EURO-DOTS : A new EC Support Action for Doctoral Training in Europe

Michel Declercq, EPFL Lausanne and MEAD S.A., Switzerland (michel.declercq@epfl.ch)
Herman E. Maes, IMEC Leuven and KULeuven, Belgium (maesh@imec.be)

I. OVERALL OBJECTIVES OF THE SUPPORT ACTION

The EURO-DOTS (Doctoral Training Support) action is aimed primarily at improving the offer and the quality of training proposed to European PhD students. It helps fulfilling the new requirements for ECTS credits imposed to PhD students by major European universities for obtaining the Doctoral (PhD) degree in Engineering.
A coherent set of advanced courses in micro/nanoelectronics explicitly accredited by major European universities in the framework of their Doctoral Program, will be made easily accessible to European PhD students, offering the opportunity to collect ECTS credits thorough Europe.
The global objective is to create a delocalized (virtual) platform for supporting the Doctoral Schools in Europe in micro/nanoelectronics.
The courses will respect specific organization criteria (short, intensive one-week modules with optional exam) that will make them very flexible, accessible and attractive as well for high-level continuous education of engineers from industry.
Scholarships will be made available to PhD students for boosting the start-up of the project, while other sources of scholarships will be explored for the long-term continuation of the project.

II. PhD STUDENTS AND SCIENTIFIC BACKGROUND

The field of Micro/nanoelectronics has reached today a high-level of complexity and is entering in a period of major moves. As a matter of fact:

- In this “more Moore” era for CMOS, major challenges are appearing at the level of deep sub-micron technologies, characterization techniques, device physics, device models, circuit design techniques using low-voltage and leaky devices, spread of device parameters, power dissipation and many others.
- In the so-called “More than Moore” domain, new opportunities are emerging every day with the capability to combine a wide variety of components in a SoC or SiP and microsystems approach, opening the door to numerous innovative applications in RF, automotive, biomedical and numerous others.
- In the “beyond CMOS” field, totally new components are issued from disruptive research, including SET, nano wires, CNT and others, that request to reinvent circuit and system design techniques.

In the framework of the basic engineering curriculum (Bachelor and Master degrees), it is nearly impossible to cover all these fields in detail up to the state-of-the-art level. For this reason, doctoral training programs (doctoral schools) have been created for allowing PhD students to select a set of advanced courses that fit their needs for their PhD thesis.

III. NEW RULES IMPOSED BY MAJOR EUROPEAN UNIVERSITIES FOR PhD STUDENTS

Requirements imposed to PhD students for obtaining their degree have known a significant evolution during the last few years, taking into account the increasing complexity of the engineering fields as explained here above.
Even if some differences exist between universities, typical rules can be summarized as follows:

- Strict admission requirements;
- Final admission after one year, conditioned by the approval of a jury, on the basis of a sound research program;
- PhD students must follow a doctoral training program and collect a number of ECTS credits. At present the requirements differ from university to university, at EPFL: 12 ECTS, at KULeuven >6 ECTS, at KTH and STUBA >12 ECTS;
- Research progress reports must be produced annually;
- At least one scientific publication in an international journal and/or presentation of a paper at a major international conference in the field is mandatory;
- A final PhD exam must be presented in front of an international jury within a timeframe of four years;

IV. ECTS CREDITS (EUROPEAN CREDIT TRANSFER SYSTEM)

ECTS is an European learner-centered system for credit accumulation and transfer based on the transparency of

learning outcomes and learning processes. It aims to facilitate planning, delivery, evaluation, recognition and validation of qualifications and units of learning as well as student mobility. ECTS is widely used in formal higher education and can be applied to other lifelong learning activities.

ECTS credits are based on the workload students need in order to achieve expected learning outcomes. Learning outcomes describe what a learner is expected to know, understand and be able to do after successful completion of a process of learning. They relate to level descriptors in national and European qualifications frameworks.
Workload indicates the time students typically need to complete all learning activities (such as lectures, seminars, projects, practical work, self-study and examinations) required to achieve the expected learning outcomes.
60 ECTS credits are attached to the workload of a full-time year of formal learning (academic year) and the associated learning outcomes. One academic year corresponds to 30 weeks of courses.
Therefore, for intensive, modular courses such as the courses considered in this doctoral program, a one-week course, completed by the personal work and exam, corresponds to 3 ECTS credits.

Credits are awarded to individual students after completion of the learning activities required by a formal program of study or by a single educational component and the successful assessment of the achieved learning outcomes. Credits may be accumulated with a view to obtaining qualifications, as decided by the degree-awarding institution. If students have achieved learning outcomes in other learning contexts or timeframes (formal, non-formal or informal), the associated credits may be awarded after successful assessment, validation or recognition of these learning outcomes.

V. PROBLEMS TO BE ADDRESSED

Today, Engineering Schools or Universities are confronted with the problem of organizing high-level doctoral programs covering several engineering fields at the state-of-the art level, i.e. in direct connection with research. Especially in view of the increasing multidisciplinary nature and content of the emerging research domains, a broad but in-depth coverage of related problems has become indispensable. If major European universities are at the top level in some specific research fields, they can however hardly cover the whole domain of microelectronics and microsystems, both for scientific and financial reasons. The doctoral program they can offer is therefore restricted to some fields, and can hardly cover all the special topics that could be requested by innovative PhD topics.

On the other hand, for PhD students, the choice of doctoral-level courses is mainly restricted today to local courses for various reasons:

- foreign courses are hardly accessible because most courses are spread on a full semester at a rate of 1 or 2 hours per week;
- the cost for attending the few existing modular, intensive courses is actually prohibitive for students;
- ECTS credits are usually not offered today for these courses (no exam organized, no official recognition of the courses);

Another problem to be addressed is the fast moving field of microelectronics and microsystems. Some disruptive developments are expected in these fields in the near future, requesting a rapid and coherent answer of the doctoral courses and/or continuous education courses in order to maintain Europe at the state-of-the-art in R&D. An evaluation of medium and long term needs in high-level courses is therefore mandatory.
This has been since the very beginning one of the salient objectives of the ETCB, the Education and Training Coordinator Board of the European Nanoelectronics Research Platform ENIAC (the European Nanoelectronics Initiative Advisory Council). It was emphasized that the mission of the Nanoelectronics-related research teams in academia was not only to perform ground-breaking research in the relevant areas but also to provide education and experience to graduating students to allow them to successfully pursue a career in Nanoelectronics. Matching the ‘technology push’ from the science and engineering community with the ‘market pull’ from the industrial partners and end-users, is essential to ensure that the research is industrially and economically relevant and maximally beneficial to society. This engages academia and industry alike. For this purpose the ETCB had proposed a Strategic Action Plan in which a survey and assessment was to be made of the Education and Training (E&T) curricula in European Universities in nanoelectronics, complemented with an identification of the near and long term needs of industry, an analysis of the supply gap and finally the establishment of an E&T Roadmap that would close the gap. Essential in all of this is that the selection, preparation and adaptation of relevant course modules would be very dynamic and able to respond quickly to identified needs and adequate to address also professionals. As it became obvious that such rapid and in-depth adaptation of courses at master level is rather limited and nearly impossible, it has also been decided by the ETCB to focus primarily on PhD course modules and to include ease and room for adaptation as one of the important criteria. The plan was approved by the ENIAC SCC and the CSA proposal submission received full endorsement.

VI. SOME EXISTING EXPERIENCE AT THE ORIGIN OF THE CONCEPT OF THIS SUPPORT ACTION

- Modular, intensive one-week courses (3 ECTS credits including report and exam) offer a good formula that eases the participation to courses in different countries/universities for European PhD students;
- Such high-level, well-focused modular courses address both PhD students (Doctoral School) and engineers from industry (continuous education, see also the ENIAC E&T mission).
- This formula has been successfully experienced with PhD students during the last 4 years at EPFL, where the summer courses in microelectronics have been officially accredited by the Doctoral School. ECTS credits are offered after the successful presentation of an exam. (In 2009, more than 60 such oral exams have been organized in this framework).
- Both IMEC/KULeuven and MEAD/EPFL actually already offer several such high-level modular courses. Their fields are complementary, covering respectively technology and MEMS at one side and Circuit Design at the other side. Moreover, a close cooperation is foreseen for the creation of design courses for technologists, and technology courses for designers (for which already modules exist, such as a Technology Aware Design package at IMEC).
- STU Bratislava is developing and offering the advanced courses related to complex characterization of advanced semiconductor materials, structures, devices, circuits, and systems based on complementary electrical, analytical and optical characterization methods. Increasing sensitivity and resolution down to nanometer region is a very important part of those courses.
- At present KTH Royal Institute of Technology offers larger courses (7.5 ECTS) on this level, and modules can easily be extracted from these. Proposed modules are for instance drift diffusion and balance equation based device simulation, Monte Carlo based device simulation, Design of Experiments (DoE), Statistical Process Control (SPC), and variability in device and circuit design. Also electrical characterization courses for SPICE parameter extraction, high frequency devices, or 1/f noise. To exploit the European leading facilities within the NANOSIL network, KTH is also planning advanced process technology lab course modules, for instance on sidewall transfer lithography for FinFETs.
- Innovation and entrepreneurship are of utmost importance for today's demand in the working life of the new PhDs. Hence, modules in these topics will be integrated in the EURO-DOTS program.

VII. CONCEPT OF THE SUPPORT ACTION

The present Support Action is aimed at addressing the problems described here above. It involves:

- A study of medium/long-term needs in advanced education in micro/nano-electronics;
- A survey of available and appropriate course offerings at European Universities and/or Education & Training centers, that could fulfill the imposed requirements;
- The creation of new courses based on these surveys, filling the gap in existing courses, as necessary and the set-up of a comprehensive set of doctoral-level, modular courses in microelectronics. These courses will progressively cover the full field ranging from advanced device physics and technology supported by advanced characterization techniques to circuit and system design, and address state-of-the-art questions in the so-called "More Moore", "More than Moore" and "Beyond CMOS" domains; A framework will be created that will allow PhD students to easily get ECTS credits throughout Europe : financial support, accreditation of courses for PhD ECTS credits, organization of exams, etc. A certificate of attendance and of successful completion of the exam would be issued to PhD students, mentioning the corresponding number of credits. However, the full and unique responsibility for delivering the doctoral degree remains of course at the university of origin of the student.
- The attribution of scholarships to PhD students that fulfill the imposed conditions. Scholarships that are included in this proposal are necessary for the smooth start-up of the European Doctoral School. Other sources of scholarships, such as People (Marie Curie), will be studied during the course of the project and will be proposed for the long-term continuation of the action.
- Proposed scholarships will cover approximately half the costs of the PhD student fulfilling the rules.

The organizing consortium consists of partners that have ample experience with such pan-European course offering and that are prepared to join forces in working out a workable concept. It includes IMEC (BE), EPFL (CH), KUL (BE), MEAD (CH), KTH (S) and STUBA (SK). The Action is however totally open. Several major Universities, Research and Training Organizations will be consulted in the course of the project and calls will be open for course proposals.

As mentioned above, close links will be established with ENIAC. The EURO-DOTS Support Action fully fits within one of the Objectives of the ETCB (Education and

Training Coordination Board) . Moreover, also links with EUROTRAINING and other European initiatives will be explored. The partners in the present consortium are active members of both Actions and are therefore in good position to guarantee this coordination. Last but not least, whenever appropriate, links will also be established in due time with the EIT (European Institute of Technology).

VIII. PRACTICAL IMPLEMENTATION & WORKING RULES

Academic Committee

An Academic Committee (AC) will be installed. The key role of this Academic Committee is to decide on the accreditation of the proposed courses for being accepted in the EURO-DOTS Platform and on the selection of suited course modules. This accreditation is based on the criteria defined here after.
Members of the AC will mainly be selected among professors in Micro/nano-electronics from major European universities, including directors of local doctoral programs.
The AC will guarantee an objective safeguarding of the quality of the selected courses, with full respect of the accreditation rules, and the overall coherence of the course package offered by EURO-DOTS.

Eligibility Criteria for Course Modules

For course modules to become part of the EURO-DOTS Platform, they will have to fulfill specific criteria on which the possible selection by the Academic Committee (see WP4) will be based. Besides strict requirements on quality and scientific level, also a set of criteria will be established for the accreditation of the submitted courses, inspired by the existing rules at European Universities. The set of rules also has the purpose of easing the mobility of European PhD students and must guarantee the possibility to acquire ECTS credits.

The criteria will therefore be based on the following rules:

- modular, intensive course (by preference of one week duration)
- timely announcement of the course containing all details on program and organization.
- quality and scientific level: content, handling and reference to actual state-of-the-art issues, teachers and mixture of speakers, expertise of the organizing group in the covered field, lecture notes, infrastructure and organization, etc
- degree of response to the industrial E&T needs and the recommendation for new specific course modules
- accessibility to both PhD students and professionals. Flexible format to address PhD students (Tutorial introductions, hands-on sessions, lectures) and professionals (lectures with reference to industrial needs and issues)
- registration fee of PhD students within an imposed limit
- course fitting the rules for the proposed number of ECTS credits (hours, level)
- course accredited by the Doctoral School of at least one major European university at the start of the project, to be progressively accredited by the Academic Committee within the course of the project
- exam/evaluation organized at the completion of the course and issue of a certificate for ECTS credits

Rules for Attribution of Scholarships

Proposed scholarships will cover approximately half the costs of the PhD student fulfilling the rules. Considering that the total cost includes the course registration fee, travel expenses and subsistence, the scholarship will be limited to the coverage of course registration fee.

In order to be eligible for a scholarship, a PhD student must fulfill a set of requirements that will be edited. These requirements may include some of the following criteria:

- proof of registration as a PhD student in a European university;
- at least one year of PhD work completed with final acceptance in the doctoral program of their university of origin;
- certificate from the PhD advisor that the acquired ECTS credits by the PhD student will be accepted by the home university;
- the course should fit with the PhD topic of the student (short justification required);
- the student takes the engagement to take the exam;
- scholarships are restricted to one per student (to be revised during the course of the project);
- students can not apply for scholarships for courses organized by their home university;

IX. CONCLUSION

The EURO-DOTS Support Action is aimed at paving the path towards a delocalized (virtual) platform for support of the European Doctoral Schools in micro/nanoelectronics in Europe.

EURO-DOTS is a Support Action funded by the 7th Framework Program of the European Union, starting on May 1st, 2010.

CONTACT, info & registration for PhD Students:
euro-dots@mead.ch