FOR APPLICATION, PLEASE CONTACT ADVISOR(S) BY EMAIL WITH COPY TO:
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Research Topic for the ParisTech/CSC PhD Program

Field: Materials Science, Mechanics, Fluids
Subfield: Mechanical Engineering
Title: Grain boundary formulation to investigate size effects on the formability of ultra-thin sheet metals.
ParisTech School: Arts et Métiers ParisTech
Advisor(s):

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Short description of possible research topics for a PhD:
Due to the increasing trend towards miniaturization, ultra-thin sheet metals have become widely used in various high technology fields, such as microelectronics and microbotics. However, when the thickness of a sheet decreases, some parameters, such as grain size and number of shallow grains, remain unchanged. This may have a strong influence on the mechanical properties, e.g., the ductility limit, of this sheet. Consequently, knowledge and understanding of conventional sheet behavior are no longer applicable to ultra-thin sheets. Further research effort is needed to meet the emerging scientific challenges posed by the technological progress towards miniaturization. In a current PhD project on the subject, a strain gradient crystal plasticity model is developed to describe size effects. This model, which is currently under validation, shows great capabilities and provides very promising results for sheets containing sufficient number of grains in the thickness. However, its use for sheets with only few grains (less than two) in the thickness would be critical. Indeed, at this number of grains, the grain boundary effects become extremely important. As continuation of this work, the present project aims to extend the newly developed model in order to account for the interaction between dislocations and grain boundaries. The extended model will after be coupled with plastic instability criteria to study the impact of size effects on the ductility of ultra-thin sheet metals without constraints on the number of grains in the thickness.

Required background of the student:
Computational mechanics, Material behavior, Sheet metal forming processes

A list of 5(max.) representative publications of the group:

[1] Ben Bettaieb, M. and Abed-Meraim, F., *Effect of kinematic hardening on localized necking in substrate-supported metal layers*, International Journal of Mechanical Sciences 123 (2017), pp. 177-197.
[2] Ben Bettaieb, M. and Abed-Meraim, F., *Theoretical and numerical investigation of the impact of out-of-plane compressive stress on sheet metal formability*, International Journal of Mechanical Sciences 130 (2017), pp. 244-257.
[3] Bouktir, Y. and Chalal, H. and Haddad, M. and Abed-Meraim, F., *Investigation of ductility limits based on bifurcation theory coupled with continuum damage mechanics*, Materials & Design 90 (2016), pp. 969-978.
[4] Akpama, H. K. and Ben Bettaieb, M. and Abed-Meraim, F., *Numerical integration of rate-independent BCC single crystal plasticity models: comparative study of two classes of numerical algorithms*, International Journal for Numerical Methods in Engineering 108 (2016), pp. 363-422.
[5] Ben Bettaieb, M. and Abed-Meraim, F., *Investigation of localized necking in substrate-supported metal layers: Comparison of bifurcation and imperfection analyses*, International Journal of Plasticity 65 (2015), pp. 168-190.