IMPLEMENTATION PROGRAMS TO MODELING IC VIA INTERNET

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1. Introduction

Due to progress in the field of information technologies and constant rising of accessibility to the global Internet network, education at the on-line mode as a variety of so named distance learning (e-learning, e-education) is become more and more popular. Modern information technologies provide new possibilities for increasing of learning and training efficiency in such scientific-capacious sphere of human activity as microelectronics, including integrated circuit (IC) and technology design. Use of Internet-learning reduces the financial expenses, as well as allows getting knowledge in the suitable time and with suitable rate for each person.

At the Department of Mathematics and Computer Science of the University of Bialystok (Poland) and Department of Micro- and Nanoelectronics of the Belarusian State University of Informatics and Radioelectronics (Belarus) and Department of Computing Technologies and Informatics of the Saint Petersburg Electrotechnical University "LETI" (Federation of Russia) investigations are carried out for the development of methods and software both for learning, and for design of microelectronic technology via Internet/Intranet network [1-3].

The presented system “e-rudio” and module created by authors software-hardware complex allows to realize learning and design in sphere of IC technology both at local (Intranet) and global (Internet) network.

2. Programs to modeling IC via Internet

The realized scheme for the performance of the design/learning IC technology via Internet network is shown in the Figure 1. The main place at this diagram belongs to a module GUI-SUPREM III. The module functions via Apache Web-server. Web-server provides access of the user to the site, as well as processes all requests received from users who use Web-browsers for communication with the server. Another function of the Web server is to provide information about the current status of the project (i.e. the status of actions requested by the user).

![Figure 1. The flow illustrated the software-hardware platform for Internet learning/design](image)

Thereby, the Web-server is a connecting link between the hardware of the Internet network and the user's browser. The Web-server Apache is most suitable and the most efficient tool in the respect of specified
requirements. Apache is easily configurable, allowing adjusting the Web services in accordance with needs of individual and corporate users. Configuration of Apache is achieved by means of directives kept in configuration files. Apache allows to create virtual Web nodes, as well as to execute the functions of a proxy server.

The next problem is to create dynamic template pages, written in HTML language. Use of the PHP language (Personal Home Page) is the most efficient for the development of applications realizing interactions with databases and with templates. Another function implemented in PHP is the organization of the file with the input data and with definition of the design or simulation task for the software placed at the server (for instance, program SUPREM for simulation of IC technology).

It is suitable to use standard, free program gnuplot [5] for saving in graphic format (for instance, in png) simulation results since it possesses flexible adjustment and is compatible with wide used operation system UNIX.

3. Training Programs

Dynamic shell (Figure 2) was developed for entering commands and parameters in the file with simulation task for module GUI-SUPREM III. This procedure may be realized directly at the Web-site. Dynamic shell is written with use the interpreted language JavaScript.

Results of simulation are transformed in graphic dependencies (files in the png format) using program GnuPlot and are sent to user via e-mail. Typical presentation of obtained results of IC technology simulation/design is shown at Figure 3. Here are concentration profiles of impurities (boron, arsenic and antimony) in the structure of n-p-n bipolar transistor.

Web-site (http://kim.uwb.edu.pl) with described instruments is used successfully in Belarusian universities in the frame of discipline “Computer Aided Design in Microelectronics”.

Process simulation

![Figure 2. Screen-shot of the dynamic shell for entering commands and parameters in the file with simulation task at the module GUI-SUPREM III](image)

![Figure 3. Results of simulation via Internet the concentration profiles of impurities (boron, arsenic and antimony) in the structure of n-p-n bipolar transistor](image)

One training complex (Figures 4, 5) is intended for research multidimensional ion-implanted dopant profile (B, P, As, Sb), represented in the form of 3D graph or isoconcentration lines, depending on the dose and energy of implanted ions. Implantation process is realized into free surface of silicon substrate or through mask window.

The other training programs (Figures 6, 7) are intended for research of the polysilicon technology including the dependence polysilicon grain dimension of prolonged and pulsed thermal processing technological variables: concentration of implanted doping, length of process, temperature at prolonged mode and radiation power at pulsed mode, and initial polysilicon grain dimension.
3. Conclusions

Concept of the e-learning system "e-rudio" is presented. Compounds of the "e-rudio" system are described. The hardware-software platform for design and simulation via Internet network was realized with use of the modern Internet technologies (the server Apache, database MySQL, programming languages PERL/PHP). The scheme for realization of the platform was described and illustrations of its operation were presented. Examples of training programs are presented for the simulation of some base technological operations in microelectronics: many-dimensional post-implanted profiles of impurities, deposition of polycrystalline silicon on non-planar surface in LPCVD process and polysilicon grain growth during the long and impulse thermal treatment. Presented results illustrate possibilities of the developed active virtual laboratory at the Internet for a distance learning. All calculations are performed in on-line regime.

References