PhD project

Experimental study of hydrogen/crystalline defect interactions in martensitic steels and impact on the embrittlement mechanisms

Supervisors
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Beginning of the project: **as soon as possible, ideally September 2024**

Keywords: Martensitic steels, Hydrogen, Crystalline defects, Segregation, Electron microscopy, Atome probe tomography, Structure/property relationships

This thesis project is part of the ANR-funded project (https://anr.fr/) entitled "Hydrogen in Steels - A transition scales problem - HYSTYLE" (consortium: GPM - Univ. Rouen, LaSIE - Univ La Rochelle, MATEIS - INSA Lyon, IJL - Univ. Lorraine, IM2NP - Univ. Aix Marseille).

Context

Metallic alloys are essential materials at all levels for the production, storage or transport of hydrogen. The aim of this project is to deepen fundamental knowledge of the interactions at atomic scales between hydrogen and crystalline defects or carbides in steels. This is an important issue, since it is linked to hydrogen embrittlement, a phenomenon with major industrial consequences. Several phenomenological models already exist which are based on hypothesis related to these hydrogen/defect interactions. There is however a lack of knowledge especially in complex or dynamic configurations when other solutes are present (such as carbon in solid solution) or when dislocations interact with carbides that have potentially trapped H atoms.

Objectives

In this PhD project, we propose an original approach based on model microstructures obtained by heat treatment of steels to obtain different configurations (martensite, tempered martensite, ferrite with nanoscaled carbides). These materials will be electrolytically charged with hydrogen, and the trapping sites identified by TDS and atom probe tomography. Particular attention will be paid to the competition between carbon and hydrogen atoms for segregation on dislocations and grain boundaries. This information will be correlated with simulation undertaken by the other partners of the “Hystyle ANR Project”. To study dynamic effects, microstructures will be aged in-situ by transmission electron microscopy under hydrogen atmosphere. Finally, correlation with embrittlement mechanisms will be undertaken via micromechanical tests (in-situ compression or bending of micro-samples) enabling individual structural entities (grain boundaries, for example).

Profile required

- Engineering degree and/or a Master degree.
- Strong motivation for experimental research on advanced techniques.
- Solid background in materials science and physical metallurgy (phase transformations, crystalline defects and relationships between microstructures and mechanical properties).
- Prior experience in the field of microstructural characterization, mechanical properties and study of structure/properties relationships in a metallic alloys would be highly appreciated.
- Good written and oral communication skills, and fluency in English.

Host laboratories

The PhD project will be based at the Groupe de Physique des Matériaux UMR CNRS 6634 laboratory, located at the University of Rouen Normandy. https://gpm.univ-rouen.fr/

Part of the PhD work will be carried out at the “Laboratoire des Sciences de l'Ingénieur pour l'Environnement (LaSIE)” - UMR CNRS 7356 located at the University of La Rochelle, where various visits are planned. https://lasie.univ-larochelle.fr/Presentation

As part of the "Hydrogen in Steels - A transition scales problem - HYSTYLE" project, scientific exchanges will also take place with other laboratories of the consortium.

Contact persons and application

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