Heterostructure materials are the new Uranium!

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Structural materials (i.e., designed primarily to transmit forces), given their wide variety and importance in many industrial sectors, give rise to numerous research programs worldwide, often carried out in partnership between academic and industrial laboratories. Two types of research can be carried out: (i) research on "traditional" materials (metal alloys, composite materials, etc.), for which it is a question of optimizing the properties for a given application, and the industrial sectors mainly concerned are then those of energy, transport, aeronautics, civil engineering, mechanics, ... and (ii) research on new materials (foams, metallic glasses, nanostructured materials, multi-materials. ..) for which the structural function is no longer necessarily the only primary function sought and for which industrial applications are still marginal or affect other sectors such as microelectronics or biomaterials.

In this context, the main goal of the design of new materials ("materials by design") is to adapt to the new societal demand, which includes both growing needs and improved performance, and increased recyclability. For example, in the field of structural materials, the need to lighten structures in the areas of transport and aeronautics has generated a great deal of research on the optimization of the transformation processes of traditional metal alloys (Fe, Al, Ti…in particular) or the optimization of their microstructure and chemical composition by adding alloying elements. Alongside these relatively conventional methods, which already allow significant gains in terms of lightening and mechanical properties, new ways are being developed which make it possible to further increase the gains in terms of energy saving and recycling while at the same time working from the most easily accessible materials. These methods favor the optimization of microstructures rather than the addition of expensive alloying elements.

In this presentation, we illustrate the approach implemented for several years at the laboratory of process and materials sciences of Sorbonne Paris Nord University. This approach thus aims to develop a methodology for generating innovative microstructures (multimodal, multi-structured materials), taking advantage of the properties linked to the different types of contrasts (mechanical, chemical, morphological) induced by heterogeneous microstructures[1]. Powder metallurgy, but not only, proved to be an optimal and very versatile method for such an objective. The example of the *HighS-Ti*[2] project funded by the French National Research Agency (ANR) carried out in collaboration with the group of Prof. K. Ameyama at Ritsumeikan University will be presented.

1) Yuntian Zhu, Xiaolei Wu, *Progress in Materials Science*, **2023**, *131*,101019.
2) High Strength Titanium with Harmonic Microstructure: Processing, properties, and multi-scale modelling. **ANR-14-CE07-003**.