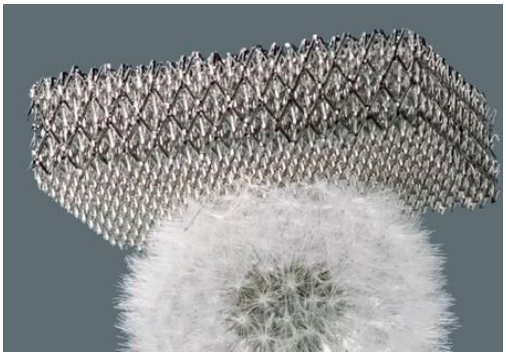
CEA Saclay –Service de Physique de l'Etat Condensé (SPEC) (page web)
Laboratoire *SPHYNX* (page web)

PROPOSITION DE STAGE/THESE 2019

BONES-INSPIRED METAMATERIALS: TOWARD ULTRALIGHT/ULTRASTRONG MATERIALS

The quest toward high-performance materials combining lightness and mechanical strength gave rise to a flurry of activity: desire to reduce CO2 emissions and develop fuel-efficient vehiclesin the transport industries for instance. In this context, meta-materials or architectured materials offer considerable potential (e.g. micro-lattice invented at Caltech and produced by Boeing) and significant progresses have been achieved recently.



Microlattice développé par Boeing

The routes explored so far have mainly focused on periodic architectures. This project aims to explore random architectures, imitating that of bones, with specific scale invariant statistical properties (fractals). Particular attention will be paid to the consequences of such a random structure in terms of "risks", ie statistical fluctuations around the average failure behavior. The ultimate goal is to provide rigorous rationalization tools to define one or more optima in terms of lightness, crack resistance and risk (as defined above) in this new class of materials.

Our previous research has provided some formalisms, between continuum mechanics and statistical physics, which permits (in simple cases) to take into account explicitly material the spatial inhomogeneities at the microstructure scale and induced statistical aspects. We will seek to adapt this formalism to the case of fractal porosity. The study will rely on numerical approaches based on Random Lattice models of increasing complexity. Particular attention will be paid to a proper characterization of the statistical fluctuations around the average breaking behavior. The approach will then be confronted to experiments carried out on 2D printed samples of fractal porosity broken by means of an original experimental device developed in our laboratory and giving access to both fracture toughness and its statistical fluctuations.

This Ph.D. thesis takes place astride Statistical Physics, Continuum Mechanics and Materials Science. The candidate will have the opportunity to use, - and to familiarize himself with -, both the theoretical and experimental techniques developed in these three fields. A collaboration with the FAST laboratory in Paris-Saclay University is being currently developed. This PhD topic, combining both fundamental aspects and potential industrial applications, will permit the candidate to find job openings either in the academic field or in industry..

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