

ESF Exploratory Workshop on

# Organic Bioelectronics

Sardagna, Trento (Italy), 13-16 June 2010

Convened by:

**Fabio Cicoira**

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Istituto di Fotonica e Nanotecnologie, Consiglio azionale delle Ricerche, Trento (Italy)

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# SCIENTIFIC REPORT

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## **Executive summary**

The ESF workshop Organic Bioelectronics has been a great success.

As planned, the event has taken place at the Centro Congressi Sardagna, in Trento, Italy, home of the Convenor's institution (CNR-IFN), between June 13<sup>th</sup> and June 16<sup>th</sup> 2010. The large majority of the designed speakers were present.

All the participants (with the exception of the ESF rapporteur and one participant) were hosted at the Centro Congressi Sardagna, which also provided most of the meal (lunches, coffee breaks and dinners). A Social Dinner was held at a Restaurant in Trento Downtown.

The meeting was well attended from the beginning to the end. Most of the participants arrived on Sunday June 13<sup>th</sup> and left between Wednesday June 16<sup>th</sup> and Thursday June 17<sup>th</sup>.

In addition to the ESF grant (14000 Euros) additional funds were allocated by the Area della Ricerca di Trento of the Consiglio Nazionale delle Ricerche (450 Euros) and by Wiley VCH publishing (250 Euros). Thanks to this additional funding, the meeting and travel expenses for all the participants were entirely covered. CNR also provided secretarial support for the meeting and handling of travel reimbursement. The company Starck GMBh agreed to send a participant and to pay the travel expense (which is equivalent to an indirect contribution of About 300 Euros). The conference logo was generously drawn and offered by the Italian comic artist Giorgio Serra.

A total of 28 participants attended the meeting, with an excellent geographic and gender balance. Also there was an excellent balance between experienced and early stage researcher. Most of the participants did not know each other in person, so the meeting was also a catalyst for the creation of an organic bioelectronics community.

The workshop was articulated as a series of presentations (between 25 and 40 minutes) followed by 10-15 minutes discussions and round table discussions.

The participants provided good feedback for the organization and the scientific content of the meeting.

## Scientific content of the event

The meeting has been a great success. According to the original proposal, the main purpose of the workshop Organic Bioelectronics was to draw a state-of-the-art roadmap of the European research in Organic Bioelectronics and to promote European-scale collaboration through an Organic Bioelectronics Network.

This has been achieved thanks to the active participation of researchers from almost all over Europe with a broad research spectrum. Even though most of the meeting attendees came from the organic electronics community, the audience included several scientists working in other fields, such as spectroscopy, electrochemistry, carbon nanotubes, plasma physics, organic and inorganic synthesis, sensors and microsystems. A very useful part of the meeting was the interaction with the ESF representative, which provided valuable information for follow up activities.

Due to the multidisciplinary character of the research in Organic Bioelectronics, the presentations have covered a broad list of topics. This provided a unique opportunity to the participants to have an overview of state-of-the-art knowledge in Organic Bioelectronics. Among the most important subjects touched by the speakers are:

- A brief history of Organic Bioelectronics
- Material for Organic Bioelectronics (polymers, graphene, nanotubes, quantum dots, etc)
- Processing of materials for Organic Bioelectronics
- Devices for Organic Bioelectronics (electrochemical and field effect transistors)
- Electrochemistry
- Biointerfaces
- Sensors and actuators
- Nanopore membranes

Many progresses in Organic Bioelectronics have been achieved thanks to novel approaches to chemical synthesis. Synthetic chemists are nowadays able to create new materials able to interact efficiently with biological systems as well as to be integrated into electronic devices and/or to be

used in optical probes. This involves, for instance, water soluble nanoparticles based on small molecules or polymers.

The enormous progresses in chemical synthesis have made possible the fabrication of novel organic electronic devices, which are able to exchange signals with the biological worlds. Among these devices are organic electrochemical transistors (OECT). OECT are very attractive for use in biosensing due to the possibility to operate in aqueous environment. Various type of sensors based on OECT have been presented by different group. Also, recent advances in biosensor fabrication, based on unconventional lithography, have been extensively discussed.

A Grand Challenge posed for the sensor community is to develop a capability for sampling and monitoring air, water and soil much more extensively and frequently than is now possible. Such goals will require improvements in sampling methodology and in techniques for remote measurements, as well as approaches that greatly lower per-sample and per-measurement costs. For this reason a part of our discussion has been devoted to progresses in Internet sensing. Biosensors based on nanowires, graphene and carbon nanotubes were also discussed. The industrial representative provided an overview of industrial aspects of the production of materials for organic bioelectronics.

Another important subjects of discussion have been the integration of electrochemical techniques with organic devices. Electrochemistry can provide very high sensitivity, low detection limit and versatility. These properties, coupled to the well-known advantages of organic electronics devices such as low-weight, low cost and tunability, are expected to play a primary role for future generation of bio sensors.

Last but not least, it has been outlined how Organic Bioelectronics has enormously benefited by the understanding of the fundamental properties of biointerfaces (i.e. interaction of biomolecules with charges).

With the aim to enlarge the Organic Bioelectronics community, a few talks have been dedicated to topics apparently not directly related to Organic Bioelectronics, such as the use of carbon nanotubes in cancer research and the creation of bio-surfaces by means of plasma processes.

## **Assessment of the results, contribution to the future direction of the field**

The perspectives and challenges have been discussed during three round table discussions. The common opinion among the participants has been that the field of Organic Bioelectronics is nowadays mature enough to start Europe- and World- wide collaborations between multi-disciplinary fields of research.

The most important key to consolidate and expand the success of Organic Bioelectronics will be based on the ability to collaborate with scientist from the communities of biology and medicine. This is still a challenge in European research, even if the situation has improved a lot within the last few years.

It is worth to mention that the interaction between materials science and biology/medicine was totally absent only 10 years ago. More recently, it has become more and more clear that research in Materials Science may have some clinical relevance. Also, language barriers, that are the main obstacle to fruitful collaborations, start to be overcome thanks to a more multidisciplinary approach.

An important point, which came out from our discussion is the following: when collaborating between different fields scientist and engineers need to back off and not to take state of the art of their research.

According to the biochemists present in the audience the most fruitful area of collaboration between materials scientist and biologists are cell biology, neuron transmission and protein chemistry. Other very promising potential partner are veterinary researcher and companies making bioelectronics devices.

# FINAL PROGRAMME

## Sunday 13 June 2010

Afternoon *Arrival*

Evening *Get-together (Downtown Trento, Hotels and Centro congressi Sardinia)*

## Monday 14 June 2010

09.00-09.20 **Welcome by Convenor**  
**Fabio Cicoira** (CNR-IFN Trento, Italy)

09.20-09.40 **Presentation of the European Science Foundation (ESF)**  
**Ana Helman**, ESF Standing Committee for Physical and Engineering Sciences

**09.40-12.30 Morning Session. Chairs Fabio Cicoira, Albert Schenning**

09.40-10.20 **Presentation 1 "Organic bioelectronics: present and future"**  
**Magnus Berggren** (Linköpings Universitet, Norrköping, Sweden)

10.20-10.50 **Presentation 2 "Fluorescent nanoparticles for sensing and imaging"**  
**Albert Schenning** (Eindhoven University of Technology, Eindhoven, The Netherlands)

10.50-11.20 *Coffee / Tea Break*

11.20-12.00 **Presentation 3 "Soft electronic hydrogels for electrical sensing and actuation of excitable cells"**  
**Olle Inganas** (Linköpings Universitet, Norrköping, Sweden)

12.00-12.25 **Presentation 4 " Supramolecular push-pull substituted allene complexes for molecular electronic devices "**  
**Jean Luc Mieusset** (University of Vienna, Vienna, Austria)

12.30-14.00 *Lunch*

**14.00-18:30 Afternoon Session. Chair Olle Inganas.**

14.00-14.25 **Presentation 1 "Organic electrochemical transistor for detection of pathogenic organisms"**  
**Roisin Owens** (Centre Microelectronique de Provence, Gardanne, France)

14.25-14.50 **Presentation 2 "Oligothiophene biohybrids for application in biodevices"**  
**Manuela Melucci** (ICCOM-CNR, Firenze, Italy)

14.50-15.30 **Presentation 3 "Nanopore based single molecule detection"**  
**Yann Astier** (University of Lisbon, Lisbon, Portugal)

15.30-16.00 *Coffee / tea break*

16.00-16.30 **Presentation 4 "Polymer Electronics for Point-of-Care Diagnostics"**  
**John De Mello** (Department of Chemistry, Imperial College, London, UK)

16.30-18.00 **Round table discussion: "Organic Bioelectronics in FP7 and Eurocores"**

19.30 *Dinner*

## Tuesday 15 June 2010

**09.00-12.45 Morning Session. Chairs: George Malliaras, Manuela Melucci.**

09.00-09.30 **Presentation 1 "Progresses on PEDOT:PSS"**  
**Mathias Intelmann** (Starck GmbH, Leverkusen, Germany)

09.30-10.00 **Presentation 2 "Novel sensing functionalities by kinetic activated organic sensitization of inorganic nanostructures"**  
**Salvatore Iannotta** (CNR-IMEM, Parma, Italy)

10.00-10.30 **Presentation 3 "Merging the Digital and Molecular Worlds - How to integrate Chemo/Bio-Sensors into Wireless Sensor Networks"**  
**Dermot Diamond** (DCU, Dublin, Ireland)

10.30-11.00 *Coffee / Tea Break*

11.00-11.40 **Presentation 4 "Applications of conducting polymers in biosensors and bioelectronics"**  
**Phil Bartlett** (School of Chemistry, University of Southampton, UK)

11.40-12.05 **Presentation 5 "Electrostatics and the origin of the double layer in bioelectronic devices "**  
**Dusko Cakara** (Department of Biotechnology, University of Rijeka, Croatia)

12.05-12.45 **Presentation 6 "Conducting polymers in chemical sensing and biosensing"**  
**Vladimir Mirsky** (Lausitz University of Applied Science, Germany)

12.45-14.00 *Lunch*

**14.00-17.00 Afternoon Session. Chair: Agneta Richter-Dahlfors.**

14.00-14.40 **Presentation 1 "Electronically controlled polymer films for biosensing, drug delivery, and interfacing biology "**  
**Tomaso Zambelli** (ETH, Zurich, Switzerland)

14.40-15.05 **Presentation 2 "Carbon nanotubes for biomedical applications: from imaging to drug delivery"**  
**Cecilia Menard Moyon** (IBMC-CNRS, Strasbourg, France)

15.05-15.30 **Presentation 3 "Detecting and controlling single ions-molecules and electrons via highly selective and sensitive bio-organic and inorganic composite devices"**  
**Nikos Chaniotakis** (Department of Analytical Chemistry, University of Crete, Greece)

15.30-16.00 *Coffee / tea break*

- 16:00-16:30 **Presentation 4 “Plasma processing of materials for biomedical applications”**  
**Eloisa Sardella** (CNR-IMIP, Bari, Italy)
- 16.30-18.00 **Round Table Discussion: How materials scientist can interact with the biomedical world?**
- 19.30 *Dinner at Osteria il Cappello, Piazza Lunelli, Downtown Trento*

## Wednesday 16 June 2010

- 09.00-12.30 Morning Session. Chairs: Michele Sessolo, Cecilia Menard-Moyon.**
- 09.00-09.40 **Presentation 1 “Interaction of Bio-Molecules with Charges”**  
**Frank Schreiber** (institut fur Angewandte Physik, University of Tuebingen, Germany)
- 09.40-10.10 **Presentation 2 “Organic electrochemical transistors in sensing and bioelectronics”**  
**George Malliaras** (Centre Microelectronique de Provence, Gardanne, France)
- 10.10-10.40 **Presentation 3 “Read- out schemes for organic transistor sensor”**  
**Martin Grell** (Department of physics and Astronomy, University of Sheffield, UK)
- 10.40-11.30 *Coffee / Tea Break*
- 11.30-13.30 **Round table discussion: “Discussion on follow-up activities/networking/collaboration “**
- 13.30-15.00 *Lunch*
- 15.00-19.00 Free time, departures
- 16.30 *Dinner*

## Thursday 17 June 2010

Morning: Departure of the remaining participants (about 10)



## Final List of Participants and statistical information

1. **Fabio CICOIRA**  
Istituto di Fotonica e Nanoecnologie  
Consiglio Nazionale delle Ricerche, Trento , Italy  
Gender: M; Country of origin: Italy; Age: 39.
2. **George MALLIARAS**  
Centre Microélectronique de Provence  
Ecole Nationale Supérieure des Mines de Saint Etienne, Gardanne, France  
Gender: M; Country of origin: Grece; Age: 41.
3. **Róisín OWENS**  
Centre Microélectronique de Provence  
Ecole Nationale Supérieure des Mines de Saint Etienne, Gardanne, France  
Gender: F; Country of origin: Ireland; Age: about 35
4. **Martin GRELL**  
Department of Physics and Astronomy, University of Sheffield, UK  
Gender: M; Country of origin: Germany; Age: about 45
5. **Jean-Luc MIEUSSET**  
University of Vienna, Austria  
Gender: M; Country of origin: France; Age: about 45
6. **Olle INGANAS**  
309, Dept. of Physics, Chemistry and Biology (IFM), Linköping University, Sweden  
Gender: M; Country of origin: Sweden; Age: about 60
7. **Magnus BERGGREN**  
Dept. of Science and Technology (ITN), Linköpings Universitet, Norrköping, Sweden  
Gender: M; Country of origin: Sweden; Age: about 45
8. **Esma Ismailova**  
Nationale Supérieure des Mines de Saint Etienne, Gardanne, France  
Gender: F; Country of origin: Uzbekistan; Age: about 26
9. **Frank SCHREIBER**  
Institut fuer Angewandte Physik, Universitaet Tuebingen, 72076 Tuebingen, Germany  
Gender: M; Country of origin: Germany; Age: about 44
10. **Omid YAGHMAZADEH**  
LPICM, Ecole Polytechnique, Palaiseau, France  
Gender: M; Country of origin: Iran; Age: about 26
11. **Michele SESSOLO**  
Instituto de Ciencia Molecular, Universitat de Valencia, Spain  
Gender: M; Country of origin: Italy; Age: about 30

12. **Yann ASTIER**  
University of Lisbon, Portugal  
Gender: M; Country of origin: France; Age: about 40
  
13. **Cecilia MENARD-MOYON**  
CNRS, Institut de Biologie Moléculaire et Cellulaire, Strasbourg Cedex, France  
Gender: F; Country of origin: France; Age: about 26
  
14. **Vladimir M. MIRSKY**  
Lausitz University of Applied Science, Senftenberg, Germany  
Gender: M; Country of origin: Russia; Age: about 50
  
15. **Dermot DIAMOND**  
The Centre for Sensor Network Technologies, Dublin City University, Ireland  
Gender: M; Country of origin: Ireland; Age: about 50
  
16. **Dr. Salvatore IANNOTTA**  
CNR, IMEM, Parma, Italy  
Gender: M; Country of origin: Italy; Age: about 55
  
17. **Tomaso ZAMBELLI**  
ETH Zurich, Institute for Biomedical Engineering, Zurich, Switzerland  
Gender: M; Country of origin: Italy; Age: about 42
  
18. **Dusko CAKARA**  
Department of Biotechnology, University of Rijeka, Croatia  
Gender: M; Country of origin: Croatia; Age: about 37
  
19. **Nikos CHANIOTAKIS**  
University of Crete, Vassilika Voutes, Greece  
Gender: M; Country of origin: Greece; Age: about 50
  
20. **Phil BARTLETT**  
School of Chemistry, University of Southampton, UK  
Gender: M; Country of origin: UK; Age: about 50
  
21. **Manuela MELUCCI**  
ICMO, CNR, Firenze, Italy  
Gender: F; Country of origin: Italy; Age: about 33
  
22. **Yoann OLIVIER**  
University of Mons-Hainaut, Mons, Belgium  
Gender: M; Country of origin: Belgium; Age: about 30
  
23. **Albert SCHENNING**  
Eindhoven University of Technology, The Netherlands  
Gender: M; Country of origin: The Netherlands; Age: about 45

24. **Delia PUZZOVIO**  
 University of Sheffield, Sheffield S3 7RH, UK  
 Gender: F; Country of origin: Italy; Age: about 30
25. **John De MELLO**  
 Imperial College London, UK  
 Gender: M; Country of origin: UK; Age: about 40
26. **Matthias INTELMANN**  
 H.C. Starck Clevios GmbH, Leverkusen, Germany  
 Gender: M; Country of origin: Germany; Age: about 35
27. **Eloisa SARDELLA**  
 Dipartimento di Chimica Università di Bari, Italy  
 Gender: F; Country of origin: Italy; Age: about 35

Gender:

Female: 6            Male: 21            Total: 27

Age bracket

< 30 : 3            30-40: 11            41-50 : 7            >50: 6

Countries of work:

Austria: 1	Belgium: 1
Croatia: 1	France: 5
Germany: 3	Greece: 1
Ireland: 1	Italy: 4
Netherlands: 1	Portugal: 1
Spain: 1	Sweden: 2
Switzerland: 1	United Kingdom: 4

