CENTRE OF EXCELLENCE OF MULTIFUNCTIONAL ARCHITECTURED MATERIALS
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IRP 3: STRUCTURAL WEIGHT SAVING

IRP3 gathers research teams from several laboratory partners. It promotes a "materials by design" approach, starting from "engineering challenges", and proposing a strategy to meet multi-functional requirements by associating multimaterials and architectures. Weight saving can be achieved according various strategies, in particular increase of properties and reduction of density. It is frequently coupled to multifunctionality.

SCIENTIFIC ISSUES AND ASSOCIATED EQUIPMENTS

Several scientific issues are directly connected with this Interdisciplinary Research Program:

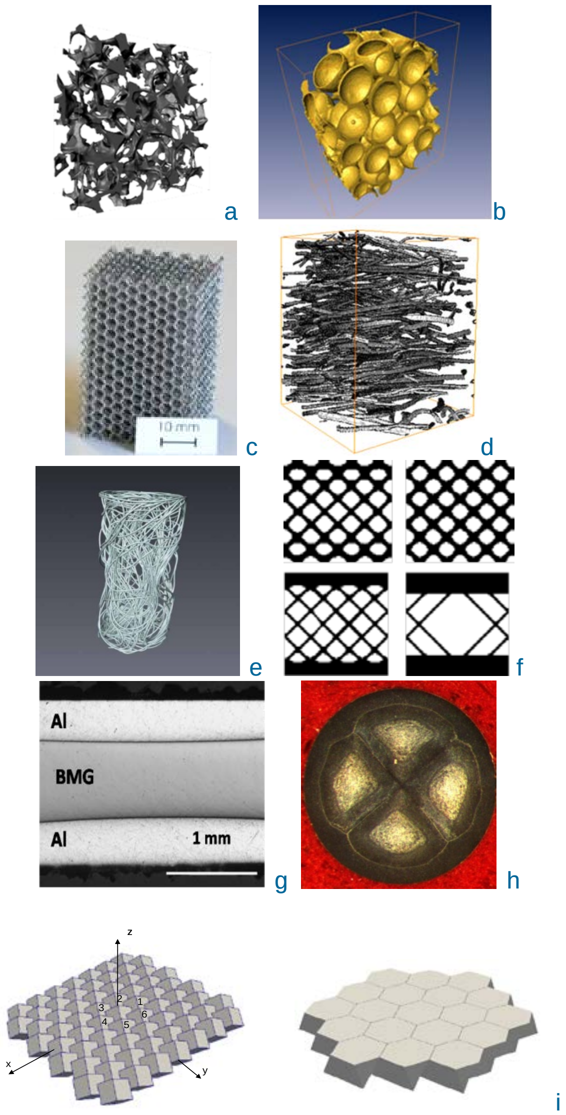
- Elaboration processes for materials with controlled topologies. In this framework, the preferentially dedicated equipments are thermomechanical processing, powder metallurgy and additive manufacturing.

- Structural characterisation via multiscale explicit mapping including X-ray micro tomography, TEM with ASTAR mapping or SEM-EBSD.

- Characterisation of multifunctional properties (dedicated experiments, modelling using "numerical" materials based on structural characterisation, topological optimisation)

Additional details concerning the elaboration equipment can be found in the datasheet dedicated to Architectured Materials Elaboration Platform (AMEP) of the CEMAM labex. Similarly, additional details concerning the structural characterisation equipments can be found in the datasheet dedicated to Structural Characterisation Platform of the CEMAM labex.

TARGETED MATERIALS



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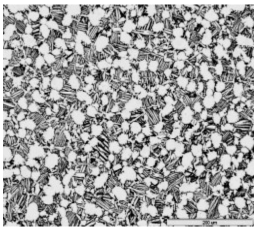
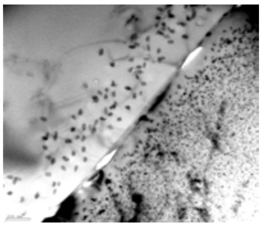
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Structural weight saving is a key issue for dense and non dense materials. It can be related to various scales, from nanometre scale to component. In this context, one particular interest of architecture is the capacity to control the topology of the phases in the material. Most architectured materials are targeted as good candidates for structural weight saving. These materials are mainly:

- Cellular (a-c) and entangled (d,e) materials
- Sandwich structures (f)
- Multi materials (g, h)
- Interlocked materials (i)
- Materials with metallurgical architectures (j)

STAFF AND INDUSTRIAL PARTNERSHIP

Full time equivalent staffs of about 15 people with ≈ 20 Ph. D. students are involved in this Interdisciplinary Research Program. The targeted applications are mainly materials elaboration (steels, light alloys, ceramics…), transport (aeronautics, automotive), energy (nuclear energy, renewable energies…), building or medicine with industrial partners like Constellium, Arcelor Mittal, Aubert & Duval, Ugitech, EADS, Airbus, ONERA, EDF…

RECENT STUDIES

Properties of metallic wools studied by in situ X-ray micro tomography

Entangled materials like metallic wools find applications in thermal insulation, mechanical reinforcement or filtration. These kinds of materials are close to cellular materials, with regard to their low density and discrete architecture. Compared to metal foams, entangled materials have been much less investigated. The mechanical behaviour of steel wools has been studied and modelled by discrete three-dimensional (3D) simulations.

A particular attention was given to the effect of static friction on the mechanical response of assemblies of semiflexible fibers during cycles of isostatic compressions and releases.

Indentation of interlocked assemblies

A strategy or "ductilizing" brittle materials consists in pre-fragmenting the material into blocks whose geometry prevents any relative sliding (interlocked materials), leading to remarkable both tolerance to damage and damping capacity. Planar assemblies of osteomorphic blocks have been tested in indentation loading and also modelled. These studies have confirmed that such interlocked structure could dissipate mechanical energy much more efficiently than a similar monolithic plate and a particular attention was given to the effect of the friction coefficient between the blocks.

Development of new multifunctional architectures in duplex stainless steels

Dual-phase alloys are used for structural applications due to their combination of high mechanical properties and other functional properties (corrosion resistance, thermal conductivity), which are particularly relevant for structural saving applications and for applications in the construction sector. The dual-phase nature of the alloy makes the relationship between microstructure and mechanical properties particularly challenging to understand. In fact, there are synergetic effects that lead to mechanical behaviour that cannot be predicted from the properties of the constituents alone. A first study is devoted to evaluate the effect of the internal architecture (fraction, geometry and spatial distribution of the phases) on the combination of properties whereas a second one aims at developing new concepts in terms of architecture of the two phases.

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