Hands-On Laboratories in the NanoEl Project

Danilo Demarchi1*, Gianluca Piccinini1, Mariagrazia Graziano1, Jack Barokas2, Silvia Schintke3, Philippe Morey-Chaisemartin, Slavka Tzanova5

1Politecnico di Torino, Italy, 2Tel Aviv University, Israel, 3HEIG-VD, University of Applied Sciences of Western Switzerland, 4Institut National Polytechnique de Grenoble, France, 5University of Sophia, Bulgaria

*Danilo.demarchi@polito.it
Tel: +39 011 0904122, Fax: +39 011 0904099

Abstract—The NanoEL is an Erasmus LLP project about sharing technology and human resources. Knowledge and information made available at project partner’s universities, in order to develop teaching material in the form of courses or modules within the interdisciplinary field of nanotechnology.

I. INTRODUCTION

The NanoEl project [1], of which the Home Webpage is showed in Fig. 1, focuses on a closer cooperation within Universities, adding transparency of qualification and recognition methods on MSc degree level. Course development is aiming the new skills needed in order to fulfill the professional multidisciplinary requirements within the area of Nanoelectronics. Only few research teams, laboratories and companies are able to fulfill this technological challenge. In order to over bridge lacking resources, the project NanoEl, supplies a shared infrastructure between several European Universities, including technological and human resources, and recognizes the mutual ECTS certified course modules used in MSc programs within the Nanotechnologies field. NanoEl will support course development performed by the most qualified laboratories and University departments, disposing of the necessary practical infrastructure. NanoEl will also develop e-learning courses and support the recording of practical exercises in clean rooms of nano/biotechnology labs. Aspiring students need to successfully perform the practical opponents’ in order to become part of the nano/biotechnology labs.

II. THE NanoEL COURSES AND LABS

The final goal of NanoEl is the student mobility, and the transfer of the students to external Universities is done for the practical work (Hands-On sessions), else the theoretical preparation and the study of what will be done in the laboratory sessions are done remotely, strongly using e-learning platforms. With this approach, the setup of a network of Universities where the laboratories can be done, opens a lot of new possibilities. In fact for the students of one University is possible to do hands-on laboratories with instrumentations and expertise not present in their own place. They can study and be prepared in advance staying at their own institutes, and then they can move only for the practical works, saving time and expenses, but having a special experience, not possible if they were staying at home.

The laboratory exercises are developed using different methodologies. In the first training step, the necessary theoretical preparation is based on recorded material, published in the NanoEl website. Then, the laboratories are presented in different ways, depending on the goal of the work to be executed by the students:

A. The laboratory is live recorded and, in case it would be helpful, some supporting slides are showed on one half of the screen, and on the remaining screen section the practical operations are presented
B. In case of a use of a CAD tool, the screen where the work is executed is recorded, and all the steps are commented
C. A fully web-based laboratory is implemented, and all the laboratory is executed through a web browser

A. Laboratory live recording

One of the laboratories developed in NanoEl, based on live recording, is the experimental fabrication of nanogaps. In this laboratory custom electronic boards are used as control of the fabrication of the nanogaps. These boards are connected to a silicon chip, where are pre-deposited some
gold wires, in which the nanogaps are created by electromigration. All the fabrication process is controlled by a software. So, in the laboratory are present different parts: PCB boards, a silicon chip and a software control.

All these parts are presented in a video where, as can be seen in Fig.2, slides and live show of the devices are done together, allowing to the student to have a precise perception of which are the components involved in the hands-on work and in the meantime the practical procedures are clearly explained.

In another module prepared in NanoEl, where the course is on the preparation of Carbon Nano Tubes (CNTs) and their use in Nanoelectronics, a video related to the preparation of the CNTs was recorded. In that recording it is practically shown which are the steps in a laboratory to fabricate CNT electrodes.

B. CAD tool tutorial

In courses on Nanoelectronics, working at molecular level is an important topic to consider. For this reason in one of the NanoEl courses some CAD tools for simulation at molecular level are examined, Gaussian and Atomistix Virtual NanoLab.

For the training about the use of these softwares a tutorial, with the step-by-step tool configuration and simulation of a simple structure, is produced in a video (Fig. 4). The result is a merge of slides, practical work on the software and comments of simulation results.

With this approach is possible for the student have a clear idea of how to use the software and learn the basics as to be inside a real laboratory, so they will be more effective when they will develop the hands-on exercises in the lab rooms.

C. WEB based laboratory

One of the course developed is on the trend of technology for microelectronics, starting from the analysis of 100 nm to 20 nm nodes and concluding with novel beyond CMOS technological solutions (SET, CNFET, MOFET, CNT Wires, ...). Currently very few laboratories are available on these subjects in the micro and nanoelectronics teaching scenario. Practical exercises are provided by a WEB based tool (Fig. 5) for the analysis and the impact of technological choices at device and system level, both for CMOS and beyond CMOS structures.

III. CONCLUSIONS

The NanoEl project is a joint effort of several Universities with the goal of exchanging students for doing lab exercises in the different places, having the possibility to have a potentiality of tools and instruments larger than the one available at their own University.

The preparation of the laboratories is done exploiting as much as possible e-learning methodologies, so the students can start to study the laboratory exercises remotely and be more ready when they will be in the hosting institution and
do the real work.

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REFERENCES

[2] MASTAR (Model for Assessment of CMOS Technologies And Roadmaps) available free of charge, ST-Microelectronics courtesy; available on ITRS web site