24 months post-doc position (starting from May or June 2021) **at the Laboratoire de Mécanique des Solides, CNRS, Ecole Polytechnique, Palaiseau, France**

Synthesis and multiscale mechanical investigation of ultrafine-grained Al-based nanocomposites

Context :

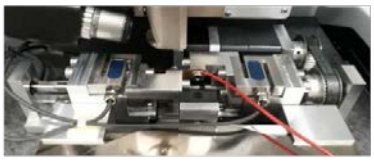
Nanocrystalline and ultrafine-grained (UFG) metals exhibit a high yield stress, but a disapointing ductility, partly due to a lack of strain hardening. Furthermore, they are prone to grain boundary sliding when the temperature rises or when the strain rate decreases, so that the gain in flow stress observed at room temperature can be lost [1]. In addition, they are subject to thermally or even mechanically-induced recrystallisation and grain growth. The addition of hard nanoparticles with a mismatch in their thermo-elastic properties, distributed both inside the grains and along the grain boundaries has the potential to generate dislocation loops and a stress field around them, to hinder dislocations glide and to pin the grain boundaries, so that a gain in resistance, ductility, and microstructural stability at high temperature can be expected.

Equal Channel Angular Pressing (ECAP) of ball-milled powder mixtures encapsulated in closed tubes is a promising way to produce nanocomposites made of a ultrafine grained (UFG) matrix (< 1µm) reinforced by a wide variety of nanoparticles (oxydes, carbides, nitrides, metallic glass or carbon nanotubes) [3-6]. However, this technique is relatively recent (see the references below) and the mechanical characterization of the synthetized materials was, until now, limited.

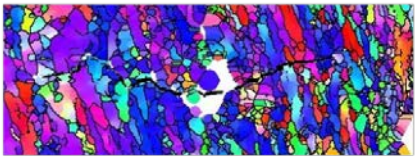
The LMS is equipped with a heated ECAP device, and has developped skills in the synthesis of UFG alloys from solid rods, as well as in the multiscale mechanical investigation and modelling of resulting properties [1-2].

<u>Nature of the work :</u>

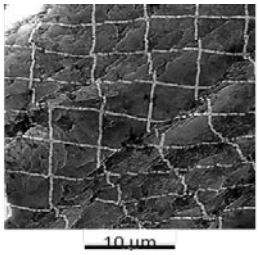
Within a project funded by the Department of Defense, and with a solid technical support, the post-doc will : 1) contribute to extend this skills to mixtures of aluminum powders and various nanoparticles (starting with alumina), 2) characterize the microstrutures of synthetized materials (grain size distribution, morphological and crystallographic texture, porosity, nanoparticles distribution) in relation with the nanoparticles fraction, as well as with the ball milling and ECAP processing parameters, 3) characterize the tensile, creep, fatigue, and wear properties of the nanocomposites by classical or *in situ* tests with HR-DIC in a SEM or under an AFM [14] 4) as far as possible, model these properties in relation with the microstructure.



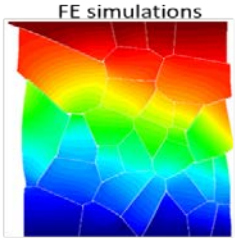
Push-pull testing device under an AFM or in a SEM

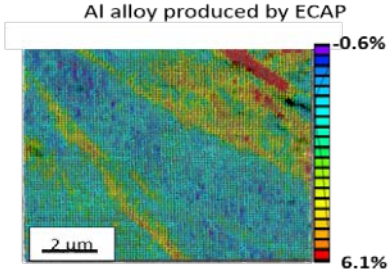


EBSD analysis of fatigue crack path in a UFG Al alloy produced by ECAP



GB sliding in a UFG Al alloy in tension at 200°C and FE simulations





HR-DIC measurement of the tensile strain field in a UFG alloy

About the workplace (**https://portail.polytechnique.edu/lms/fr**):

The LMS, associated with CNRS, is one of the 22 labs of a campus also hosting 3 engineering schools (Ecole Polytechnique, ENSTA, ENSAE) with nice sports facilities, connected to Paris by fast trains (30 min), and to many cities in France by the TGV (Massy station 10 mins away). The laboratory brings together students and researchers from more than 12 nationalities, and enjoys a wide set of state-of-the-art devices for materials synthesis, as well as for their microstructural and mechanical characterization.

About the candidate :

The candidate should hold a PhD in mechanics of metallic materials with a substantial experimental part, including both microstructural (surface preparation, SEM, EBSD) and mechanical characterization. He/she should be familiar with the mechanisms of plastic flow and strain hardening. Applications (with a detailed CV, including the e-mail addresses of PhD and previous post-doc supervisors, if any, or recommendation letters from them) should be sent to veronique.doquet@polytechnique.edu (supervisor)

References

[1] Grain Boundary Sliding and Strain Rate Sensitivity of Coarse and Fine/Ultrafine Grained 5083 Aluminum Alloys, A. Goyal, V. Doquet, and A. Pouya, Metal. Trans. A, 51 n°3, (2020) 1109-1122

[2] Ultrafine versus coarse grained Al 5083 alloys: from low-cycle to very-high-cycle fatigue, M. Li , A. Goyal, V. Doquet, N. Ranc, J-P Couzinié, International Journal of Fatigue 121 (2019) 84-97

[3] Microstructural and Mechanical Properties of Al-Based Composites Reinforced with In-Situ and Ex-Situ Al2O3 Nanoparticles, R. Casati, et al, Adv. Eng. Mater. 18 n°4 (2016) 550-558

[4] Mechanical properties of Al7075 alloy with nano-ceramic oxide dispersion synthesized by mechanical milling and consolidated by ECAP, S. Bera et al Journ. Alloys & Compounds 548 (2013) 257–265

[5] A Comparison Between ECAP and Conventional Extrusion for Consolidation of Aluminum Metal Matrix Composite, R. Derakhshandeh Haghighi et al, JMEPEG (2012) 21 : 1885–1892

[6] Equal channel angular pressing of powder processed Al6061/SiC nano metal matrix composites and study of its wear properties, A. M. Bongale, S. Kumar, Mater. Res. Express 5 (2018) 035002,