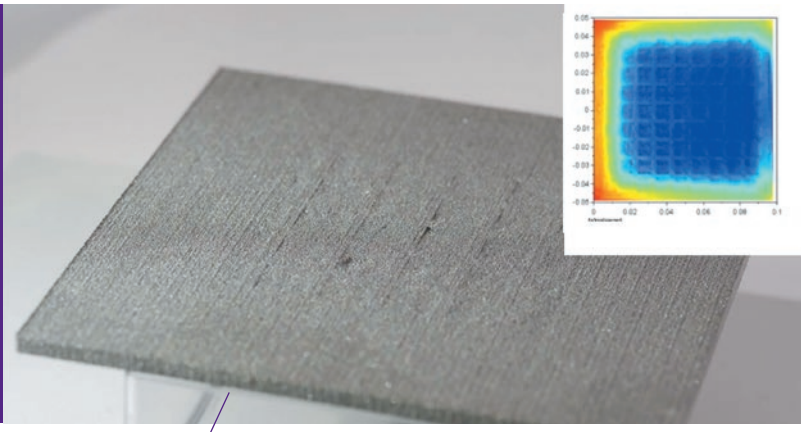
MOSART
Metallic porous materials for enhanced cooling capabilities

A porous material can be protected from heat by flowing through cold fluid, such as air, which regulates its temperature by internal convection. An additional benefit is obtained by forming a film cooling onto the surface. This is called transpiration cooling. The capability of a material for transpiration cooling is related to its internal porosity, which should be interconnected and open to the surface. One of the targeted applications is to improve the cooling efficiency of inner walls of aeronautical combustion chambers.



Material for transpiration cooling with porous zones 1x1cm2; on the right, temperature map showing cooling

The approach was to design, to make and to test some materials for transpiration cooling by metallic 3D printing. First of all, a process allowing the melting of metallic powders (EBM or Electron Beam Melting) was used to obtain the finest porosities, and thus the largest surfaces for heat exchange. With this process, powders can be partially sintered with limited fusion thus leaving an internal porosity, and allowing transpiration cooling. The scan speed as well as the electron beam power were found to be relevant parameters for the achievement of an effective porous material.

Architectured supports have also been achieved by EBM and then covered by a finishing porous layer made by a conventional sintering process. All the architectured materials have been tested on aero-thermal benches and an enhanced cooling efficiency was established thanks to transpiration cooling. Indeed, experimental tests have shown that the temperatures within the materials and onto their surface were close to the air temperature flowing through them.

By this way, multi-layer systems with more or less complex design can been created for enhanced transpiration cooling, taking advantage of the design flexibility of 3D printing processes. The geometry can therefore be adjusted for the application. In the case of protective walls for aeronautical combustion chambers, the design was made by considering mass, dimensions, permeability and structural strength criteria. Numerical simulations have enriched the experimental approach. This enabled us to gain a better understanding of the phenomenon of transpiration cooling, and to appropriately size the thicknesses of the studied systems in order to ensure the correct air flow and thus offer the best cooling.

PERSPECTIVES

Design custom geometry is a reality thanks to 3D printing. It is now possible to tune the properties of the material itself, as here its internal porosity, to design increasingly complex systems. These new tools offer opportunities for designing «patches» for combustion chamber repair.

MOSART

Implementation of architectured structures for transpiration cooling

ANR programme:
Astrid

Fully funded by the Direction générale de l'Armement

Edition, Project duration:
2014, 36 months

ANR grant: €300,000

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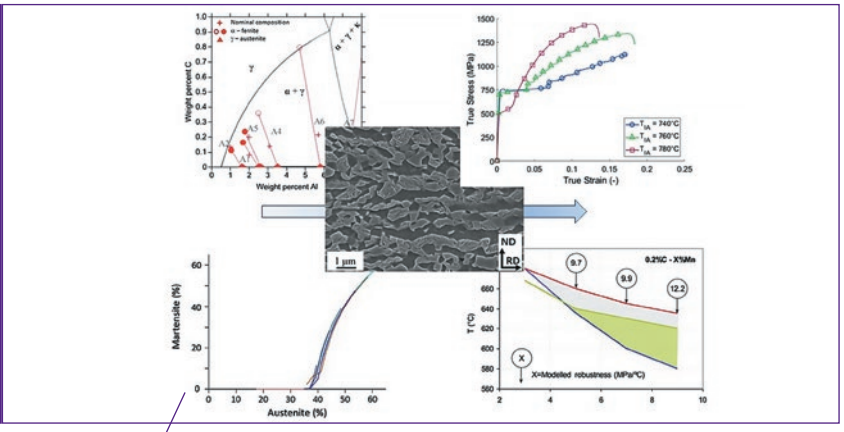
Main publication or contribution:
O. Lambert, Thèse, 2017 &
S. Pinson, Thèse, 2016 sous la direction de R. Dendievel, Grenoble Alpes

Partners:
Onera – The French Aerospace Lab, Materials and Structures Department, Université Paris-Saclay;
SIMaP – Science and Engineering of Materials and Processes, Grenoble
SafranTech, Magny-les-Hameaux;
SinterTech (PORAL®), Veurey-Voroize

MeMnAl Steels

A new generation of steels with optimized mechanical properties for automotive parts

The European regulation on CO_2 emissions below 130 g/km lead the automotive industry to lighten vehicles. The development of new very high strength steel grades, decreasing the weight of the body-in-white by almost 20%, requires knowledge and tools to speed up industrialization of a 3rd steel generation. Thanks to additions of medium amounts of Mn and Al, a duplex microstructure is obtained which gives these steels mechanical strength and formability.



Understanding and modeling microstructures and mechanical behavior of advanced high strength steels for a reliable industrial process

Physical metallurgy and mechanical metallurgy are combined to investigate the final properties of these steels: (i) modelling of microstructure genesis, and (ii) modelling of the relations between resulting microstructures and mechanical properties. This knowledge defines the composition range and the optimum thermomechanical schedules to reach the mechanical targets, while accelerating steel developments and reducing efforts for industrialization.

Microstructure prediction: Investigation at the atomic scale allows a first prediction of the equilibrium domains of the Fe-Mn-Al-C system. Mesoscopic experiments and modelings inform about the nature of the equilibrium phases, their relative volume fractions, and their compositions. Some DICTRA simulations quantify transformation kinetics during annealing.

Mechanical behavior: Deformation mechanisms were investigated thanks to transmission electron microscopy in-situ experiments. In-situ characterization of the strain fields and magnetic measure of the austenite volume fraction evidenced strain localizations linked to martensitic transformation. The ductile-to-brittle transition was related to the different microstructures which were studied.

The results gathered during the project open many ways to improve the 3rd generation steels for automotive:

- Mn/Al/C interactions within ferrite, and the conditions for stability and nucleation of kappa carbide were specified.
- The elastoplastic behavior closely depends on the austenite stability and its transformation kinetics.
- At room temperature, strain instabilities result from displacement of intense strain bands linked to a local transformation of austenite.
- Ductile-to-brittle transitions were characterized for the fine-grained domains (interface fracture) and the delta phase (cleavage, also specified by the atomic calculations).

PERSPECTIVES

The project allows the production requirements to be specified to reach the mechanical properties and define the critical domains (risk of strain localization, cleavage fracture). The experimental methodologies and the models help ArcelorMittal to develop the 3rd high strength steel generation by accelerating the process parameter identifications to obtain the targeted in-service properties.

MeMnAl Steels

Development of a 3rd duplex steel generation for automotive applications

ANR programme: MATETPRO

Edition, Project duration: 2013, 48 months

ANR grant: €1,199,501

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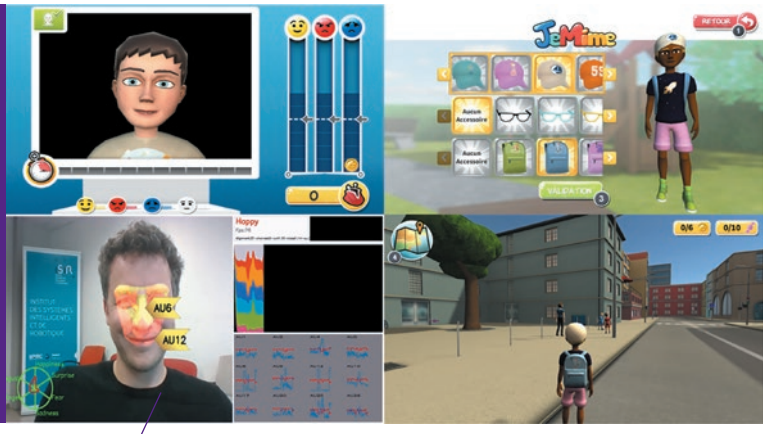
Main publication or contribution: A.Perlade et al. - Development of 3rd generation Medium Mn duplex steels for automotive applications, Mater Sci Technol 35 (2019) 204.

Partners: MSSMat (CentraleSupélec–CNRS) ; ArcelorMittal Maizières Research ; UMET (Univ. Lille 1–CNRS) ; SIMAP (Grenoble INP–CNRS) ; IM2NP (Univ. Aix Marseille–CNRS) ; CEMES (CNRS) ; ARMINES (Mines ParisTech)

JEMImE, the first serious game that teaches children with autism to produce facial expressions adapted to the social context

Children with autism experience great difficulty in understanding and producing socio-emotional signals such as facial expressions. The objective of the game developed within the framework of the JEMImE project was to teach them to imitate and mime facial emotions in order to reproduce the appropriate expression in a given context. The technological core of the project was therefore to design new artificial intelligence algorithms capable of evaluating the quality of the emotional expressions produced by the children.



Screen captures of the serious game and visualisation of the processing done by the facial expression recognition algorithm

In order to complete this multidisciplinary research project successfully, complementary skills in the fields of automatic emotion analysis, serious game design and clinical treatment of autism were brought into play. The consortium's research studies concentrated on two aspects: designing a serious game and producing a facial expression analysis module.

The game's creation involved designing scenarios adapted to clinical requirements and technical constraints, creating a graphic environment, as well as developing the game itself. Designing the facial expression recognition module called for the implementation of innovative automatic learning algorithms which would obtain a robust and precise analysis of facial emotions in real time. To achieve such artificial intelligence algorithms, the consortium collected and entered data of typical children and data of children with autism. The latter were also used in a clinical perspective in order to better understand the specificities of the emotional productions of children with autism.

The project gave rise to a demonstrator combining the expertise of all the partners in the project. A preliminary version of the facial expression recognition module won the Facial Expression Recognition and Analysis Challenge 2015. The project also led to abundant scientific production: 12 articles in international journals (of which 2 multipartner publications), 11 international communications (of which 3 multipartner communications) and numerous outreach and enhancement programmes at congresses, thematic days and seminars.

PERSPECTIVES

The JEMImE project demonstrated the feasibility of a serious game focussing on automatic analysis of the emotional productions of children with autism. The next phase of the project will consist in showing the clinical contribution of this game by means of a wide-ranging study which will eventually enable it to be disseminated to therapists and families via the Curapy.com platform.

JEMImE

Educational Multimodal Emotional Imitation Game

ANR programme:
Digital Contents and Interactions (CONTINT)

Edition, Project duration:
2013, 54 months

ANR grant: €615,513

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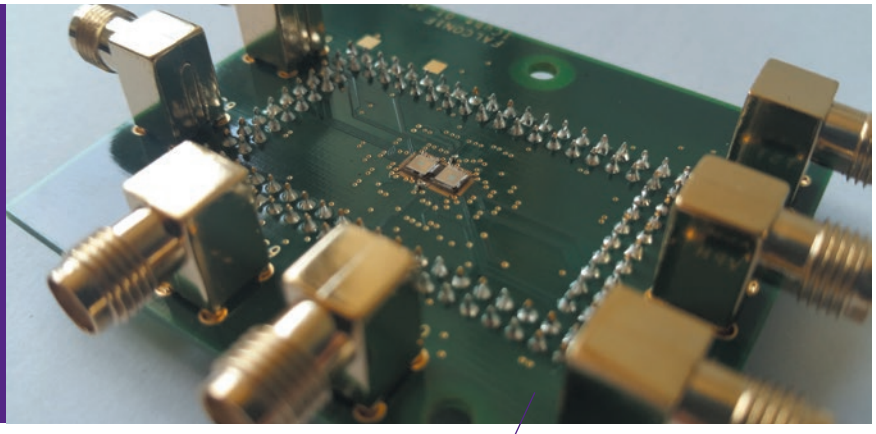
Main publication or contribution:
Emotion recognition algorithms (First prize, FERA Facial Expression Recognition and Analysis Challenge 2015)

Partners:
Sorbonne Université (ISIR)
GENIOUS Systems
École Central de Lyon (LIRIS),
Université de Nice (CoBTek)

FALCON, the very first ultrafast burst video sensor with digital storage achieving 10 up to 100 millions frames per second

In the field of high-speed imaging, the fastest cameras use the concept of burst imaging to bypass the bottleneck of the IO speed to achieve an acquisition speed of more than 1 Tera pixels per second. The Falcon sensor takes benefits of the 3D microelectronic technology process to push the performance well beyond the state of the art by gathering more than 1000 images at a speed of 10 up to 100 million frames per seconds.



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Photograph of the prototype demonstrating the FALCON sensor

A key to go beyond the Moore's law is the 3D microelectronic which consists to stack several chips in order to increase the integration density. This technic allows splitting the functionalities of a system on the different tiers while offering a potentially gigantic data rate. Thus, this technology is ideal to design an ultrahigh speed video sensor in which the bottleneck is mainly the bandwidth of the data transmission. Moreover, as the electronic is merged on several tiers, the pixel can embed a more complex function. So, the analog to digital conversion (ADC) is integrated within the architecture of the system. Additionally, to the image integrity improvement, this feature allows increasing the number of stored images in the pixel by one order of magnitude with respect to the state of the art.

The Falcon sensor is the very first architecture of ultrafast burst image sensor with a digital storage. The measurements carried out on the realized demonstrator have validated the complete operation of the system. The maximal speed of 100 million frames per second and the number of 1200 images stored are both 5 times beyond the commercial products at the current state of the art. All the design technological bricks of the systems also show some performances above the state of the art and can be used for the design of another image sensor or sensor for the Internet of Thing. For instance, the designed SRAM architecture is in agreement with all the targeted quality and performance criteria, more specifically in terms of power consumption that makes it possible to use it in the Internet of Thing applications. Finally, the obtain progress on the ADC have contributed to the emergence of a new generation of converters dedicated to the CMOS image sensors exploited by the startup XDIGIT.

PERSPECTIVES

With this new type of imager, ultrafast imaging has made a technological leap forward and now makes it possible to film more than 1,000 images with a complex physical phenomenon. The different technological bricks designed by the consortium partners are state of the art and can also be used within the framework of other imaging applications or IoT.

FALCON

Fast Acquisition Lattice Camera Owing to Nanotechnology

ANR programme:
CE26-0024-01

Edition, Project duration:
2014, 48 months

ANR grant:
€648,378

Coordinator:
Wilfried Uhring
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Main publication or contribution:
W. Uhring et al., « A Scalable Architecture for Multi Millions Frames per Second CMOS Sensor With Digital Storage, » IEEE NEWCAS 2018

Partners:
ICube Laboratory, UMR 7357, Strasbourg, project initiator
Tima, UMR5158 Grenoble
CEA Ieti, Grenoble
Dolphin Intégration, Grenoble

BAKERY

Farmers' and artisanal bakery practices at the heart of biodiversity

Although bread is a food of historic, cultural and nutritional importance in France, the advantages of its low-input bakery sector for the development of a sustainable food supply are not widely known. The purpose of the BAKERY was to increase awareness of the variety of bakery practices, the diversity of microbial species present in yeasts, and their effects on the nutritional and organoleptic quality of bread as well as on consumers' perceptions.

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Wheat, flour and yeast

The BAKERY project adopted an interdisciplinary participatory research approach, involving bakers, psychosociologists, biomathematicians, agronomists and microbiologists, to analyse current practices in sourdough bread production, microbial diversity and bread quality.

Sourdough is a mixture of flour and water fermented naturally by yeasts and lactic bacteria. It helps the dough to rise and produces lactic and acetic acids as well as aromas. The project revealed that breaking with the dominant model of white bread production by means of commercial yeast led to a greater diversity of bread-making practices, beneficial for the preservation of microbial diversity. The well-known baker's yeast species Saccharomyces cerevisiae, is not in the majority. Other species of yeast, of the Kazachstania genus, are frequent and some had never been described until now. Bakery practices can be differentiated as farmers' and artisanal practices, which maintain different microbial species and thus contribute to the preservation of biodiversity. An experiment was carried out whereby farmers cultivated ancient wheat populations and modern varieties which the bakers used to obtain and propagate new yeasts. These were then used to bake experimental loaves.

The project showed that the bakehouse environment and the baker are the main drivers of yeast microbiota. There is thus a "bakery terroir" effect. Organoleptic and sensory analysis of the loaves revealed that their aromatic profiles differed not only according to the "bakery terroir" of the yeasts but also depending on the terroir where the wheat was cultivated. Moreover, interviews with consumers showed that as well as health concerns, they seek a social connection by choosing to eat sourdough bread.

PERSPECTIVES

At scientific level, the results of the BAKERY project allowed for the emergence of the yeast microbiota and the bakery industry as a model applicable to ecology, evolution and participatory research. At societal level, they show that the development of local industries based on farmers' and artisanal practices helps promote biodiversity and diversity of tastes. It is now important to follow the rapid development of these industries, and its impact on the dynamic of bakery practices and biodiversity.

BAKERY

Diversity and interactions of a low-input agrofood ecosystem "Wheat/Man/Yeast": towards a better understanding of the sustainability of the bakery industry

ANR programme:
ALID

Edition, Project duration:
2013, 54 months

ANR grant:
€669,694

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Main publication or contribution:
Carbonetto, et al. (2018) Bakery yeasts, a new model for studies in ecology and evolution. doi:10.1002/yea.3350

Partners:
UMR SPO, UMR GQE-Le Moulon, CIRM-Levures, CIRM-BIA, ONIRIS, UBO, ITAB, Réseau semence paysanne, Association Triptolème, 40 bakers/farmer-bakers