and obviously on participate in his design and content.

**Originality/value:** The project of the virtual laboratory corresponds with the global tendency for expand the investigative and academical centers about the possibilities of training and experiments performance with use of the virtual reality. This enriches the education programme of the new abilities reserved so far exclusively for effecting only on real equipment.

**Keywords:** Computer aided teaching; Virtual laboratory; Computational material science and mechanics; Training simulations

## 1. Introduction

The continuous progress of the computer technology opens new fields of the computer scientific activity. Virtual reality can

be effectively adapted to continuous processes of education guided with use of traditional and e-learning methods. Presented in this paper material science virtual laboratory (Fig. 1) is an open scientific, investigative, simulating and didactic medium for the realization of the educational tasks, Despite of the considerable

difficulties of the study, it is a future solution for the engineers, designers and students to raise their skills and abilities in material science matter, e.g. in investigations guidance subject: to learn the methodology of investigations performed with usage of the scientific equipment [1-3].

The presented project corresponds with the global tendency for expand the investigative and academical centers about the possibilities of training and experiments performance with use of the virtual reality. [4-7].

## 2. The development of material science virtual laboratory

Computer programmes, which are simulating the work of real devices, should be their possibly faithful imaging. Naturally, the simulation will never reach the full usability of the real equipment, but the simulator should describe possibly large quantity of function and the possibility of the original, particularly these, which are used in training and education.

The fidelity of the simulation is very important in this case, because it has the cognitive character for students just getting to know the techniques of scientific investigations performed with use of the given device.

The best virtual laboratory will never be so good, that the modest and smallest real laboratory. Technologies virtual and real are complementary [8-10].

In the virtual laboratory are placed the virtual simulations of investigative equipment installed in the laboratories own by Institute of Engineering Materials and Biomaterials, Silesian University of Technology, Gliwice, Poland. Except this the user will also find instructions and educational materials, necessary for execution of training experiments in the virtual reality, the description of real investigative equipment and scientific investigations guidance methodology, current information on subjects connected with the wide understood material science matter, multimedially scientific help for better understanding of

problems, educational animations, supervisory, examination tests and advises, thematic services, the scripts of the lesson and didactic presentations [11-14].

## 3. Virtual workroom of the light and confocal microscopy as the example of laboratory implementation.

As the implementation example of the virtual laboratory for the didactic and educational tasks he will be introduced the virtual laboratory of the light and confocal microscopy. This is one from many laboratories placed in the virtual reality.

The interface of the laboratory and virtual devices is created in the techniques of the network programming adequate to the kind of the device and according to the worked out conception for the building of virtual laboratories.

The laboratory was tested on machines working under control of operating systems such Windows 98/Me, Windows 2000/Xp, Mandriva Linux 2006 and FreeBSD 6.2. Browsers, used to the view laboratory supplies were Microsoft Internet Explorer 6/7, Firefox 2.0, Opera 9 and Konqueror 3.5. No difficulties were encountered in any case. The access to the system and his service was fast and smooth [15-19].

### 3.1. Virtual light microscope

The light microscope allows disclosing the microstructure of the materials and internal defects which can't be perceive during macroscopic observations. The worked out virtual laboratory post has to simulate the rule of the light microscope Leica MEF 4A/M (Fig. 2).

It simulate the basic functions of this device, such as: the displacement of the objective table, the change of magnification, different observation techniques in the bright field, in the dark field and in polarized light with contrast. In real device all functions are called out by use of the suitable levers or knobs, in

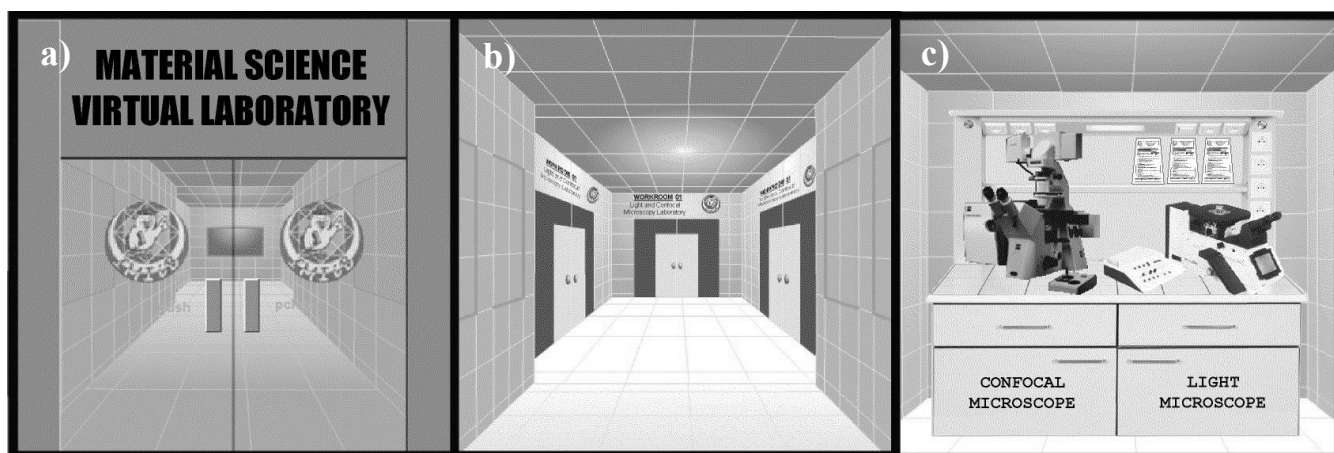


Fig. 1. Material science virtual laboratory placed in the educational e-learning platform of the Institute of Engineering Materials and Biomaterials, Gliwice, Poland; a) entrance, b) workrooms, c) virtual laboratory of light and confocal microscopy

simulated microscope, by „clicking” on corresponding buttons, or by pressing appropriate key on the keyboard. All buttons and switches are placed in positions adequate to real effectors [21-22].

The work with the simulation begins from the choice of interesting sample from menu placed over the objective table near the real sample in the microscope. Now the user must select the observation method of microstructure marking the tail near appropriate lever, and then, establish the increase with use of panel on the right side. We arrows on the displacement knobs moves observed microstructure in the observation field making possible the viewing of the whole sample.

### 3.2. Virtual confocal microscope

The simulation was based on Zeiss LSM500 microscope, (Fig. 3) [22]. It lets the user acquaint with the basic possibilities of the confocal microscope. Images of the microstructure are presented dimish on the screen of the monitor, the full size image is accessible through the ocular. Simulation gives the control over three channels of data acquisition, suitably red, green and blue, steered through the menus on the microscope. Switch placed on the right side regulate the depth of scanning. Options on the keyboard tunes up the parameters of the observed image, such as

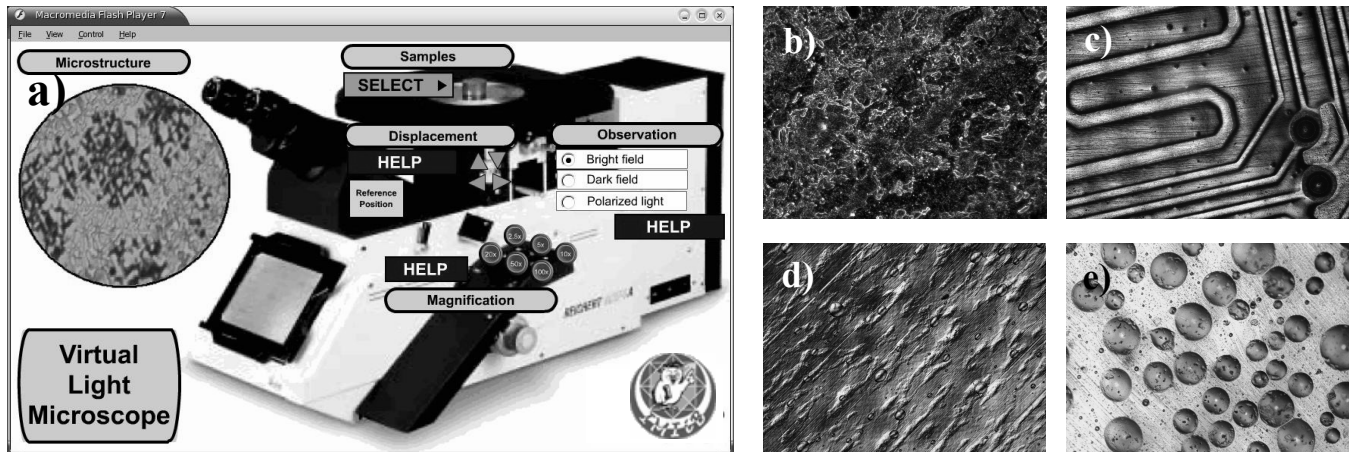


Fig. 2. a) Virtual simulation of light microscope accessible on every computer with access to the global net. The loaded sample is ZIMn1.2 manganese cast iron, magn. 50x, bright field (Linux OS), b-e) Examples of microstructures applied for observation in the virtual microscope b) 16MnCr5 steel, magn. 100x, dark field, c) electric circuits on silicon substrate, magn. 25x, bright field, d) polyethylene strip, magn. 100x, polarized light with contrast, e) Bubbles of air in the epoxy resin, magn. 100x, bright field [23]

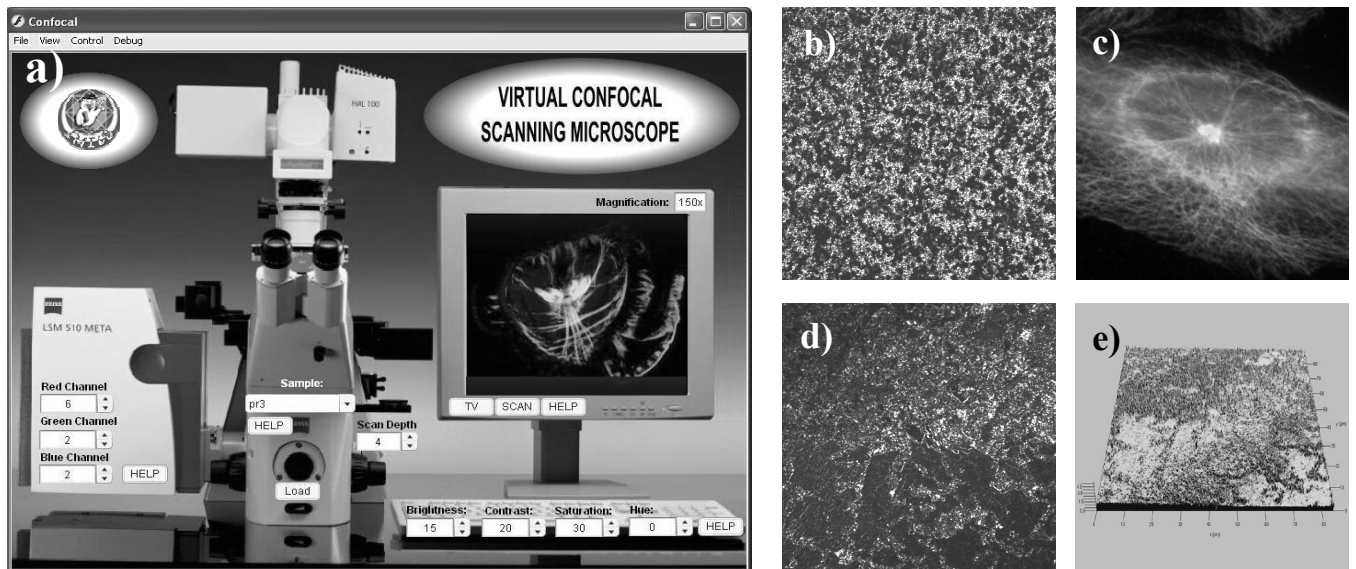


Fig. 3. a) Virtual simulation of confocal microscope, loaded is the biological sample of Crepidula Fornicata, (Windows OS), b-e) Material samples applied for observation in the confocal microscope, b) AISr10 steel, magn. 100x, c) Aphidicolin treated CHO cells, magn. 600x, d) 16MnCr5 steel, magn. 100x, e) the surface topography of 16MnCr5 steel from view d [22-23]



brightness, contrast, saturation and hue. Additionally, the help buttons explaining the meaning of individual options and the way of their use.

Similarly as in the light microscope the observation begin from the choice of the sample from menu placed on the corps of the microscope. Loading of the sample into microscope follows after load button usage. The next steps are the choice of demanded penetration level and adjust the parameters of scanning lasers. Modifications can be done using controllers from the left side of the microscope. We observed image is shown on the monitor screen and through the ocular in full dimensions. The options of the monitoring are quick scanning with poor quality or slow scanning movements with good quality image. Additionally, user can steer the parameters of the image though accessible options on the keyboard.

### 3.3. Application of virtual microscopes in engineering education.

Thanks to the virtual workroom of the light and confocal microscopy, it's possible to perform of investigations on posts equipped in the unique optical apparatus, without entering the real laboratory, accessible only in specialist scientific centers.

Wide team of scientists and students can use the results of microscopic observation, independently from the place of their current stay, the only requirement is the computer with access to the global net.

This workroom is a unique chance of acquaintance with metallographic microscopes given to persons without access to real investigative equipment. Virtual microscope simulations used for microstructures observation for such persons are the only method for introduction and presentation of these investigative tools and its application in material engineering.

Application of this workroom for didactic purposes allows realization of experiments and investigations with use of microscopes without the physical presence of students in the laboratory. That's why possible becomes teaching in laboratory classes performed by e-learning methods. Traditional students can prepare their lectures in home and execute training experiments before entering to the real laboratory in real world.

## 4. Conclusions

The frames of this article allowed only for the very cursory presentation of the virtual laboratory as the computer aided didactic environment. However, this few examples show potential use possibilities of the virtual reality to scientific and educational aims. The interaction with simulation of the investigative device opens new possibilities in acquiring of knowledge and skill from the field of material engineering.

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