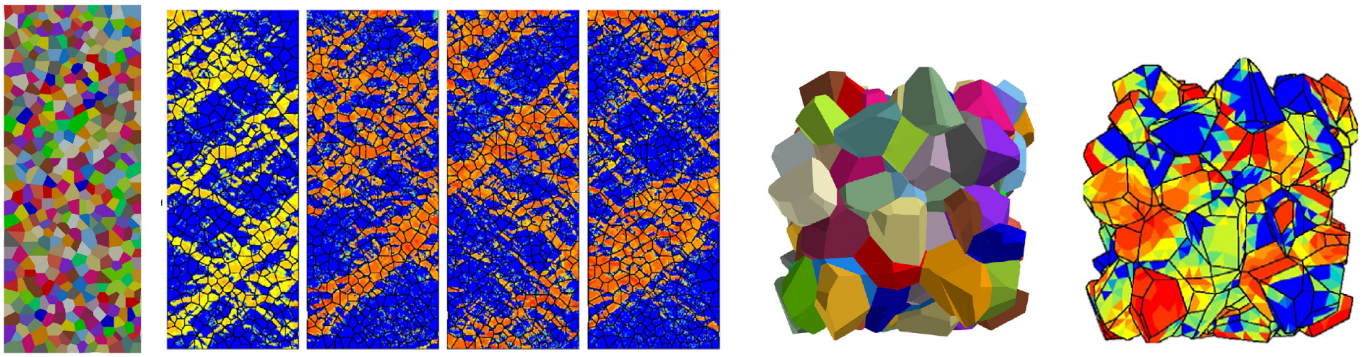
Post–Doctoral Position
at Mines ParisTech

Multiscale modelling of new high strength and high strain hardening titanium alloys

The objective of the research is to develop constitutive models describing the mechanical behaviour of a new generation of titanium alloys with promising properties for aeronautic applications [1, 6]. The multiscale model will include plastic slip and twinning mechanisms that are active in these alloys at room temperature. For that purpose, two types of approaches will be proposed. The first one is based on nonlinear homogenisation techniques recently developed for metallic polycrystals [3, 4]. This model will be extended to twinning mechanisms and to large deformations within efficient algorithms for the computation of a large number of grains to represent the texture of the material. The second approach is dedicated to the plasticity and twinning at the grain scale within polycrystalline aggregates. Continuum crystal plasticity models will be used to compute the heterogeneous deformation field inside the grains and the interaction with neighbouring grains depending on grain misorientations [2]. The development of twins inside the grains will be accounted for using phase field methods coupled with crystal plasticity [5]. Comparisons will be drawn, on the one hand, with experimental observations of the deformation mechanisms and, on the other hand, with phase field simulations of twinning and phase transformation performed by the two other partners of the project. Special attention will be paid to the optimization of strain hardening of these new materials by controlling the relative importance of the various deformation mechanisms and their interaction, as evidenced by experimental observations. Implications for the ultimate strength of these materials will be drawn.

This research will take place in close cooperation with the Chimie ParisTech Research institute (CNRS UMR 8247) and LEM-ONERA-CNRS (UMR 104) within the ANR project TiTWIP *New titanium alloys with a combination of high strength, strain hardening and high ductility, induced by TRIP and TWIP effects.*

We are looking for a post–doctoral researcher with an outstanding PhD in mechanics of materials and strong background in computational mechanics and crystal plasticity. Financial support is provided for 18 months.



Finite element computations of 2D and 3D polycrystalline titanium aggregates : finite element mesh and plastic slip maps during tension, after [2].

Duration: 18 months over the period 2017–2019
Place: Mines ParisTech, Centre des Matériaux, Paris and Evry, France
Wanted skills: A strong profile combining computational mechanics and crystal plasticity.
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References

[1] C. Brozek, F. Sun, P. Vermaut, Y. Millet, A. Lenain, D. Embury, P.J. Jacques, and F. Prima. A β-titanium alloy with extra high strain-hardening rate: Design and mechanical properties. *Scripta Materialia*, 114:60 – 64, 2016.

[2] M. Marchenko, M. Mazière, S. Forest, and J. L. Strudel. Crystal plasticity simulation of strain aging phenomena in alpha-titanium at room temperature. *International Journal of Plasticity*, 85:1–33, 2016.

[3] G. Martin, L. Nazé, and G. Cailletaud. Numerical multi-scale simulations of the mechanical behavior of β-metastable titanium alloys Ti5553 and Ti17. *Procedia Engineering*, 10:1803– 808, 2011.

[4] G. Martin, N. Ochoa, K. Sa, E. Hervé-Luanco, and G. Cailletaud. A multiscale model for the elastoviscoplastic behavior of Directionally Solidified alloys: Application to FE structural computations. *International Journal of Solids and Structures*, 51:1175 – 1187, 2014.

[5] V. de Rancourt, B. Appolaire, S. Forest, and K. Ammar. Homogenization of viscoplastic constitutive laws within a phase field approach. *Journal of the Mechanics and Physics of Solids*, 88:35–48, 2016.

[6] F. Sun, J.Y. Zhang, M. Marteleur, C. Brozek, E.F. Rauch, M. Veron, P. Vermaut, P.J. Jacques, and F. Prima. A new titanium alloy with a combination of high strength, high strain hardening and improved ductility. *Scripta Materialia*, 94:17–20, 2015.