Presentation of the funded projects in 2010 for the Blanc International SIMI 9

Blanc International program
Year 2010

Title	ArchiFlame – Flame Retarding Nanoarchitectured Fibers
Abstract	The development of polymer nanocomposites is very significant because of the strong improvement of the final properties and in particular, the reaction to fire of the materials. The objective of ARCHIFLAME project is to develop textile structures composed of polyamide 6 (PA6) nanocomposite fibers with enhanced flame retardant properties. Attention will be focused on the fibers nanoarchitecture control during the extrusion process. In fact, to ensure the nanoparticles (NP) dispersion, one must act at the NP/polymer interface during the elaboration of nanocomposites materials. Among the different methods that can be considered, the one retained in this project is the grafting of components at the NP surface. After a first step of selection of the coupling agents (CA) that can ensure a good compatibilization between the NP and the polymer matrix, the functionalization of NP will be achieved. Moreover if the presence of the unique NP is not sufficient to bring acceptable flame retardant (FR) properties, FR agents will be added in the systems. The influence of the type of NP, specially the aspect ratio, as well as the nature and quantity of CA and FR compounds on the nanoarchitecture (fillers dispersion and orientation) will be studied. The control of this nanoarchitecture depends not only on the above mentioned parameters linked to the chemistry of the system but also on the parameters related to the extrusion/melt spinning process. Thus, experimental conditions such as temperature, speed of the screw, draw ratio of the fibers… have to be taken into account because they affect the morphology of the end material. Various PA6 nanocomposite fibers will be realized varying the "chemistry/process" parameters and the mechanical and flame retardant properties of the samples obtained in this way will be evaluated. The use of several characterization techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), nuclear magnetic resonance (NMR)… will allow the observation and the quantification of the dispersion quality while studying the nanoparticules orientation inside the fibers. All the information derived from the different analyses will be joint and relations between morphology and flame retardant properties will be established. Then, the selected optimal

experimental conditions will be applied to obtain high-performance material. The approach followed all along the project will be validated on the lab scale with the production of fibers but also knitted structures that will be submitted to mechanical and fire tests. A more fundamental study will complete the project to understand the physical and chemical mechanisms involved in the improved flame retardant properties. In the frame of this project, a new collaboration between the laboratory “Materials Science and Engineering” of the University of Beijing and the laboratory “Unité Matériaux et Transformations” (UMET UMR/CNRS 8207) of the University of Lille will be established. The expertise of the two groups, chemical engineering on one hand and materials functionalization to achieve enhanced properties on the other hand will be combined to conduct the project. The dissemination of the results will be done through publications and communications but industrial applications can also be considered.

Partenaires	UMR 8207 BUCT – CHINE - (BEIJING UNIVERSITY OF CHEMICAL TECHNOLOGY)
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Aide de l’ANR	188 032 €
Début et du ée	36 months
Référence	ANR-10-INTB-0901
L b l pôle	UP-TEX

Title	COBMUL – New Co-based multilayer materials for optics applications in the EUV range
Abstract	It is necessary to design and fabricate new optics elements due to the large development of photon sources and applications working in the extreme UV (EUV) and soft x-ray ranges, such as He-II emission line at the wavelength of 30.4 nm for imaging of solar corona, Ni-like Ta x-ray laser working at the wavelength of 4.48 nm near “water window” region, for example. Periodic multilayers are suited for this purpose, because their layers of nanometric thickness lead to period of the order of the nanometer suitable to diffract EUV and x-ray radiations. To be efficient these optics should have large reflectance and suitable thermal and time stabilities. For numerous applications the multilayers should also need to be stable up to a few hundreds °C. We expect to establish a methodology of interface analysis and a reasonable theory demonstrating what is happening at the interfaces of periodic multilayers, based on the study of Co-based multilayers. We also expect to accomplish the preparation of new Co-based multilayers with not only outstanding optical properties but also competent stability in some harsh working environment such as synchrotrons or free electron laser facilities. To achieve this goal we propose in this project to pursue our investigations along three paths: (i) optimizing the parameters of the Co/Mg system (thickness of the layers and deposition pressure, power and temperature, …) on which preliminary promising results have already been obtained (43% reflectivity), and will be used as a prototype of the Co-based multilayers, (ii) changing magnesium by another material chosen for its adequate optical constants and also its ability to not react with cobalt, (iii) considering tri-layer systems, the two layers other than Co being two metals or one metal and a high formation enthalpy compound; indeed, it has been shown that tri-layer systems can present higher reflectance than bi-layer systems. In the project the Co/Mg system will be first used as a prototype of the Co-based multilayers to be developed. A methodology combining non-destructive characterization techniques, hard x-ray and EUV reflectance measurements, x-ray emission and nuclear magnetic resonance spectroscopies, magneto-optic Kerr effect measurements, will be applied to understand the interface interactions occurring in this kind of multilayers. Then, from this knowledge, interface engineering will be applied to improve the structural quality of the stacks as well as to anticipate their behaviour as a function of annealing up to some hundreds °C, in order to design novel Co-based

	multilayers that can used in practical applications. The designed multilayers will be fabricated and characterized and their interfacial behaviour controlled in order to give high and reliable reflectivities. The project will be considered successful if a set of Co-based multilayers is produced, designed and optimized for the EUV range and having thermal stability well above 200°C, suitable for applications in synchrotron radiation, soft X-ray laser, EUV solar observation, …
Partenaires	LCPMR (Laboratoire de Chimie Physique - Matière et Rayonnement) Centre National de la Recherche Scientifique- Institut de Physique et Chimie des Matériaux de Strasbourg, UDS, CNRS UMR 7504, IPOE – CHINE - (Insititute of Precision Optical Engineering, Tongji University -)
Coordinateur	Philippe JONNARD - LCPMR philippe.jonnard@upmc.fr
Aide de l'ANR	75712 €
Début et durée	36 months
Référence	ANR-10-INTB-0902

Title	COMAGNET – Growth of Co-based magnetic films by high magnetic field assisted pulsed electrodeposition
Abstract	The COMAGNET project is positionned in the following topic developed over several years by each partner laboratory (LACMDTI University of Reims Champagne-Ardenne (France) and Laboratoire EPM at Northeastern University - China): the magnétoscience. The interaction of a magnetic field with a materials elaboration process can change the characteristics of the compounds obtained. The main interest of this project is to develop magnetic films of cobalt based metal alloys or oxides, with applications in the magnetic field. Candidates for our studies are nanostructured alloys such as CoX (X = Cu, Ni, Fe, Cr, Pt ..) and oxides such as $CoFe_2O_4$ for different applications: permanent magnets, magnetic recording, magnetoresistive effect GMR giant magneto-optical. The major objective is to show that the magnetic properties (coercive force, saturation magnetization, magnetic anisotropy) are modified by the imposition of a high magnetic field (HMF) during the production process. Originality and innovative aspect of COMAGNET is to couple two processes carried out under high magnetic field: -firstly develop alloys and oxides of nanostructured cobalt electrodeposition under pulsed magnetic field -on the other hand, perform thermal treatments or oxidation of electrodeposited materials in the presence of magnetic field under controlled atmosphere. The coupling of both processes is to increase the functionality of the material. Studies of the electrodeposition (low-cost method) in a magnetic field of thin films of oxides or alloys have shown the influence of magnetic field on the morphology, crystallographic phase composition or the physical properties of the material. The magnetic field generally promotes deposits denser and more homogeneous with grain sizes reduced. The magnetic field then becomes an alternative brighteners and leveling agents during the process. In the case of deposits of cobalt or cobalt alloys such as FeCo, the magnetic field influences the structure and magnetic properties of the material. Generally, deposits made by electrodeposition require thermal treatments under controlled atmosphere to improve the functionality of the material. The EPM Laboratory has significant experience in the field of metallurgical phenomena in high magnetic fields such as solidification, diffusion, and reactions to the film-substrate interface. In this project, both thick deposits or nanometric thickness depending on the desired application could be developped.

The part of the project "electrodeposition under high magnetic field " will be coordinated by the LACMDTI and will be completed by the recruitment of two post-doctoral positions while the EPM hire a postdoc to conduct the study “treatment under HMF. The characterizations of the materials obtained will be shared by both partners, since their equipment are highly complementary (Analysis by XRD, ICP, XPS, AES, SEM, TEM, MFM, VSM ...). The formation mechanisms of various materials during processes used will be captured by fundamental studies in the third year based on the experience of the both laboratories.

Partenaires	URCA - Laboratoire d'Analyses des Contraintes Mécaniques et Dynamique de Transferts aux Interfaces (LACMDTI) CHINE - Northeastern University - Key Laboratory of Electromagnetic Processing of Materials
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Aide de l’ANR	192 400 €
Début et durée	36 months
Référence	ANR-10-INTB-0903
Label pôl	Materalia (ex MIPI matériaux innovants et produits intelligents)

Title	CURIE-TSINGHUA – Biomimetic responsive surfaces made of liquid crystalline elastomers: construction and function exploration
Abstract	The present project focuses on a soft lithography approach that aims at developing new biomimetic responsive surfaces made of liquid crystalline elastomers. The targeted responsive surfaces should present large and reversible changes in their surface roughness under external stimuli, which, in turn, will have very strong effects on various physical or physico-chemical properties of the surfaces: changes in adhesion, wetting properties, color to name a few. Recently, a number of studies have been devoted to responsive surfaces processing specific properties (adhesion, wettability), which can be changed by application of some external stimuli. However, most of the surfaces underwent a reversible change of their physico-chemical properties under the action of the stimuli, with only a few examples reporting reversible changes induced by a change of roughness at the micro or/and nano scale. Departing significantly from other related research programs, the present project describes a new approach toward the preparation of biomimetic responsive surfaces, associating smart materials (or stimuli-responsive materials) with a soft lithography technique called replica molding. Smart materials are materials, which respond by a change in shape and/or size to an external stimulus. Polymers play a leading role in the domain of smart materials, also called actuators or “artificial muscles”. Many actuators based on polymers have been developed and, among them, liquid crystalline elastomers (LCEs). LCEs are a very attractive kind of smart material, which, in proper conditions, can contract reversibly of several hundred percents under the action of various stimuli, mainly thermal and photochemical. On the other hand, soft lithography and more specifically replica molding has been developed recently by Whitesides’ group. In short, it consists in coating the solid surface to be duplicated with a liquid mixture of poly(dimethylsiloxane) (PDMS) elastomer precursors, which transform with time in a PDMS soft elastomer without shrinkage. The PDMS elastomer being non-sticky, the mold could be peeled off from the surface, producing a negative replicate of the micro and nano relief present on the “mother” surface. This technique was originally developed to replicate hard inorganic surfaces but has been extended to almost any surface, including surfaces of biological origin such as leave surfaces, butterfly wing surfaces, etc. Combining the two domains and using

appropriate experimental conditions, could give biomimetic responsive surfaces made of LCEs. To reach this goal, the project will rely on the expertise's brought in by the 3 partners in the field of: (i) molecular design and synthesis of liquid crystalline monomers, crosslinkers and elastomers; (ii) structural characterization of the biomimetic responsive surfaces via environmental scanning electron microscopy and in situ visualization of the surface evolution of the surfaces under thermal stimulus; (iii) preparation of the PDMS molds from selected mother surfaces of biological origin; (iiii) selection of the most interesting mother surfaces according to the potential applications expected: superhydrophobic surfaces (leaf surface), reflective properties (butterfly wing, exoskeleton of beetle), etc. The 3 participating partners have currently established successful collaborations with already published papers.

Partenaires	CURIE - Laboratoire Physico-chimie Curie UMR 168 ARMINES - CMGD - Ecole des Mines d'Alès CHINE - Tsinghua University - Department of Chemical Engineering
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Aide de l'ANR	179 247 €
Début et du ée	36 months
Référence	ANR-10-INTB-0904

Title	HSynThEx – Effect of He, H and their synergy on bcc metal systems of fusion interest: a combined theoretical experimental study
Abstract	One of the bottleneck problems for the realization of the nuclear fusion energy is to choose the key materials in a fusion Tokamak as well as the future reactor. The successful development of fusion power plants is dictated by the successful research of suitable component materials able to resist irradiation by the 14 MeV neutrons as well as the high flux H/He from the deuterium-tritium fusion. Despite many efforts so far, the interaction of H/He with the fusion materials with bcc structure and the blistering mechanism are still not fully understood, making the development of the radiation resistant materials difficult. We thus propose to perform a combined modelling and experimental study on the effect of He, H and particularly their synergy on Fe and W based model systems in order to predict the corresponding microstructural modification. This project brings together French and Chinese expertises on fundamental research of nuclear materials, which is particularly motivated by the fact that both countries are strongly involved in the ITER project. The present scientific project is composed of three main tasks. Task 1 deals with experimental characterizations on Fe and FeCr specimens after multiple-ion-beam irradiations and W samples after He implantation and direct contact with H/He plasma with low-energy and high-flux. Task 2 proceeds simultaneously with the Task 1 and consists in atomistic studies of the properties of diffusion and clustering of He and H with self-defects in Fe and W using complementary techniques. Task 3 deals with direct simulation of our experimental outputs using mesoscopic models parameterized by results of task 2. In practice, the present project is characterized by a close comparison of simulated and experimental data which is useful to validate and improve the various approximations assumed in the theoretical approaches and to explain the atomic-scale origins that drive the experimentally observed data. The synergistic effect of He and H is emphasized as one of the most important objective of this project. All the partners involved in the project have devoted significant effort in the field of nuclear materials from both experimental and modelling sides, characterized by more than 100 publications in international journals including Nature Materials, Physical Review Letters, Physical Review B and Acta Materialia. The computational kinetic Monte Carlo and the rate theory methods in SRMP (CEA-Saclay) and the

	molecular dynamics and the phase field method in BUAA, the experimental JANNuS in CEA-Saclay and the LPG in BUAA are totally complementary, motivating the present international collaboration.
Partenaires	SRMP - Service de Recherches de Métallurgie Physique, CEA USTB - University of Science and Technology Beijing - CHINE BUAA - Beijing University of Aeronautics and Astronautics - CHINE
Coordinateur	Chu Chun Fu - SRMP chuchun.fu@cea.fr
Aide de l'ANR	200 243 €
Début et durée	36 months
Référence	ANR-10-INTB-0905

Title	MINAFC – Microwave dedicated nanostructured ferrite ceramics: from basic research to integrated devices.
Abstract	MINAFC is a bilateral technological project supported by 5 partners involved in the preparation of magnetic nanopowders (nanoparticles and nansotrutcured particles), their consolidation as nansotructured ceramics using Spark Plasma Sintering (SPS) technology, their characterization and the study of their magnetic properties with a special emphasis on their microwave behavior. The main aims of this project are to perform basic research in order to understand the magnetic properties of nanocrystalline materials and to tentatively transfer this general knowledge to the fabrication of new and more efficient microwave devices. Ferrite materials are choosen as model materials. Due to their tuned magnetic properties in relation with their large variety of structures (spinel, hexaferrite, garnet) and their rich chemical compositions, they were widely used in recording systems for magnetic storage, high frequency inductors, microwave absorbers, radar systems, phase array antennas, and in virtually all communications systems. Spinel and garnet ferrites can be applied in the high-frequency region of several hundred MHz to several GHz and hexaferrites can be applied in the whole GHz region. If the technical opportunities, opened by the nanometer scale, become possible through the success in the consolidation of ferrite nanoparticles as nanostructured ceramics, a new limit in microwave technology will be crossed and real advances can be performed in the information and communication technology. The present French and Mexican consortium offers real opportunities for the achievements of this goals: Two groups of chemists, ITODYS lab. from Université Paris Diderot, who developed the chimie douce nanoparticles synthesis method, (Partner 1) and the AAM lab. from Universidad Autonoma del Estado de Hidalgo, who has an expertise in the preparation of nanoparticles by mechanosynthesis (Partner 5) ; Two groups with expertise in the study and applications of magnetic materials, SATIE lab. from Ecole Nationale Supérieure de Cachan (Partner 3), and IRM Instituto de Investigaciones en Materiales from Universidad Nacional Autonoma de Mexico (Partner 4) and a group with expertise in the analysis of magnetic structures by Mossbauer Spectroscopy and their theoretical study, LPEC lab. from Université du Maine Le Mans (Partner 2). It is important to note that general properties of nanosized particles can be extremely different from those of bulk, essentially because

the surface of nanoparticles (or interfaces of nanocrystals) becomes quite significant as compared with the total particle core or grain. The surface or interface has many defects and irregular bonding, and this is the main reason for the current interest in nanostructured materials. In the case of magnetic nanoparticles, magnetic interactions between nanoparticles (which depends in a complex way of average distances, dipolar fields, the possibility to form clusters, etc.), leading to macroscopic magnetic properties completely different. This is an important issue that will be investigated, since it is at the basis of many technological applications (high-density magnetic recording, microwave response, etc.). Obtaining high-density consolidated samples keeping the nanosized grains, in order to preserve the magnetic properties, is also a great challenge. SPS technology is a promising technique, as shown by preliminary results already obtained by a previous collaboration between partners 1 (France) and 4 (Mexico). In SPS, sintering times and temperatures are strongly reduced by the application of a high pressure and high electric current pulses. Finally, experimental and theoretical studies of the magnetic properties as a consequence of the nanostructured microstructure of these ceramics will be attempted and all the collected data, especially the high-frequency (microwave) related ones, will be discussed in order to develop some pertinent technological applications

Partenaires

ITODYS - Interface, Traitement, Organisation et DYnamique des Systèmes
LPEC - - Laboratoire de Physique de l'Etat Condensé
SATIE - Systèmes et Applications des Technologies de l'Information et l'Energie
IRM - Instituto de Investigaciones in Materiales - Institut of Research on Materials - MEXIQUE
AAM - Academica Area de materials - Particulate materials Group - MEXIQUE

Coordinateur

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Aide de l'ANR

286 700 €

Début et durée

36 months

Référence

ANR-10-INTB-0907

Title	NanoBioCarbonate – Organic control on nanostructured biomaterials, biomimetic example of otoliths and freshwater pearls
Abstract	Mineralized tissues (as mother-of-pearl, bone or tooth) are produced in nature to optimize the mechanical performances. This result is obtained thanks to a strategy of hybrid multiscale structure in which the organic matrix controls the mineral deposit and increases the tenacity as well as the resistance. Our approach consists in studying two natural materials to understand the protein control on these structures and properties. The identification of proteins which are of use as mediator or template for mineralization is a promising challenge to shape new nanostructured materials; we can learn a lot of the natural models, in this domain. Our starting materials are two typical biominerals (fresh water pearl and otolith). We plan to extract and purify the proteins in them. Then, to validate their role, we plan to experience in vitro mineralization using the extracted proteins. The research focuses on different types of organic macromolecules with different molecular weights, their effects on the crystal structure and the nanomechanical properties that can be tailored this way. Tsinghua University has accumulated a lot of knowledge in the study of biomineralization. ISTO of Orleans University has a great experience of organo-mineral ultrastructure and access to a proteomic characterization on the CNRS campus of Orleans (CBM). FEMTO Institute in Besançon France possess the specialist in nanomechanics of mother-of-pearl (nano-indentation and nano-tribology). The cooperation between our two Universities has been effective till 2005 when we have obtained the first PRD grant. The cooperation between our two countries will further concretize our efforts and improve the understanding of mineral growth in nature with the aim to open a new route for preparing hybride nanomaterials, using proteins or other organic molecules as template or mediator.
Partenaires	CNRS-ISTO - Centre National de la Recherche Scientifique-Institut des Sciences de la Terre d'Orleans Tsinghua University - Department of Materials Science and Engineering (DMSE) - CHINE
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Aide de l'ANR	204 880 €
Début et durée	36 months
Référence	ANR-10-INTB-0909

Title	NAPOLECO – Nanotubes in Polymers for Energy Conversion
Abstract	The proliferation of wearable and consumer electronics, as well as integrated systems, has raised the issue of powering up such devices. In particular, the use of primary batteries raises many issues, such as maintenance cost due to their limited lifespan and environmental concerns because of their complex recycling process. Hence, it has recently been proposed to use environmental sources for supplying electronic systems. In particular, vibrations are one of the most commonly available sources for energy harvesting. While many works in this field focused on piezoelectric materials, these latter feature drawbacks such as limited strain abilities and complex manufacturing process. In contrast, electroactive polymers (EAP) present high flexibility, and can be processed in various shapes. However, their conversion abilities are still far lower than piezoelectric materials. Therefore, it is mandatory to explore new ways for magnifying the ability of EAPs for converting mechanical energy into electricity, through the elaboration of new compositions or by the use of proper electronic interfaces. The aim of the proposal is to optimize the development of new nano-filled polymer composites for energy harvesting on ambient sources. These new nano-filled polymer composites will be prepared by dispersing functionalised carbon nanotubes within a polymer matrix. They will be characterized at various scales (from nano-scale to macro-scale). This characterization includes imaging (interaction between the nanofillers and the matrix, interaction between the composite and its electrodes) and measurement of the macroscopic conversion properties (i.e. electrostrictive coefficient Q or M, harvested current or power under thermal gradient and mechanical vibration, relevant electrical and mechanical parameters (permittivity, percolation threshold, Young modulus, etc.)). This project will support the on-going and worldwide effort for optimizing the conversion efficiency by a better understanding of the mechanism of conversion from nano-scale to macro-scale and to develop new harvester systems using thermal and mechanical ambient sources. This project will help to develop new self powered, autonomous wireless and friendly environmental smart systems (i.e. health monitoring systems, autonomous sensors…) and will also contribute to a rational use of energy and to the reduction of batteries needs.

Partenaires	INSA-MATEIS - INSA de LYON - Matériaux: Ingénierie et Science CID - Centro de Investigacion y Desarrollo Tecnologico - MEXIQUE INSA-LGEF - Laboratoire de Génie Electrique et de Ferroélectricité UIA - Universidad Iberoamericana - MEXIQUE
Coordinateur	Karine MASENELLI-VARLOT - INSA-MATEIS karine.Masenelli-Varlot@insa-lyon.fr
Aide de l'ANR	299 500 €
Début et durée	36 months
Référence	ANR-10-INTB-0910

Title	ONCO-SCREEN – Developing new microfluidic chambers for cancer cell screening
Abstract	The research program presented here is jointly conducted by Singaporean and French partners with strong expertise in biophysics, cancer biology, ultra-sensitive analytical chemistry and microfluidics who wish to implement an integrated microsystem designed to simultaneously quantitate motility and gene expression of live cancer cells challenged by different chemical environments. Cancer cell migration will be induced and directed by a concentration gradient of chemoattractant generated by a microfluidic system and cells will be separated and collected in individual chambers according to their velocity. We have demonstrated that cells migrate as expected in the microfluidic device and we now wish trough this franco-singaporean partnership to integrate in the microfluidic device an ultrasensitive biosensor arrays for on site and on chip molecular analyses of gene expression. Our goal is to provide the community with a scientific tool that will allow thorough characterisation of cancer cells based on the quantitative characterisation of their activity (migration, velocity) and molecular signature (gene expression) and to examine how these characteristics change with the nature of their environment. A microfluidic device that diffuses nanoliter volumes of a unidirectional chemoattractant molecule (Epidermal Growth Factor or stromal-derived factor-1) into a microchamber will be loaded with three human cancer cell lines (MCF-7, HBL-100, MDA-MB-231) known for their strikingly different migratory properties. Quantitative analysis of cell migration, velocity and polarisation will be carried out by real-time microscopy and computer-assisted. Cancer cells will be collected (either by using trypsin or a hydrodynamic protocol) and processed for routine molecular analysis using quantitative reverse-transcriptase-polymerase chain reaction (qRT-PCR) of selected markers including epithelial differentiation markers (E-cadherin, beta-catenin) and mesenchymal cell markers (Vimentin, twist). Next, a protocol will be developed to ensure on-chip detection of specific messengers ribonucleic acids (mRNA) that are only expressed in MCF-7 (oestrogen receptor), HBL-100 (activin ßa) and MDA-MB-231 (vimentin) cells. Following their migration in the chemotaxis chamber, each cancer cell population will be collected in individual chambers and exposed to an electrical field to induce total cell membrane rupture. Released cytoplasmic mRNA will be pushed towards the detection area to carry out molecular analyses using a nanostructured electrical

sensor array. Following hybridization between the target mRNA and the immobilized complementary probe, a bridging mechanism will enable the production of an electrical conductivity. Measured current will be proportionally correlated to the amount of stable hybrids formed and will permit to correlate a gene signature with the phenotype of each cancer cell line and to examine the effect of changing chemical environments on the phenotype and genotypic expression. This project will allow the production of an ultrasensitive electrical sensor array-based system in the shortest possible time, providing a powerful tool for vast molecular analyses in biological research. The knowledge derived from this project will have tremendous potential benefits through the development of a new lab-on-chip screening device for cancer cells and will further accelerate the transfer of microfluidic and nano-gap sensor technologies to human cancer diagnosis and prediction

Partenaires	INL – UCBL - Institut des Nanotechnologies de Lyon GMC – UCBL - Centre de Génétique Moléculaire et Cellulaire IBN - Institute of Bioengineering and Nanotechnology - SINGAPOUR
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Aide de l'ANR	236 087€
Début et durée	36 months
Référence	ANR-10-INTB-0913

Title	ProCoMedia – Propagation of waves in complex media
Abstract	This project aims at the control of wave properties through the control of disorder, an objective that can be achieved with waves that propagate in macroscopic media. It builds on a fruitful Chilean-French collaboration that goes back ten years, that has provided a solid theoretical backbone to our understanding of wave propagation in complex media. In addition, both sides have developed a close interaction with experimental groups in their respective countries. This proposal raises the ongoing collaboration to a new level of ambition, by bringing the experimental groups into a jointly articulated initiative. Research activities will be both of a theoretical and experimental nature, and carried out symmetrically in Chile and France. There will be significant cross-talk among the various participants in the different labs and countries, reflecting the existing culture of collaboration. Extensive use will be made of current communications technology to link the various groups, and face-to-face meetings will be organized to enable the type of communication that can only be achieved through personal, collective contact. The propagation of waves in complex media is a vast subject. Particularly, lack of quantitative understanding, much less control, of the role of disorder, hampers progress in many fields, from the technology of amorphous semiconductors, to the control of turbulence in fluids, to the characterization of granular materials in the mining, food, and pharmaceutical industries. In this proposal, two specific topics have been chosen for research: 1) Wave propagation in slightly disordered periodic media, and 2) Effect of nonlinearities on wave propagation through disordered media. Available theory will be revisited and expanded as needed and suggested by currently available numerical capabilities and experimental hardware. Specific experiments will be performed with centimetric microwaves in a metallo-dielectric metamaterial; with acoustic waves in a wave guide endowed with a chain of resonators; with surface waves on a fluid, and with ultrasonic waves in solid materials. The criteria that have been used to arrive at these topics are: A) Familiarity of proposers with one or several recently developed, and available, technologies that enable unique data-gathering capabilities. B) Ease of control of disorder in the propagating medium. C) Close relation between theoretical and experimental capabilities of proposers. D) Track record of successful collaboration among participants.

Partenaires	LOA/ESPCI, - Institut Langevin LAUM - Laboratoire d'Acoustique de l'Université du Maine PMMH - Physique et Mécanique des Milieux Hétérogènes POEMS/ENSTA - Propagation des Ondes : Étude Mathématique et Simulation UChile - Depto de Fisica - Facultad Ciencias Fisicas y Matematicas -Universidad de Chile - CHILI
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Aide de l'ANR	305 116 €
Début et durée	36 months
Référence	ANR-10-INTB-0914

Title	PROMET – Anaerobic process for the sludge treatment and methane valorisation: multiscale approach
Abstract	Modern anaerobic digestion is receiving a new fillip within the framework of actual energy and environment context, and plays an increasing role for its abilities to further transform organic matter into biogas composed mainly of 50-75% methane, as thereby it also reduces the amount of final sludge solids for disposal whilst destroying most of the pathogens present in the sludge and limiting odour problems associated with residual matter. Anaerobic digestion thus optimises WwTP costs, its environmental footprint and is considered a major and essential part of a modern WwTP. The biogas can be easily used as a renewable energy source through the robust and established gas-engine technology such as combined heat-and-power units on site. Moreover, it is finding other applications such as vehicle fuel, substitute for natural gas and raw material in industrial processes for methane after purification and upgrading. The controlled production and exploitation of the biogas prevents methane from greenhouse gas emissions. As such, the anaerobic process for the sludge treatment and methane valorisation shifts then a sustainable paradigm from "treatment and disposal" to "beneficial utilisation" as well as "profitable endeavour". While many efforts have being devoted to the application of anaerobic technologies worldwide, the research projects are still missing up to now on the core of an anaerobic process that is the reactor, in particular the sound understanding of various mechanisms involved in such a process to intensify the efficiency. Most of high rate upflow reactors, i.e. Upflow Anaerobic Sludge Blanket (UASB) reactor, Internal Circulation Anaerobic Reactor (ICAR) and Expanded Granular Sludge Blanket (EGSB) reactor, etc. have been leading anaerobic reactors in the world. As all multiphase reactors in Chemical and Environmental Engineering, these reactors are of very complex nature, particularly due to the coupling between the biochemical aspects and multiphase flows. While the biological mechanisms have been widely studied in the literature, the physical parameters and physico-chemical mechanisms involved in an anaerobic process were scarcely reported. It is widely recognized that except substrates and organic loading, hydrodynamic conditions are the most important operating parameter on the process efficiency in whatever upflow anaerobic reactors. This research project within the framework of ANR Blanc – NSF China aims at initiating an innovative

process study on the fundamental understanding and thereafter intensification of the anaerobic sludge treatment and valorisation of biogas through a multiscale approach. Two main axes will be addressed in this project: (1) the behaviours of sludge granules will be exhaustively investigated from a hydrodynamic point of view between three phases in presence: sludge granules – biogas bubbles and water. Both physical and biological behaviours of a single granule in a microdevice will be linked to the global properties characterised in a 3D pilot at macroscale; (2) the mechanism and efficiency of methane generation will be studied from the nucleation of a microbubble at the surface of a granule until to the analyse of the biogas production issued from a 3D pilot at macroscale under various conditions. These works will be completed in a 2D pilot in presence of major interactions between three phases. Besides the hydrodynamic aspect considered with both advanced metrology such as Particle Image Velocimetry (PIV) at different scales and numerical simulation, complex rheological and biochemical characters of the sludge in the reactor will also be taken into account in this study. The perfect complementary partnership between our two teams allows us to proposing an original research program based on a multiscale approach to gain insight into several key fundamental mechanisms never investigated until now in the process of the anaerobic sludge treatment and valorisation of biogas.

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Aide de l'ANR	176 280 €
Début et durée	36 months
Référence	ANR-10-INTB-0906

Title	T-shock – Experimental-Theoretical-Numerical Studies on the Fracture in Ceramic Materials by Thermal Shock
Abstract	Because of their favourable properties at high temperature, as well as in corrosive and erosive environments, ceramic materials are finding ever wider applications in industrial and many other fields. Because of their inherent brittleness and combination of other pertinent properties, ceramic materials, however, exhibit poor resistance to catastrophic failure under thermal conditions which generate thermal stresses. Therefore, for the purpose of reliable engineering design, it is important that the variables which control thermal stress failure of brittle ceramics are well understood. The degradation of the ceramic materials underwent thermal shock can be shown by quenching tests. One can clearly observe that the residual strength of specimens after quenching falls down considerably once a critical quenching temperature is reached. It is commonly accepted that the appearance of macro-cracks is the principal cause of falling down of the residual strength. Ceramic materials are developed to satisfy a wide industrial and engineering requirement. Even though considerable progress has been made in the elaboration of high-performance ceramics, researches on evaluation and simulation of damage and fracture of ceramics seems to advance still with difficulty, especially in the case of thermal shock loading. In fact, engineers and scientists often need a detailed and precise description of initiation and growth of macro-cracks in the material under thermal shock. Conventional theoretical and numerical tools cannot provide fully satisfactory responses to this exigency. New methodologies have to be developed for this purpose. In this project, we propose to establish damage models to deal with the damage and fracture in ceramic materials subjected to thermal shock on the basis of a detailed multi-scale analysis and then to implement these models into a finite element code. To this end, we will combine the competencies of all the partners who participate to the present project, namely: - The powerful experimental capacity of the Chinese partners, in skill as well as in equipment; - The long experience in multi-scale modelling of both the Chinese and French partners; - The leading position in damage and fracture analyses and in related numerical simulations of the French partners. All these elements guarantee the formation of an outstanding research team and high-level research quality of the present project.

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