18-month experimental post-doc position at SRMP, CEA/Saclay, France, starting from October/November 2018

Title: Solute interaction with dislocation cores in alloys: influence on plasticity

Summary of the Project: **Research area: Solid State Physics, Materials Science**

Recent *ab initio* calculations four our group in iron suggest a strong interaction between carbon and screw dislocation in iron, which induces a reconstruction of the dislocation core structure with local cementite Fe_3C-type geometry [Ventelon2015]. Direct evidence of solute segregation at dislocation cores, forming the so-called Cottrell atmospheres, is extremely rare because of the very high spatial resolution required and the low probability to intercept a dislocation line within the sample.

Recent experiments based on high angle annular dark field (HAADF) scanning transmission electron microscopy (TEM) imaging, suitable to perform Z-contrast analysis, have been applied successfully to the oxygen segregation at dislocation cores in pure α-Ti samples with few oxygen contents [Yu2015]. Moreover, clouds of boron atoms near dislocation lines have been evidenced in FeAl alloys using three-dimensional atom probe tomography (APT) techniques [Blavette1999].

In the present study, we plan to perform STEM/HAADF imaging and electron energy-loss spectroscopy (EELS) experiments in order to obtain a chemical mapping of solute segregation on dislocations in pure iron with carbon addition. EELS mapping will be performed in the Laboratoire de Physique des Solides at Université Paris Sud, Orsay through the collaboration of Michael Walls using novel in-house developed multivariate analysis techniques such as independent component analysis (ICA) [Peña2011] previously applied to Cr and Ti segregation in ODS steels [Badjeck2015]. The dislocations will be aligned with the electron beam by orienting along <111> in the matrix grains. This should provide C-K edge signal from the entire thickness of the sample. Should the signals prove sufficient (this will require the summing of the spectra from many dislocation cores, which is semi-automatically performed in ICA) the fine structure will be compared with that seen in cementite in the literature [He2006] and in our own Fe_3C-containing samples. In this way the dislocation core atomic structure model can be evaluated. Our EELS mapping will be coupled to APT to analyze the distribution of carbon atoms along dislocation lines. Based on leading edge techniques that combine atomic-scale resolution and quantitative chemical analysis, these APT experiments and EELS mapping will enable us to bring to light the solute effect on plastic deformation of alloys. In-situ traction experiments at room temperature or at liquid nitrogen temperature will also be done.

To go further, interactions of others impurities (O or N) with screw dislocation in Fe will be investigate also. The study could be extended to W alloys.

This experimental work benefits from a French ANR grant (ANR Degas) and will be performed in close collaboration with a post-doctorate working on the modelling part of the project.

[Badjeck2015] J. Nucl. Mater., 456, 292 (2015).
[Blavette1999] D. Blavette et al., Science 286, 2317 (1999).
[He2006] J. Mater. Sci. 41, 5235 (2006).
[Peña2011] F. de la Peña et al., Ultramicrosc. 111, 169 (2011).
[Yu2015] Q. Yu et al., Science 347, 635 (2015).
[Ventelon2015] Phys. Rev. B, 91, 220102 (2015).

Qualifications: Applicants must have an earned Ph.D. degree in Solid State Physics, Materials Science or in a closely related area. A few years of experience in transmission electron microscopy and/or atom probe tomography will be appreciated.

Practical information: The Service de Recherches de Métallurgie Physique (SRMP) is part of the Department of Materials for Nuclear energy at CEA-Saclay. It is located 20 km south-west of Paris, in the area called Plateau de Saclay. The SRMP research laboratory has 30 full-time members with 25 graduate students.

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Time frame: **October/November 2018** to **March/April 2020**.

How to apply: Candidates must return a statement of research interests, CV, and names and contact information of two references to estelle.meslin@cea.fr