



AMADEus

Advanced MAterials by DEsign



université
de BORDEAUX



Instituts
thématiques

Inserm

Institut national
de la santé et de la recherche médicale



Bordeaux INP
AQUITAINE





The overall ambition of AMADEus is to become a worldwide-recognized major cluster in materials science, engineering and technology, carrying out scientific research and innovation at the interfaces of chemistry, physics, biology and engineering.



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Preparing the future

Higher education and research are the levers of new intelligent growth that is both sustainable and inclusive. This involves preparing a knowledge society that future generations will flourish in.

The University of Bordeaux and its partners intend to respond to this challenge by developing a campus of excellence with international influence, joining research forces around high-level scientific pillars:

- neuroscience,
- medical imaging,
- cardiology,
- public health,
- materials of the future,
- environment,
- archaeology,
- laser optics,
- digital technologies.

These priorities reflect the research strengths of the Bordeaux site whose excellence is clearly recognised in terms of the standards applicable to the discipline and its high international profile.

Certifications by the French national "Investments for the Future" scheme in 2011 have strengthened this dynamic of ambitious multidisciplinary projects. Today, these centres of excellence backed by innovative training offer great prospects for development, French research and the socio-economic world.

The quest for excellence is thus at the heart of the development policy of the Bordeaux site. Through this remarkable dynamic, the University of Bordeaux intends to provide solutions to the challenges of our environment and pave the way for the society of tomorrow.

« We are ready and capable today of designing next-generation high-added value materials we need for tomorrow, which will be more efficient, functional and sustainable. »

Etienne Duguet, AMADEus director

AMADEus

Materials are key components of the products manufactured by almost all industrial sectors. In fact, many 21st century innovations will depend on the development of new materials, with increasingly stringent demands on their intrinsic properties, costs, processing conditions and on their impact on human health and the environment.

→ Multiple objectives...

AMADEus has four main objectives:

- > Maintain and strengthen the high level of excellence of Research and Education in the field of Advanced materials in Bordeaux
- > Attract and retain top junior talents
- > Provide flexible and responsive support for innovative and collaborative projects
- > Promote transfer of knowledge and technology with partners in industry

→ Key figures

35 research teams from 12 research laboratories of the University of Bordeaux

160 researchers and academics involved

4 disciplines: Chemistry, Physics, Biology, Engineering

3 IUF members, 4 CNRS medals and 1 ERC nomination

2 industrial partnerships

Between 2012 and 2015:

13 PhD students and 32 postdoctoral researchers recruited

2 junior talents recruited

Over **€9M** in public/private co-financing

Governance

Executive board

Director: Pr. Etienne Duguet

Research director: Pr. Georges Hadziioannou

Training director: Pr. Corine Mathonière

Technology transfer director: Pr. Alain Soum

Steering committee

This committee is composed of the directors of the 12 partner laboratories.

International Advisory Panel

The International Advisory Panel is consulted on general strategy, scientific policy, research achievements and junior-chair applicants. It is composed of 7 world-renowned external scientific personalities:

- Pr. M.Tirrell (Pres.), University of Chicago
- Pr. K.Matyjaszewski, Carnegie Mellon University, Pittsburgh
- Pr. A.Carty, Waterloo Institute of Nanotechnology
- Pr M.Antonietti, MPI Colloids and Interfaces, Potsdam
- Pr. L. De Cola, ISIS University of Strasbourg,
- Pr. C.Soukoulis, Iowa State University, Ames
- Pr. C.Sanchez, Collège de France, Paris

Our community

ORGANIC
BIO CHEMISTRY
INNOVATION
EXCELLENCE
SOFT METAMATERIALS
PHYSICS ELECTRONIC
MATERIALS
RESEARCH
TRAINING
TRANSFER
MATTER

> Academics

AMADEus gathers 35 research teams from 12 research laboratories on the Bordeaux campus involved in a number of scientific and technological issues in Materials Science and carrying out research and innovation at the interfaces of chemistry, physics, biology and engineering.

> Industry

AMADEus members have a long tradition in active relationships with large companies and SMEs in various sectors (energy, health, and environment).

> International

AMADEus develops international relationships and cooperation with academics through mobility, education development, scientific events and research collaborations. Since 2012 AMADEus is involved in an International Joint Laboratory for Next generation Photovoltaic Cells "NextPV", hosted by RCAST in the University of Tokyo.

→ Attracting young high-level researchers

AMADEus is committed in a tenure-track strategy and offers 4 research chair positions for young scientists.

Objective: to strengthen the academic and scientific community of the University of Bordeaux in strategic fields by supporting young, high-profile international researchers.

> A first position was filled in September 2014 with Luca Muccioli. His project is entitled "From molecules to organic electronics devices: a bottom-up computational approach".

> A second position was filled in June 2015 with Daniel Torrent. His project is entitled "Homogenization Theory for Dense Electromagnetic and Sonic Materials".



© Luca Muccioli



© Daniel Torrent

International collaborations

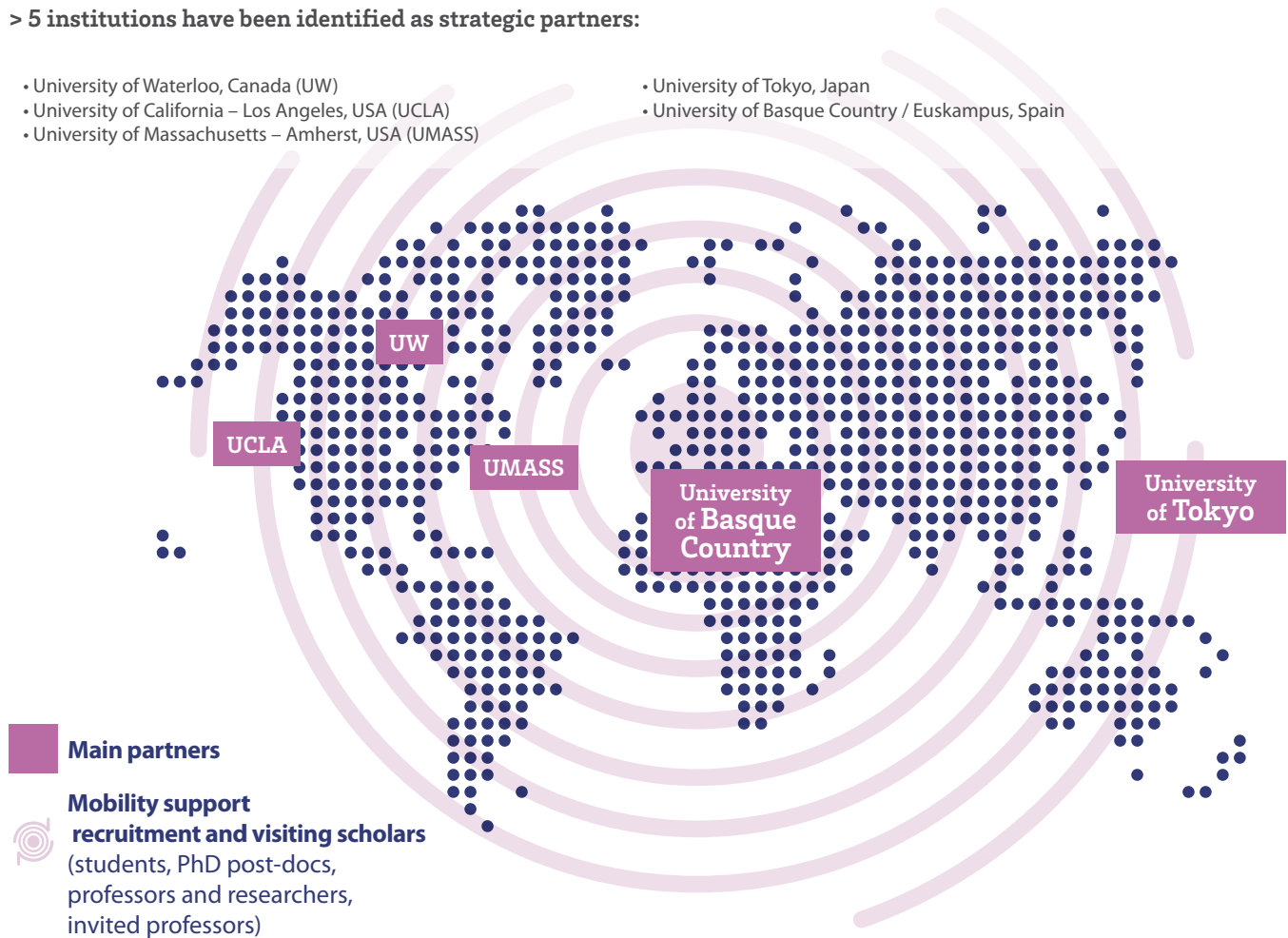
→ Objective

To develop and reinforce partnerships with universities.

It was decided to give priority to a few number of universities abroad rather than support all current and possible collaborations of the researchers involved in AMADEus. This selection results from either a previous strong collaboration, strategic targets of IdEx or specific AMADEus initiatives.

> 5 institutions have been identified as strategic partners:

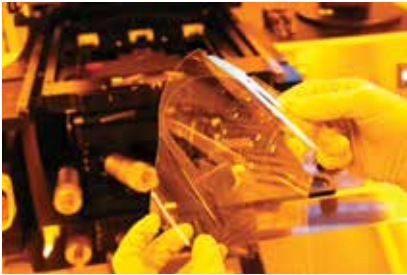
- University of Waterloo, Canada (UW)
- University of California – Los Angeles, USA (UCLA)
- University of Massachusetts – Amherst, USA (UMASS)
- University of Tokyo, Japan
- University of Basque Country / Euskampus, Spain



The international activities of AMADEus appear to be very positive, one of its strongest points. The partnerships are productive and are yielding both cooperative research and exchanges. The strong cohort of international postdocs within AMADEus is also a positive benefit of the international activities of our cluster.

An interdisciplinary approach to **research**

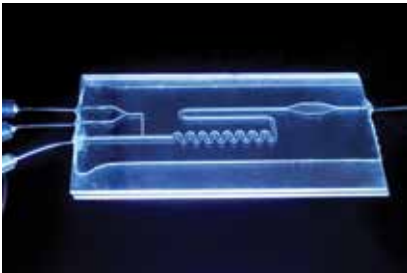
→ Our targeted research challenges:



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> **Printable and flexible Organic electronics**

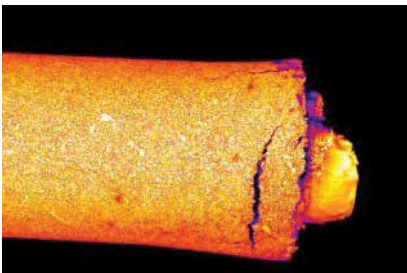
Organic semiconductors constitute a new class of functional materials and represent an alternative to conventional silicon-based technologies. They are well suited to applications needing large areas and/or flexibility, compatible with paper and plastics. Thanks to these unique properties, organic electronics has the potential to give birth to disruptive innovations, meeting some of the challenges in energy, environment, health, information and communication technologies. The efforts of AMADEus are particularly focused on the development of high-performance inks, the production of microelectromechanical systems (sensors and actuators), and the recovery of mechanical and thermal energy.



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> **Self-assembled metamaterials**

The field of metamaterials emerged at international level in 2000 with theoretical studies and the first experimental realizations of electromagnetic metamaterials in the microwave regime by "top down" lithographic techniques. The distinctive contribution of AMADEus is its bottom-up approach, i.e. through the self-assembly of active components (resonators). Researchers are concentrating their efforts on the design, modeling and production of active metamaterials, either in the field of electromagnetism (visible spectrum or terahertz frequencies) or acoustics.

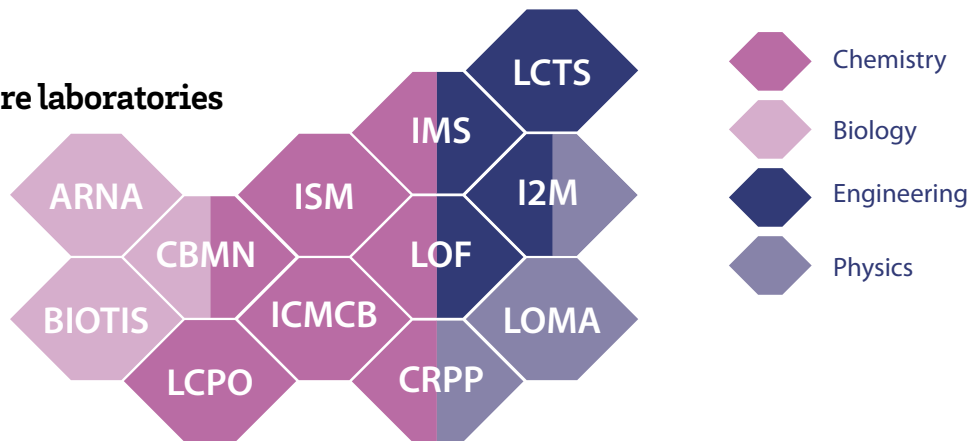


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> **Bioactive and biocooperative materials**

Feedback loop-based individualized integrated medical systems comprising for example among others miniature sensors and drug delivery systems that improve the effectiveness and safety of drugs do not exist because these devices are limited by several crucial points closely related to the sophisticated design of adequate material properties. Through its expertise in the fields of miniaturization, sensors, controlled drug delivery and enzyme engineering, AMADEus is developing an original device to be used as a permanent implant, with an autonomous power source, capable of permanently monitoring a biological constant and releasing an active principle when necessary.

Our core laboratories



ARNA: Natural and artificial regulation – INSERM

BIOTIS: Tissue bio-engineering – INSERM

CBMN: Chemistry and Biology of Membranes and Nano-objects - University of Bordeaux / CNRS

I2M: Institute of Mechanics and Engineering - CNRS / University of Bordeaux / Bordeaux INP/ Arts et Métiers - Paristech

CRPP: Paul Pascal Research Centre - CNRS

LOF: Laboratory of the Future - Solvay / CNRS / University of Bordeaux

IMS: Laboratory of Material and Systems Integration - CNRS / University of Bordeaux / Bordeaux INP

ISM: Institute of Molecular Sciences - CNRS / University of Bordeaux

ICMCB: Institute of Condensed Matter Chemistry of Bordeaux – CNRS

LCPO: Organic Polymer Chemistry Laboratory - University of Bordeaux / CNRS / Bordeaux INP

LOMA: Aquitaine Waves and Matter Laboratory - University of Bordeaux / CNRS

LCTS: Thermostructural composites laboratory - University of Bordeaux / CNRS / CEA / Herakles

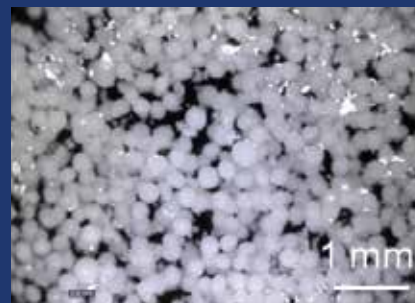
Could the fantasy of invisibility become a reality?

Who hasn't dreamed of wearing an invisibility cloak like Harry Potter? Thanks to metamaterials, this may soon become a reality. Researchers from the AMADeUS Laboratory of Excellence recently developed the first acoustic metamaterials in 3 dimensions.

Boasting electromagnetic properties unseen in any homogeneous natural material, metamaterials are composite materials capable of bending and controlling waves, in particular sound and light waves. Based on these uncommon properties, researchers have developed the first negative index 3D material supporting ultrasounds. To achieve this, they have created a new type of metamaterial, made up of porous

silicone micro-beads suspended in a water-based gel, and literally had ultrasounds doing the moonwalk. These new-generation "flexible" metamaterials hint at numerous applications in ultrasound imaging (ultrasound scans, sound insulation, stealth in submarine acoustics, etc.) or for the manufacturing of materials. Most significantly, they bring the old fantasy of invisibility back into the limelight.

The results of this research were published in the *Nature Materials* journal on December 15, 2014.



Silicone beads suspended in a water-based gel

© CRPP

Excellence in training

→ Training in and through research

> What are our aims?

AMADEus is a project where research and education are deeply linked. Graduate and PhD students integrate a very active research excellence community. AMADEus goes hand in hand with the actors of training in chemistry and physics at the University of Bordeaux, in order to extend the innovation effort in the field of advanced materials and engineering.

AMADEus aims to cover the diversity of the student population within its actions, and to provide an educational environment at the highest level.

> Education

The corresponding program was partly designed on the basis of the existing FAME (Functionalized Advanced Materials and Engineering) Erasmus Mundus Master. Particular attention is paid to the skills needed for international careers, the implementation of e-learning tools, the improvement of employability in the industry and the preparation for academic careers.

> Master's Degree

Objectives:

- Provide high-level academic and research-oriented education about the synthesis, characterization and processing of all classes of materials with special emphasis on Nanomaterials, Hybrids and Ceramics,
- Offer mobility during the two-year master program to take advantage of the complementary skills of the universities in the network,
- Prepare the students for entering a PhD program in Europe or elsewhere for instance in one of the FAME network laboratories.

Since 2012 AMADEus funded **10 scholarships** in the frame of the FAME master.

> Doctoral training

The ambition of AMADEus is to provide all its PhD candidates with the best learning environment and working conditions, in order to facilitate their integration into the national and global academic environment and their smooth access to the job market.

13 PhD positions funded since the beginning of the programme.

> Mobility grants

Objective: encouraging young researchers' travel to key geographical areas

This program supports short stays of young researchers (PhD and postdocs) in international or French laboratories to acquire new technical skills and theoretical knowledge for AMADEus.

25 mobility grants funded since 2012.

> Visiting scholars

Objective: welcoming internationally renowned researchers and lecturers to share their experience and set up international collaborations and partnerships.

AMADEus has annually five to ten positions open for visiting scholars from around the world to promote external collaborations. This program is efficient in establishing collaboration and potential student exchange. Visiting professors give general seminars and some of them also lectures for students at the master/PhD level to improve the knowledge of the AMADEus staff.

30 scholars already funded since the beginning of the project.

Aleksandar Karajic, Serbian doctoral student at AMADEus

© University of Bordeaux



The University of Bordeaux is renowned for its research in materials science. In particular, several electrochemical teams have earned recognition by linking this discipline with that of the architecture of materials. The advantage of being part of the AMADEus Cluster is the possibility of developing my scientific and personal skills by participating in international conferences, exchange programs and inter-laboratory meetings.



William Greenbank, New-Zealander PhD student at IMS Lab and beneficiary of an AMADEus mobility grant

© William Greenbank



My one month AMADEus mobility at the University of Stanford (USA) – Dauskardt Group proved to be an excellent experience. The Dauskardt group are world leaders in the area of organic photovoltaics, so my visit provided me with a unique opportunity. The AMADEus mobility grant enabled me to carry out essential research for my PhD that I couldn't have done anywhere else. It was an extremely valuable experience for both my work and my career prospects after I finish my studies.



S. Manoj Gali, Indian FAME Master student funded by AMADEus between 2012 and 2014 and now PhD student within the AMADEus Chair on Theoretical modelling of advanced polymeric materials for the organic electronics

© S. Manoj Gali



AMADEus meetings organized once every six months allowed me to present my research and get valuable suggestions that enabled me to develop a multi-disciplinary line of research to better understand my subject. Furthermore, visiting scientists and invited lectures by researchers from across the world enable the cluster and its members to interact and explore the field of current date research. According to me, being a part of the cluster AMADEus is an experience which only a lucky few could experience during their academic career.



Innovation

switching to next-generation high-added value materials

AMADEus supports projects with a high potential for disruptive innovations and seeks to efficiently exploit the results of its research activities including valuable new patent-protected technologies. The results of research supported by AMADEus make technological innovation possible, as well as development of new products and/or business creation.

→ ELORPrintTec: Facility for printed organic electronics



© ELORPrintTec

ELORPrintTec is a platform funded by the national Investments for the Future program (EquipEx) with specific equipments dedicated to organic polymer electronics.

Objectives

- The design and understanding of new materials and processes as well as their integration to devices
- The design, prototype fabrication and testing of new products as well as their market introduction

The facility: 850 m² ISO6 cleanroom fully equipped with chemical, physicochemical and printing processing tools for the organic electronic polymer materials: synthesis, formulation, processing and their integration to devices and systems.

Georges Hadziioannou, Professor at LCPO and director of ELORPrintTec



© ELORPrintTec

The ELORPrintTec facility, unmatched anywhere in the world, was set up to design organic electronic materials integrating innovative characteristics. Building ELORPrintTec, brick by brick, was in itself a huge challenge, the product of a long history and a dream that eventually came to fruition. The system for processing and characterization of the electronic devices and systems installed in the facility will satisfy the most curious scientific minds while leading to the discovery and production of objects capable of being industrialized.



→ R&D partnerships with private companies



AMADEus is already engaged in long term partnerships with large industrial groups – Solvay and SAFRAN Herakles -, in the form of joint laboratories, bringing together academic staff and industrial researchers.

Arkema also has strong links with AMADEus, since it was one of the cofounders of the Excellence Chair which now has been transformed into the HOMERIC industrial chair directed by Prof. Georges Hadziioannou. As well as publications, this cooperation has already yielded 10 patents/patent applications and one commercial product.

Patrick Maestro, Solvay Scientific Director and founder of the Laboratory of the Future (LOF)

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There are still many challenges facing mankind, particularly in the areas of clean energy and the environment. Scientists are expected to solve these problems with solutions that don't exist today. I firmly believe that we will find these solutions, but only if industry and science continue to work closely together. The transversal approach that we are using and the on-site cooperation of industrial and academic people have actually opened new battlefields for the research activities of both partners. In addition, the development of skills and competencies at the highest level allows us to develop new programs, with both academic and industrial stakes as we did through AMADEus with the subject on metamaterials, where we together developed scientific breakthrough while contributing to the understanding of drying mechanisms in suspensions.



→ Patents and Technology Transfer



AMADEus collaborates with Aquitaine Science Transfert® (AST) the Society for Accelerating Technology Transfer in the Aquitaine Region created as part of the Investment for the Future programme.

AST covers the whole value chain of technology transfer from sourcing high potential inventions in academic research labs to marketing “ready to industrialize” technologies through licensing out agreements, or creating start-up businesses.

Alexander Kuhn, Professor at the ISM and coordinator of Bioactive and biocooperative materials project

© Alexander Kuhn



Thanks to the fruitful synergy between AMADEus teams we succeeded in developing the very first example of a fully integrated miniaturized electrochemical cell, and as a consequence we were able to file two patents related to this work. Industrial applications are foreseen in any electrochemical device requiring miniaturization and high specific surface area electrodes, especially for applications in the field of energy storage such as batteries, supercapacitors, fuel cells and biofuel cells.



AMADEus

Contact

Etienne Duguet – Director
etienne.duguet@u-bordeaux.fr

For more information

amadeus.labex.u-bordeaux.fr

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