European Doctoral Training Support in Micro/Nano-electronics-2

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Report 1 on the identification of Needs from Industry

Deliverable D1.2

Work Package 1 – EURO-DOTS platform operation and course portfolio management

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Abstract :

In this Deliverable a short update is provided of the Needs as expressed by industry. This update was made based on the response to the previous list and on the discussion at the first Consortium Meeting of 17-18 June 2013

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1. Introduction

This document contains the update of the needs that have been identified in the course of EURO-DOTS-1 and which was used in the 3th Call for proposals. Based on the response from course providers and on the filling in of these needs, the list has been updated and this will be used for the next call for Courses that will be launched in August 2013. It was agreed that the further analysis of needs which will lead to Report 2 after 1 year within the project, will be made by involving the members of the 2 committees and by direct and personal contacts with selected companies and universities.

2. List of Needs

Within EURO-DOTS-1 surveys have been made regarding the needs for education at the PhD level in nano-electronics. The results and conclusions of these surveys (first exercise) were described in Deliverables D1.1 and D1.2. As a conclusion of these surveys, a list of topics/themes of high priority were identified by industry and academia. These themes are (without order of preference and coming from D1.2 in EURO-DOTS-1) :

- Wide technical knowledge : e.g. system, process and modeling for designers
- Wide market knowledge: market analysis, societal analysis…
- Design for high robustness (6 sigma, corner variations, rough environments)
- Design for testability (in a production environment with automated testers)
- Robust design
- Power electronics
- Basic high-voltage IC design techniques
- High-voltage devices
- Basic elements of biology
- Statistics
- Fundamental physics
- Broad knowledge of electronics (not just the subject of the thesis)
- Math skills, like statistics
- CMOS operation, CMOS scaling (advanced)
- CMOS processing: MBE, CVD, ALD, etch, litho…
- Characterization techniques: RBS, SIMS, TEM
- Technology, processes to build devices

- Advanced microprocessor architectures
- Low-power techniques of IC design
- Hardware and embedded software co-design
- Statistical modeling and simulation methodology
- Safe state machine (hardware and software) design, formal proof

This list does not hold many surprises.

A second list of themes was extracted from an overview of PhD courses organized at numerous universities in Europe (including some of the partners of EURO-DOTS), not necessarily providing 1-week modules, but rather few day courses. These topics could rather form the content of a full course or be combined with other topics to result in a comprehensive course. These themes are (Deliverable D2.4 in EURO-DOTS-1)

- Emerging, disruptive and/or prospective materials and devices: properties, preparation, applications mainly for More than Moore and Beyond CMOS
- Bio-electronics, bio-medical engineering, bio-sensors
- Physical and electrical characterization of materials and structures: techniques, principles, equipment, applications
- Organic semiconductors and devices: theory, technology, characterization, applications
- Material, process, and device modeling and simulation: methodology, tools
- Optoelectronics / photonics / also photovoltaics: devices, principles, technology, measurement, parameters
- Sensors, actuators, microsystems, smart systems: physics, modeling, technology, applications)
- Nanotechnology “Beyond CMOS”, nano-electronics: structures, preparation, analysis, applications
- More specific micro/nano-electronic and technology applications: e-health, environment, energy harvesting, security and safety,
- 3D technologies, packaging issues, wafer bonding should be included in relevant courses.

In a third exercise (see Deliverables D2.3 and D2.4 in EURO-DOTS-1) these topics were compared with the existing course offering in the EURO-DOTS portfolio after 18 months of EURO-DOTS, at the time when a new call was to be launched. Based on that comparison, a priority list was made up, in which the topics appearing on top of the list were those that were not (or hardly) addressed, whereas the topics at the bottom had received some or minor coverage. The used ‘priority’ reference was somewhat misleading and only referred to the level of coverage by already existing courses. The themes mentioned above that were already fully or to a large extent covered by the

available EURO-DOTS courses were not even retained in this list. This resulted in the following recommendation for coverage (see the General and WP2 Presentations at the Final Review Meeting of EURO-DOTS) :

1. Highest priority

1) electronic system design flow; design of embedded systems & software
2) advanced signal processing for electronic systems
3) integrated high-voltage, high-power design & technology (GaN, SiC...)
4) variability effects and their mitigation in advanced technologies
5) advanced sensors and smart sensor systems
6) 3D integration : technology and design
7) security and dependability in electronic systems

2. High priority

8) opto-electronics and photonics (incl. PV)
9) high-frequency and mm-wave IC design
10) energy harvesting and autonomous applications
11) design for short-range applications (WSN, BAN...)
12) IP management and valorization (for PhD students)

3. Lower priority (due to already partial overlap with existing courses)

13) biomedical electronics & biosensors
14) reliability and testing of ICs
15) emerging materials and devices (advanced)
16) organic electronics: technology and design

Some courses that were submitted and organized in response to this 3th Call for courses indeed addressed some of these topics/themes. These are the topics that are underlined in the list above. The other themes have not or have only marginally been covered. A discussion with members of the Academic, Scientific and Steering Committees at the 1st Consortium Meeting of EURO-DOTS-2 led to the conclusion that all these themes remain important and that no priority should be assigned, as was done before. Moreover a number of other themes were recommended : Nanotechnology for Health, MEMS for RF applications, smart system integration. Instead of the theme under heading 12, it was agreed to add "innovation" to this theme. Finally, also topics fully covered in some courses should remain in the list, as each year a new flow of PhD students arrives and many of them are looking for such themes. These could be covered by re-organizing formerly successful courses.

This leads to the following list of topics that will used in launching the next Call for Courses in August 2013. The themes/topics are now listed more or less in alphabetical order.

- Advanced microprocessor architectures
- Advanced sensors and smart sensor systems
- Advanced signal processing for electronic systems
- Basic elements of biology

- Basic high-voltage IC design techniques
- Biomedical electronics & biosensors
- Broad knowledge of electronics (not just the subject of the thesis)
- Characterization techniques: RBS, SIMS, TEM, ...
- CMOS operation, CMOS scaling (advanced)
- CMOS processing: MBE, CVD, ALD, etch, litho…
- Design for high robustness (6 sigma, corner variations, rough environments)
- Design for short-range applications (WSN, BAN...)
- Design for testability (in a production environment with automated testers)
- Electronic system design flow; design of embedded systems & software
- Emerging materials and devices (advanced)
- Energy harvesting and autonomous applications
- Fundamental physics
- Hardware and embedded software co-design
- High-frequency and mm-wave IC design
- High-voltage devices
- Integrated high-voltage, high-power design & technology (GaN, SiC...)
- IP management, innovation and valorization (for PhD students)
- Low-power techniques of IC design
- Math skills, like statistics
- MEMS for RF applications
- Nanotechnology for Health
- Opto-electronics and photonics (incl. PV)
- Organic electronics: technology and design
- Power electronics
- Reliability and testing of ICs
- Robust design
- Security and dependability in electronic systems
- Smart system integration
- Statistical modeling and simulation methodology
- Safe state machine (hardware and software) design, formal proof
- Technology, processes to build devices
- 3D integration : technology and design
- Variability effects and their mitigation in advanced technologies
- Wide technical knowledge : e.g. system, process and modeling for designers
- Wide market knowledge: market analysis, societal analysis…

After the launch of the call, a new analysis will be done and a refined extraction of uncovered course topics will be made. This will be the content of deliverable D1.5 at month 12.

The members of the Academic Committee, together with the partners will use the list above to identify colleagues in their network who are experts in some of the topics/themes and to approach these colleagues and encourage them to work out a new course or adapt an existing course is

response to this call. This action has been agreed at the Consortium Meeting. It should also be noticed here that the theme Nanotechnology for health will already be covered in a course submitted by imec (and organized on 23027 September 2013) and which has been approved by the AC. KTH intends to submit a course on IP management and Innovation.

3. Conclusions

Based on the studies carried out in EURO-DOTS-1, the result of the 3 calls for courses and the discussion held at the 1st Consortium Meeting on 17-18 June 2003, an adapted list of topics/themes considered by industry and academia as of major importance for the future developments in the nano-electronics field is proposed. This list will be used in the next Call for Courses and will be used by the members of the Academic Committee and the Steering Committee to personally address colleagues in their network in order to enhance the chance for success and increase the involvement of the real centers of expertise in the different fields.