

HARDWARE-SOFTWARE PLATFORM FOR INTEGRATED CIRCUIT TECHNOLOGY LEARNING AND DESIGN VIA INTERNET

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Abstract:

The module GUI (Graphical User Interface)-SUPREM III for design and training of microelectronic technology via Internet is described. The module is the part of the software-hardware suit intended both for studying principles of design in computer integrated circuit technology, and for simulation/design of a technological route of integrated circuit manufacturing. Program package SUPREM III is the base platform for physical simulation of processes in microelectronics. Modern information technologies (the server Apache, programming languages PHP and PERL, standard GnuPlot program) are utilized for realisation of the described platform. The module is used at Belarusian universities and abroad during lectures and computer training classes as part of disciplines dedicated to design in microelectronics.

Keywords: e-learning, internet, CVS, design, hardware, software.

1. Introduction

Due to progress in the field of information technologies and constant increase of accessibility to the global Internet network, on-line education in form of a variety of so-called distance learning (e-learning, e-education) is becoming more and more popular. Modern information technologies provide new possibilities for increased learning and training efficiency in the 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 at a rate suitable for each person.

Nowadays, e-learning methodologies and tools are well-perfected, but simulation and design *via* Internet have specific particularities and unsolved problems. This new service is intended to help designers overcome the expense and time-consuming effort of establishing and maintaining a state-of-the-art, comprehensive IC design environment. Using this service allows to focus on own unique intellectual property (IP) while avoiding expensive infrastructure development.

Such Internet sites provide customers (in particularly small and medium-size enterprises, SMEs) with the tools and support needed to quickly and easily take advantage of the cost and performance benefits offered by modern (but expensive!) design tools. For example, companies Synopsys and Avant! have joined together to provide Internet-based design *via* DesignSphere Access [1]. The alliance combines electronic design automation tools with extensive computing resources, network capability and security services acces-

sible via Internet. DesignSphere Access ensures data safety and integrity with a strong system of firewalls, physical access security, customer-dedicated hardware configurations, and log-in and password restrictions.

NEC Electronics launched in 2001 Internet-based collaborative design environment for gate arrays as part of the NEC Gate Array Design Center Internet site [2]. The easy-to-use site includes real-time pricing, turnaround time and packaging information to speed the evaluation process and also facilitates quick product development through online training, design tutorials and technical and sales support. There are a lot of other references devoted to use of Internet as a power tool for remote design and experiments (see for example [3]).

One more aspect of the use of Internet network for design is the possibility of collaboration in the frame of one project of many specialists representing various kinds of skills and levels of experience and working in different places. The CVS technology, widely used in the SourceForge, is the example of such a system for group development of applications when large projects are carried out.

Essential problem, particularly in the field of microelectronics, is high cost and, as a result, inaccessibility of modern software for IC design. The overall value of the software for IC design on the world market was well above billion dollars in 2000, and it constantly increases with the rate near 8% per year. The design software distributed free of charge (with Open Source-type licenses) has limited functionality, contains many errors and often does not follow industrial standards. Lack of possibility to study and use modern and fully functional tools for IC design adversely affects, in particular, the level of skills and qualifications of IC designers.

Obviously, use of the Internet network for learning of software inaccessible directly for the designer, as well as for design in the client-server mode, by means of appropriate software running on a central server, can be very efficient. Here it is assumed that end user license does not restrict Internet access to the design software.

At the Department of Micro- and Nanoelectronics of the Belarusian State University of Informatics and Radioelectronics [4]-[6] investigations are undertaken for the development of methods and software both for learning, and for design of microelectronic technology *via* Internet/Intranet network.

Here we describe approaches and the realized hardware-software platform for a distance learning of integrated circuit (IC) manufacturing, physical modeling of technology processes and simulation/designing of technology route with the use of modern program package maintained at the central server.

Presented module GUI (Graphical User Interface) -SUPREM III with the created by authors software-hardware package allows to realize learning and design of integrated circuit technology both at local (Intranet), and global network Internet.

2. Module GUI-SUPREM III

The module GUI (Graphical User Interface)-SUPREM III is based on the free distributive of Linux Slax [11] and free package SUPREM III for IC technology simulation and design [12]-[13]. SUPREM III is an analogue of the commercial program Suprem3, which costs more than a hundred of thousands dollars. Suprem3 is the part of module ATHENA of the Silvaco package [14]. Silvaco is the leader company amongst developer of modern software programs intended for design in microelectronics. SUPREM III is used for 1-dimensional physical simulation of separate processes and technological flow of IC manufacturing. The Program SUPREM III allows realizing physical modeling of basic technological steps, including diffusion and implantation doping, diffusion redistribution of decants, oxidation, epitaxy, etching, etc. Output file SUPREM III contents information about concentration profiles and geometry of the modeled device structure.

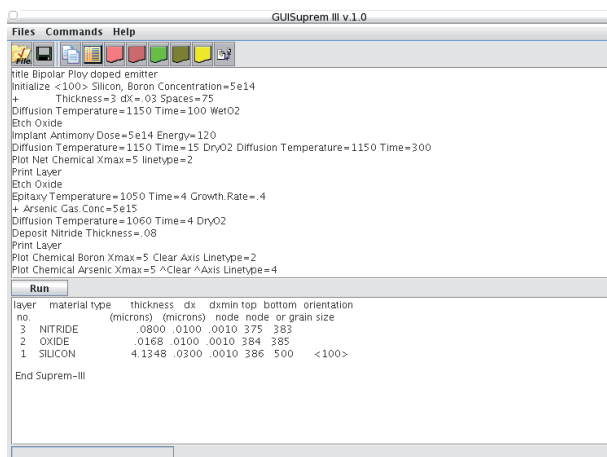


Fig. 1. Module GUI-SUPREM III. Screen-shot of the main page.

Format of the output file of module GUI-SUPREM III is compatible with the format of the input file of the package PISCES [15] intended for modeling of device electric features. This important particularity allows to realize the closed cycle of simulation including modeling and design both technology and device. The used distributive Linux Slax LiveCD does not require installation on hard disk. It is loaded from removable disk such as USB disk or compact disk. Distributive Slax has a module structure. Such preference property allows easy to modify the distribution programs under particular requirements of the user. Standard start of the module GUI-SUPREM III is realized by use of self-loading compact disk Linux Slax LiveCD. As a result the main page of the module GUI-SUPREM III is opened (Figure 1). The main page of the module GUI-SUPREM III consists of a standard menu, instrumental panels, area for entering input parameters in file with the task for modeling and area for image of simulation result in tabular form.

3. Methodology of the design and learning via internet

The realized approach to the design/learning of IC technology via Internet network is shown in the Figure 2. The main part on this diagram belongs to a Web server on which the design software is placed. Web server provides user access to the site, as well as processes all requests received from users who use their 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).

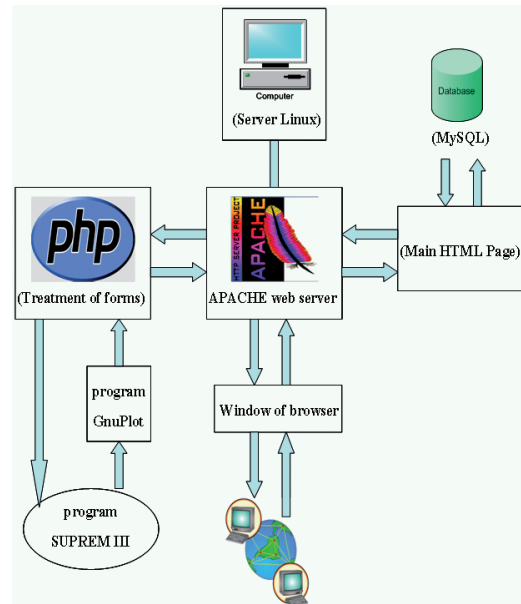


Fig. 2. The block-diagram illustrating the software-hardware platform for Internet learning/design with use GUI-SUPREM III.

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 allocated computer complexes can be built on the base of protocol HTTP (Hyper Text Transfer Protocol), which supports the interface with CGI (Common Gateway Interface) applications on Web-servers and allows ensuring an access to server computing resources from browsers. The Java language gives an opportunity to create the computing system even more allocated, transferring a part of computing loading, which carries out Web-server, to browser. In result there is a possibility to construct more flexible and productive computing systems.

The next problem is to make dynamic template pages, written in HTML language. Use of the PERL language (Practical Extraction and Report Language) is the most efficient for the development of applications realizing interactions with databases and with templates.

Another function implemented in PERL is the organization of the file with the input data and with definition of the design or simulation task for the software placed on the server (for instance, program SUPREM for simulation of IC technology).

Processing of the forms, which contain the requests for design or simulations, as well as results of calculations, is also performed by means of PERL, as a script language well tailored to OS UNIX. Integration of modules of such programming and scripting languages as PERL and PHP with Apache is often used to enhance capabilities of HTML in processing and creating of dynamic Web pages.

It is suitable to use standard, free program gnuplot [16] for saving simulation results in graphical format (for instance, in png) since it is a flexible format that can be easily adjusted and is compatible with widely used operation system UNIX.

Presented Internet software-hardware suite, realized as depicted in Figure 2, is placed at the server Apache and is available at Web-address: <http://kim.uwb.edu.pl>

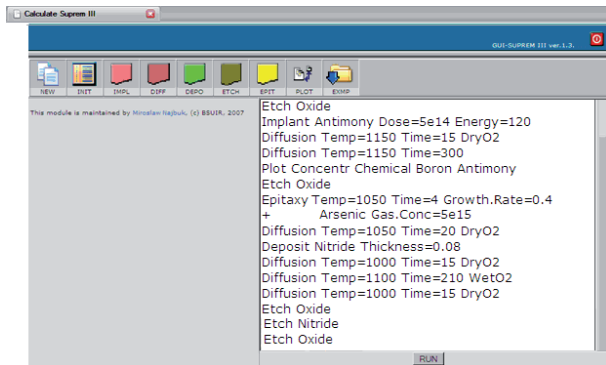


Fig. 3. Screen-shot of the dynamic shell for entering commands and parameters in the file for simulation task in the GUI-SUPREM III module.

Dynamic shell (Figure 3) was developed for entering commands and parameters in the file necessary for a simulation task performed by GUI-SUPREM III module. This procedure may be realized directly at the Web-site. Dynamic shell is written with use the interpreted language JavaScript.

Processed data (the results of calculations) may be sent to client via e-mail if hardware resources are insufficient for real time communication. The server POSTFIX is used for sending the e-mail as an efficient way for automation of the sending of the postal messages. The server POSTFIX provides reliable protection from malfunctions and warranty of the message reception by the client.

Results of simulation are transformed in to graphical attachments (files in the png format) using program Gnu-

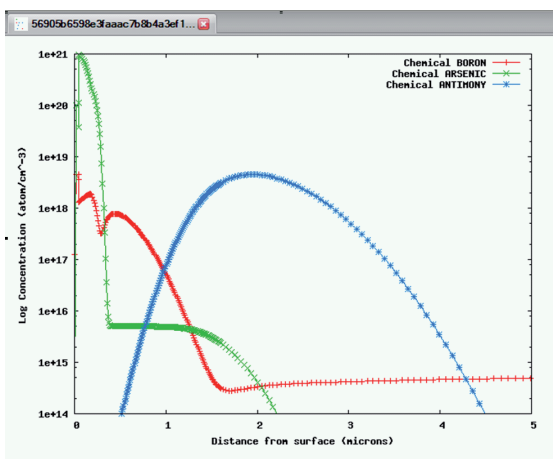


Fig. 4. Results of simulation via Internet the concentration profiles of impurities (boron, arsenic and antimony) in the structure of n-p-n bipolar transistor.

Plot and are sent to user via e-mail. Typical presentation of obtained results of IC technology simulation/design is shown in Figure 4. Here, concentration profiles of impurities (boron, arsenic and antimony) in the structure of n-p-n bipolar transistor are shown.

4. Conclusions

The module GUI (Graphical User Interface)-SUPREM III for organization of design and training of microelectronic technology via Internet is developed. The module is the part of the created software-hardware suite intended both for studying of principles of computer integrated circuit technology design, and for simulation/design of a technological flow of integrated circuit manufacturing via Internet. Modern means of information technology are used in the complex including the server Apache, programming languages PHP and PERL, database MySQL, standard GnuPlot program. It is obvious that presented methodology and principles for microelectronic technology may be successfully used in any applications for organization of calculations in the client-server mode via Internet. Website (<http://kim.uwb.edu.pl>) with described instruments is used successfully in Belarusian universities as part of “Computer Aided Design in Microelectronics” course.

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