PolyNet

# Report on the existing training programs for students and young researchers in the field of Organic and Large Area Electronics


Responsible for this report: Prof. Gilles Horowitz, Université Paris Diderot
horowitz@univ-paris-diderot.fr



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# Contents

# 1. Questionnaire concerning the educational situation in Europe

## 1.1. Introduction

The industrial members of the *European Organic and Large Area Electronics Community* are experiencing currently a growing demand of well-educated personal for the emerging industry. To gather broader information about the European situation the Quadriga projects Polynet and PRODI developed in close cooperation with the Organic Electronics Association a questionnaire which was sent to about 500 institutions, companies and individuals using the mailing lists of POLYNET, PRODI, OPERA, POLYMAP, OE-A and ORGAPVNET.

The goal of the questionnaire was to collect broader information about needs of the industry and offers from the institutions of education in Training and Education in Large Area Electronics in Europe as a whole and foster the network of the community.

We received about 50 detailed responses corresponding to a response rate of 10 % representing answers from 16 counties: Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Italy, Netherlands, Poland, Russia, Spain, Sweden, Switzerland, United Kingdom, USA.

## 1.2. Summary of offers and needs regarding the education in OLAE

| Subject | T&E offer | Planned T&E offer | T&E requested | T&E requested form |
|---|---|---|---|---|
| introduction into large area electronics | 4 | 1 | 3 | master study, workshop, lecture |
| markets | 3 | 1 | 11 | see Table 2 |
| materials | 10 | 2 | 11 | lecture, seminar |
| flexible substrates | 3 | 1 | 6 | lecture, seminar |
| barrier materials | 1 | | 7 | seminar, workshop |
| sealants | | | 5 | seminar, workshop |
| adhesives | | | 4 | seminar |

***Table 1**. Education and training offers and demands in major fields of OLAE*

Table 1 summarizes offers and needs regarding the education in different subjects of OLAE. It reveals major knowledge deficiencies but strong interest regarding support materials (substrates, barrier materials, sealants, and adhesives), markets and fabrication technologies. The requested education forms are the regular ones known from further education and training but we see direct requests for master study programs at universities.

## 1.3. Summarized demands and offers

| Market, development | T&E offer | T&E offer form | Planned T&E offer | T&E requested | T&E requested form |
|---|---|---|---|---|---|
| Roadmap of organic electronics | 4 | Seminar, lecture, conference and summer school | 1 | 12 | Paper, conference, seminar, white paper, newsletters, workshop, lecture |
| Roadmap of inorganic electronics | | | | 9 | Paper, conference, seminar, white paper, newsletters, workshop |
| Organic electronics market/ inorganic electronic market | 1 | lecture | | 9 | Lecture, conference, seminar, white paper, newsletters, workshop |
| Market Segment | | | | 6 | Lecture, conference, seminar, white paper, newsletters, workshop |
| Business start-up in EU: some good example of OLAE | | | | 1 | workshop |

***Table 2**. Education and training offers and needs in the field of market development*

Obviously, there exists a strong demand to learn more about the emerging market of OLAE. Table 2 dislpays demands and offered forms and underlines that the appropriate subjects shall be moved in the focus of education activities for small and medium sized companies.

A third field of knowledge support which we consider to be urgent is the understanding of the different devices which are known from inorganic electronics and currently ported to OLAE technologies. Table 3 shows that the community shall focus on forms of further education and training.

| Devices of organic / inorganic electronics | T&E offer | T&E offer form | Planned T&E offer | T&E requested | T&E requested form |
|---|---|---|---|---|---|
| Electrochrome displays | 1 | lecture | 1 | 8 | seminar, lecture, master studies, summer school |
| Photovoltaic cells | 6 | Workshop, lecture | 2 | 7 | seminar, lecture, summer school, workshop |
| memory | 1 | | | 8 | Seminar, lecture, master studies, summer school |
| RFID | 2 | lecture | | 9 | Seminar, master studies, lecture, summer school |
| sensors | 2 | lecture | 2 | 9 | Seminar, master studies, lecture, summer school |
| Flexible power source | 1 | lecture | 1 | 6 | Lecture, seminar, summer school |
| Smart objects | 1 | | | 6 | master studies, seminar, lecture, summer school |
| Passive devices | 1 | lecture | | 7 | master studies, seminar, lecture |

***Table 3.*** *Education and training offers and needs in the field of devices of organic and inorganic electronics*

The actual competence needs of the industry are rising from the growing activities in the industrial R&D sector and they are concentrating on bachelor, master and PhD degrees from Universities directly or well organized further education of employees with university education. In parallel with the growth of the Industry we will see growing demands to train employees on technician level and even production associate level.

The analysis indicates that the education of the personal for major industrial players (e.g. Merck Chemical Ltd, Agfa Gevaert, PolyIC GmbH & Co. KG, SOFILETA, Solaronix or Solvay S. A) will be the challenge for the European education institutions which should establish a close cooperation and develop education and training programs jointly.

# 2. Identified courses and lectures

Organic and large area electronics is an emerging technology. For this reason, education at the undergraduate level appears to be very limited, if not quasi absent, in the educational programs of European universities and technology institutes. In this first report, we will therefore restrict ourselves to the Master level, and more particularly the second year of the Master, where the great majority of the education and training activity is concentrated.

Our investigation on the currently available offers in education and training in organic and large area electronics mainly consisted of a search through the internet. We also used the information gathered after short questionnaire that was sent to the partners of the PolyNet network and to other national networks (particularly in France).

## 2.1. Masters in Organic Electronics

Through this first inquiry, we have identified two master courses that are entirely devoted to organic electronics; one was given in the University of Linköping, in Sweden. It is worth pointing out that this first master course was discontinued in 2008 because of a lack of students. The second course is a project that is expected to start in the year 2009 in the south-west of France; the courses are split over three universities (Limoges, Bordeaux and Toulouse), each of which focusing on a particular electronic device (field-effect transistors in Limoges, light-emitting diodes in Bordeaux and photovoltaic cells in Toulouse).

### 2.1.1. Main characteristics

The main characteristics of these two master courses are detailed in Table 4.

| Institution | Person in charge | Title of the master | Teaching methods | Notes |
|---|---|---|---|---|
| Linköpings Universitet, Sweden | Mats Fahlman | Organic electronics | | Discontinued in 2008, will reopen in 2009 |
| Université Limoges, France<br>Université Paul Sabatier, Toulouse, France<br>Université Bordeaux I, France | Thierry Trigaud | Organic electronics and optoelectronics | lectures (180h)<br>lab work (90h) | To be started in 2009 |

***Table 4.*** *Identified master courses entirely devoted to organic electronics.*

### 2.1.2. Examples of master program

The example presented is that of the project developed by three universities of the south-west of France. The program extends over two semesters, the first one comprising lectures and lab work, while the second semester consists of a six-month stay in a research laboratory. Each of the three universities has specialized in a given organic electronic device: organic field-effect transistors in Limoges, organic light-emitting diodes in Bordeaux, organic photovoltaic cells in Toulouse. An overview of the program of the first semester is given in Table 5.

| Institution | Topic |
|---|---|
| Bordeaux (OLEDs) | • Small molecules — polymers<br>  • physicochemical properties<br>  • characterization<br>• Deposition from the solution<br>• Structures of OLEDs; basics of colorimetry and photometry<br>• Materials in OLEDs<br>  • active materials (small molecules, polymers)<br>  • electrodes<br>• Electrical and photometric characterization<br>• Improving the efficiency<br>  • band engineering; multi-layer systems<br>  • fluorescence, phophorescence<br>  • doping<br>• OLEDs in displays: State-of-the-art, properties, addressing the pixels<br>• OLEDs in lighting: State-of-the-art, properties, obtaining white emission |
| Toulouse (OPVs) | • Doping semiconductors<br>• Organic pn junctions<br>• Charge transport in diodes and transistors<br>• Chemical bonding; sp2 carbon, pi-bonding, band structure and interfaces<br>• Intermolecular forces; adhesion of multi-layers, wetability of structured and micro-structured surfaces<br>• Analysis of surfaces (NMR, IR, Raman, ESCA); aging<br>• Why photovoltaic cells?<br>• Operating mode; characterization<br>• Drawbacks and workarounds; prospective<br>• Characterization of organic semiconductor layers by ellipsometry; aging in air, humidity and with temperature<br>• Matter-jet deposition, soft lithography, innovative processes |

| | |
|---|---|
| Limoges (OFETs) | • Dry deposition techniques for organic thin films<br>• Operating mode of the MISFET<br>• Charge transport in OFETs in the channel and at interfaces; photoconductivity<br>• Interface engineering; the various structures of OFETs; electrical characterization<br>• Materials for OFETs; transparent electronics; optical characterization; aging<br>• Physics and technology of the deposition techniques<br>  • ion beam assisted deposition (IBAD)<br>  • silk printing<br>• Applications<br>  • active matrix<br>  • RFID<br>  • phototransistors |

***Table 5.*** *Program of the master course in project in the south-west region of France.*

## 2.2. Lectures on organic electronics at Master and PhD level

Alongside with these two master courses, we have identified several more general master courses that include at least one lecture that can be clearly identified as pertaining to the domain of organic and large area electronics.
The list is based on the report "Organic & Printed Electronics in Europe" (Peter Harrop, Susann Reuter and Raghu Das) published by IDTechEx in April 2008

### 2.2.1. OLAE lectures & courses in EUROPE

#### *2.2.1.1. Lectures & courses in Austria*

##### ***2.2.1.1.1. Graz University of Technology***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | 513.141 Organic Semiconductors - Fundamentals and Applications | | lectures | 40h | 3 |
| **Aim/Contents** | • Introduction to organic semiconductors<br>• Molecular & crystalline structure, liquid crystals<br>• Theoretical models for the description of the electronic structure<br>• Charge transport in organic semiconductors<br>• Photophysical properties<br>• Nonlinear optical properties. two-photon absorption<br>• Optoelectronic devices (OLEDs, plastic solar cells ...)<br>• Field effect transistors | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | 513.201 Organic Electronics | Msc Advanced Materials Science<br><br>Msc Technical Physics | Lectures & lab work | 30h | |

| | |
|---|---|
| **Aim/Contents** | • Introduction to Pi-Conjugated Materials<br>• Introduction to basic principles of Organic Chemistry<br>• Structure to Property Relations in Organic Semiconductors<br>• Organic Conductors and Coatings<br>• Electrochromic Devices<br>• Sensors<br>• Processing techniques I<br>• Processing techniques II<br>• Basic Principles of Organic and Polymer LEDs<br>• Organic and Polymer LEDs: Displays and Lighting<br>• Organic Solar Cells<br>• Organic FETs |

#### *2.2.1.1.2. Johannes Kepler University*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Organic Electronics | MSc Industrial and Polymer Engineering | lecture | 3h/week | 4.5 |
| **Aim/Contents** | | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Lab. Course Organic Transistors | MSc Industrial and Polymer Engineering | Lab work | 4h | 6 |
| **Aim/Contents** | | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Lab Course in Organic Electronics Practical | MSc Industrial and Polymer Engineering | Lab work | 4h | 6 |
| **Aim/Contents** | | | | | |

### *2.2.1.2. Lectures & courses in Finland*

#### *2.2.1.2.1. Åbo Akademi University Finland*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Ronald Österbacka | Organic electronics | Msc Materials Technology | Lecture & seminars | | 3 |
| **Aim/Contents** | Principles of operation and device physics of organic electronic devices such as light emitting devices, solar cells, organic transistors, bistable devices, electro-chemical transistors... | | | | |

### *2.2.1.3. Lectures & courses in France*

#### *2.2.1.3.1. Bordeaux I University*

This university is involved in the Msc "Organic electronics and optoelectronics" to be started in 2009 and described in section 2.1.2.

#### *2.2.1.3.2. Ecole Centrale de Lyon*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Jacques Tardy | Plastic optoelectronics | Msc Integrated electronic devices | lectures | 2 | |
| **Aim/Contents** | | | | | |

#### *2.2.1.3.3. Ecole Nationale Supérieure des Techniques Avancées ENSTA*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Organic electronics | Msc Technological innovation | lectures<br>lab work | 6h<br>10h | 1.5 |
| **Aim/Contents** | | | | | |

#### *2.2.1.3.4. Ecole Polytechnique*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Yvan Bonnassieux, Bernard Geffroy | Organic electronics | Msc Electrical engineering | lecture<br>lab work | 4h<br>8h | 1 |
| **Aim/Contents** | • introduction to organic semiconductors<br>• charge transport in organic semiconductors<br>• optoelectronic devices (OLEDs, plastic solar cells ...)<br>• field effect transistors | | | | |

#### *2.2.1.3.5. Ecole Supérieure des Mines de Saint Etienne*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Jean-Luc Autran | Plastic electronics | Msc MINELEC | lectures | 20h | 3 |
| **Aim/Contents** | | | | | |

#### *2.2.1.3.6. Lille I university*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Kamal Lmimouni | Molecular and organic electronics | Msc Micro and nanotechnologies | lectures | 15h | 3 |
| **Aim/Contents** | | | | | |

#### *2.2.1.3.7. Limoges University*

This university is involved in the Msc "Organic electronics and optoelectronics" to be started in 2009 and described in section 2.1.2.

#### *2.2.1.3.8. Paris Diderot University*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Gilles Horowitz | Organic electronics | Msc Molecules, materials, surfaces | lectures | 15h | 2 |
| **Aim/Contents** | • Introduction to semiconductor physics<br>• Inorganic electronic devices<br>  ○ pn junction<br>  ○ metal-semiconductor junction<br>• Organic electronic devices<br>  ○ Charge transport in organic semiconductors<br>  ○ OLED<br>  ○ Organic photovoltaic cells<br>• The field-effect trasnsistor<br>  ○ MOSFET<br>  ○ OTFT | | | | |

#### *2.2.1.3.9. Paul Sabatier University*

This university is involved in the Msc "Organic electronics and optoelectronics" to be started in 2009 and described in section 2.1.2.

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Pascale Jolinat | Organic microelectronics | Msc Micro and nanosystems | lectures | 10h | 1.5 |
| **Aim/Contents** | | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Pascale Jolinat | Organic semiconductors | Msc Materials for microelectronics | lectures | 10h | 1.5 |
| **Aim/Contents** | | | | | |

### *2.2.1.4. Lectures & courses in Germany*

#### ***2.2.1.4.1. Jacob University***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Dietmar Knipp | Organic electronics and photovoltaic | Msc Nanomolecular science<br>Msc communications and systems | | | 5<br>5 |
| **Aim/Contents** | | | | | |

#### ***2.2.1.4.2. Technical University of Chemnitz***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Arved C. Hübler | | Msc Media production | | | |
| **Aim/Contents** | | | | | |

#### ***2.2.1.4.3. University of Berlin***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Karlheinz Bock | Technologies of Polytronic Microsystems | | lectures | 24h | |
| **Aim/Contents** | | | | | |

### *2.2.1.5. Lectures & courses in the Netherlands*

#### ***2.2.1.5.1. University of Gröningen***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Bert de Boer | CHMFP05E. Electronic Properties of Polymers: Functional Polymers | Msc Chemical Engineering | Lectures | | 5 |

| | |
|---|---|
| **Aim/Contents** | This course is about polymers with special optical and electrical properties. More specifically, we will deal with semi-conducting polymers, or conjugated polymers. The latter two notions are more or less equivalent and we will see why. These polymers are new, promising materials. There are also some novel basic phenomena involved, some phenomena that had been predicted to exist or treated theoretically but were not found in actual materials until these polymers came along. Semiconducting polymers show these phenomena and make them experimentally accessible. Physicists were very delighted and began to take interest in polymers, finally. So, one prominent aspect of this field is that it is highly interdisciplinary. This field has evolved through the collaboration of solid-state physicists, polymer chemists, theoretical physicists and chemists, polymer engineers, physical engineers and even electrical engineers.<br>This course consists of 7 Chapters namely: 1. Introduction, 2 Electronic Structure, 3. Interaction with Light, 4. Charge Transport, 5. Solid-state Structure, 6. Synthesis and Molecular Design, and 7. Applications and Device Principles. |

### *2.2.1.6. Lectures & courses in Spain*

#### ***2.2.1.6.1. Universitat de Barcelona***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Molecular Electronics | Master in Nanoscience and Nanotechnology | | | 2.5 |
| **Aim/Contents** | • Introduction to molecular electronics<br>• Optical and photonic applications<br>o Liquid crystals based devices<br>o Molecular devices for non lineal optics<br>o Photovoltaic molecular devices<br>o Light emitting organic diodes (OLEDs)<br>o Optical based molecular memories<br>• Electronic and magnetic applications<br>o Molecular and polymeric conductors<br>o Organic field effect transistors (OFETs)<br>o Organic labels<br>o Flexible screens and electronic paper<br>o Smart fabrics<br>o Molecular and magnetic memories<br>• Chemical and biological applications<br>o Molecular sensors (molecular phenomena in electronic nose and tongue) | | | | |

### *2.2.1.7. Lectures & courses in Sweden*

#### ***2.2.1.7.1. Linkoping University***

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| Mats Fahlman | | Msc Organic electronics | Lectures<br>lab work | 2 years | 120 |
| **Aim/Contents** | Organic electronics are electronics based on semiconducting and conducting organic molecules and polymers. This master's programme has access to researchers on the cutting edge of a rapidly developing area of technology.<br>The core curriculum of the programme consists of a set of organic electronics courses covering molecular physics, material physics, design of electronics devices such as transistors and LEDs, and device fabrication. The programme gives skills in traditional electronics system design, with an emphasis on communication electronics and high frequency technology. Other courses deal with more general engineering topics such as project management and industrial economics.<br>The faculty includes two European Union Descartes Prize winners and two Göran Gustafsson Prize winners for research in the field of organic electronics. Linköping University is an international leader in the field of organic electronics and is number one in Sweden.<br>The programme is designed to prepare students for career options at cutting-edge developers of organic electronic applications or in the traditional electronics industry. | | | | |

### *2.2.1.8. Lectures & courses in the United Kingdom*

#### *2.2.1.8.1. Bangor University*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Organic Electronics | PhD<br>MPhil | Research | 3 years<br>2 years | |
| **Aim/Contents** | Research is undertaken into: Synthesising new monomers and polymers for electronic device application; Fabrication of polymer MISFETs, Schottky diodes, LEDs, electrical and optical characterisation of polymers and devices, AFM/EFM/Kelvin probe studies on fabricated devices | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | | MSc Organic Engineering | | | |
| **Aim/Contents** | Organic Electronic Devices are now emerging into the market place with Organic Light Emitting Diodes (OLEDs) being used in displays that range from camera viewfinders to large TV screens. Organic materials are also being developed for photovoltaic applications both in combination with oxides and as blends. Organic field effect transistors are now well advanced and are being integrated into sophisticated circuits for active matrix addressing of displays and for radio frequency identification (RFID) tags | | | | |

#### *2.2.1.8.2. Imperial College*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | The Plastic Electronics Doctorial Training Center | PhD | | | |
| **Aim/Contents** | The Plastic Electronics DTC aims to train doctoral scientists in this exciting, fast moving and interdisciplinary field. Students will take a 12 month MRes programme, the MRes in Plastic Electronics (subject to GSEPS and Senate approval) during which they will be taught the physics, chemistry, materials science and device engineering of plastic electronic materials and complete an interdisciplinary research project. They will receive hands-on training in diverse areas including microscopy, printing and processing, device fabrication and molecular modelling. Visiting industrial lecturers will teach advanced courses in the state-of-the-art methods and technology, and an option to develop the MRes project as an entrepreneurship exercise is offered. During the Ph.D., students will pursue their chosen research area in depth, under the guidance of two supervisors from different disciplines, and with continuing participation in advanced courses, and professional skills development. Some students will carry out projects in collaboration with industrial or overseas labs while others will visit such labs for specific measurements. Both experimental and theoretical projects will be available.<br>Examples of project titles include:<br>• Organic solar cells on flexible substrates<br>• Contact printed polymer thin film transistors for liquid crystal displays<br>• Modelling Light Efficiency Enhancement in Polymer LEDs<br>• Hybrid Organic/Inorganic Quantum Dot Photosensitive Devices<br>• Electroabsorption Spectroscopy of organic Light Emitting Diodes<br>• Phase behaviour of binary blend films for organic photovoltaics<br>• Complementary-like logic with organic field effect transistors<br>• Design, synthesis and characterisation of high mobility p-type organic semicondcuctors<br>• Molecular dynamics study of the self assembly of discotic liquid crystals<br>• Organic photodetectors for medical X-radiography<br>• Photophysical study of excited states in donor-acceptor blend films<br>The participating departments are Physics, Chemistry and Materials at Imperial and the School of Materials Science and Engineering at Queen Mary, University of London. Over 40 industrial and academic partners have offered their help in the design and support of projects. | | | | |

#### *2.2.1.8.3. University College London*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Plastic and Molecular Electronics (PME, PHASG474) | MSc Nanotechnology | lectures | | |
| **Aim/Contents** | Organic semiconducting (macro)molecules; Polymer-based light-emitting diodes (LEDs), Polymer-based photovoltaic diodes (PVDs), Polymer-based field-effect transistors, FETs, Molecular switches and motors, Supramolecular structures and dendrimers, Insulated molecular wires, IMWs and threaded molecular wires (TMWs). Discotic systems (e.g. hexabenzocoronenes (HBC), porphyrine and phthalocyanine, rylenes, perylenes, terrylenes, and quaterrylenes). Core-shell and other encapsulated systems. Biological and/or biomimetic structure of potential interest. Dendrimers and dendronised materials as a tool to control supramolecular architectures. Potential applications. | | | | |

#### *2.2.1.8.4. De Monfort University*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Printable Electronics | Msc MicroElectronics and NanoTechnologies (MEANT) | lectures | | |
| **Aim/Contents** | Covers materials (both organic and inorganic) used in printable electronics. You will study properties, fabrication methods, and applications of printable electronic devices such as LEDs and TFTs. You will learn and practice a variety of current and emerging printing methods used to fabricate electronic devices. | | | | |

#### *2.2.1.8.5. University of Liverpool*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| William Eccleston | Carbon based electronics | Micro and nano technologies | lectures | 18h | 3.75 |
| **Aim/Contents** | | | | | |

#### *2.2.1.8.6. University of Manchester*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Organic and inorganic semiconductor nanostructures | MSc in Nanoelectronics | lectures | | |
| **Aim/Contents** | Provide an advanced education in modern Organic and Inorganic Semiconductor engineering, emphasising the physical principles and their practical application<br>Provide practical training into the different stages of the fabrication of nanoelectronic component, from synthesis of the raw material to processing and fabrication of the final device, experiencing all the different stages of assessment | | | | |

#### *2.2.1.8.7. University of Sheffield*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| David Lidzey | Organic semiconductors | Aspect of modern physics | lectures | 15h | 5 |
| **Aim/Contents** | | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | PHY6007 Electronic & Photonic Molecular Materials and Devices | MSc Polymers for advanced technologies MSc(Eng) Polymers and polymer composites science and engineering PhD Integrated studies (Advanced materials) | | | |
| **Aim/Contents** | • Fundamental Polymer Chemistry<br>• Biopolymers and Biomaterials<br>• Polymer Characterisation and Analysis<br>• Polymer Laboratory Course<br>*(the above courses are taught by the Department of Chemistry in semester 1)*<br>• The Physics of Polymers<br>• Polymer Materials Science and Engineering<br>• Polymer Fibre Composite Materials<br>*(the above courses are taught in the Department of Engineering Materials across both semesters)*<br>• Students also have the choice of one option from the following in semester 2:-<br>• Design and Manufacture of Composites<br>• Smart Polymers and Polymeric Materials<br>• Macromolecules at Interfaces and Structured Organic Films<br>• Molecular electronics and photonics | | | | |

### *2.2.1.9. Other European universities*

The report "Organic & Printed Electronics in Europe" (Peter Harrop, Susann Reuter and Raghu Das) published by IDTechEx in April 2008 mentions other universities involved in research in OLAE. Yet, we did not find any information about lectures at master or PhD level. A questionnaire will be sent and the results will appear in the next issue of this deliverable.

| | | |
|---|---|---|
| **Belgium** | Katholieke Universiteit Leuven | University of Ghent |
| | University of Mons Haunaut | |
| | | |
| **Greece** | Technological Education Institute of Larissa | Aristotle University of Thessaloniki |
| | | |
| **Czech Republic** | Czech technical University in Prague | |
| | | |
| **Denmark** | University of Copenhagen | |
| | | |
| **Finland** | University of Helsinki | University of Oulu |
| | | |
| **France** | Ecole Nationale des Ponts et Chaussées ENCP | Ecole Nationale Supérieure de Chimie de Paris ENSCP |
| | Joseph Fourier University | Louis Pasteur University Strasbourg |
| | University of Paris Sud Orsay | University of Picardie Jules Verne |
| | University of Versailles UVSQ | |
| | | |
| **Germany** | Technical University of Braunschweig | Technical University of Darmstadt |
| | Technical University of Dresden | Technical University of Erlangen-Nuremberg |
| | Technical University of Munich | Ulm University |
| | University of Augsburg | University of Bonn |
| | University of Freiburg | University of Karlsruhe |
| | University of Kassel | University of Regensburg |
| | University of Stuttgart | |
| | | |
| **Ireland** | Trinity College Dublin | |
| | | |

| | | |
|---|---|---|
| **Italy** | Milan Polytechnic | University of Bari |
| | University of Lecce | University of Milan |
| | University of Rome | |
| | | |
| **Netherlands** | Delft University of Technology | Eindhoven University of Technology |
| | Fontys University of Applied Sciences | Radboud University - Institute for Molecules and Materials |
| | | |
| **Poland** | Kraków University | Jagiellonian University |
| | Lodz University | |
| | | |
| **Portugal** | New University of Lisbon | Technical University of Lisbon |
| | University of Algarve | University of Aveiro |
| | University of Lisbon | |
| | | |
| **Slovenia** | University of Ljubljana | |
| | | |
| **Sweden** | Chalmers University of Technology | Mid Sweden University |
| | | |
| **Switzerland** | Electronic Technical High School ETH Zurich | Ecole Polytechnique Fédérale de Lausanne EPFL |
| | | |
| **United Kingdom** | Durham University | Loughborough University |
| | University of Bath | University of Cambridge |
| | University of Hull | University of Leeds |
| | University of Reading | University of Southampton |
| | University of Surrey | University of Sussex |
| | University of Wales, Bangor | |

## 2.2.2. OLAE lectures & courses in USA

For the sake of comparison, we give hereafter the description of a few master and PhD courses on organic electronics in the USA. Note that the list does not intend to be exhaustive. The universities were selected upon their known high research level in the field of OLAE. This description will be extended to Asia in the forthcoming issues of this deliverable.

### *2.2.2.1. Stanford University*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | MATSCI343 Organic Semiconductors for Electronics and Photonics | MS Materials Science and Engineering | lectures | | |
| **Aim/Contents** | This course if for those students interested in the science of organic semiconductors and their use in electronic and photonic devices.<br>Topics Include<br>• Methods for fabricating thin films and devices.<br>• Relationship between chemical structure and molecular packing on properties such as band gap, charge carrier mobility and luminescence efficiency.<br>• Doping.<br>• Field-effect transistors.<br>• Light-emitting diodes.<br>• Lasers.<br>• Biosensors.<br>• Photodetectors and photovoltaic cells. | | | | |

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | MS 9031 Organic Polymer Electronics and Devices | MS Materials Science and Engineering | lectures | 39h | |

| | |
|---|---|
| **Aim/Contents** | This course will introduce students to area of polymer electronics materials, processing, and applications. It ranges from introduction to synthetic chemistry to device fabrication, materials characterization, and device and materials physics.<br>This course consists of:<br>• Fundamentals of Organic Electronic Materials<br>• Materials & Materials Synthesis<br>• Device Physics & Characterization<br>• Devices & Processing<br>• Applications, Roadmaps |

#### *2.2.2.2. University of Rochester*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | CHE 430 Organic Electronics | MASTER OF SCIENCE IN CHEMICAL ENGINEERING | lectures | | |
| **Aim/Contents** | Basic optical and electronic processes of organic molecules and polymers. Charge transport and luminescent properties of organic solids. Metal/organic contacts and charge injection. Applications in thin-film organic electronic devices including organic light emitting diodes, solar cells, photoconductors, and transistors. Review of selected papers. | | | | |

#### *2.2.2.3. University of Washington*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | MSE 560 Organic Electronic and Photonic Materials/Polymers | Master MATERIALS SCIENCE & ENGINEERING | lectures | | |
| **Aim/Contents** | Physical and material concepts determining properties of organic electronic and photonic materials. Discusses electronic structure, physico-chemical characterization, and device application. Includes introduction of electronic band structure of polymers, electrically conducting polymers; organic nonlinear optical electroluminescent materials; polymer optical fibers; tow-photon absorption materials for 3-D microfabrication | | | | |

#### *2.2.2.4. University of California Berkeley*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | Organic Materials in Electronics -- Electrical Engineering (EL ENG) 290Y | M.S. in Engineering Ph.D. in Engineering - EECS | lectures | | |
| **Aim/Contents** | Organic materials are seeing increasing application in electronics applications. This course will provide an overview of the properties of the major classes of organic materials with relevance to electronics. Students will study the technology, physics, and chemistry of their use in the three most rapidly growing major applications--energy conversion/generation devices (fuel cells and photovoltaics), organic light-emitting diodes, and organic transistors. (F,SP) Subramanian | | | | |

#### *2.2.2.5. University of Texas at Dallas*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration |
|---|---|---|---|---|
| | MSEN 5375 (PHYS 5375) Electronic Devices Based On Organic Solids | Msc Materials Science & Engineering Master of Science in Applied Physics | lectures | 3 h/semester |

| | |
|---|---|
| Aim/Contents | Solid state device physics based on organic condensed matter structures, including: OLEDs (organic light emitting diodes), organic FETs, organic lasers, plastic photocells, molecular electronic chips |

### *2.2.2.6. University of Pennsylvania*

| Person in charge | Title of the lecture | Level | Teaching methods | Duration | ECTS |
|---|---|---|---|---|---|
| | MSE 790<br>SPECIAL TOPICS IN ELECTRONIC MATERIALS | Msc Material Science and Engineering | lectures | | |
| **Aim/Contents** | This is an advanced graduate seminar course in which several advanced electronic materials systems will be studied in depth. First-year graduate students and exceptional seniors will be permitted to enroll if their background in quantum mechanics and solid state physics is at a sufficiently high level. Grading will be based on a term paper and in-class presentations (2 for grad students, 1 for undergrads). Emphasis will be on structure and composition, electronic properties, synthesis and processing.<br>Topics for study will be selected from the following<br>• Inorganic semiconductors at the cutting edge: optoelectronic alloys based on Ga, P and In nanowires<br>• Noncrystalline solids: hopping and dispersive transport, short-range order and how to measure it, control of electronic properties for thin film transistors,solar cell material requirements<br>• Organic electronic and optoelectronic materials conjugated polymers, electroactive oligomers and small molecules OLED (organic light-emitting diode) materials and devices molecular electronics<br>• Carbon nanotubes, band structure, zone folding, quantum confinement, ballistic and diffusive transport, nanotube electronics<br>• Giant magnetoresistive materials<br>• Spintronic materials | | | | |

### *2.2.2.7. Comparison between lectures in the USA and the European Union*

In spite of the restricted coverage of the courses and lectures in the US, we can highlight the following elements:

- There is a great similarity among the topics covered; the lectures basically address the same fields of competence that include, among others, the chemistry of polymers, solid state and device physics and techniques of thin film deposition.
- It is worth mentioning that, at variance with what we found in the European Union, the US universities do not seem to offer any master entirely devoted to OLAE. All the detected courses and lectures are included in more general Masters (usually physics or chemistry of polymers).