Internship MASTER 2/Bac+5 Materials & Mechanics

Academic Year: 2023-2024

Supervisors

Pierre-Antoine DUBOS
Phone: 02 72 64 87 51
Mail: pierre-antoine.dubos@univ-nantes.fr

Baptiste GIRAULT
Phone: 02 72 64 87 43
Mail: baptiste.girault@univ-nantes.fr

Location of internship

GeM, Institute of Civil Engineering and Mechanics :

- Nantes Université (Heinlex, Saint-Nazaire)

Title: In situ analysis of obtaining and characterization of metallic multicrystals

Description of the subject:

CONTEXT: The necessary contribution of transport, energy or electronics industries to sustainable development leads them to lighten structures and/or reduce the dimensions of their parts, particularly in terms of sheet thickness, but also to use materials with a mechanical behavior remaining efficient, even when they are miniaturized. However a dramatic degradation of mechanical properties is observed during dimensional reduction [Hall 1951, Petch 1953, Thompson et al. 1973, Miyiazaki *et al.* 1979, Dubos et al. 2013]. The ambition of the MOCAMOR ANR project, within which this internship is proposed, is to remove these hindrances by an original approach and methodology combining experiments and modeling.

To do so, a Physical Vapor Deposition (PVD) method is proposed to coat a material on a substrate with the same chemical composition (deposit thickness in the order of one micron on a sheet with only few grains in its thickness) in order to restructure the subsurface area of the substrate by a gradual evolution of this type of deposit [Dubos et al. 2022]. The challenge of MOCAMOR is to understand the physical mechanisms of the plastic deformation taking place in the newly generated subsurface zone. A particular attention will be paid to the film/substrate interfacial zone with the aim of restoring the mechanical performances of polycrystals to multicrystalline materials.

OBJECTIVES: During this internship, two approaches will be implemented to get the muticrystals so as to decorrelate the process effects. On the first hand, 500 µm thick sheets will be used and subjected to different granular growth heat treatments (under secondary vacuum to avoid any oxidation) in order to obtain various thickness to grain size t/d ratios. On the second hand, sheets with different thicknesses set between 10 µm and 6 mm will also be heat treated to get identical grain size. For both strategies, the aim will be to monitor the formation of multicrystals in order to control granular growth during *in situ* annealing under a scanning electron microscope (SEM).

Secondly, their mechanical behavior will be monitored through *in situ* tensile tests in a SEM to obtain the necessary geometric dislocation evolution laws (GND) on the surface.

Depending on the time remaining, the properties will be optimized using PVD deposition. It will therefore be possible to carry out these initial coatings, which will form the core of the PhD work following this MASTER internship.

The applicant will be able to take advantage of the new equipment acquired in 2023 as part of the CPER MAPE programme.

FINANCIAL CONTEXT: This internship is part of the MOCAMOR ANR project (2024-2028) involving 1) the manufacturing of multicrystals and two-sided coatings manufactured with different strategies 2) the mechanical and microstructural characterization of coated multicrystals combined with an analytical work hardening modeling 3) the full field modeling of crystal plasticity considering the sheet microstructures. To fulfil this project, two Master students, two PhD students (starting fall 2024) will be recruited.

The candidate will have the opportunity to apply to one of these PhD thesis.

REFERENCES

[Dubos *et al.* 2013] P.-A. Dubos, E. Hug, S. Thibault, M. Ben Bettaieb, C. Keller, Size Effects in Thin Face-Centered Cubic Metals for Different Complex Forming Loadings, Metall. Mater. Trans. A. 44 (2013) 5478–5487. (hal-02271152v1)

[Dubos *et al.* 2022] P.-A. Dubos, A. Zaouali, P.-Y. Jouan, M. Richard-Plouet, V. Brien, D. Gloaguen, B. Girault, Flow stress improvement of a nickel multicrystal by physical vapor thin film deposition to reduce surface effects, Mat. Let. X. 14 (2022) 100145.(hal-03671734)

[Hall 1951] E. O. Hall, The deformation and ageing of mild steel: III discussion of results. Proc. Phys. Soc. 64 (1951), 747-753.

[Petch 1953] N. J. Petch, The cleavage strength of polycrystals. J. Iron Steel Inst.174 (1953), 25-28.

[Miyiazaki *et al.* 1979] S. Miyazaki, K. Shibata, H. Fujita, Effect of specimen thickness on mechanical properties of polycrystalline aggregates with various grain sizes, Acta Met. 27 (1979) 855–862.

[Thompson *et al.* 1973] A.W. Thompson, M.I. Baskes, W.F. Flanagan, The dependence of polycrystal work hardening on grain size, Acta Metall. 21 (1973) 1017–1028.

Keywords

Metallurgy, multicrystals, heat treatment, mechanical testing, plasticity

Required skills

- Highly motivated by scientific research, serious, curious
- Metallic material science, Strong experimental skills, Electron microscopy and diffraction, micro-mechanic testing

Additional information

Duration of the internship: 6 months
Internship scholarship: Yes
Amount: In accordance with the French legislation
PhD opportunity after this internship: YES (ANR project)

Other useful information (housing, ...)?
Possibility to provide a financial help regarding traveling costs during the internship

Application procedure

Online application : no application by e-mail, fill the online form
https://questionnaires.univ-nantes.fr/index.php/737823?lang=en
with cover letter, curriculum, grades of the past 2 years, recommendation letter
Application deadline : February 4th, 2024
Interviews and selection : mid-February 2024
Internship starting date : March 11th, 2024