AGENCE NATIONALE DE LA RECHERCHE

Presentation of the funded projects in 2010 for the Materials and Processes Programme

ACRONYM and project title **Page**

AFAQ ISO 9001

Project title	**ASAP : A technological breakthrough for the development of a new, more innocuous PVDC with enhanced properties**
Abstract	Polyvinylidene chloride (PVDC) is widely used in food and drug packaging, due to his excellent water vapor and oxygen barrier properties. PVDC is sold as either an extrudable resin or as an aqueous dispersion (latex) for coating. These applications, and also legislation related to these products, require that the level of degradation products be minimized, and the migration of any additives and/or by-products be well controlled and documented. This polymer has some limitations: migration of additives, which is a common problem to all industrial polymers synthesized by heterogeneous polymerization, and resistance to storage conditions and certain treatments. Limitations could be reduced if the following identified properties can be improved : • resistance to UV and visible light, • resistance to Beta radiation during processing of multilayer films, • thermal stability of PVDC during extrusion processing, • thermal stability of coated films, and • reduction of the migration of by-products and additives. The ASAP industrial research project aims to understand the degradation mechanisms, identify the various species which can be generated during PVDC degradation, and develop suitable solutions to limit the migration phenomena of both desirable species (such as surfactants and additives) and undesirable species (such as by-products). This understanding requires a preliminary analysis of the co-extruded and coated films produced with PVDC. Therefore, the proposed research programme will focus on the following points: • to know the critical UV and visible light wavelengths which contribute to PVDC degradation, • to know the impact of ? radiation on the PVDC layer in a coextruded film, • to better understand the relative contributions of both the monomer units used and the end groups present in the PVDC backbone to thermal degradation of PVDC products, and • to compare latexes using molecular surfactants to latexes without molecular surfactants. Research project results will lead to the development of a new generation of PVDC. In order to reach that goal, there is a high need for technological breakthrough by working on innovative processes, based on high level studies carried out at academic level, and which have demonstrated real benefits in terms of both polymer properties and processing.

The multidisciplinary team brought together to execute the ASAP project includes renowned industrial and academic parties to ensure improvement of the current state-of-the-art and compliance with future industry (and market) specifications. SOLVIN SA, as project scientific coordinator, will lead this team with future industrial/market needs in mind. Academic partners UPMC, C2P2, ICG, LCP andTue Eindhoven, will all contribute with specific know-how, knowledge and experience in well defined areas and develop specific competencies.

Partners	SOLVIN SA UPMC Laboratoire de Chimie des Polymères UCBL Chimie Catalyse Polymère et Procédés Université de Provence Laboratoire Chimie Provence Institut Charles Gerhardt
Coordinator	Jérôme VINAS SOLVIN SA Jerome.vinas@solvay.com
ANR funding	1 226 140 €
Starting date and duration	January 2011 – 36 months
Reference	ANR-10-RMNP-005
Cluster label	AXELERA

Project title	**ASPOME :** Adhesion for structures made of polymers and metals
Abstract	The plastic-metal hybrid technology was developed to bridge the gap between the two worlds of metal and plastics. The technology allows the combination of the advantages of metals (stiffness, strength, ductility, low cost) and plastics (function integration, low density). It is now extensively used in automotive but it is currently limited to semi structural applications such as front end carriers or other bolt on body in white parts. The standard hybrid technology consists in placing a metal insert inside an injection mold and to over-mold it with plastics. The plastic goes through holes and wraps around the insert edges. The link between the metal and the plastic is mainly mechanical and the shear bond strength if limited to 2 MPa.In the case of structural parts, high strength steel is used and not a preferred solution to have holes in a load bearing structure. For these two reasons, the hybrid technology is not currently used for load bearing structures. The objective of the ASPOME project is to extend the use of the hybrid technology to load bearing structural parts. To reach this target, the direct adhesion of injected thermoplastics on a metal or composite structural substrate will be developed. The substrates will be surface-treated by atmospheric pressure cold plasma process. Atmospheric plasma treatment is currently used mainly for cleaning surfaces, activation of surfaces, and surface coating. It is not yet used for the purpose of the study. The surface treatment will be adapted by ENSCP to the substrate (steel with or without e-coat treatment, aluminum, continuous fiber reinforced polyamide composites) and the over-molded plastic to reach adhesion strength between the injected plastic and the insert of 20 MPa or more. To reach this target, the atmospheric plasma treatment will be coupled if needed with the deposition of a thin layer of a primer that can be adapted to the substrate. The effect of physical treatment of the insert (heating before injection, grit blasting) will also be assessed on the quality of the interface. The effect of mechanical loading and ageing of the structure on the quality of the interface between the injected polymer and the surface-treated substrate will be evaluated by Mines de Paris. A mechanical model of the interface between the thermoplastic and the surface-treated substrate will be developed to enable an improved simulation of load bearing polymer metal structures To define the conditions, two case studies will be developed by the industrial partners FAS and FAE. The first case study is a seat structure element with multi-axial static, crash, and fatigue conditions. The structure and the interface will also be evaluated for long term ageing for interior conditions. The recyclability of the polymer-metal hybrid structures will be assessed, as well as the life cycle

analysis of the component. The second case study is a front end carrier with multi-axial static, fatigue and vibration conditions. The structure and the interface will be evaluated for long term ageing for under the bonnet conditions (temperature, humidity, and resistance to fluids). In conclusion, ASPOME has the following objectives 1. Adhesion strength between polymer and metal or composite substrate of 20 MPa minimum by direct injection of the polymer 2. Development of surface treatments adapted to the substrate and the over-molded thermoplastics 3. Evaluation of the effect of mechanical loading and aging on the quality of the interface 4. Simulation of the structures in static and in crash by modeling the interface 5. Development of a cost effective process for direct adhesion of injected thermoplastics on a metal substrate and application to load bearing structures in large series 6. Replacement of seat structures made in metal by hybrid structures metal/plastics/composite) 7. Assessment of the recycling of hybrid structures and life cycle analysis.

Partners	Faurecia Sièges d'Automobile ENS Chimie de Paris Faurecia Automobile Exteriors ARMINES CDM
Coordinator	Thierry Renault – Faurecia sieges d'Automobile Thierry.renault@faurecia.com
ANR funding	712 177 €
Starting date and duration	January 2011 – 36 months
Reference	ANR-10-RMNP-008
Cluster label	MOV'EO

Project title	**FLUOTI :** Cold Flow Forming of Ti-6Al-4V
Abstract	The principal objective of project FLUOTI consists in simulating the spin forming process of TA6V at room temperature to produce long tubes by successive work hardening and local large deformation stages. The advantage lies in the high geometrical precision for obtaining thick tubes used in aeronautics for instance. The material behaviour of the a+ß microstructure of TA6V under large "cold" deformation is still a challenge. However, and this is how the project is original in its purpose, the spin forming process could allow, for successive incremental deformations, to push the limits of the standard formability of the material. Indeed, preliminary tests at ROXEL with repeated deformations up to 30% have already been obtained but the industrial interest is above 70%. Despite this, there is no certainty that an industrial solution exists. Today there are no cold scale spin formed tubes in TA6V produced at an industrial scale. However, room temperature is certainly less favourable to deformation but allows for better reproducibility and less distortion and oxidation during step by step operations. Accordingly the quality of the tubes will be better assured during an easier cycle and the processing cost to form the tube will be less expensive. Furthermore the quality of the tube at the end of the processes must be known throughout its whole length and thickness because many of theses pieces are parts of class 1 for aeronautics. Therefore the company ROXEL wishes to continue these preliminary investigations and implement the means necessary to obtain a 1st prototype tube realised by cold spin forming of TA6V. If one combines the high cost of material, multiple settings of spin forming conditions and the many possibilities of heat treatments, we soon realize that the number of trial and error would be prohibitive for ROXEL. Therefore the numerical simulations of the process are then proposed to try to minimize the number of tests on industrial site by identifying and optimizing the operating conditions and status of the tube after the forming operation. The simulation will also incorporate changes in the material behaviour from its raw supply state to the finished piece. A blocking point of numerical simulations of flow forming is computing time. Indeed, like all processes of incremental forming, spin forming is an unsteady process which leads to time-intensive computing. The flow zones are located in contact with the wheels and are always in motion. We must therefore optimize the size of the mesh in adequacy with both the geometry reproduction and the level of distortion experienced by the material. The detailed managements of free surfaces and the contact are also important numerical issues. More accurate representation of the kinematics of tools (mandrels and rollers) is complex. Its influence on the quality of

simulation results is very important. Many parameters come into play when evaluating the processing of the tube during the cold spin forming operation. There is of course the influence of operating conditions (kinematics and geometries of the tools) and geometries (initial, intermediate and final) of the tube on the rheology and behaviour of the material. There is also the influence of thermal treatments between two pass of spin forming that will help to push the material to its very far limit of deformation. Improving the cold formability of TA6V is going through a series of cross linked steps of analyses and characterizations of the influence of strain paths with respect to evolutions of mechanical properties and microstructure.

Partners	ROXEL France SA ARMINES (CEMEF) TIMET Savoie TRANSVALOR SA
Coordinator	Aurélie BUISSON – ROXEL France SA a.buisson@roxelgroup.com
ANR funding	598 038 €
Starting date and duration	January 2011 – 48 months
Reference	ANR-10-RMNP-015

Project title	**HYPERCAMPUS :** High efficiencY PiezoElectRiC leAd-free Materials (comPosites and textured ceramics) for UltraSound applications
Abstract	Piezoelectric ceramics have been in commercial use for several decades and they have always witnessed a tremendous growth rate. Nowadays, these materials are integrated in a wide range of devices and in particular in ultrasonic applications. Since the discovery in the 50's of lead-zirconate-titanate (PZT), derived compositions have been developed to optimize the efficiency of this material. Thanks to use of dopants/additives and efficient production processes, PZT-based compositions are the dominant piezoceramics since their electroacoustic properties are high. This increasing success of PZT is associated to health and environmental problems because PZT contains lead. As a consequence, the European Union in 2003 and also many countries in the world included PZTs in their legislation as hazardous substances to be substituted by safer materials. Their objective is to protect human health and environment. The European regulations will be reviewed every four years, and whenever a viable replacement to hazardous substances exists, the exemptions will be cancelled. We propose through this HYPERCAMPUS project that a complementary French Consortium sets up a research axis from the development and optimisation of high efficiency piezoelectric lead-free materials to the manufacturing of several demonstrators for underwater, NDT and medical imaging applications (with centre frequencies between 500kHz and 20 MHz for the ultrasonic transducers). This Consortium is composed of six partners with four public laboratories (François-Rabelais University of Tours (U930), University of Limoges (SPCTS), Chimie-ParisTech (LCMCP), Institut d'Electronique de Microélectronique et de Nanotechnologie (IEMN)) and two companies (Thales Research & Technology, VERMON SA). The scientific and technical objectives, which concern mainly experimental developments, are multiple, to cover requirements of several applications, but with the same goal: obtaining high efficiency lead-free piezoelectric materials. The development of these materials will be declined in three forms. First the fabrication of dense and reproducible lead-free KNN-based ceramics will be performed. Secondly lead-free textured ceramics by TGG method will also be developed with high expected degree of texturation. Two basic compositions will be studied (barium titanate ($BaTiO_3$) and KNN ($K_{1-x}Na_xNbO_3$) based ceramics with corresponding single crystal templates). Third, the fabrication of 1-3 piezocomposites with lead-free single crystals (KNN) using a new fabrication process (lamination method) will allow obtaining large area and homogeneous properties. This fabrication process will be favoured as opposed to the classical dice and fill method. With these different new materials, several prototypes will be

designed and manufactured. Single and multi-element ultrasonic transducers (HF linear array and 2D array) will be fabricated. The new generations of lead-free piezoelectric materials (ceramic, textured and piezocomposites) will have performance at least equivalent to that of lead-based materials to confirm the possible replacement of the lead-based materials by new lead-free materials developed in the project. Specific numerical models (for composite materials and demonstrators) will be developed and will support the optimization of piezoelectric materials and transducer prototypes. For the two industrial partners, HYPERCAMPUS expected results are essential for future activities. For the first industrial, control the lead-free piezoceramic production is the opportunity to remain in a leading position among few major actors in sonar applications. Moreover, the second industrial has to be at the early stage of the lead-free materials development to remain competitive in case of the non prolongation of the exemption. With the HYPERCAMPUS project, one can imagine that a new generation of green arrays will be commercialized and will supplant the current state of art devices.

Partners	Université François-Rabelais de Tours Thales Research & Technology Sciences des Procédés Céramiques et de traitement de surface Institut d'Electronique de Microélectronique et de Nanotechnologie LCMCP VERMON SA
Coordinator	Franck Levassort – Université François Rabelais de Tours levassort@univ-tours.fr
ANR funding	771 987 €
Starting date and duration	January 2011 – 36 months
Reference	ANR-10-RMNP-006
Cluster label	CERAMIQUE – Pôle Européen de la Céramique

Project title	**IDEFFAAR :** Influence of casting defects on fatigue behaviour of aerospace alloys
Abstract	The objective of IDEFFAAR is to propose an engineering tool to asses the influence of casting defects on the fatigue behaviour of cast Aluminum alloys. The project is focussed on aeronautical applications but the active role of CTIF in the project allows extending the valorisation of results to other industries. The expertise and skills of the partners will support a quantitative evaluation of allowable casting defect in casting component production. Furthermore, fatigue tool proposed can be used to compute justification dispensation on a given component containing higher defect than expected. Industrial partners (MESSIER, HISPANO and AIRBUS) will have the opportunity to validate the tool on real components so that the methodology will result in a compromise between scientific advance and reasonable computational cost. IDEFFAAR aims to work on the following topics in order to overpass scientific issues on this topic. - Produce fatigue samples with representative defects (or bigger) in order to define allowable defect criterion. - Study 3D fatigue mechanisms from defects using high resolution X-ray Tomography. A special focus will be the competition between surface and internal defect regarding environmental effect. - Determine the role of environment on the fatigue behaviour in order to characterise the representative environment for an internal defect. - Define the equivalent defect size and morphology regarding fatigue. This definition should include relevant physical characteristics of the defects (morphology and microstructure) as well as constraints induced by the final implementation in an industrial FE code. - Propose a fatigue assessment methodology for structural components integrating directly the defect size. This methodology should be easy to use and time efficient. - Validate the Through Process Modelling proposed on industrial component (casting / NDT / fatigue) by the mean of fatigue tests performed on the structure. - Evaluation of the methodology in the case of temperature (150 °C) on fatigue samples. - Evaluation of the role of HIP and associated welding repair on the fatigue behaviour of fatigue samples. The whole project should allow doing scientific advances in fatigue mechanisms from defects and simulations while keeping a reasonable complexity in order to be used by fatigue design engineers.

Partners	ENSMA Institut PPRIME Centre Technique des Industries de la Fonderie AIRBUS Opérations SAS HISPANO SUIZA CNRS MATEIS Fonderie MESSIER SAS
Coordinator	Yves NADOT-ENSMA Institut PPRIME Yves.nadot@lmpm.ensma.fr
ANR funding	874 292 €
Starting date and duration	Janvier 2011 – 36 months
Reference	ANR-10-RMNP-016
Cluster label	ASTECH Aerospace Valley

Project title	**MEMFIS :** Extraction of Radioelement using Innovative Functionalized Membranes
Abstract	The treatment of effluent and wastewater has become a major environmental concern of our society. Whatever the application area, regulations on wastewater discharges are becoming more severe and require efficient reprocessing technologies. This must take into account the recycling or conditioning of some products and water reuse after decontamination. Perhaps more than any other industrial activity, a strong requirement for the nuclear industry is to reach radioactive releases as low as possible with the best technology available at an economically acceptable cost. Thus many industrial and nuclear scientists are now mobilized to improve the efficiency of decontamination processes of radioactive effluents. In France, the activity of these effluents after decontamination is far below current standards, and is still decreasing since few years. However, to reach the ambitious objective of an activity of the waste close to zero, it is necessary to develop innovative treatment processes. The needs of the nuclear industry waste water treatment concern (i) fixed installations such as reactors and power stations, liquid waste treatment (STEL) of plants or research centres (ii) more specific applications to specific waste, and often abroad. In general, treatment of effluent requires particle filtration and extraction of a series of radionuclides such as cesium, cobalt, nickel, etc., by ion exchange resins, or by a selective co-precipitation. The current processes of extraction, simple and robust present some drawbacks to solve: for example, in the case of ion exchange resins, their capacity is limited, and the water retains some activity mainly due to 60Co. On the other hand the radioactive nature of extracted elements may cause a deterioration of the resin in storage conditions. In the case of coprecipitation process, the amount of waste generated is high and the recovery of particles after precipitation remains a limiting step. The objective of this project is to provide a method of complexation-filtration membrane for decontamination of radioactive waste, competitive with current processes. The use of membrane process is actually interesting in order to decrease effluent volume and to improve the waste confinement. The originality of this project is that in addition to filtering of particles this process also allow thanks to the membrane's functionalization extracting soluble components. The development of functionalized membrane technology implies a field of interdisciplinary research involving chemists for the synthesis of new materials, physical chemists for the characterization of these materials and description of their transport properties, but also specialist's chemical engineering to optimize the implementation process on an industrial scale. The known-how and experience of the

different teams and partners can achieve this goal: for the "academic" point of view a chemist's team will be responsible for the synthesis of materials and their functionalization, the second research team of the consortium will follow their characterization; regarding the industrial side, an industrial specialist of filtration membranes and an industrial active in the field of decontamination of radioactive waste are both partners of this project. Recent developments made by our teams at the laboratory scale in using of solid supports functionalized with specific Cs ion-exchange groups, allow us to look at this project from their implementation on an industrial scale, with industrial teams project partners. The generalization of this concept to other radioisotopes is a scientific and technological challenge to be met if the project is accepted.

Partners	CEA - ICSM Institut Charles Gerhardt ONECTRA Céramiques Techniques Industrielles
Coordinator	Agnès GRANDJEAN – CEA - ICSM Agnes.grandjean@cea.fr
ANR funding	763 121 €
Starting date and duration	January 2011 – 36 months
Reference	ANR-10-RMNP-003
Cluster label	TRIMATEC

Project title	**OPTIPRO-INDUX :** Multi-Scale Optimisation of induction hardening processes for complex geometrical parts
Abstract	The goal of this project is to implement a process of analysis, control and optimisation of a surface induction heat treatment process followed by a quenching stage. The part which will be used in this project if an automotive crankshaft, which is one of the most critical parts in the future powertrains prescribed by the EURO6 regulations. This part may be reinforced in the most mechanically loaded areas by burnishing or by induction. If induction has become largely used for large-size engines, its use for automobiles is scarcer, mostly due to badly mastered process and costs. Indeed, small crankshafts are more sensitive to deformation after induction hardening due to their geometry (weaker massiveness). These distortions make the use of induction hardening quite delicate and increase the global cost of the part. The analysis, study approach and results of this project will not be limited to crankshaft production, but may alos be reused for studying the induction hardening of other parts with a complex geometry subject to distortions The scientific approach will be based on the use of complementary approaches to reach the prescribed goals: - accurate understanding of material behaviour during fast heating - modelling of multiphyssics couplings between electromagnetism, heat transfer, solid mechanics and metallurgical phases transformation - experimental validation of the optimised solutions The complementarity between consortium partners (laboratories in the field of numerical modelling of processes and in material science, automotive industry, steel industry, experts in electromagnetic processing of materials) will help to make this project to a success. Project benefits are manifold - Scientific: improve knowledge of metallurgical behaviour for fats heating, fine analysis of thermal-mechanical-metallurgical couplings, progress towards process optimisation through an accurate predictive multphysics computational model - Process and material optimisation (structure, hardness, residual stresses, deformation,..) with the help of computational modelling (predictive aspects) to better take it into account in the part design process - Technological: induction heat treatment is an economic process easily implementable on a new production line, and which can potentially lead to very good in-use properties - Economical: enable manufacturing of small automotive crankshafts with minimal and reproducible deformation. We need to recall here that straightening of induction heat treated crankshafts cannot be carried out – since it leads either to unfavourable residual stresses, or worse to breaking - Environmental; reduction of energy consumption during manufacturing processes complies with sustainable development goals.

Partners	ARMINES (CEMEF) Ascometal CREAS EDF SA EFD Induction Peugeot Citroën Automobile SA Institut Jean Lamour – Institut National Polytechnique de Lorraine Transvalor Sa
Coordinator	François BAY – ARMINES (CEMEF) François.bay@mines-paritech.fr
ANR funding	1 043 377 €
Starting date and duration	January 2011 – 48 months
Reference	ANR-10-RMNP-011
Cluster label	Materalia

Project title	**PEPS :** Printed electronics for future secured packaging
Abstract	The battle against counterfeiting has become a major national priority for the French Ministry of Budget, the Colbert Committee as well as on international level with the EU Customs Action Plan set by the EU Council in March 2009. Huge interests are concerned in terms of financial and employment losses and deteriorated image of the Companies. Indeed, counterfeited products, mostly based on low-quality materials and poorly controlled processes, are never submitted to the required legal conformity tests. Besides robustness, such products may also seriously affect the customers safety. The components used in counterfeited products may also lead to recycling problems as the product life cycle is not taken into account during the conception phase. The latest statistics clearly showed the fast expansion of counterfeiting. The protection of trade marks is nowadays taken very seriously and should be integrated early in the product life cycle, during its design phase. All stakeholders have now agreed that only technology is a position to develop effective tools for the detection of counterfeited products. The ideal solution would be based on a technology very difficult to apply by counterfeiters, and at the same time low-cost and very easy to identify by both control authorities and customers. The main goal of this research project is to demonstrate the scientific feasibility of such a device. The demonstration will be based on the development of a new concept of printed electronics using connected components directly printed on the packaging. This device includes a display to be activated by the energy delivered by a mobile phone placed in near vicinity. Except for the display, the whole printed electronics could be hidden behind an opaque layer applied onto the package through conventional printing. Each functional building bloc, as well as their assembly, involves technical challenges to overcome, which guaranties the effectiveness of the counterfeiting protection device. The proposed solution is thus difficult to copy and nevertheless low-cost while requiring no specific detection equipment thanks to the use of mobile phones, contrary to current RFID or DNA techniques. Generally speaking, the consortium will work on new materials and processes to ensure enough robustness of both the printed components, using fast deposition techniques of functional inks on paper like Ink Jet and Flexography printing, and their connections throughout the product lifetime. The selected materials and their processing will be submitted to life cycle analyses during the design phase in order to minimise the environmental impact and ensure the recycling ability of the new anti-counterfeiting and security products. The first target applications address the sector of manufactured products

through the integration of the device directly in the packaging. The applications are obviously not be limited to packaging as they should include other sectors such as fiduciary papers, secured medical prescriptions, etc. In addition, the expected impacts of the project are much large than the mentioned applications, since the research aims at developing cellulose based substrates with high barrier efficiency and top surface properties required for the printing of electronic components. The project will enable demonstrating the technical and industrial feasibility of printed electronics on paper substrate towards the stakeholders and SMEs of the paper industry sector. Eventually the whole paper sector including converting and printing industries will get tools and knowledge that will enable integrating printed electronics in their processes and supply their customers with new products and services.

Partners	Centre Technique du Papier Institut de Microélectronique Electromagnétisme et Photonique et de Laboratoire d'hyperfréquences et de Caractérisation Papeteries Luquet & Duranton PYLOTE SAS CNRS – Institut de Chimie de la matière et de la chimie condensée
Coordinator	Guy Eymin Petot Toutollet – Centre Technique du Papier dgept@webctp.com
ANR funding	1 053 911 €
Starting date and duration	January 2011 – 36 months
Reference	ANR-10-RMNP-002
Cluster label	SCS

Project title	**PLATFORM :** Flatness control in the rolling of sheet metal
Abstract	Delivering metallurgical strips with increasing mechanical properties at the right price is one of the major stakes of the industry of metallurgy. For the transformation step, it induces an increasing difficulty to roll perfectly flat sheets and preventing from the occurrence of major defects due to buckling of strips. This high level of quality is required for downstream operations like stamping. To support industrialisation of new high performance grades of aluminium and steel strips, we propose to develop innovative measurement methods and predictive models to assess flatness of rolled strips. The Project consists of two intrinsically coupled phases: 1) A significant improvement of the flatness measuring tools i) for the residual stresses, by developing a new concept of flatness roll using Optical Fibre Sensors based on Fiber Bragg Gratings embedded under a roll surface, providing a high spatial resolution combined with an intrinsic compensation of thermal effects, ii) for wave defects, a global measurement using laser scanners giving a high spatial resolution and allowing combined measurement of both latent and manifest shape 2) Development of predictive models for flatness. Two modelling approaches will be assessed: i) an integrated approach where buckling is taken into account using a defined material law integrated in a 3D FE model for rolling ii) a "hybrid" one using "Arlequin" methodology to couple the above FE model with a shell FE model. Results from numerical models will be compared to experimental ones, allowing for a very fine validation of flatness (not available today) in particular at the very edges of the products, where significant stress gradients are observed. Project management will allow for a strong interaction of the complementary know-how of the seven highly skilled partners in their respective field. The main project innovations are: 1) On the experimental side, the development of a residual stresses measurement method using high resolution Optical Fiber birefringent Bragg Gratings and the development of innovative rigs to study the relation between buckling and residual stresses in a controlled environment 2) Advanced numerical modelling to allow for the coupled analysis between roll gap mechanics and buckling instabilities occurrence at the exit of the roll gap. These researches are highly strategic for the French industry in the field of rolling. Short term economical benefits are expected after the completion of this project. The associated aim is to guarantee the metallurgical plants competitiveness and sustain a high level of excellence on flatness control tools for rolling of thin gauge products. The projects results will contribute to shorten the ramp-up of new technical products from current and future market demands for wider, thinner and stronger

	products.
Partners	CNRS Laboratoire de Physique et Mécanique des Matériaux CEA LIST ARCELORMITTAL MAIZIERES RESEARCH SA ALCAN Centre de recherché de Voreppe Laboratoire de Mécanique des Sols Structures et Matériaux Laboratoire de Génie Civil et d'Ingénierie Environnementale Armines (CEMEF)
Coordinator	Hamid ZAHROUNI - LPMM zahrouni@univ-metz.fr
ANR funding	996 386 €
Starting date and duration	January 2011 – 48 months
Reference	ANR-10-RMNP-019
Cluster label	Materalia

AFAQ ISO 9001

Project title	**PREVISIA :** Multiphysical approach of the ageing of martensitic stainless steels under loading and on its consequences onto the fatigue crack growth properties
Abstract	This project shall permit to realise innovations in terms of mechanical behaviour prediction of engine pylon parts made out of martensitic stainless precipitate hardening steels. It is dedicated to demonstrate that a multi-scale modelling will permit to optimise the static and damage tolerance design of structural parts in 15-5PH used at 1200MPa taking into account their highly severe in-service conditions. It answers a more general approach on engine pylon parts made out of high strength materials as titanium or nickel based alloys and answering to severe loads under long time temperature exposure (in service temperature between 120°C et 325°C), for which designers want to adapt the predicting tools currently used for other metallic materials employed in less severe conditions. Scientific and technical stakes concern the aging of 15-5PH under stress between 275°C and 325°C for long term use and the effects of load spectrum on the fatigue crack propagation in relationship with the aging of the material and the oxydation of the fracture because it avoids the use of this steel for the new applications. The project is proposing to update our metallurgical and mechanical knowledge on the material used under severe thermomechanical conditions. At first, the aging mechanisms will be studied and modelled in order to predict the evolution in service of the static and fatigue properties. Then, the fatigue crack growth mechanisms will be studied in relationship with the aging and the oxydation mechanisms to enlarge the application of various models. Finally, the results put in place during PREVISIA project will be compared to the results of a representative test of fatigue under temperature of a representative element of the aircraft. The organisation is to put in place the understanding phases from nanometric scale, going through microscopic and macroscopic scales until testing under spectrum on representative element : - Nanometric scale of the microstructure to characterize the aging from metallurgical observations - Microscopic scale to characterize and model the behaviour laws as a function of the temperature and the aging to describe the fatigue crack growth mechanisms - Millimetric scale to characterize the effects of the fatigue sprectrum in relationship with the behaviour laws, the oxydation effects and the fatigue crack mechanisms - Part scale to validate the predicting tools. The partnership is as follows : - Academic partners : SIMAP, CIRIMAT, INSTITUT P' ENSMA, LMT Cachan. - Industrial partners : Aubert & Duval, Airbus Operation SAS, EADS IW. The tasks are defined hereafter : - Task 1 : Definition of the field of the study from real load cases, given by AIRBUS. - Task 2 : Study and modeling of the

microstructures aged under mechanical loading . - Task 3 : Study and modelling of static behaviour and fatigue laws after aging under mechanical load. - Task 4 : Characterisation and modeling of the fatigue crack growth under spectrum on aged materials. - Task 5 : Validation on industrial part. - Task 6 : Coordination of the project by EADS IW.

Partners	EADS F IW AIRBUS Opérations SAS ENSMA Institut PPRIME Centre Interuniversitaire de Recherche et d'Ingénierie des Matériaux Aubert & Duval Institut de polytechnique de Grenoble ENS Cachan – Laboratoire de mécanique et de technologie
Coordinator	Yannick Girard – EADS F IW Yannick.girard@eads.net
ANR funding	1 031 901 €
Starting date and duration	January 2011 – 42 months
Reference	ANR-10-RMNP-017
Cluster label	ASTECH Aerospace Valley VIAMECA

Project title	**PRINCIPIA : Industrial innovative casting processes for the aeronautical industry**
Abstract	The project PRINCIPIA aims at contributing significantly to the definition of innovative new melting and ingot casting processes for the production of thick plates in high performance aluminium alloys (7xxx and 2xxx families, including the new AlCuLi alloys) for the civil aircraft industry - through the understanding of factors allowing the reduction of porosity and inclusions in DC cast ingots for the rolling and forging stock - through the multi-physics and multi-scale modelling of melting and solidification processes and their integration in an industrial dedicated softwaer - through the evaluation, both at lab-scale and on an industrial pilot, of improvement or innovative solutions delivered from the project tasks. The production of high quality aluminium solutions (in terms of inclusion cleanliness, low porosity level, homogeneous metallurgical structure) and improved properties (light weighting, increased durability) for heavy gage products is a major target for Alcan Engineered Products and his customers from the aerospace industry. In the case of thick rolled products porosities potentially present in the as-cast state may not be fully closed during further processing. Technical challenges associated to the casting of thick gage rolling ingots are particularly critical for the new alloys of the AlCuLi family with enhanced specific properties (e.g. 2050). The high tendency to oxidation results in an increased inclusion risk associated to a higher gas content in molten metal, leading to porosity formation in the as-cast product which is increased by almost an order of magnitude as compared to Li-free alloys. The project associates 2 industrial partners and 5 public research teams, collaborating on 4 technical tasks (in addition to the management and industrial transfer activities). - Improvement in the molten metal cleanliness o Hydrodynamic modelling and inclusion capture assessment for an optimum casting furnace process - Reduction of porosity o Understanding of the impact of refractory materials on the hydric exchanges with molten aluminium and definition of new multi-functional refractory solutions. o Understanding of the link between the as-cast DC structure (macrosegregation and grain morphology) and the size of the pores, and of the impact of process parameters on the structure by multi-scale and multi-physics modelling associated to trials o Exploration of innovative routes for the reduction of hydrogen content in molten metal This project has a significant economic impact on the strengthening of the world competitive positioning of Alcan Engineered Products (Global Aeronautic, Transport and Industry business group, European leader and n°2 worldwide for the production of semi-products for the aircraft industry), on the long term activity of Issoire plant with Alcan CRV support. It will provide a support to the current industrial developments for this industry, with the perspective of

	a new process generation. Aside from answering the industrial needs in terms of refractory materials for the aluminium application the project will provide to Saint Gobain CREE and additional knowledge in the area of the functionalising of specialty refractory materials, which is a differentiation factor on the metallurgical market.
Partners	Alcan Centre de recherche de Voreppe Saint Gobain Centre de Recherche et d'Etude Européen Institut Jean Lamour ICMPE Laboratoire Chimie Métallurgique des Terres Rares ECP Ecole centrale des Arts et Manufactures de Paris
Coordinator	Pierre Le Brun – Alcan Centre de Recherche de Voreppe Pierre.lebrun@alcan.com
ANR funding	1 155 192 €
Starting date and duration	January 2011 – 48 months
Reference	ANR-10-RMNP-007
Clust r label	VIAMECA Materalia

Project title	**PROFEM :** PROcess influence on the Fatigue of Elastomeric Materials
Abstract	The use of elastomeric parts is today very widespread in all industrial markets to fulfil very different requirements (static or dynamic tightness, damping of vibrations or shocks, high chemical resistance…). If the design of static or dynamic requirements is today well mastered, the field experience underlines that the two main failure mechanisms are related to fatigue and ageing. For a dozen years, coupled studies of industrials and academic partners allowed to propose several phenomenological criteria to evaluate the fatigue lifetime of elastomeric structures. But the requirements for higher durability under even more severe conditions lead now to overcome the next difficulty, which is the coupling between the process and the fatigue properties. Indeed, fatigue of elastomeric materials is strongly driven by the process. This comes from the heterogeneous nature of these materials (for a wide range of matrix and fillers and with crucial influence of compounding) and from the huge influence of a complex two steps process (mixing, and injection) on the microstructure. It is therefore crucial to understand the couplings between process and microstructure, on the one hand, and between the microstructure and the fatigue properties on the other hand. To understand these links, it is mandatory to answer three main questions, associated to the three different scales: 1.What are the basic damage and dissipation mechanisms? 2.What is the damage scenario for a given matrix and inclusions distribution (in size and space) and how can it be used to understand and to evaluate quickly the fatigue properties? 3.What are the influences of the injection process on the microstructure of injected samples and are the previous answers relevant to understand the fatigue phenomenon observed on massive samples with a heterogeneous microstructure? These are precisely the answers aimed at by the PROFEM project, which will take profit of several tools used and developed in very recent preliminary studies: -Association of X-Ray Computed tomography and infrared measurements thanks to an energy-based criterion, in order to quickly evaluate the fatigue properties of elastomeric materials; -Micromechanical modelling using a complex morphological pattern which takes into accounts occluded rubber, carbon black, bound rubber and a percolating network. These specific features give the opportunity to extend the model to the dissipation and damage mechanisms for local relevant scales. The scientific and technical outcomes are very numerous leading to answer not yet understood issues of the field of elastomers fatigue. It is aimed: 1.To understand and to model the initiation and growth mechanisms (coupling several scales observations and micromechanical modelling) ; 2.To validate a way to evaluate quickly the fatigue properties for several kind of matrix and fillers, and to extend it to the

prediction of lifetime dispersion; 3.To understand the influences of mixing and injection on the fatigue properties, for healthy zone as well as sensible zones (parting line, injection point). These achievements will greatly help manufacturers to reduce the parts weight and time development and to meet environmental requirements. The scientific originality of the PROFEM project also stands in two specific aspects: --The use of mechanical modelling to couple two experimental techniques (X-Ray CT and thermal measurements) which allow overcoming their specific limitations --The strong dialog between a phenomenological approach (based on energy criterion) and a micromechanical modelling, with are usually seen as diverging ways rather than partners ones. It should be underlined that the goals of this study are very challenging and require a very wide skills range. Mixing industrial and academic partners, the PROFEM partners propose extensive technical and scientific complementarities that are relevant to achieve efficiently this project challenges.

Partners	ENS D'Ingénieur des Etudes et Techniques de l'Armement Techniques de l'Armement TRELLEBORG MODYN Ecole Centrale de Nantes UBS LIMATB Laboratoire de Recherche et de Contrôle du Caoutchouc et des Plastiques
Coordinator	Yann Marco ENSIETA Yann.marco@ensieta.fr
ANR funding	575 885 €
Starting date and duration	January 2011 – 48 months
Reference	ANR-10-RMNP-010
Cluster label	iDforCAR – ELASTOPOLE

Project title	**RTMPLAST :** Thermoplastic RTM
Abstract	The proposal comes from the growing interest for thermoplastic composite materials including high performance ones in the aeronautic field. It is an anticipation of industry needs for this type of composite in the coming years compared to thermosetting matrix composites. It also has a strong economic potential in sectors where parts are widely produced as long as the manufacturing cost is reasonable and the pace is high. This project aims to achieve a thermoplastic composite piece with continuous fibers in one step manufacturing (using RTM process) where polymer matrix and composite part are designed in the same self-working mold. This is an alternative to thermosetting matrix composites with an undeniable ecological interest and important in terms of assembly (welding) and recycling. It aims to develop a new process controlled by the thermo-mechanics to control the cycle times (varying from one application to another: from several minutes to an hour). Several original early-stage work have to be done. The optimization of the process cycle requests an accurate knowledge of physical and chemical phenomena in both the filling phase of the mold and the consolidation phase to model them correctly. It also requires the development of physical and chemical characterization methods and devices of resins, reinforcements at all stages of in situ polymerization development. The filling phase is a delicate issue. Numerically, we propose to locally describe the rheology of matter coupled to heat and mass transfers and its transformation with a numerical suitable scheme. The computation times should be reasonable and the developed code must ultimately describe the macroscopic behavior of the matrix. It will also include the thermal control of the consolidation phase during which the crystallization of the matrix and the shrinkage occurs and therefore the properties of the part. From a thermal point of view, the challenge is to characterize experimentally the heat transfers in order to use them as a monitoring tool of the saturation of the reinforcement during the flow, with consideration of thermal dispersion phenomena. This characterization involves the determination of the thermal conductivity tensor. The monitoring of saturation via the thermal conductivity tensor is original and could lead to important advances in the field of modeling of the reinforcements permeability. In terms of materials, we aim to develop a new oligomer which the in situ polymerization will lead to the synthesis of thermostable macromolecules of PEKK-type polymer. It represents a challenge in terms of chemistry considering the complexity of the usual synthesis conditions for such high performance polymers (in the case of PEKK, the Friedel / Kraft type chemistry is clearly not feasible for the RTM process).

Partners	Laboratoire de thermocinétique de Nantes Laboratoire de génie civil et Mécanique Ingénierie des Matériaux Polymères UMS CNRT Matériaux Polymères EADS IW/CT/MP Pôle de plasturgie de l'Est ARKEMA France Polymères Biopolymères Surfaces
Coordinator	Didier Delaunay – Laboratoire de thermocinétique de Nantes Didier.delaunay@univ-nantes.fr
ANR funding	883 376 €
Starting date and duration	January 2011 – 36 months
Reference	ANR-10-RMNP-009
Cluster label	EMC2

Project title	**VIRMIL** : Nanoparticles of MOFs for the treatment of HIV infections and opportunistic bacterial infections
Abstract	Biodegradable Nanoparticles of porous MOFs with suitable pore sizes, non toxic compositions (Fe, Ca, Mg and carboxylates), different topologies (channels, cages), being either rigid or flexible, will be synthesized. We will focus first on MOFs whose synthesis at the nanoscale has already been reported. Then, the synthesis of other MOFs reported only at the micrometric level will be done using top of the art techniques (microwave assisted synthesis, ultrasounds…). We will also try the synthesis of nanoMOFs using bioactive molecules as the linker. Their degradation in different biological medium will be investigated as well as the stability of the nanoparticles solutions. In a second step, a screening of encapsulation and release of several drugs of interest for AIDS treatment such as antiretroviral molecules (AZT-TP, Efavirenz (EFV) and delavirdine (DLV) or a combination of them to reconstitute triterapy), and resistant anti-bacterial treatment (antuberculous : ciprofloxacine, isoniazid...) will be performed. Quantitative Structure Activity Relationship (QSAR) study on the encapsulation will be used to predict the best MOF for each drug of interest. Based on the stability and encapsulation results, a few selected MOFs (2 or 3) will be surface functionalized using several surface agent molecules (PEGs, Ig-G…). The drug nano-sponge interactions and of drug delivery will be studied using calorimetry combined to molecular simulations of a selected anti-HIV drugs. Methods of producing and conserving stable formulations will be also developed. In a third step, anti-VIH activity tests and antibacterial activity tests will be done as well as a study of the mechanism of the anti-VIH activity of the nanosponges. Finally, the synthesis of labelled nanoparticles (fluorescence or radioactivity) will help to analyse the crossing of physiological barriers by the nanosponge. We will investigate also the cell internalization kinetics and mechanisms of the nanosponges. The mechanism of the antimicrobial agent delivery from the nanosponges as well as the in vivo toxicity and biodistribution of the drug loaded nanoparticles will be the last part of the project.
Partners	Institut Lavoisier de Versailles CNRS Physico-Chimie Pharmacotechnie Biopharmacie BERTIN Pharma Institut Charles Gerhardt Montpellier
Coordinator	Christian Serre – Institut Lavoisier de Versailles serre@chimie.uvsq.fr
ANR funding	825 489 €

Starting date and duration	January 2011 – 48 months
Reference	ANR-10-RMNP-004
Cluster label	Medicen